Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

Authors: Laura Rockwood
Noah Mayhew
Artem Lazarev
Mara Pfneisl

Vienna Center for Disarmament and Non-Proliferation
Vienna, Austria

Research

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IAEA Safeguards: Staying Ahead of the Game

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SSM perspective

Background

The Swedish Radiation Safety Authority (SSM) called for research proposals relating to non-proliferation. This call resulted in SSM accepting a proposal from the Vienna Center for Disarmament and Non-Proliferation (VCDNP) on "Improving IAEA Safeguards for Non-Proliferation and Disarmament: Assessing the Options for, and Feasibility of, Further Strengthening Safeguards".

SSM has a long history of supporting research on nuclear safeguards and non-proliferation, for example by providing funding for universities as part of building competence for future challenges and to help resolve technical issues. Since much of the practical international safeguards work is carried out by the International Atomic Energy Agency (IAEA), this organisation is one of the focal points of SSM's interests. Sweden also runs a support programme for IAEA safeguards, which is administered by SSM. Combining efforts devoted to general safeguards research with additional technical support to the IAEA makes for a productive working environment.

In the interest of guiding not only the work of SSM, but also other Swedish and international safeguards initiatives, SSM was attracted by the concept of assessing possible options for further strengthening of safeguards and the feasibility of achieving such strengthening measures. For this reason, the decision was made to provide funding for this project. In no way should SSM's funding of this project be perceived as criticism of the current approach to safeguards – SSM fully supports the IAEA's mandate and mission. However, since evolutions in e.g. technology must be taken into account, SSM is of the view that the international community needs to keep safeguards measures and approaches up to date. In this regard, all interested parties have a role to play in ensuring that safeguards remain effective and efficient..

Results

The report describes a large number of recommendations relating to:

- Outreach and communications;
- Balancing independence and transparency;
- Evolution of safeguards; and
- Applications of emerging technology.

The recommendations presented in this report are directed at all parties and stakeholders with interests in further strengthening of safeguards. Several of the recommendations focus on the IAEA, as this organisation is the centre of gravity for international safeguards in practice; however, interested States also have a large role to play.

Objective

The report can serve as guide to those who are interested in lending their effort to technically high standard nuclear safeguards. At the same time, the practical work sometimes brings political aspects into play. Ultimately, this demonstrates that multiple stakeholders around the globe have a role to play. Both political and technical viewpoints need to be addressed. This is an important but difficult task, something that this report has striven to achieve.

Need for further research

There is always room for improvement in a field such as nuclear safeguards, and SSM has the ambition to continue supporting relevant research. In the future, this may be accomplished by SSM making broad calls for research proposals

Project information

Contact person at SSM: Joakim Dahlberg
Reference: SSM2017-2253 / 7030193-00

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The VCDNP would like to express its appreciation to the individuals who dedicated the time and effort to contribute to the VCDNP’s workshop on “IAEA Safeguards: Staying Ahead of the Game”, which preceded this report. The VCDNP would also like to thank the Swedish Radiation Safety Authority for funding this project.

Content

Sammanfattning

Internationella atomenergiorganets (IAEA) internationella kärnämneskontroll har sedan dess början genomgått en betydande utveckling. Det startade på 1960-talet med framtagandet av det första dokumentet och dess reviderade versioner som användes som grund för specifika avtal. Detta följdes av utvecklingen av ett system för omfattande kärnämneskontroll (CSA), med dokument som definierar strukturen och innehållet i CSA.

Den senaste stora utvecklingen skedde för över 20 år sedan i och med det framgångsrika genomförandet av *Program 93 + 2*, vilket kulminerade i IAEA:s styrelses godkännande av modelltilläggsprotokollet i maj 1997. Sedan början av 2000-talet har IAEA därefter utvecklat kärnämneskontroll på statsnivå som integrerar åtgärder föreskrivna i CSA och tilläggsprotokoll (AP) på ett verkningsfullt och kostnadseffektivt sätt.

IAEA arbetar fortlöpande för att "förbättra kostnadseffektiviteten av kärnämneskontroll och samtidigt upprätthålla eller stärka dess verkningsfullhet". Bland de mer framgångsrika insatserna för att stärka kärnämneskontrollen var 2005 års revision av protokollet om små mängder (SQP).

Det föränderliga globala läget medför nya utmaningar i en allt högre takt. För att ligga före i utvecklingen och maximera IAEA:s förmåga att förutse och ta itu med utmaningar i tid är det viktigt att tänka "outside the box", bland annat kring hur IAEA och dess medlemsstater kan omvandla dessa utmaningar till möjligheter.

Med stöd av Strålsäkerhetsmyndigheten (SSM) åtog sig Vienna Center for Disarmament and Non-Proliferation (VCDNP) att genomföra en studie med syfte att utvärdera behovet och genomförbarheten av nya åtgärder för att ytterligare stärka kärnämneskontrollen. Förutom forskning vid VCDNP omfattade projektet ett två dagars arbetsmöte med inbjudna kärnämneskontrollexperter från IAEA:s medlemsstater, icke-statliga organisationer och akademier, samt före detta IAEA-personal. Denna rapport är resultatet av det sammantagna arbetet.

Tre kapitel i rapporten beskriver aktuella utmaningar, framväxande och framtida utmaningar samt avslutningsvis möjligheter som följer med nya verktyg och ny teknologi. Vart och ett av dessa kapitel åtföljs av ett antal rekommendationer för att möta dessa utmaningar och utforska sätt på vilka framväxande teknologier kan vara avgörande för att uppnå det syftet.

I rapporten identifieras aktuella utmaningar vilka beskrivs i kapitel II fördelat på fyra underavsnitt med 31 rekommendationer avseende:

- Den rättsliga ramen för IAEA:s kärnämneskontroll
- Att stärka stödet för IAEA:s auktoritet inom kärnämneskontroll
- Utmaningar som uppstår vid genomförandet av kärnämneskontroll
- Interna administrativa utmaningar.

Det första underavsnittet i rapporten innehåller 12 rekommendationer för att möta behovet av att ingå utestående CSA, expandera antalet stater som undertecknar tilläggsprotokoll, ändra och återkalla SQP samt möjliggöra uppdateringar av bilagor till

AP. Många av rekommendationerna avser en förstärkning av den kommunikation och uppsökande verksamhet som bedrivs av IAEA, dess medlemsstater samt icke-statliga organisationer, i synnerhet när det gäller att bistå stater som saknar information eller resurser för att teckna eller effektivt implementera CSA eller därtill hörande AP, alternativt att ändra eller upphäva SQP, där det är relevant.

Rapporten innehåller några rekommendationer som syftar till att uppmuntra differentierad behandling via regionala ansatser, inklusive bilaterala och multilaterala möten, samt skapandet av ett forum för statssystem (SSAC) eller regionala system (RSAC) för att utbyta erfarenheter. När det gäller bredare uppsökande insatser rekommenderas utbildning av nya diplomater och annan personal i Wien rörande kärnämneskontrollens historia samt en ökning av uppsökande verksamhet riktad mot allmänheten genom att i resuméer publicera frågor som är viktiga för IAEA .

Tre andra rekommendationer fokuserar på åtgärder som stater kan åta sig antingen på egen hand eller inom ramen för internationella organisationer. Dessa åtgärder kan vara svåra att genomföra på kort sikt då de i viss utsträckning är beroende av medlemsstaternas vilja och ekonomiska kapacitet.

Trots slutsatsen att en uppdatering av bilagorna till modelltilläggsprotokollet för närvarande sannolikt inte är genomförbar innehåller rapporten alternativa rekommendationer som generellt syftar till att stärka genomförandet av AP.

Rapportens andra underavsnitt behandlar förnyade utmaningar för IAEA i rollen som auktoritetsutövare vid genomförandet av kärnämneskontroll, i synnerhet dess rätt och skyldighet att verifiera korrektheten och fullständigheten av staters deklarationer, användningen av särskilda inspektioner och dess befogenhet att undersöka indikationer på vapenframställning. Medan merparten av totalt fem rekommendationer behandlar behovet av insyn, konsultationer och ett allmänt förhållningssätt som understryker ett kärnämneskontrollförhållande som karaktäriseras av partnerskap snarare än ifrågasättande, noteras även att både sekretariatet och IAEA:s medlemsstater aktivt ska motverka grundlösa bestridanden av IAEA: s nuvarande legala auktoritet. Alla dessa aktiviteter bedöms vara genomförbara på kort och medellång sikt. Ytterligare en rekommendation rör möjligheten att justera SAGSI:s roll, men det anses vara svårare att genomföra.

Tredje och fjärde delavsnitten pekar ut externa implementeringsutmaningar samt interna administrativa utmaningar och 14 rekommendationer presenteras med avseende på detta. Rörande externa utmaningar fokuseras i huvudsak på hur stater kan hjälpas att förbättra sin kapacitet för genomförande av kärnämneskontroll och att utbilda inspektörer, som IAEA:s ansikte utåt, inte bara med avseende på praktisk kärnämneskontroll och lagrum utan även inom så kallade mjuka vetenskaper relaterade till förhandlingskunskaper. Delavsnittet om interna administrativa utmaningar fokuserar på två centrala områden: genomförande av rotationspolitiken samt hur en tillräcklig finansiering för IAEA:s kärnämneskontroll kan säkerställas.

I kapitel III diskuteras nya och framtida utmaningar både avseende nya typer av kärnbränslecykelanläggningar och material samt nya teknologier med dubbla användningsområden. Rapporten innehåller sju rekommendationer som främst fokuserar på de risker som uppstår i samband med snabb framväxt av nya bränslecykeltekniker (t.ex. nya reaktortyper, pyrokemisk behandling och slutförvaring av använt bränsle), vikten av att implementera kärnämneskontrollen redan i design av anläggningar och tidigt samråd mellan IAEA och medlemsstater, särskilt kärnvapenstaterna, om tidig leverans av designinformation och dess kontroll. Den erbjuder också en rekommendation om engagemang mellan IAEA och Nuclear Suppliers Group (NSG) för att diskutera konsekvenserna för kärnämnes- och exportkontroll av ny och framväxande teknik med dubbla användningsområden.

I kapitel IV beskriver rapporten möjligheter som följer med en rad nya verktyg och teknologier för användning vid genomförandet av kärnämneskontroll, både vid IAEA:s huvudkontor (såsom DLT, datavisualisering, artificiell intelligens och maskininlärning och *crowdsourcing*) samt i fält (t.ex. drönare och bärbar teknik). Två av nio medföljande rekommendationer fokuserar på hur dessa nya verktyg och tekniker bör uppfattas, specifikt att de inte ska ses som en ersättning för mänskliga analytiker, utan snarare som effektiva hjälpmedel för förbättring och effektivisering av analytikers arbete, samt att utbyggnaden av IAEA-utrustning och teknik kommer att kräva överväganden av säkerhetsfrågor samt kärnämneskontroll.

Det femte och sista kapitlet innehåller sammanfattade rekommendationer som generellt sett placeras inom en av följande fyra typkategorier:

- Uppsökande och kommunikation;
- Balansera oberoende och öppenhet
- Utvecklingen av kärnämneskontroll och
- Tillämpningar av ny teknik.

I kapitlet presenteras även en bedömning av rekommendationernas genomförbarhet, inklusive förslag som syftar till att skapa en miljö som tros kunna öka sannolikheten för åtgärdernas acceptans.

Sammanfattningsvis anses många rekommendationer vara genomförbara på omedelbar eller kort sikt. Några av de nyare förslagen kan dock komma att kräva ytterligare studier och/eller ett mer positivt politiskt klimat innan de kan genomföras.

Summary

The international safeguards regime of the International Atomic Energy Agency (IAEA) has undergone significant evolution over time. It began with the formulation in the 1960s of the first safeguards document and its revised versions used as the basis for item-specific safeguards agreements. This was followed by the development of a system of comprehensive safeguards and the document defining the structure and content of comprehensive safeguards agreements (CSAs).

The last major evolution occurred over 20 years ago with the successful conclusion of *Programme 93+2*, which culminated in the approval by the IAEA's Board of Governors of the Model Additional Protocol in May 1997. Since the early 2000s, the IAEA has been developing State-level safeguards approaches that integrate the measures provided for in CSAs and additional protocols (APs) in the most efficient and cost-effective way possible.

The IAEA continues on an on-going basis to "improve the efficiency of safeguards implementation while maintaining or strengthening its effectiveness". Among the more successful efforts to strengthen safeguards was the 2005 revision of the small quantities protocol (SQP).

The fast-changing global environment poses new challenges at an ever-increasing rate. To stay ahead of the game and maximize the IAEA's ability to anticipate and address challenges in a timely fashion, it is important to think "outside the box", including about how the IAEA and its Member States might turn these challenges into opportunities.

With funding by the Swedish Radiation Safety Authority (SSM), the Vienna Center for Disarmament and Non-Proliferation (VCDNP) undertook to conduct a study with a view to assessing the need for and feasibility of implementing measures to further strengthen safeguards. In addition to the research carried out by the VCDNP, the project included a two-day workshop with invited safeguards experts from Member States of the IAEA, non-governmental organizations and academia, as well as former safeguards staff. This report is the result of those efforts.

The report addresses in three chapters current challenges, emerging and future challenges and finally opportunities offered by new tools and emerging technologies. Each of these chapters is accompanied by a number of recommendations for addressing those challenges and exploring ways in which emerging technologies might be instrumental in achieving that purpose.

In Chapter II, the report identifies in fours sub-chapters, and 31 recommendations with respect to current challenges associated with:

- The legal framework of IAEA safeguards;
- Strengthening support for the IAEA's safeguards authority;
- Challenges posed in the implementation of safeguards; and
- Internal administrative challenges.

In the first sub-chapter, the report offers 12 recommendations to address the need for the conclusion of outstanding CSAs, expanding the number of APs, modification and rescission of SQPs and the possibility of updating the Annexes of the Model Additional Protocol. Many of the recommendations relate to enhanced communication and outreach by the IAEA, its Member States and non-governmental organizations, in particular with

respect to assisting States that lack information or resources to conclude or effectively implement CSAs or APs thereto, or to amend or rescind SQPs, where relevant.

The report offers some novel recommendations for encouraging differentiated treatment using regional outreach approaches, including bilateral and multilateral meetings, as well as the creation of a forum for SRAs/SSACs to exchange experiences and best practices. In terms of broader outreach efforts, it offers recommendations with respect to training for staff members and new diplomats in Vienna on the history of safeguards, as well as increased outreach to the general public through the publication of short briefs on issues important to the IAEA.

Three other recommendations focus on actions that States might undertake either on their own or within other international organisations. As these measures depend to some extent on the will and economic capabilities of Member States, they may be less feasible in the near term.

Although it is concluded that the amendment of the Annexes of the Model Additional Protocol is not for the time being likely to be feasible, the report offers alternative recommendations for strengthening the implementation of APs in general.

In the second sub-chapter, the report addresses renewed challenges to the IAEA’s authority in implementing safeguards, in particular its right and obligation to verify the correctness and completeness of States’ declarations, its use of special inspections and its authority to investigate indications of weaponization. While most of the five recommendations revolve around the need for transparency, consultations and messaging that underscores a safeguards relationship characterised by partnership rather than contestation, the recommendations also note the responsibility of both the Secretariat and IAEA Member States actively to rebut baseless challenges to the IAEA’s existing legal authority. All of these activities are believed to be feasible in a short to medium term timeframe. One of the other recommendations relates to the possible modification of the role of SAGSI, this recommendation is considered to be less feasible.

The third and fourth sub-chapters address external implementation challenges and internal administrative challenges, with respect to which the report offers 14 recommendations. With respect to the former, the focus is largely on how to assist States in improving their capacity to implement safeguards, and training inspectors, as the “face of the Agency in the field”, not only in safeguards implementation practices and law, but in the so-called soft sciences related to negotiation skills. The sub-chapter on internal administrative challenges focuses on two key issues: implementation of rotation policies and how to secure adequate funding for IAEA safeguards.

In Chapter III, the report discusses emerging and future challenges both in the context of new types of nuclear fuel cycle facilities and materials, and new and emerging dual-use technologies. The report offers seven recommendations, focuses predominantly on the risks posted by the rapidly emerging fuel cycle technologies (e.g., new reactor types, pyroprocessing and final storage of spent fuel), the importance of safeguards by design and early consultations between the IAEA and Member States, in particular the nuclear-weapon States, on the early provision of design information and its verification. It also offers a recommendation on engagement between the IAEA and the Nuclear Suppliers Group to discuss the implications for safeguards and export controls of new and emerging dual-use technologies.

In Chapter IV, the report describes opportunities offered by a range of new tools and emerging technologies for use in the implementation of safeguards, both at IAEA Headquarters (such as distributed ledger technology, data visualization, artificial intelligence, machine learning and crowdsourcing) and in the field (e.g. drones and wearable technology). In the nine resulting recommendations, two are focussed on how these new tools and technologies should be perceived, specifically, that they should not be seen as substitutes for human analysts, but rather an efficient aide for analysts to do their jobs better and more efficiently, and that the deployment of IAEA equipment and technology will require consideration of issues related to safety and security as well as safeguards.

The fifth and final chapter summarizes the recommendations, categorizing them as falling generally within one of the following four types:

- Outreach and Communications;
- Balancing Independence and Transparency;
- Evolution of Safeguards; and
- Applications of Emerging Technology.

The conclusions chapter also provides an assessment of the feasibility of implementing the recommendations, including suggestions for creating an environment that might enhance the likeliness of their acceptance.

In summary, there are many recommendations that are immediately or in the short term considered to be feasible. However, some of the more novel suggestions may require more study and/or a more positive political climate before they can be implemented.

Chapter I: Introduction

The international safeguards regime of the International Atomic Energy Agency (IAEA) has undergone significant evolution over time. It began with the formulation in the 1960s of the first safeguards document[1] and its revised versions[2] used as the basis for item-specific safeguards agreements. This was followed by the development of a system of comprehensive safeguards and the document defining the structure and content of comprehensive safeguards agreements (CSAs).[3]

The last major evolution occurred over 20 years ago with the successful conclusion of Programme 93+2, which culminated in the approval by the IAEA's Board of Governors of the Model Additional Protocol in May 1997.[4] Since the early 2000s, the IAEA has been developing State-level safeguards approaches that integrate the measures provided for in CSAs and additional protocols (APs) in the most efficient and cost-effective way possible.

The IAEA continues on an on-going basis to "improve the efficiency of safeguards implementation while maintaining or strengthening its effectiveness".[5] Among the more successful efforts to strengthen safeguards was the 2005 revision of the small quantities protocol (SQP), as discussed below.

However, other efforts to further strengthen safeguards have been less successful. Key among those was the ill-fated open-ended "Advisory Committee on Safeguards and Verification within the Framework of the IAEA Statute" (Committee 25), established by the IAEA Board of Governors in 2005 for an initial period of two years. Its mandate expired without the Committee being able to reach agreement on even the most modest proposals by the Secretariat.[6]

Another example was the effort by the Secretariat to further evolve the application of the State-level concept in the mid-2010s, an effort that, rather than being received as intended—as a blueprint for the next logical step in the evolution of safeguards—triggered a decidedly negative response on the part of some Member States and even resulted in challenges to important measures to strengthen safeguards that had been in place since the early 1990s.[7]

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[1] International Atomic Energy Agency – IAEA (1961). *The Agency's Safeguards*, INFCIRC/26, https://www.iaea.org/sites/default/files/publications/documents/infcircs/1961/infcirc26.pdf.

[2] IAEA (1965). *The Agency's Safeguards System (1965)*, INFCIRC/66, https://www.iaea.org/sites/default/files/publications/documents/infcircs/1965/infcirc66.pdf; IAEA. (1967). *The Agency's Safeguards System (1965, as provisionally extended in 1966)*, INFCIRC/66/Rev. 1, https://www.iaea.org/sites/default/files/publications/documents/infcircs/1965/infcirc66r1.pdf; and IAEA (1968). *The Agency's Safeguards System (1965, as provisionally extended in 1966 and 1968)*, INFCIRC/66/Rev. 2, https://www.iaea.org/sites/default/files/publications/documents/infcircs/1965/infcirc66r2.pdf.

[3] IAEA (1972). *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, INFCIRC/153 (Corrected), https://www.iaea.org/sites/default/files/publications/documents/infcircs/1972/infcirc153.pdf.

[4] IAEA (1997). *Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, INFCIRC/540 (Corr.), https://www.iaea.org/sites/default/files/infcirc540c.pdf.

[5] See, e.g. IAEA (2018). *Safeguards Statement for 2017*, para. 46. https://www.iaea.org/sites/default/files/18/06/statement-sir-2017.pdf.

[6] Committee 25 was established in 2005 by the Board of Governors as an open-ended committee of the Board with a two-year mandate, which was not extended by the Board.

[7] For an in-depth analysis, see L. Rockwood (2014). "The IAEA's State-Level Concept and the Law of Unintended Consequences", *Arms Control Today*, September 2014, available at https://www.armscontrol.org/act/2014_09/Features/The-IAEAs-State-Level-Concept-and-the-Law-of-Unintended-Consequences.

Notwithstanding, the fast-changing global environment poses new challenges at an ever-increasing rate. To stay ahead of the game and maximize the IAEA's ability to anticipate and address challenges in a timely fashion, it is important to think "outside the box", including about how the IAEA and its Member States might turn these challenges into opportunities.

With funding by the Swedish Radiation Safety Authority (SSM), the Vienna Center for Disarmament and Non-Proliferation (VCDNP) undertook to conduct a study with a view to assessing the need for and feasibility of implementing measures to further strengthen safeguards. In addition to the research carried out by the VCDNP, the project included a two-day workshop with invited safeguards experts from Member States of the IAEA, non-governmental organizations and academia, as well as former safeguards staff.

This report is the result of those efforts. It identifies some of the most pressing current and future challenges for IAEA safeguards and offers a number of recommendations for addressing those challenges, exploring ways in which emerging technologies might be instrumental in achieving that purpose. The report also provides an assessment of the feasibility of implementing the recommendations, with some suggestions for creating an environment that might enhance the likeliness of their acceptance.

Chapter II: Current Challenges

1. Legal Framework

1.1. Conclusion of Outstanding CSAs

Article III of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) requires each non-nuclear-weapon State (NNWS) party to the NPT to accept safeguards, as set forth in an agreement to be negotiated and concluded with the IAEA, "in accordance with … the Agency's safeguards system, for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices". In accordance with the NPT, such safeguards are to 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". As such, the safeguards agreements concluded with the NPT NNWSs, all of which are based on IAEA document INFCIRC/153 (Corr.)[8], are referred to as comprehensive safeguards agreements or CSAs.

Pursuant to Article III.4. of the NPT, the negotiation of such agreements was to commence within 180 days of the entry into force of the NPT (i.e., by September 1970). For States depositing their instruments of ratification or accession after September 1970, negotiation of such agreements is to commence not later than the date of such deposit, and are to be brought into force within 18 months after the initiation of such negotiations (i.e. not later than a year and a half after the State becomes party to the NPT). As of March 2019, of the 186 NNWSs party to the NPT[9], 175 have brought CSAs into force[10]. The remaining 11 States have had outstanding CSAs for as few as four years and as many as 49 years.

As noted in the Director General's *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*[11] (discussed in further detail below), all of these countries are small, many are unfamiliar with safeguards and many do not have Missions in Vienna. Of these 11 States, eight are located in sub-Saharan Africa, each with problems of higher domestic priority (including extreme poverty, war and/or prolonged conflicts).

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[8] *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, IAEA, INFCIRC/153 (Corrected), June 1972.

[9] The number 186 includes the Democratic People's Republic of Korea (DPRK), nothing that there are differences of views among the States Parties to the NPT as to whether the DPRK has perfected its withdrawal from the NPT. For a list of the States Parties, see http://disarmament.un.org/treaties/t/npt.

[10] Of the remaining 11 States, the status is as follows: Benin (CSA and AP signed 7 June 2005, small quantities protocol (SQP) amended 15 April 2008); Cabo Verde (CSA and AP signed 28 June 2005, SQP amended 27 March 2006); Equatorial Guinea (CSA and SQP approved by Board of Governors 13 June 1986); Eritrea (no action taken on its CSA); Guinea (CSA, SQP and AP signed 13 December 2011); Guinea-Bissau (CSA, SQP and AP signed 21 June 2013); Micronesia (CSA and SQP signed 1 June 2015); Palestine (CSA and SQP approved by the Board 7 March 2018); São Tomé and Principe (no action taken on its CSA); Somalia (no action taken on its CSA); Timor-Leste (CSA, SQP and AP signed 6 October 2009). See "Status List: Conclusion of safeguards agreements, additional protocols and small quantities protocols", 6 March 2019, https://www.iaea.org/sites/default/files/status-sg-agreements-comprehensive.pdf.

[11] IAEA (2018). *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*, https://www.iaea.org/sites/default/files/18/09/sg-plan-of-action-2017-2018.pdf.

1.2. Expanding the Number of APs

The IAEA's Board of Governors approved the text of *The Model Protocol Additional to the Agreements between State(s) and the International Atomic Energy Agency for the Application of Safeguards* (the Model Additional Protocol) in May 1997.[12] As reflected in its foreword, the Model Additional Protocol was designed to "strengthen the effectiveness and improve the efficiency of the safeguards system as a contribution to global nuclear non-proliferation objectives". The Board requested the Director General to use the Model Additional Protocol as the standard for APs concluded by States and other parties to CSAs with the Agency.[13]

In the Final Document of the 2000 NPT Review Conference, the States Parties were able to agree on consensus language that recommended that the IAEA's Director General and its Member States consider "ways and means, which could include a possible plan of action, to promote and facilitate the conclusion and entry into force of such safeguards agreements and additional protocols, including, for example, specific measures to assist States with less experience in nuclear activities to implement legal requirements".[14]

In September 2000, the IAEA General Conference recommended that the Director General, the Board and Member States consider implementing such an action plan.[15] The Conference further recommended that the plan involve an increased effort by the Director General to conclude safeguards agreements and APs, particularly in States with significant nuclear activities, as well as increased bilateral and regional consultations, assistance and coordination between the IAEA Secretariat and Member States. The General Conference also recommended that Member States themselves take additional steps to promote safeguards agreements and APs.

The following year, the Director General's report on safeguards included an update on the implementation of the *Plan of Action*[16] in which he highlighted three types of activities that might be continued and intensified: activities for the Secretariat to implement; activities that States might undertake; and activities that should be done in collaboration between the Secretariat and Member States.

In June 2001, the Japanese Government convened an international meeting focused on the practical aspects of concluding and implementing APs in the Asia-Pacific region. In December 2002, Japan hosted another conference in cooperation with the IAEA with the aim of promoting wider adherence to APs.[17] Eighty-two participants representing 36 States attended the conference. Among the recommendations in the chairman's summary were calls for maximum cooperation between the IAEA and States, as well as for the establishment of an informal group of "Friends of the Additional Protocol" in

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[12] IAEA, INFCIRC/540 (Corrected), December 1998.

[13] The Board also requested the Director General to negotiate APs with: nuclear-weapon States (NWSs), incorporating those measures that each NWS "has identified as capable of contributing to the non-proliferation and efficiency aims of the Protocol, when implemented with regard to that State, and as consistent with that State's obligations under Article I of the NPT"; and with other States that are prepared to accept measures from provided for in the Model "in pursuance of safeguards effectiveness and efficiency objectives." See INFCIRC/540 (Corr.), Foreword.

[14] United Nations Office of Disarmament Affairs - UNODA (2000). *NPT/CONF.2000/28 (Parts I and II)*, para. 47, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N00/453/64/PDF/N0045364.pdf.

[15] IAEA (2000). *Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System and Application of the Model Protocol: Resolution adopted on 22 September 2000 at the tenth plenary meeting*, GC(44)/RES/19, para. 14, https://www-legacy.iaea.org/About/Policy/GC/GC44/GC44Resolutions/English/gc44res-19_en.pdf.

[16] IAEA (2001). *Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System and Application of the Model Additional Protocol*, GC(45)/23, https://www-legacy.iaea.org/About/Policy/GC/GC45/GC45Documents/English/gc45-23_en.pdf.

[17] Ministry of Foreign Affairs of Japan (2004). *MOFA: Japan's Efforts in the Universalization of the International Atomic Energy Agency (IAEA) Additional Protocol*, https://www.mofa.go.jp/policy/energy/iaea/protocol.html.

order to help States coordinate their national and regional efforts and to maintain momentum.[18] The group does not seem to be active as of today, although its work was mentioned during the 2010 NPT Review Conference.[19]

The Director General's *Plan of Action* was last updated in September 2018 and continues to be implemented by the Secretariat with its goals much unchanged. The Plan identifies three categories of target States that must be reached:

- IAEA Member States with substantial nuclear activities (Group 1);
- IAEA Member States with limited nuclear material and activities (Group 2); and
- Non-Member States of the IAEA (Group 3), including the DPRK.

The highest priority is still given to the conclusion of APs with the States in Group 1 (including Argentina, Brazil, Egypt, Syria and Venezuela), in particular with States that have declared conversion, enrichment, fabrication or reprocessing facilities. Outreach activities for States in Group 2 also focus on the amendment of small quantities protocols (SQPs) (see discussion below). In the latest *Plan of Action*, the Secretariat noted that "[a] special situation – thus special working methods – also apply to most non-Member States" (Group 3), where there are no working level relations with IAEA staff and, with the exception of North Korea, little or no experience with the IAEA's mandated activities".[20]

The Nuclear Suppliers Group (NSG), following a decade-long debate about whether to require an AP as a condition of supply for all nuclear materials, equipment and technology, agreed in 2011 to adopt modified language in connection with transfers of sensitive fuel technology (uranium enrichment and reprocessing (ENR)).[21] The revised guidelines urged NSG members to limit the transfer of ENR technology to countries that have brought into force a CSA and an AP based on the Model Additional Protocol "or, pending this, is implementing appropriate safeguards agreements in cooperation with the IAEA, including a regional accounting and control arrangement for nuclear materials, as approved by the IAEA Board of Governors".[22]

As of March 2019, of the 175 States that have brought a CSA into force, 128 have also brought an AP into force. Another 14 States have signed an AP, but have not yet brought it into force.[23] Although over 75 per cent of the NPT NNWSs have thus brought into force or signed an AP, a number of States have not yet done so. The reasons for some of these States are similar to those of the States that have yet to bring into force a CSA. For

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[18] Ministry of Foreign Affairs of Japan (2002). *International Conference on Wider Adherence to Strengthened IAEA Safeguards Chairman's Summary*, https://www.mofa.go.jp/policy/energy/conf0212.html.
[19] UNODA (2010). *2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons: Main Committee II, Summary record of the 1st meeting*, NPT/CONF.2010/MC.II/SR.1, para. 32, http://cns.miis.edu/nam/documents/Summary_Record/NPTCONF.2010MC.II-SR.1-p.2-para3.pdf
[20] IAEA (2018). *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*, p. 9, https://www.iaea.org/sites/default/files/18/09/sg-plan-of-action-2017-2018.pdf.
[21] INFCIRC 254/Rev.10/Part I
[22] See *INFCIRC/254/Rev.10/Part 1* (2011). "Communication Received from the Permanent Mission of the Netherlands regarding Certain Member States' Guidelines for the Export of Nuclear Material, Equipment and Technology", IAEA, https://www.iaea.org/sites/default/files/publications/documents/infcircs/1978/infcirc254r10p1.pdf. The full text of paragraph 6(c) reads as follows: "Suppliers will make special efforts in support of effective implementation of IAEA safeguards for enrichment or reprocessing facilities, equipment or technology and should, consistent with paragraphs 4 and 13 of the Guidelines, ensure their peaceful nature. In this regard, suppliers should authorise transfers, pursuant to this paragraph, only when the recipient has brought into force a Comprehensive Safeguards Agreement, and an Additional Protocol based on the Model Additional Protocol or, pending this, is implementing appropriate safeguards agreements in cooperation with the IAEA, including a regional accounting and control arrangement for nuclear materials, as approved by the IAEA Board of Governors."
[23] Of those 14, nine have a CSA in force; the other five have not yet brought their respective CSAs into force. See "Status List: Conclusion of safeguards agreements, additional protocols and small quantities protocols", 6 March 2019, https://www.iaea.org/sites/default/files/status-sg-agreements-comprehensive.pdf.

some it is due to a lack of awareness of safeguards or the benefits of concluding an AP. For others it is the inability to implement an AP due to lack of resources or experience and domestic priorities that take precedence over strengthening safeguards. The most challenging group to address includes those States that have expressed an unwillingness to conclude an AP, citing collateral policy decisions (i.e., frustration with the pace of nuclear disarmament on the part of the NWSs or the lack of progress on peace in the Middle East).

As discussed below, there may be ways to tailor outreach and assistance to many of these countries that can ameliorate these problems. While the IAEA has seen considerable improvement in AP adherence over the years, work remains to be done with States that still have not brought an AP into force. The IAEA should continue its work through the *Plan of Action*, but new approaches are required. It may also be worthwhile to revisit some old approaches.

1.3. Modification and Revision of Small Quantities Protocols

Since 1974, the IAEA has been concluding with NPT NNWSs that have no significant nuclear activities a protocol to their respective CSAs which has the effect of holding in abeyance most of the operative provisions of the CSA. The purpose of these protocols, commonly referred to as "small quantities protocols" or "SQPs", was to "minimize the burden of safeguards activities on States with little or no nuclear activities, while ensuring that the IAEA's safeguards conclusions for SQP States are soundly based".[24] The model text for such SQPs was published in 1974 as Annex B to GOV/INF/276.[25]

Prior to 2005, all that was required of a State to conclude an SQP was for the State to confirm to the Secretariat that it had limited quantities of nuclear material[26] and that it had no nuclear material in a nuclear facility. The SQP would remain operational for so long as the State concerned satisfied the eligibility criteria. Under the 1974 model, the State is required to report the information required under paragraph 34 of INFCRC/153 on the import and export of nuclear material, but may submit such information in an annual report on a consolidated basis. The 1974 model also provides that, in order to enable the timely conclusion of the Subsidiary Arrangements required under paragraph 39 of INFCIRC/153, the State is also required to notify the Agency "sufficiently in advance of its having nuclear material in peaceful nuclear activities within its territory or under its jurisdiction or control anywhere in quantities that exceed the limits or six months before nuclear material is to be introduced into a facility …, whichever occurs first".

In September 2005, the Board, in response to proposals offered by the Secretariat, acknowledged that SQPs based on the 1974 model represented a weakness in the safeguards system, but determined that there was still value in minimising the safeguards obligations of States that had no significant nuclear activities. To address this weakness, the Board decided to change the eligibility criteria and to modify the text of the model SQP with respect to the substantive requirements. The Board authorized the Director General to conclude exchanges of letters with all States with SQPs to give effect to these modifications and to the changed criteria and called upon the States concerned to

[24] IAEA (June 2016). *Safeguards Implementation Guide for States with Small Quantities Protocols*, https://www.iaea.org/publications/10493/safeguards-implementation-guide-for-states-with-small-quantities-protocols.
[25] *Id,* at p. 93.
[26] I.e., less than the quantities specified in paragraph 37 of INFCIRC/153.

conclude such exchanges of letters as soon as possible. It also requested the Secretariat to assist States with SQPs in the establishment and maintenance of their State systems of accounting for and control of nuclear material (SSACs).[27]

Under the modified text for SQPs (reproduced in GOV/INF/276/Mod.1 and Corr.1)[28], a State is now eligible to conclude an SQP only if it has less than the specified quantities of nuclear material *and* has no nuclear facility, whether existing or planned. Under a modified SQP, the protocol becomes non-operational if the specified quantities of nuclear material are exceeded or if the State decides to construct or to authorize construction of a facility. The modified text also reintroduces the requirement that a State provide an initial report on all of its nuclear material, and reinstates the Agency's right to carry out ad hoc and special inspections.[29]

While the IAEA has since 2005 only concluded SQPs based on the modified text, as of March 2019, 36 States have not yet agreed to amend their respective SQPs based on the 1974 model, or to rescind them where the State would no longer qualify for an SQP.[30] While the General Conference and the Board have repeatedly called for States with SQPs based on the old model to amend or rescind them, as appropriate, more action is needed to encourage those States to do so.

Yet again, for many of these States, the reasons are the same as those for not having concluded their respective CSAs or an AP to their CSAs: a lack of familiarity with safeguards, the perception of safeguards as a burden and/or a lack of infrastructure and resources.

1.4. Updating Annexes I and II of the Model Additional Protocol

Article 2.a.(iv) of the Model Additional Protocol requires a State with an AP to submit an initial declaration containing a description of the scale of operations for each location engaged in the activities specified in Annex I to the AP ("List of Activities Referred to in Article 2.a.(iv) of the Protocol"), and to update that information annually. The activities relate to the manufacture, assembly or upgrading of certain equipment and materials related to enrichment, reactor operation, heavy water production and reprocessing. Many of these activities involve both single (nuclear) and dual-use materials, equipment and/or technology and result in the production of items listed in Annex II of the Model Additional Protocol.

Annex II of the Model Additional Protocol contains the "List of Specified Equipment and Non-Nuclear Material for the reporting of Exports and Imports According to Article 2.a.(ix)". Article 2.a.(ix) of the Model Additional Protocol requires the State to

[27] IAEA (2006). *Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System Including Implementation of Additional Protocols*, GC(50)/2, https://www-legacy.iaea.org/About/Policy/GC/GC50/GC50Documents/English/gc50-2_en.pdf.
[28] IAEA (June 2016). *Safeguards Implementation Guide for States with Small Quantities Protocols*, at p. 95.
[29] IAEA (2006). *Safeguards Statement for 2005*, para. 34, https://www.iaea.org/sites/default/files/es2005.pdf.
[30] Barbados, Belize, Bhutan, Bolivia, Brunei Darussalam, Cameroon, Dominica, Equatorial Guinea, Ethiopia, Fiji, Guyana, Haiti, Kiribati, Kyrgyzstan, Laos, Maldives, Mongolia, Myanmar, Namibia, Nauru, Nepal, Oman, Saint Lucia, St. Vincent and the Grenadines, Samoa, Saudi Arabia, Sierra Leone, Solomon Islands, Sudan, Suriname, Trinidad and Tobago, Tuvalu, Yemen, Zambia and two States that have territories within the zone of application of the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Netherlands and United Kingdom). See "Status List: Conclusion of safeguards agreements, additional protocols and small quantities protocols", 6 March 2019, https://www.iaea.org/sites/default/files/status-sg-agreements-comprehensive.pdf.

provide the following information regarding specified equipment and non-nuclear material:

(a) For each export out of the State of such equipment and material: the identity, quantity, location of intended use in the receiving State and date or, as appropriate, expected date, of export; this information is to be provided on a quarterly basis; and

(b) Upon specific request by the Agency, confirmation by the State, as the importing State, of information provided to the Agency by another State concerning the export of such equipment and material to it; this information is required to be provided to the IAEA within 60 days of the Agency's request.

The list contained in Annex II was derived from the NSG's export Trigger List of single-use equipment and non-nuclear material published in INFCIRC/254/Rev.2/Part.1 in October 1995.[31] However, the title of Annex II was specifically crafted in such a way as not to require strict symmetry with the NSG's Trigger List or to preclude the later inclusion of dual-use or weaponization-related equipment or material.

The Model Additional Protocol contains a simplified process for amending the two annexes, a mechanism that was included to ensure that, if and when they were amended, all APs would be simultaneously amended so as to avoid a proliferation of divergent reporting requirements. Article 16.b. provides that:

> The list of activities specified in Annex I, and the list of equipment and material specified in Annex II, may be amended by the Board upon the advice of an open-ended working group of experts established by the Board. Any such amendment shall take effect four months after its adoption by the Board.[32]

In 2006, the Secretariat prepared a paper at the request of the Advisory Committee on Safeguards and Verification within the Framework of the IAEA Statute (Committee 25) in which it reviewed certain analytical capabilities required for safeguards and proposed measures for improving those capabilities. In that paper, the Secretariat noted that it would be "useful at this time to review the Annexes of the Model Additional Protocol to ascertain whether amendments should be made" and proposed that consideration be given to reviewing the two Annexes "with a view to assessing the need for their amendment".[33]

In a subsequent paper prepared for the Committee, the Secretariat identified amendment of the Annexes to include "the most current lists of items that fall within the original scope of the Annexes (e.g., fully up-to-date lists of specialized equipment related to enrichment and reprocessing)" as a "straightforward mechanism for the provision of additional information" to the Agency. It was also noted that it "may also be useful to consider amending the Annexes to include additional types of activities, technologies and materials relevant to safeguards".[34] The Secretariat offered 18 recommendations for the

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[31] IAEA, INFCIRC/254/Rev.2/Part 1 (October 1995). As noted in the footnote to the title of Annex II, the list used in that Annex "is the list which the Board agreed at its meeting on 24 February 1993 would be used for the purpose of the voluntary reporting scheme [VRS], as subsequently amended by the Board." The list approved by the Board for the VRS was based on the Trigger List contained in Part 1 of the NSG Guidelines published in July 1992 (INFCIRC/254/Rev.1/Part1). The VRS list was updated by the Board twice before the Model Additional Protocol was finalized, once in December 1994 and again in March 1996 following changes by the NSG to the export Trigger List (INFCIRC/254/Rev.1/Part 1/Mod.2 (April 1994) and INFCIRC/254/Rev.2/Part 1 (October 1995), respectively).

[32] IAEA, INFCIRC/540 (Corr.), Art. 16.

[33] IAEA (2006). *Review and Improvement of the Effectiveness and Efficiency of the Safeguards System: Enhancing Analytical Capabilities*, GOV/2006/Note 2, 4 April 2006, paras. 30-32.

[34] GOV/2006/Note 23, *A Report on the Implementation of Measures to Improve the Effectiveness and Efficiency of the Safeguards System*, 7 April 2006, para. 67.

Committee's consideration, one of which was that the Committee recommend to the Board that it establish an open-ended working group to review the Annexes and advise the Board on their amendment.

The Secretariat issued another note on the recommendations, expanding on the previous note, as follows:

> With the aim of reflecting the evolution of nuclear technology, improving safeguards effectiveness and efficiency, and obtaining a complete picture of States' nuclear activities, consideration might be given to including in the Annexes additional activities and items relevant to safeguards. An example of an activity that might be added to Annex I is the use of an accelerator in which transmutation might be carried out to produce undeclared fissile material. The Agency currently does not have a routine mechanism (except complementary access, if the activity is on a site) for verifying that the associated neutron flux in an accelerator-driven system is not misused to produce such material. Another activity for possible inclusion in Annex I is the storage of items identified in Annex II. Except in connection with the manufacture, assembly, construction and/or upgrading of the few items referred to in Annex I, or the presence of items located on a site reported under Article 2.a.(iii), the Agency has no routine mechanism for acquiring information about the location, use and/or status of other sensitive equipment and components which may be manufactured in the State or removed by the State from decommissioned installations. The Agency is therefore not in a position to provide assurances that such equipment and components are not used in undeclared nuclear activities.[35]

It further noted, with regard to Annex II, that since May 1997, when the Board approved the Model Additional Protocol, the NSG's Trigger List had been updated six times and a number of other changes had been made, including with respect to reactors and components, non-nuclear material for reactors, and plants for reprocessing, fuel fabrication, the production of heavy water and the conversion of uranium and plutonium for use in the fabrication of fuel and the separation of uranium isotopes.[36]

The Secretariat noted that updating both of the Annexes would "ensure that the Agency's safeguards system keeps pace with developments in nuclear technology, and the information acquired as a result thereof would contribute to the transparency of a State's nuclear activities and the Agency's understanding of these activities. This would contribute to increasing confidence that the additional activities identified in Annex I, and the additional specified equipment and non-nuclear material identified in Annex II, are being used only for peaceful purposes".[37] However, as noted above, the Committee was unable to agree on any recommendations.[38]

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[35] GOV/2006/Note 45, *Recommendations to be Considered by the Advisory Committee on Safeguards Verification within the Framework of the IAEA Statute to Further Improve the Effectiveness and Efficiency of the Safeguards System*, 25 August 2006, para. 20.

[36] Id, at para. 21.

[37] Id.

[38] Resistance to the actual goal of the Committee—to make recommendations for further strengthening safeguards—was spearheaded by Iran, which had just been found to be non-compliant with its CSA, and exacerbated by some States' distrust of the proponents of the exercise, a result of the misuse of intelligence information that had led to the invasion of Iraq in 2003. A more detailed account of the reasons for the demise of Committee 25 may be found in Rockwood, L. (2018). 'Naval Nuclear Propulsion: Seeking Verification Processes', *Institute for International Science and Technology Policy*, Washington, p. 32, https://vcdnp.org/wp-content/uploads/2018/11/Occasional-Papers_Reducing-Risks-from-Naval-Nuclear-Fuel-2anfj76.pdf.

More than two decades have passed since the Board approved the Model Additional Protocol. Notwithstanding the simplified amendment process provided for in Article 16.b., the Board has never convened a working group to consider amendment of the Annexes. As a consequence, neither list has been updated.

The NSG's Trigger List is currently in its thirteenth iteration.[39] Updating Annex II to synchronize with the NSG's current Trigger List would be relatively low-hanging fruit that could go a long way towards strengthening the implementation of APs. Consideration could also be given to amending Annex II to include certain dual-use materials and equipment, drawing on the Dual-Use List in Part 2 of the NSG's guidance on "Transfers of Nuclear-related Dual-use Equipment, Materials, Software and Related Technology" (which is on its tenth iteration since its original publication in 1992)[40], and other dual-use items that could be used for weaponization.

The open-ended working group could also consider proposing a requirement for States to report to the IAEA on export denials as well as on actual or expected exports.[41] However, that could require amendment of the text of the Model Additional Protocol, which would be more complicated and could entail some risk of collateral damage to the Model, and would require renegotiation of each AP to incorporate any such an amendment. An alternative approach could be a recommendation that States report export denials on a voluntary basis.

1.5. Recommendations and Assessments

Recommendations regarding the conclusion of CSAs and modification/rescission of SQPs:

1. Noting that many of the States that have yet to conclude the required CSA, and/or have not yet modified or rescinded their respective SQP, are located either in the Pacific region or sub-Saharan Africa, differentiated approaches to outreach activities, on a regional basis, could be effective. The IAEA and interested Member States could contribute with regional approaches through increased frequency of bilateral and multilateral meetings, and through sustained engagement with relevant stakeholders. It is important to listen to ideas and initiatives coming from within the regions to ensure their commitment.
2. Because the IAEA primarily funds outreach activities through extrabudgetary funding, outreach is dependent on Member States' contributions. The IAEA's outreach activities would benefit from enhanced communication to Member States about its funding priorities.
3. IAEA staff should participate in Member State outreach efforts whenever possible. While Member States appreciate the efforts of the Director General to maximize staff days in the office, the positive impact of the presence of IAEA staff in such outreach activities cannot be overestimated.
4. Given the minimal resources available to the Pacific Island States, a regional entity

[39] IAEA, INFCIRC/254/Rev.13/Part 1 (November 2016)
[40] IAEA, INFCIRC/254/Rev.10/Part 2 (2016), https://www.iaea.org/sites/default/files/publications/documents/infcircs/1978/infcirc254r10p2.pdf.
[41] Evans, G. and Kawaguchi, Y. (2009). *Eliminating Nuclear Threats: A Practical Agenda for Global Policymakers*, International Commission on Nuclear Non-Proliferation and Disarmament, p. 85, http://www.icnnd.org/reference/reports/ent/pdf/ICNND_Report-EliminatingNuclearThreats.pdf.

could be established that would be responsible for the implementation of safeguards in those States. This could be achieved by creating a new entity, leveraging already established safeguards, safety and/or security organisations or networks and/or through the Global Partnership for Effective Development Cooperation.

5. Safeguards should be seen as an essential contributor to development, as their application is one guarantor of the provision of technical cooperation in the IAEA. Member States participating in the Organisation for Economic Co-operation and Development's (OECD) Development Assistance Committee (DAC) should seek an expanded definition of "development" to include, as a priority, the development of relevant non-proliferation infrastructure.

Recommendations regarding the conclusion of APs:

6. As regards States that are unwilling to conclude an AP, closing the gap has been more challenging. Better and proactive messaging by the IAEA, which focusses less on "identifying bad actors" and more on the benefits to the States, should be pursued.
7. For those States that are unaware of the requirements to effectively implement an AP and for those who are aware, but are simply unable to do so, regional approaches might bear results (such as those in the style of the "Friends of the Additional Protocol").
8. Momentum in support of APs among the unwilling group could also be engendered by an increase in transparency among the NWSs, and also as between the NWSs and the other parties to the NPT, particularly in the area of arms control and disarmament.

Recommendations regarding updating the Model Additional Protocol Annexes:

9. While updating the Annexes to the Model Additional Protocol is an important measure to keep safeguards "ahead of the game", it may not be feasible in the near or medium term given the current political environment. However, initial conversations could be undertaken within SAGSI and among Member States.
10. There may be merit in the establishment of a standing Open-Ended Working Group under Article 16 of the Model Additional Protocol, much as the NSG has done with its Consultative Group (CG).[42] This would alleviate the pressure of requiring that a conclusion be drawn within a given timeframe, while providing a forum for discussion of issues related to the Annexes. The group that updated the NSG lists between 2010 and 2013 could offer valuable input into this process. The EU list could also provide a good basis for better understanding the advantages and challenges of catch-all controls as opposed to list-based controls.
11. A more feasible course of action might be to identify ways to strengthen the implementation of APs as they enter into force (e.g., encouraging the voluntary provision to the IAEA of information on export license denials or requiring an AP as a condition of supply). This could help avoid a "race to the bottom" by vendors and suppliers.

[42] In 2013, the NSG also established a Technical Experts Group (TEG), which, at the request of the CG, is tasked with ensuring that the NSG control lists are complete and up-to-date with technical advancements. It meets to discuss and make recommendations to the CG on all technical questions referred to it by the CG on an as needed basis. For further information, see http://www.nuclearsuppliersgroup.org/en/about-nsg/organisation-information.

12. Capacity building is essential for better implementation. To that end, Member States and the IAEA could explore a link between the UN Security Council resolution 1540 and safeguards as a way to increase capacity building.

2. Strengthening Support for the IAEA's Authority

2.1. Misperceptions about the Safeguards System

The discovery of Iraq's covert nuclear weapons programme in 1991 sparked a profound reassessment of the then-prevailing misperception that the IAEA's obligation and authority was limited to verifying only that declared nuclear material was accounted for. In the years immediately following that discovery, the Board of Governors took a number of decisions confirming the IAEA's right and obligation, in accordance with paragraph 2 of INFCIRC/153, to verify not just that there is no diversion of declared nuclear material, but that there are no undeclared nuclear materials or activities, in States with CSAs in force. Or more succinctly put, that the States' declarations are not just correct but that they are also complete.

This position is reflected in several decisions by the Board of Governors, supported by the General Conference, between 1991 and 1993 in the context of the DPRK and South Africa, as well as in its deliberations on special inspections.[43]

In December 1993, the Secretariat, at the request of the Board of Governors, initiated a programme to develop a comprehensive set of measures for strengthening the effectiveness and improving the efficiency of IAEA safeguards: Programme 93+2. The outcomes of that programme were two sets of measures: those that could already be undertaken under the existing authority of INFCIRC/153; and those that the Director General proposed to be formalized in a new legal instrument (eventually, the Model Additional Protocol).

The premise of Programme 93+2 was that implementation of the strengthened measures under INFCIRC/153 and the measures provided for in the Model Additional Protocol would substantially improve the IAEA's ability to detect any diversion of nuclear material in a State (whether from undeclared or declared activities) and enhance the credibility of its conclusions. If the IAEA were able to assure itself that there was no undeclared nuclear material or activities in a State, in particular enrichment or reprocessing, it could, by integrating the measures provided for in the CSA and an AP, tailor its safeguards approach for that State, taking into account all safeguards-relevant information about the State. The IAEA began implementing these State-level integrated safeguards approaches, using generic facility-type approaches, in the early 2000s.

However, questions about the strengthened safeguards measures began to re-emerge in the mid-2000s, exemplified by the failure of Committee 25 to reach agreement on any recommendations for further strengthening safeguards. Worse still, the debate during the

[43] Rockwood, L. (2014), "The IAEA's State-Level Concept and the Law of Unintended Consequences", *Arms Control Today*, https://www.armscontrol.org/act/2014_09/Features/The-IAEAs-State-Level-Concept-and-the-Law-of-Unintended-Consequences.

meetings of that Committee reflected efforts by some States to roll back achievements made in the previous decade.

In the early 2010's, renewed challenges to the IAEA's authority surfaced in the context of the Secretariat's efforts to further evolve the concept of developing State-level approaches to safeguards, or, as it came to be known the "State-level concept" (SLC). Although the SLC was simply another way of referring to the long-established IAEA practice of taking into account all safeguards-relevant information available to it about a State when drawing safeguards conclusions, debates on the SLC became a vehicle through which simmering political issues manifested themselves in expressions of concern about how the safeguards system works, including how information is obtained and evaluated by the IAEA. [44]

Since 2013, the Director General has presented three reports to the Board on the SLC.[45] In addition, the Secretariat has held multiple technical briefings on the SLC specifically, and on safeguards in general, which are open to all Member States. Despite these efforts, some States continue to raise objections about the IAEA's authority and remain sceptical about efforts to further strengthen safeguards.

Why do these debates persist? In some cases, the States are sincerely unaware of the history surrounding the IAEA's authority to verify completeness. These States should be reminded that:

- All Board decisions that resulted in reporting to the UN Security Council of non-compliance had to do with the issue of completeness;
- The negotiators of both the NPT[46] and INFCIRC/153[47] agreed that the issue of completeness was the IAEA's business; and
- The Board has reaffirmed this authority on numerous occasions, as has the General Conference.

However, there are States that are wilfully unaware, who continue to make false assertions, capitalizing on that lack of knowledge.

As noted in an article addressing the issue in 2014,

> It is possible to correct the [lack of knowledge]and to limit the impact of [calculated misrepresentations] through education and communication by

[44] Rockwood, L. (2014). *The IAEA's State-Level Concept and the Law of Unintended Consequences*, Arms Control Association, https://www.armscontrol.org/act/2014_09/Features/The-IAEAs-State-Level-Concept-and-the-Law-of-Unintended-Consequences.

[45] GOV/2013/38 (12 August 2013), *The Conceptualization and Development of Safeguards Implementation at the State Level*, http://www.isisnucleariran.org/assets/pdf/GOV201338.pdf; GOV/2014/41 (13 August 2014), *Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level,* https://armscontrollaw.files.wordpress.com/2014/09/iaea-state-level-safeguards-document-august-2014.pdf; GOV/2018/20 (31 July 2018), *Implementation of State-level Safeguards Approaches for States under Integrated Safeguards – Experience Gained and Lessons Learned*.

[46] In the course of the NPT negotiations, the representative of the Soviet Union asserted that "[i]n considering the question of the non-proliferation of nuclear weapons, the Soviet Union has steadfastly endeavoured to ensure that a treaty on this subject would not contain any loop-holes that might leave channels, direct or indirect, for the proliferation of nuclear weapons." The representative asserted further that "IAEA control will be applied on all source or fissionable material in the peaceful nuclear activities of [NNWSs]". See *Final verbatim record of the Conference of the Eighteen-Nation Committee on Disarmament*, available at: https://quod.lib.umich.edu/e/endc/4918260.0357.001?rgn=main;view=fulltext.

[47] During the negotiation of INFCIRC/153, South Africa proposed that that "safeguarding and inspection functions of the Agency … shall be concerned solely with the material reported upon by the state concerned to the Agency." The proposal was rejected by the negotiators, which led to the final text of paragraph 2 of INFCIRC/153, which provides for the IAEA's "right and obligation to ensure that safeguards will be applied … on all source or special fissionable material". International Energy Associates Ltd., "Review of the Negotiating History of the IAEA Safeguards Document INFCIRC/153," July 30, 1984, pp. 33-44, http://cgs.pnnl.gov/fois/doclib/INFCIRC153Ch1-3.pdf.

> raising the level of knowledge about safeguards and the history of their evolution. It is incumbent on all parties to understand what has already been achieved in strengthening safeguards so that it is not necessary to reinvent those achievements.[48]

The IAEA and its Member States will have to continue to work to dispel existing misperceptions about the continued evolution of safeguards, and better communicate with Member States in order to prevent misapprehensions in the future.

2.2. Special Inspections

Paragraph 73 of INFCIRC/153 authorizes the IAEA to conduct special inspections: (a) in order to verify the information in special reports made by a State; or (b) if the IAEA considers that it is unable to fulfil its verification responsibilities under the agreement.[49] Further pursuant to that paragraph 73, an inspection is "deemed to be special" when it is either additional to the routine inspection effort provided for in the safeguards agreement, or "involves access to information or locations in addition to the access specified in paragraph 76 for ad hoc and routine inspections, or both".[50]

It should be noted that, while INFCIRC/153 agreements limit IAEA access during routine inspections to "strategic points identified in the subsidiary arrangements", this limitation does not apply to ad hoc inspections (i.e., inspections conducted before the subsidiary arrangements are concluded to verify a State's initial declarations, which may extend to "any location where the initial report or any inspections carried out in connection with it indicate the nuclear material is present"[51]), or, by definition, to special inspections.[52]

According to the best information available, prior to 1991, the IAEA only formally invoked special inspections on three occasions, all of which involved requests for access to declared locations.[53]

Subsequent to the discovery of Iraq's undeclared nuclear programme, the Board, in 1992, reaffirmed the IAEA's right "to carry out special inspections at any location in a State having a comprehensive safeguards agreement if the Agency had reason to believe that the State was carrying out unreported nuclear activities".[54] The language that was ultimately agreed upon by the Board reads as follows:

> The Board urged the full exercise of all Agency rights and obligations provided under the Statute and in all comprehensive safeguards agreements (i.e. those which are based on the guidelines set for in IFNCIRC/153 (Corrected), as well as others which provide for the application of Agency safeguards to all nuclear materials in all peaceful nuclear activities within a State). The Board reaffirmed the Agency's right to undertake special inspections, when necessary and appropriate as described in the above-mentioned agreements and to ensure that all nuclear materials in peaceful nuclear activities are under safeguards. The Board anticipated that these special inspections should only occur on rare

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[48] See footnote 42.
[49] IAEA, *INFCIRC/153 (Corrected)*, para. 73 (a, b), https://www.iaea.org/sites/default/files/publications/documents/infcircs/1972/infcirc153.pdf.
[50] IAEA, *INFCIRC/153 (Corrected)*, para 77.
[51] IAEA, *INFCIRC/153 (Corrected)*, para 76(a).
[52] Rockwood, R. (2013). *Legal Framework for IAEA Safeguards*. IAEA, p. 22, https://www.iaea.org/sites/default/files/16/12/legalframeworkforsafeguards.pdf.
[53] Personal communication with former staff member circa 1991/1992.
[54] IAEA (1998). *The Evolution of IAEA Safeguards*, p. 24, https://www-pub.iaea.org/MTCD/Publications/PDF/NVS2_web.pdf.

> occasions. The Board further reaffirmed the Agency's rights to obtain and to have access to additional information and locations in accordance with the Agency's Statute and all comprehensive safeguards agreements.[55]

However, the first and only instance of the IAEA formally invoking the special inspection provisions with respect to undeclared locations was in the case of the DPRK in 1993.[56] Following the DPRK's rejection of the IAEA's request, the Board of Governors determined that access was "essential and urgent", thereby obliging the DPRK to grant the requested access.[57] The DPRK did not do so, and was subsequently reported to the Security Council for its non-compliance.[58]

Despite these affirmations of the legitimacy of special inspections when required, the IAEA has shown some reluctance to invoke the relevant provisions, a reluctance that has led to its atrophy.

With increasing adherence to APs, concerns about that reluctance have been offset to some extent by the availability of complementary access (CA) under APs, which provide in Article 4.c. and Article 5 broad authority for the IAEA to request access at any location place in a State not declared by the State "to resolve a question relating to the correctness and completeness of the information provided pursuant to Article 2 or to resolve an inconsistency relating to that information" in order to carry out location-specific environmental sampling at that location. Article 6.d. specifies that, "in the event the results do not resolve the question or inconsistency at the location specified by the Agency", the IAEA may, at that location, use "visual observation, radiation detection and measurement devices" and, where agreed to by the State, other objective measures.

However, as APs are not yet universal, CAs are not an option in all States. Resorting to special inspections could also be valuable in a number of circumstances, such as: instances where the IAEA requires additional information as well as access to additional locations; in response to an objection that the reason for the 4.c. request was not directly related to resolving a question or inconsistency concerning information provided by the State under Article 2; and instances where the IAEA would wish to carry out activities either in addition to or instead of environmental sampling.

2.3. Affirmation of IAEA Authority to Investigate Weaponization Indicators

The objective of safeguards is the timely detection of the diversion of significant quantities of nuclear material to the manufacture of nuclear weapons or other nuclear

[55] GOV/OR.776, at para. 48.
[56] In the case of Romania in 1992, a special inspection was triggered at the request of the new Romanian government (upon the submission of a special report). Romania sought to establish a clean slate with the IAEA and with the international community after the previous government was found to have covertly conducted activities involving nuclear material.
[57] While the State has a right in the first instance to decline a request by the Director General for special inspection (see para. 77 of INFCIRC/153), if the Board decides that such action is "essential and urgent in order to ensure verification that nuclear material subject to safeguards under the Agreement is not diverted to nuclear weapons or other nuclear explosive devices the Board shall be able to call upon the State to take the required action without delay, irrespective of whether procedures for the settlement of a dispute have been invoked" (INFCIRC/153, para. 18).
[58] Action, J., Fitzpatrick, M. and Goldschmidt, P. (2009). *The IAEA Should Call for a Special Inspection in Syria*, Carnegie Endowment for International Peace, https://carnegieendowment.org/2009/02/26/iaea-should-call-for-special-inspection-in-syria-pub-22791.

explosive purposes or for purposes unknown and to deter its diversion through the risk of early detection.[59]

The IAEA already conducts acquisition path analyses for States when developing safeguards strategies. These analyses are meant to identify all plausible pathways by which a specific State might seek to acquire weapons-usable material, and its subsequent weaponization, should that State decide to do so.[60] This activity is a standard part of the IAEA's safeguards process.

Although the IAEA's authority to investigate indications of possible weaponization activities has been supported in the past (e.g., in the cases of Iraq, Iran and South Africa), there remains residual scepticism about that authority, especially in connection with activities not involving the use of nuclear material. That authority is not generally challenged where the activity might directly involve nuclear material. The debate arises from activities that relate to potential weaponization which may not be directly associated with nuclear material, such as the production of high-explosive lenses or the acquisition of certain other materials, such as polonium or tritium.[61]

Some of the scepticism is directly attributable to a misunderstanding of a statement by the former Director General Mohamed ElBaradei in 2005 in which he said:

> I should point out here, in passing, that both safeguards agreements and additional protocols are focused on nuclear material – and therefore, the Agency´s legal authority to investigate possible parallel weaponization activity is limited, absent some nexus linking the activity to nuclear material. [62]

Those inclined to challenge the IAEA's authority to investigate indications of weaponization interpret this statement as meaning that the IAEA has no authority to follow up on indications of such activities where there is no "nexus" with nuclear material.

There is no legal requirement for such a nexus under CSAs. Pursuant to paragraph 73(b) of INFCIRC/153, the only requirement for the IAEA to be able to request access to "information or locations in addition to the access specified … for ad hoc and routine inspections, or both" (i.e., to invoke special inspections) is simply:

> If the Agency considers that information made available by the State, including explanations from the State and information obtained from routine inspections, is not adequate for the Agency to fulfil its responsibilities under the Agreement.[63]

The IAEA need not justify its request for access to locations on the basis that there is undeclared nuclear material at such locations or that the activities being carried out there involve nuclear material. The IAEA may seek such access if it believes that access will contribute to its fulfilling its mandate.

The point that the former Director General was making was that the IAEA's authority is not absolute. In fact, the word "nexus" was first used in discussions within the IAEA Secretariat in the context of assessing the use of special inspections, in which an analogy

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[59] INFCIRC/153, para. 28.

[60] Arno, M. (2018). *Standardizing Acquisition Path Analysis: Quantifying a State's Ability to Establish and Clandestinely Operate an Undeclared Nuclear Facility of a Given Type*, Lawrence Livermore National Laboratory, p. 1, https://e-reports-ext.llnl.gov/pdf/920146.pdf.

[61] *Id*.

[62] ElBaradei, M. (2005). *Reflections on Nuclear Challenges Today*, https://www.iaea.org/newscenter/statements/reflections-nuclear-challenges-today.

[63] INFCIRC/153, para. 73.

was drawn to the prosecution of a criminal case. As was noted then, in any such case, the prosecuting agent must determine whether to bring a case before a judge or jury and, as any good lawyer knows, the stronger ones case is, the more likely the adjudicator will rule in his or her favour. The point made was simply that, with a politically divided "jury", such as the Board, the easier it is to draw a link between the activity in question and nuclear material, i.e., the closer the nexus is to nuclear material, the more likely the Board would be willing to find consensus support in favour of special inspections.

Moreover, the IAEA can only provide assurances that nuclear material is not diverted to nuclear weapons or other nuclear explosive devices if it investigates any indication that such a programme exists, including weaponization-related activities. If the State is carrying out or has carried out what the IAEA believes to be nuclear weaponization-related activities, this gives rise to doubts about the completeness of the State's declarations about nuclear material and nuclear activities, an issue clearly within the IAEA's mandate.[64]

A standard requiring that IAEA access to locations potentially engaged in activities related to nuclear weaponization be limited to those actually involving (or suspected of involving) nuclear material could be "too little too late".[65]

2.4. Recommendations and Assessments

Seeking reaffirmation of the IAEA's rights and obligations under CSAs (in particular its authority to verify correctness and completeness of States' declarations, to conduct special inspections to follow up on indications of possible undeclared activities and to investigate indications of possible nuclear weaponization) would not come without some risk, especially in the highly politicized atmosphere that currently prevails. However, there already is general consensus on these issues, and that consensus is reflected in the annual General Conference resolution on safeguards, and largely in the NPT Review Conference outcome documents. As regards the latter, while the NPT review process has continued to reaffirm the role of safeguards in the non-proliferation regime, the purpose and definition of the safeguards system should remain in the purview of the IAEA and its Member States, particularly given the currently venomous environment surrounding the NPT review process.

There are a number of other measures, however, that might be taken that would reduce the misunderstandings associated with the IAEA's legal authority with respect to safeguards.

Recommendations:

13. Challenges to the IAEA's authority stemming from States' mistrust of the Secretariat can be ameliorated with transparency, consultations and messaging that underscores a safeguards relationship characterized by partnership rather than contestation.
14. False assertions regarding the IAEA's legal authority should be challenged by Member States and by the Secretariat.
15. The Director General could consider revising the role of the Standing Advisory Group on Safeguards Implementation (SAGSI) so that, in addition to its traditional

[64] Albright, D., Heinonen, O., Kittrie, O. (2012). *Understanding the IAEA's Mandate in Iran: Avoiding Misinterpretations*, Institute for Science and International Security, https://isis-online.org/uploads/isis-reports/documents/Misinterpreting_the_IAEA_27Nov2012.pdf.
[65] Albright, et al, at p.8.

role of advising the Director General, it would give the group a public face. The idea is that SAGSI would use this public face to help challenge false statements about safeguards, offer independent opinions on safeguards issues to the public and to the Board. Such a group, independent but informed, could help elevate the transparency of the IAEA.

16. Training for new diplomats and new staff, whether conducted by the IAEA, by Member States or by non-governmental organizations, should include historical briefings on issues surrounding the IAEA's safeguards authority, e.g., correctness and completeness.
17. The IAEA should engage in enhanced communication efforts with the broader public in respect of its verification activities. Specifically, the IAEA could publish short "school briefs" on safeguards, offering concise and clear answers to commonly asked questions, such as why and how the IAEA must concern itself with undeclared activities.

3. Implementation Challenges

3.1. State Authorities and Reporting Practices

State and regional authorities (SRAs) responsible for safeguards implementation play a critical role in the effectiveness and efficiency of the safeguards system overall in establishing and maintaining SSACs and in facilitating the implementation of safeguards in their respective States.[66]

According to the Director General's report on safeguards to the 2014 General Conference, some States still had not established SSACs and not all SRAs had the necessary authority, resources or technical capabilities to implement the requirements of their safeguards agreements. A particular problem that he identified was a lack of sufficient oversight of accountancy and control systems at nuclear facilities and at locations outside facilities (LOFs),[67] which adversely impacts a State's ability to submit timely and accurate reports to the IAEA. The Director General expressed similar concerns in his safeguards reports to the General Conference in 2015[68] and 2016.[69]

In the Director General's report to the 2017 General Conference, he emphasized the work that the IAEA was doing in order to address these problems, including by offering Member States the IAEA SSAC Advisory Service (ISSAS) and various regional

[66] IAEA (2016). *Safeguards Implementation Guide for States with Small Quantities Protocols*, p. 9.
[67] IAEA (2014). *Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards: Report by the Director General*, GC(58)16, para. 30, https://www-legacy.iaea.org/About/Policy/GC/GC58/GC58Documents/English/gc58-16_en.pdf.
[68] IAEA (2015). *Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards: Report by the Director General*, GC(59)/18, paras. 33-34, https://www-legacy.iaea.org/About/Policy/GC/GC59/GC59Documents/English/gc59-18_en.pdf.
[69] IAEA (2016). *Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards: Report by the Director General*, GC(60)/13, paras. 36-37, https://www-legacy.iaea.org/About/Policy/GC/GC60/GC60Documents/English/gc60-13_en.pdf.

workshops, seminars and training courses.[70] The IAEA continues to offer these services, along with specialized software designed to further improve the functionality of SSACs.[71]

Unfortunately, despite these efforts, as of the end of 2017, a quarter of the States that had concluded safeguards agreements with the IAEA had still not established an SRA or a responsible point of contact. Another quarter of States in which SRAs had been established did not respond satisfactorily to the IAEA's requests.[72]

The IAEA has also continued to have problems with receiving complete, accurate and timely safeguards reports from some States. Others have failed to provide design information related to new facilities and/or notifications of nuclear material transfers under their CSAs. In addition, over the past five years, over 30 per cent of States with APs in force have had problems reporting information in accordance with their APs, while others have not even submitted their initial declarations under the APs.[73]

Prompt and systematic adherence to reporting requirements is critical to the functionality of the safeguards system and should be improved. The IAEA should continue implementing and enhancing its efforts to improve reporting practices in States. The IAEA should also allay State concerns about the confidentiality of the information provided to it and how the IAEA protects such information in its collection, handling and storage.

In addition, interested States could also conduct outreach activities, providing technical support and, where appropriate, financial contributions to help bring SRAs into compliance with the States' safeguards agreements.

3.2. State Cooperation with Inspectors

In 2017, problems with securing visas for designated inspectors to travel for routine inspections were reported by the Director General to have occurred in 10 per cent of the States with safeguards agreements in force.[74] In addition, in roughly 25 per cent of States the number of designated inspectors was either limited or non-existent. Moreover, access to facilities and pertinent information was also an issue in several States. Among other difficulties, some States refused to allow environmental sampling or denied access for necessary verification activities, including to places where the IAEA was to verify the absence of undeclared nuclear material.[75]

The reasons for these problems are unclear. It is possible that these States, and/or the operators of their facilities, are simply unaware of their obligations under their respective safeguards agreements. It is also possible that the State and facility operators are simply unwilling to provide this access. While denial of access could indicate concealment efforts, the personnel involved may simply lack the knowledge and expertise about how best to cooperate with the IAEA and the importance of IAEA safeguards as an international confidence-building measure.

[70] IAEA (2017). *Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards: Report by the Director General*, GC(61)16, para. 38, https://www-legacy.iaea.org/About/Policy/GC/GC61/GC61Documents/English/gc61-16_en.pdf.
[71] IAEA (2018). *Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards: Report by the Director General*, GC(62)/8, paras. 40-41, https://www-legacy.iaea.org/About/Policy/GC/GC62/GC62Documents/English/gc62-8_en.pdf.
[72] IAEA (2018). *The Safeguards Implementation Report for 2017*, *GOV/2018/19*, https://armscontrollaw.files.wordpress.com/2018/05/iaea-2017-sir.pdf.
[73] *Ibid*.
[74] *Ibid*.
[75] *Ibid*.

Another contributing factor can also be inspector knowledge and comportment while in the field. Examples have been cited of inspectors who are unaware of or non-compliant with the requirements for safety and security in a facility, who are not fully informed of the legal framework (including constraints on the IAEA) or who simply misbehave or engage in combative behaviour with the operator or the State. Luckily, the examples are few, but warrant attention.

Critically, the source of States' resistance, whether due to lack of knowledge, lack of ability or inspector behaviour, must be identified. The IAEA and States will need to continue cooperating in order to address these problems.

It is important to keep in mind, however, that cooperation is not a one-way street. From the State perspective, the IAEA could contribute to better IAEA-State relations by improving the training of inspectors. Specifically, the inspectors should be fully aware of the legal aspects of safeguards implementation, so that inspectors understand the basis for and limitations in the conduct of in-field activities. In that context, training inspectors in soft skills, e.g. such as how better to communicate, could engender more cooperative relationships between Agency staff, State officials and operators.

Revising the Safeguards Implementation Report (SIR) so that it is more transparent could also contribute to a more collaborative relationship with States. Traditionally, problems attributable to State behaviour are highlighted in the annual report. The SIR should also, where relevant, identify when problems are attributable to the IAEA, whether due to equipment failures, staff issues or administrative challenges. In addition, consideration should be given to reintroducing the "naming and shaming" where problems arise (whether due to the IAEA or a State).

Greater transparency could also be achieved by unrestricted publication of the SIR. The Secretariat has on a number of occasions proposed to the Board that the SIR be released as a routine matter. Although the SIR is a report of the Director General, it is for the Board of Governors to determine whether to release it.

3.3. Recommendations and Assessments

The reasons that a State does not engage effectively with the IAEA are various. In some cases, the SRA and/or its SSAC are not well developed or internal State stakeholders do not take the regulator seriously. Among some, the IAEA's safeguards relationship with the State is perceived as adversarial. Other cases demonstrate active suspicion on the part of the State or the operator about what information from inspections or reports is available to whom (in reality, sensitive information is kept strictly confidential and is available only on a need-to-know basis to certain individuals within the Department of Safeguards). Simple miscommunication accounts for other examples of conflict with inspectors (e.g., inspectors' lack of awareness of safety requirements, which may cause delay or denial of inspector access to a facility).

The following recommendations, all of which are feasible, could ameliorate the situation.

Recommendations:

18. SRA/SSAC operations would benefit from more outreach to State entities, policymakers, SRAs and operators by the IAEA, Member States and non-governmental organisations. However, it is important to coordinate outreach efforts with the IAEA, ensuring that the IAEA is aware of the activities and inviting IAEA staff to participate in them. A focus of such outreach should be to

help States understand what safeguards are through SRA training at the national, regional and international level.

19. The IAEA should facilitate the creation of a forum for networks of SRAs to exchange views on the implementation of SSACs. Although the IAEA already conducts high-level policy dialogues with States on safeguards implementation, opportunities for the SRAs to exchange experiences on a regional level could be especially useful.
20. The SIR should include more information on the performance of the Secretariat as well as on individual States. Public release of the entire SIR might be contemplated, as it does not currently include any information that is safeguards sensitive. In that vein, the IAEA could consider releasing the Safeguards Technical Report (STR), which used to accompany the SIR and was made available to Permanent Missions upon request. The STR provided technical and statistical data on facilities and materials under safeguards, but was rarely requested and thus discontinued.
21. The IAEA should enhance training for inspectors to help them in the field, especially knowing what they may and may not ask for and how to ask, i.e. how to interact with operators and local authorities (i.e., behavioural sciences; negotiation skills). Training should focus on communication in the field to promote a culture of cooperation.
22. The IAEA could improve communication to its Member States on how it maintains sensitive information and who has access to those details. This could decrease tensions and misunderstandings between the Agency and its Member States.

4. Administrative Challenges

The IAEA faces several challenges in the implementation of safeguards that could broadly be described as administrative in nature. The first relates to the rotation policy as applied to safeguards inspectors; the second is the issue of chronic underfunding, which has plagued the IAEA for decades.

4.1. Rotation Policy for Safeguards Inspectors

The IAEA has a rotation policy for the majority of professional staff positions that caps a staff member's contract at a maximum of seven years, frequently referred to as "the seven-year rule", although no such formal rule exists. In accordance with this policy, a staff member is given an initial two- or three-year fixed-term contract, which is extendable, subject to performance, by one to two-year increments up to seven years. After seven years, staff members are then obliged to leave.

However, implementation of the seven-year rule has varied over the years. It originally was applied with respect to scientific staff. Safeguards inspectors were, as a matter of practice, exempted from this policy, given the importance of long-term institutional memory and the significant expense associated with recruiting and training safeguards inspectors. [76] It has only been over the last decade that the seven-year rule has been applied throughout the IAEA's ranks, including to safeguards inspectors.

In a 2012 report on "Unleashing the Nuclear Watchdog", Trevor Findlay discusses this rotation policy, including its benefits and drawbacks. In that report he describes the seven-year rule as having been formally introduced by Director General ElBaradei in light of a number of staff appeals to the International Labour Organization (ILO) in the 1990s due to non-extension of contracts.[77] While IAEA contracts contain a line that explicitly states that there is no expectation of extension beyond the term stated in the contract, the ILO found in several cases that, after a period of time (somewhere around seven years), the regular extension of contracts beyond their original terms did in fact create such an expectation.

The application of a strict rotation policy to positions that require years of on-the-job training and experience in order to gain the necessary expertise could hamper its ability to recruit and retain the highest-quality technical minds that safeguards inspection and planning require.[78] It can also adversely impact the operation of the Department of Safeguards' efforts to prevent the loss of long-term institutional memory and expertise and to ensure the independence of safeguards inspectors from national interests. There are other positions that require years for staff members to come up to speed that may warrant greater leniency in terms of the rotation policy, e.g., environmental sampling analysts and material balance analysts.

On the other hand, a rotation policy can reduce the risk of staff "retiring in place" and blocking promotion to, or hiring at, higher management levels. An alternative would be a performance based extension policy. Basing extensions on performance, however, means that managers have to be willing to document both good and poor performance by staff, which, by most accounts, is not a prevailing culture at the IAEA.

Finding the right balance between mobility and knowledge management is not easy, and warrants a policy that builds in flexibility. Internal rotation, rather than termination, would be an option. Another option is to grant or require sabbaticals for safeguards staff, which would not only expand their personal professional competencies, but would make them more valuable to the IAEA and to the Member States should they return to work in their home country. Staff contracts can be tailored to fit the needs of rotation and mobility policies.

Whatever the outcome, the extension process, including criteria, and the implementation of any such policy, should be transparent to the staff.

Apart from the rotation policy, there are other staffing related issues for the Department of Safeguards. Ensuring gender parity and diversity in nationalities should be key priorities. This can be especially challenging given the relatively small pool of candidates that are both qualified and available for employment in these capacities, as well as the shrinking pool of people with operational experience with which to replace staff members that are rotated out of the IAEA.

There are arguments to be made in favour of the rotation policy and arguments against it, especially in the case of safeguards inspectors. However, a one-size-fits-all approach to the rotation policy can be counter-productive when in the case of positions, such as those

[76] Jiang v. *IAEA* (1994), ILO Administrative Tribunal, Judgment 1312, http://www.ilo.org/dyn/triblex/triblexmain.fullText?p_lang=en&p_judgment_no=1312&p_language_code=EN).
[77] Findlay T., *Unleashing the Nuclear Watchdog*, p. 96.
[78] Ferguson, C. (2008). Strengthening Nuclear Safeguards, *Issues in Science and Technology*, Vol. XXIV, No. 3, https://issues.org/ferguson-2/.

of inspectors, requiring expensive training and years of on-the-job experience to establish competence. A more tailored or ad hoc approach could prevent "retirement in place", while ensuring mobility, diversity and the retention of qualified staff.

4.2. Chronic Underfunding

The Safeguards Statement for 2017 characterizes this problem as follows.

> The Agency has continued to improve the efficiency of safeguards implementation while maintaining or strengthening its effectiveness. This improvement has been essential since the quantities of nuclear material and other items under safeguards and the number of facilities under safeguards has increased in recent years. In contrast, the Agency's financial resources have not risen commensurately. It should be noted that while a number of facilities are being retired from service, this will not immediately reduce verification effort[s] as safeguards continue to be applied to those facilities until their status is confirmed by the Agency as decommissioned for safeguards purposes.[79]

Zero real-growth budgets, i.e. those that increase from year to year to account for inflation, but not for any other additional costs, have been the norm for the IAEA's safeguards budget for decades. This budget practice has forced the IAEA to stay relatively compact in proportion to its mandate and has also had a negative impact on its ability to employ modern managerial and technical tools, as well as update its overall infrastructure.[80] In addition, a zero-growth budget does not take into account the additional funds that will be necessary for the IAEA to take advantage of critical new technology, some of which is detailed later in this paper, and to keep up with growing stocks of material that must be safeguarded. In 2003, the IAEA received "modest budget increases" (10 per cent over four years),[81] but this neither represents a reliable flow of funding nor will it be enough to meet growing verification demands.

There have been various proposals aimed at closing the gap between the Department of Safeguards' workload and the budget required to fund that work. Director General ElBaradei convened a high-level group of experts in late 2007 in order to assess the future of the IAEA.[82] This "Commission of Eminent Persons", also referred to as the 20/20 Commission (under the Chairmanship of former Mexican President Ernesto Zedillo), addressed a number of issues facing the IAEA over the next decades. The Commission concluded that improvements must be made to the safeguards budget. According to the Commission:

> Voluntary funds support a limited number of very specific projects or activities and in-kind contributions, such as equipment, services and expertise, will nonetheless continue to be necessary. However, these types of contributions reflect the donor's priority, conditions are often attached to their use, and their timing is unpredictable, thus rendering objective programmatic decision making difficult.[83]

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[79] IAEA, *Safeguards Statement for 2017*, para. 46.
[80] Findlay, T. (2016). *What Price Nuclear Governance? Funding the International Atomic Energy Agency*, Belfer Center for Science and International Affairs, p. (i), https://www.belfercenter.org/sites/default/files/legacy/files/WhatPriceNuclearGovernance-Web.pdf.
[81] Kerr P. (2007). *ElBaradei: IAEA Budget Problems Dangerous*. Arms Control Today, https://www.armscontrol.org/print/2465.
[82] Id.
[83] IAEA, *20/20 Vision for the Future,* p. 25.

As important as voluntary contributions are to the operation of IAEA safeguards, reliance on such contributions makes the implementation of safeguards dependent on the good will of its supporters.

There may be other ways to ensure adequate and reliable financing for safeguards. A number of ideas have been offered in the past, including:

- The establishment of a non-proliferation endowment supported by the public, the nuclear industry, wealthy individuals, foundations and governments;
- Attaching a surcharge of a fixed percentage proportionate to the nuclear energy consumption of individual Member States, and based on a new legal framework;
- The sale of services in cases where the IAEA is asked to help organize nuclear operations under extraterritorial agreements, such as the provision of political frameworks;
- Engagement with a large financial institution, such as the World Bank, to help finance appropriate peaceful nuclear projects with long-term payback arrangements;
- Engagement with the investment community through the issuance of tax-exempt non-proliferation bonds; and
- Enhanced partnership between the IAEA and exporters of nuclear facilities on the manufacture and maintenance of safeguards technology.[84]

For necessary improvements in the IAEA's operating capacity, there will have to be meaningful improvements in the way in which the IAEA receives and allocates its funds.

In a recent public address, the Director General offered his views on challenges in nuclear verification. In that address, he expressed his gratefulness for the financial support provided by the IAEA Member States in what for many are "difficult circumstances". However, he noted, "the fact is that, for some years, the IAEA has had to undertake verification activities against a background of close to zero budget increases. This year, [the] budget has actually been cut". Because of the IAEA's Statute requires that inspections be financed through the regular budget as a means of ensuring that safeguards implementation is neutral and unbiased, they cannot be funded through voluntary contributions. He added that, if the regular budget continued to suffer cuts in the coming years, "a reduction in the number of IAEA inspectors will be unavoidable", which could seriously undermine the IAEA's verification activities. In his closing remarks, he noted that he was doing all he could to use the resources entrusted to the Agency by Member States as efficiently and effectively as possible. He added, however, that "efficiency gains can only achieve so much and … we are gradually approaching the limits of what is possible [given the need to maintain a sufficient number of inspectors in the field]. It is important that secure funding is available for the IAEA's nuclear activities".[85]

In the mid-2000s, the Department of Safeguards engaged an outside company to perform a thorough review of the budget and resources of the Department. It might well be timely for another robust risk analysis of the budget and its key drivers, ensuring not just that resources are protected, but that room is built in for innovation and technological developments – staying ahead of the game, so to speak.

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[84] Shea, T. (2008). *Financing IAEA verification of the Nuclear Nonproliferation Treaty (in H. Sokolski, ed., Falling Behind: International Scrutiny of the Peaceful Atom)*, Carlisle, PA: Strategic Studies Institute. pp. 323–335, http://www.npolicy.org/books/Falling_Behind/Ch11_Shea.pdf.

[85] "Challenges in Nuclear Verification", statement delivered by Director General Yukiya Amano on 5 April 2019 at the Center for Strategic and International Studies, Washington, D.D., available at https://www.iaea.org/newscenter/statements/challenges-in-nuclear-verification.

4.3. Recommendations and Assessments

Recommendations regarding the rotation policy:

23. While there are merits to a rotation policy, the strict implementation of the seven-year rotation policy for all staff should be reconsidered. Certain posts requiring specialized training and institutional memory that merit longer-term engagement should be identified. However, this should be premised on performance-based assessments: those who continue to demonstrate their value should receive contract extensions, while those who do not should not receive extensions. This will require that the performance review process be implemented more strictly and that the criteria for granting extensions be transparent.
24. The IAEA should conduct a formal study of staffing practices, including the negative impact of ad hoc safeguards requirements that might leave some divisions understaffed.
25. Cultivating staff is important, but mobility and acquisition of fresh scientific perspectives should be encouraged, e.g., through mandatory or voluntary sabbatical leave to work. This would not only benefit the IAEA and Member States but the staff members, offering opportunities for new experiences. To that end, the IAEA should establish formal relationships with national nuclear facilities to host IAEA staff members.
26. Member States could reduce the time necessary to have fully trained inspectors by offering joint training and pre-training of inspector candidates.
27. The IAEA, in collaboration with relevant stakeholders, should promote work in the nuclear field through career talks and briefings in order to increase interest in operational positions. This will assist in increasing the pool and diversity of applicants.

Recommendations regarding funding:

28. The IAEA should consider enhancing transparency regarding the IAEA's budget and the drivers of increased costs, and a better sense of where the budget currently stands. More projections based on timeframes of when more resources are needed.
29. The IAEA should consider engaging an external management company to carry out a robust risk analysis to help clarify the drivers of the safeguards budget and prioritise the demands on the budget.
30. The IAEA should have to rely less on extrabudgetary funds as such funding often comes with preconditions for its use. However, until such time as the regular budget is meaningfully increased, Member States should be encouraged to offer voluntary contributions without such preconditions, or with less specific preconditions.
31. A study should be conducted on the feasibility and possible impact of employing alternative approaches to funding for safeguards activities.

Chapter III: Emerging and Future Challenges

In its 2017 Emerging Technologies Workshop, the IAEA and invited guests addressed the trends and implications for safeguards of new nuclear technologies (including new types of facilities) and the impact of emerging dual-use or non-nuclear technologies on proliferations risks and on safeguards implementation.[86]

This section of the report is intended to elicit a discussion around the challenges associated with the emergence of these new – and rapidly advancing – technologies.

1. New Types of Facilities and Materials

1.1. Reactors and Back-End Nuclear Fuel Cycle Activities

According to the IAEA, "water-cooled reactors will continue to dominate evolutionary designs while innovative designs will include major changes in design approaches, fuels and materials".[87] Of particular concern in these advanced designs are high-enriched uranium (HEU)-fuelled reactors, lifetime cores, new thorium or plutonium fuels, liquid fuels (from the point of view of material accountancy) and online refuelling. There are also legal and institutional concerns about transportable reactors, e.g., under whose authority is a reactor on a barge operating or being refuelled.

There are many challenges posed by the development of so-called "new" or "emerging" reactors, insofar as few of the designs being developed are either new or emerging in the sense of technology, since many are based on technologies first identified decades ago. They may perhaps better be referred to as "advanced" or "commercializing" reactors.

The new disruptors include pebble bed modular reactors (PBMRs) and molten salt reactors (MSRs), both of which are associated with features that can pose challenges to safeguards. PBMRs use a large number of small fuel pebbles without identification numbers.[88] MSRs are graphite-moderated, gas-cooled, very-high temperature reactors that can use solid or liquid fuel.[89] As such, neither design uses identifiable fuel bundles, but rather a high number of small fuel pebbles and liquid fuels, respectively, and will have to be treated as bulk facilities, posing a higher statistical challenge than item facilities. MSRs also permit on-load refuelling and, in some cases, online fuel processing (not chemical), and mechanical removal of some of the fission products, including plutonium,[90] which represents yet another safeguards challenge. Not only will new safeguards approaches have to be developed, but new verification equipment may have to be developed to ensure that these facilities, designed as "proliferation resistant", are also "safeguardable".

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[86] IAEA (2017). *Emerging Technologies Workshop: Trends and Implications for Safeguards*, Workshop Report, Vienna, 13–16 February 2017, https://www.iaea.org/sites/default/files/18/09/emerging-technologies-130217.pdf.
[87] Id, p.6.
[88] IAEA (2011). *Status report 70 - Pebble Bed Modular Reactor (PBMR)*, section 2.4, https://aris.iaea.org/pdf/pbmr.pdf.
[89] IAEA, *Emerging Technologies Workshop*, p. 24. More information on molten salt reactors is available at IAEA (n. d.). *Molten salt reactors*, https://www.iaea.org/topics/molten-salt-reactors.
[90] IAEA, *Emerging Technologies Workshop*, p. 24.

Small and very small modular reactors (SMRs and VSMRs, respectively) are among the new power generation reactors whose components and systems can be fabricated in one location and then transported as fully assembled "modules" to the sites for installation on demand. They also pose challenges to safeguards.

Transportable nuclear power plants also raise a legal complication regarding the safeguards obligations of the host and supplier States.[91] The host State will still be responsible for ensuring that the IAEA is provided with reports and proper access for inspectors and will have to coordinate with the supplier accordingly. [92] This coordination would likely constitute part of the supply arrangements. That said, this model, once deployed, would be relatively new and untested. As such, the IAEA and the international community should be ready for "unknown unknowns".

One of the most fundamental safeguards challenges will be how to ensure that IAEA inspectors have access to verify the facility design information, especially during their construction (since many of these new designs are being developed in NWSs). They will also likely operate in remote locations, conceivably for extended periods of time.

Innovation is also changing back-end elements of the nuclear fuel cycle, with a handful of new types of facilities emerging in spent fuel processing, including pyroprocessing facilities, spent fuel encapsulation plants and geological repositories for spent fuel and highly radioactive nuclear waste.

Pyrochemical processing, or pyroprocessing, is a generic name for processes involving the separation of uranium, transuranic elements and fission products using electrochemical and pyro-metallurgical methods.[93] One of the characteristics of the process is the high radioactivity of the final product, insofar as uranium, plutonium and other elements are recovered together – a factor regarded as added value for non-proliferation purposes.[94] This radiation barrier will therefore make undetected proliferation activities difficult since almost all of the operations must be conducted remotely in a hot cell.[95]

On the other hand, pyroprocessing presents a number of verification challenges. Firstly, traditional methods of material control and accountability through destructive or non-destructive assay may not be applicable to the metallic process solutions or to the processed materials.[96] Secondly, the separation part of the process is generally run at a highly elevated temperature ranging from 450ºC to 550ºC, and the molten salt and metal

[91] IAEA (2013). *Legal and Institutional Issues of Transportable Nuclear Power Plants: A Preliminary Study*, IAEA Nuclear Energy Series No. NG-T-3.5, Vienna, pp. 25-31,.

[92] Paragraph 1 of INFCIRC/153 is unambiguous in this regard. A State with a CSA in force must accept safeguards "on **all** source or special fissionable material in **all** peaceful nuclear activities within its territory, under its jurisdiction or carried out under its control anywhere" (emphasis added).

[93] Durst, P.C., Wallace, R., Therios, I., Ehinger, M. H., Bean, R., Kovacic, D. N., Dougan, A., Tolk, K. and Boyer, B. (2007). *Advanced Safeguards Approaches for New Reprocessing Facilities: Final Report*, Pacific Northwest National Laboratory, p. 17, https://www.pnnl.gov/main/publications/external/technical_reports/pnnl-16674.pdf.

[94] World Nuclear Association – WNA (2018). *Processing of Used Nuclear Fuel*, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel.aspx.

[95] Garcia, H. E., Lineberry, M. J., Aumeier, S.E. and McFarlane, H.F. (n. d.). *Proliferation Resistance of Advanced Sustainable Nuclear Fuel Cycles*, IAEA, https://inis.iaea.org/collection/NCLCollectionStore/_Public/33/034/33034360.pdf.

[96] Zhang, J., Zhou, W., Wang, Y., Phongikaron, S., Yoon, D., Ramonet, J., Park, J., Andrews, H., Kim, S. H. (2017). *Safeguards in Pyroprocessing: an Integrated Model Development and Measurement Data Analysis*, Final Report of Project No. 13, US Department of Energy, p. 13. https://neup.inl.gov/SiteAssets/Final%20%20Reports/FY%202013/13-4908%20NEUP%20Final%20Report.pdf.

solutions used in the process are highly corrosive,[97] making this environment challenging for safeguards equipment and instruments.[98]

At the very back end of the nuclear fuel cycle are spent fuel encapsulation and geological repositories. Encapsulation refers to "the placement of the spent fuel into robust engineered barriers designed to protect against leakage during long term disposal".[99] In 2018, the IAEA published a technical report on safeguards in the design of facilities for long term storage of spent fuel, which discusses in detail considerations relevant to the design and construction of such long-term storage facilities.[100] The report focuses on "safeguards by design", emphasizing that in implementing best practices, the design of any encapsulation facility should take into consideration the possibility that the operator may change or that IAEA measurement technologies may evolve and improve over the operational lifetime of the facility.[101]

Managing spent fuel generated from the operation of nuclear reactors is a serious concern for States with nuclear power plants, owing to its high radioactivity and ability to generate heat for years after its removal from a reactor core.[102] It is estimated that between 2010 and 2030 some 400,000 tonnes of spent fuel will be generated worldwide, including 60,000 tonnes in North America and 69,000 tonnes in Europe.[103] A handful of States reprocess spent fuel to recover fissile and fertile materials in order to provide fresh fuel for nuclear power plants. Most countries treat spent fuel as waste with no further use.[104] In either case there exists waste that is highly radioactive and thus needs to be kept safely and securely contained over a long period of time.

This has led to the idea of deep disposal in underground repositories in stable geological formations where isolation is provided by a combination of human-made and natural barriers, such as rock, salt and clay.[105] A geological disposal of spent nuclear fuel at the Olkiluoto site in Finland, which also includes a spent fuel encapsulation plant, is scheduled to start operating in the early 2020s.[106] In 2016, the Swedish Radiation Safety Authority authorized construction of a spent nuclear fuel repository at the Forsmark site.[107] The authorisation now lies for consideration by the Swedish Government. If construction starts as planned in the early 2020s, the spent fuel repository could be ready

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97 Hoover, R. O. (2014). *Uranium and Zirconium Electrochemical Studies in LiCl-KCl Eutectic for Fundamental Applications in Used Nuclear Fuel Reprocessing*, Ph.D. Thesis, University of Idaho, Idaho Falls, ID, cited in Zhang, J. et al, *Safeguards in Pyroprocessing: an Integrated Model Development and Measurement Data Analysis*, p. 14.

98 Zhang, J. et al, *Safeguards in Pyroprocessing: an Integrated Model Development and Measurement Data Analysis*, p. 14.

99 IAEA (2018). *International Safeguards in the Design of Facilities for Long Term Spent Fuel Management*, IAEA Nuclear Energy Series No. NF-T-3.1, Vienna, p. 33. https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1767_web.pdf.

100 *Ibid*.

101 *Ibid*., pp. 33-34.

102 Clementi, C., Littmann, F., Capineri, L. (2018). Comparison of Tagging Technologies for Safeguards of Copper Canisters for Nuclear Spent Fuel. *Sensors,* Basel, Switzerland, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5949033/.

103 WNA (2018). *Processing of Used Nuclear Fuel*, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel.aspx.

104 *Ibid*.

105 WNA (2018). *Storage and Disposal of Radioactive Waste*, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/storage-and-disposal-of-radioactive-wastes.aspx.

106 Posiva (n. d.). *Annual Report 2017*, pp. 3-4, http://www.posiva.fi/files/4730/Annual_Report_2017.pdf.

107 OECD-NEA (2017). *International Conference on Geological Repositories 2016*, NEA No. 7345, Conference Synthesis
7-9 December 2016 Paris, France, p. 9. http://www.oecd-nea.org/rwm/pubs/2017/7345-icgr2016-synthesis.pdf.

to initiate operations within a decade.[108] Notable progress has also been reported in Canada, France and Switzerland.[109]

Efforts have been under way for at least two decades to develop safeguards approaches with respect to long term disposal of nuclear waste and spent fuel. In 1988, the Advisory Group Meeting on Safeguards Related to Final Disposal of Nuclear Material in Waste and Spent Fuel recommended the adoption of a policy statement that confirmed that "spent fuel disposed in geological repositories is subject to safeguards" and that safeguards were thus to be implemented "after the repository has been back-filled and sealed, and for as long as the safeguards agreement remains in force".[110] They identified a number of verification concerns particular to encapsulation plants and geological repositories, including:

- How to timely detect empty transport casks and disposal canisters;
- How to verify the storage of unshielded disposal containers in high radiation areas; and
- How to guarantee continuity of knowledge of spent fuel and/or waste during transport and deposit of canisters, from the encapsulation plant to the final repository.

The principle challenge associated with verification at a final geological repository is to provide a high level of assurance that spent fuel and waste received at the geological repository is transferred underground for emplacement and cannot be removed undetected from the repository through declared access points or through undeclared excavation activities.

All of the above-mentioned types of facilities will require an evaluation of their proliferation resistance, an assessment of the applicability of current safeguards concepts and the identification of prospective safeguards technologies, equipment and measures to use early in the design stages of a facility. To that end, the IAEA has been actively preparing for the verification of these new types of facilities. It has participated in the International Project on Innovative Reactors and Fuel Cycles[111] and the Generation IV International Forum.[112] The IAEA has also cooperated closely with a number of States that have made major advances in building long-term geological storage facilities, such as Finland and Sweden.[113]

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[108] SKB (2018). *A repository for nuclear fuel that is placed in 1.9 billion years old rock*, http://www.skb.com/future-projects/the-spent-fuel-repository/.

[109] OECD-NEA, *International Conference on Geological Repositories 2016,* p. 9.

[110] IAEA (1988). Safeguards Related to Final Disposal of Nuclear Material in Waste and Spent Fuel (AGM-660), *Proceedings of Advisory Group Meeting in Vienna in 1988*, Rep. STR-243 (Rev.) Vienna, cited in IAEA (2010).*Technological Implications of International Safeguards for Geological Disposal of Spent Fuel and Radioactive Waste*, IAEA Nuclear Energy Series No. NW-T-1.21, Vienna, p. 5, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1414_web.pdf.

[111] IAEA (n. d.). *International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)*, https://www.iaea.org/services/key-programmes/international-project-on-innovative-nuclear-reactors-and-fuel-cycles-inpro.

[112] Molten salt reactors and pebble bed modular reactors are among Generation IV technologies, as established by the Generation IV International Forum. The Forum was created in January 2000 as a multilateral endeavour to assess new nuclear energy systems, to be deployed after 2030, in the areas of proliferation resistance and physical protection, risk and safety assessment, and economics. See Organisation for Economic Cooperation and Development-Nuclear Energy Agency – OECD-NEA (2014). *Technology Roadmap Update for Generation IV Nuclear Energy Systems*, pp. 7-8, https://www.gen-4.org/gif/upload/docs/application/pdf/2014-03/gif-tru2014.pdf.

[113] Haddal, R., Finch, R., Baldwin, G., and Blair D. (2014). *Geological Repository Safeguards: Options for the Future*, p. 2, https://www.osti.gov/servlets/purl/1315146.

All of these challenges are exacerbated by the lack of knowledge about safeguards on the part of private industry and entrepreneurial non-governmental companies that are increasingly becoming more engaged in the design of new and advanced technologies.

There is a parallel dialogue needed within the export control community in three areas:

- The new paradigm in the nuclear fuel cycle and to what extent it can and should be controlled (e.g., accelerator-driven systems and pyroprocessing): advanced reactors and SMRs will offer more flexibility, may be factor-built and can be deployed more easily; new fuels will be used for advanced and small reactors, including high-assay low enriched uranium (HALEU) which may be enriched up to 19.75 per cent in U-235. All of these may require the development of new safeguards approaches and/or techniques.
- The evolution in supply chains (e.g., private capital investors, start-ups, hedge funds): this creates a challenge in terms of outreach for export control compliance and for safeguards implementation; and
- Opportunities offered by emerging technologies in the context of verification (discussed in further detail below in this report).

In addition to considerations linked to new types of fuel and facilities, the emergence of cyber threats presents challenges at all stages in the fuel cycle – from the design stage to the decommissioning stage – and in the protection of the integrity of verification-related information.

Advanced fuel cycle activities are characterized by increasing digitization of information and processes, thereby increasing their vulnerability to cyber attacks (as compared with older processes and facilities that were predominantly analogue). At the design stage, an attacker may be able to identify system and facility vulnerabilities; at the manufacturing stage, since components are often outsourced, supply chain security is critical; at the operation stage, process or facility software could be attacked; and even at the decommissioning stage, where an attacker can still gain valuable information and use it for planning future acts at a similar facility.

1.2. Alternative Nuclear Materials

In the mid-to-late 1990s, a number of countries conducted research into the removal of neptunium-237 and americium from radioactive nuclear waste.[114] The chemical properties of those two elements make them suitable candidates for the fabrication of a nuclear explosive device. Although neptunium-237 and americium mixed with separated plutonium are indirectly safeguarded under CSAs, the two elements are not covered by the definition of nuclear material in the IAEA Statute. They are not required to be placed under safeguards, since "the availability of meaningful quantities of separated neptunium and americium was considered remote, and their detailed consideration was not warranted for safeguards purposes" at the time of the adoption of the Statute in 1956.[115]

In 1999, the Board endorsed the implementation of a scheme to monitor separated neptunium and requested the Director General to report to the Board on information from

[114] Albright, D. and Kramer, K. (2005). *Neptunium 237 and Americium: World Inventories and Proliferation Concerns*, p. 1, https://isis-online.org/uploads/isis-reports/documents/np_237_and_americium.pdf.
[115] IAEA (2004). *Implications of Partitioning and Transmutation in Radioactive Waste Management*, Technical Reports Series No. 435, Vienna, p. 22, https://www-pub.iaea.org/MTCD/publications/PDF/TRS435_web.pdf.

States regarding separated americium. As a result, the IAEA Secretariat requested that the Member States annually provide it with updated declarations regarding the separation, use and inventories of neptunium and americium.[116]

In a report issued in 2005, it was estimated that, in 2003, the world inventory of neptunium-237 and americium exceeded 140 tonnes (metric tons), enough for more than 5,000 nuclear weapons, and the amount was growing at a rate of about 7 tonnes per year.[117] The report noted the likely impact on those quantities as a result of on-going efforts to reduce the radiotoxicity of nuclear waste by separating or partitioning certain, long-lived radioactive isotopes such as neptunium and americium from spent fuel or high level waste. After partitioning long-lived actinides and fission products, the half-lives of such radioisotopes can be transformed through transmutation into shorter half-lived or stable elements by fission or neutron capture. As further noted in that report, the separation of americium and neptunium as part of partitioning and transmutation programs has been limited. Nonetheless, such programs continued to make progress in a number of countries, including NNWSs.

At the 2018 IAEA workshop on emerging technologies, the IAEA's Deputy Director General for Nuclear Energy noted that innovative approaches and technologies, such as accelerator driven systems, were being considered by several countries for transmutation of high level waste. For its part, the Wassenaar Arrangement provides that transfers of separated neptunium in quantities greater than one gram should be controlled.[118] Perhaps it is timely for the IAEA to address the issue of alternative nuclear materials, at least with the goal of evaluating the current situation and the implications for safeguards of further transmutation activities involving emerging technologies.

[116] IAEA (2000). *Annual Report for 1999*, GC(44)/4, p. 18, https://www.iaea.org/sites/default/files/anrep1999_full.pdf.
[117] Albright D. and Kramer, K., *Neptunium 237 and Americium*, p. 1.
[118] The Wassenaar Arrangement (2015). *The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies List of Dual-Use Goods and Technologies and Munitions List*, p. 30, https://www.wassenaar.org/app/uploads/2015/06/WA-LIST-14-2.pdf.

1.3. Recommendations and Assessments

Recommendations:

32. Member States, designers, vendors and the IAEA should be actively promoting safeguards by design to all stakeholders, but especially to reactor designers, taking into account the timeline for possible deployment of these new reactors. This would allow the IAEA and Member States to narrow the gap between the commercialization of the new facility types and the time needed for the IAEA to ensure that it possesses the requisite equipment and technology to safeguard the new facilities.
33. Outreach to private enterprise reactor designers should be emphasized with a view to informing them of the importance of safeguards. In some States new reactor designers are working with national laboratories on reactor prototypes. Such engagement among non-government designers and government entities should be encouraged, promoted and standardized to help raise awareness of the importance of engaging the IAEA at an early stage.
34. The IAEA and its Member States should actively cooperate now in order to ensure that safeguards concerns are addressed with advanced reactor designs and alternative nuclear fuels. There are a number of safeguards questions that do not yet have answers, including but not limited to accountancy issues with MSRs and PBMRs. In particular, the IAEA should initiate discussions with the NWSs about arrangements for the verification of facility design information in the early stages of construction of new reactors that will be built in NWSs and subsequently exported.
35. Member States and industry should develop a code of conduct for the export of new reactor designs with a view to ensuring their "safeguardability" (e.g., early consultation with the IAEA about IAEA access and design information verification).
36. The IAEA, Member States and industry need to address cyber vulnerabilities, especially in supply chains and decommissioned facilities. Given the rapid change in technology, these vulnerabilities need to be reassessed constantly and security measures implemented accordingly.
37. The IAEA should evaluate the current situation with respect to alternative nuclear materials and the implications for safeguards of further transmutation activities involving emerging technologies.

2. New and Emerging Dual-Use Technologies

Many emerging technologies are dual-use by their nature, representing both opportunities and challenges to the safeguards regime.

One example is the development of laser technology. Lasers are now used by the IAEA to scan and identify uranium hexafluoride (UF_6) cylinders, to perform measurements of UF_6 at enrichment facilities and as a design information verification (DIV) tool.[119] On the

[119] Poirier, S. (2007). *Laser Based Applications: Existing and Future Solutions*, https://www-pub.iaea.org/MTCD/Meetings/PDFplus/2007/cn1073/Papers/4B.4%20Ppr_Poirier-%20Laser%20Based%20Applications%20-%20Existing%20and%20Future%20Solutions.pdf.

other hand, the use of lasers for uranium enrichment is also currently being developed. Already in 2009, a group of experts warned that the use of laser technology to enrich uranium could lead more countries to acquire the ability to "produce nuclear weapons material".[120] Lasers become more powerful, smaller, more energy efficient, cheaper and easier to operate, so laser enrichment may pose a proliferation challenge due to the fact that a laser separation plant could be small and easy to hide and could leave a smaller footprint than centrifuges.[121] An AP already empowers the IAEA to monitor exports and imports of components required for certain laser enrichment technologies, such as atomic vapour laser isotope separation, molecular laser isotope separation and chemical reaction by isotope selective laser activation.

Similarly dual in nature is additive manufacturing. Strictly speaking, additive manufacturing is defined as the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.[122] A kind of additive manufacturing, 3D printing is the fabrication of objects through the deposition of a material using a print head, nozzle or other printer technology. The term is often used synonymously with additive manufacturing. However, they are not, as described by one expert:

> 3D printing is the operation at the heart of additive manufacturing, just as "turning" or "molding" might be the operation at the heart of a conventional manufacturing process. In short, additive manufacturing requires and includes 3D printing, but it also entails more than 3D printing, and it refers to something more rigorous.[123]

Concerns have been raised about the possibility of additive manufacturing being used to "print" robust items for a nuclear fuel cycle, which could help bypass export control regimes and affect time considerations in the acquisition path analysis, or even complex parts of a nuclear weapon device. [124]Additive manufacturing, for example, may be deployed to produce vacuum pumps, which are useful for the production of enriched uranium and for other applications relevant to nuclear proliferation and thus are included in the NSG's export-control lists (NSG Guidelines Part 1 if specifically designed for enrichment of uranium; Part 2 Category 3.A.8 if usable for both nuclear and non-nuclear applications).[125]

One study concluded that by mid-2014 there were already "at least 36 commercially available, industrial additive manufacturing/3D printing systems" that could produce aluminium and titanium alloys and maraging steel with the characteristics identified in Section 2.C. of the updated NSG Part 2 Dual-Use List.[126] These materials are included in

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[120] NTI (2009). *Experts Warn of Proliferation Dangers Posed by Laser Enrichment*, https://www.nti.org/gsn/article/experts-warn-of-proliferation-dangers-posed-by-laser-enrichment/.

[121] Kemp, R. S. (2012). *SILEX and proliferation*, Bulleting of Atomic Scientists, https://thebulletin.org/2012/07/silex-and-proliferation/.

[122] ASTM F2792-12a, Standard Terminology for Additive Manufacturing Technologies, (Withdrawn 2015), ASTM International, West Conshohocken, PA, 2012, www.astm.org

[123] More on differences between the two terms can be found in Zelinski, P. (2018). *Additive Manufacturing and 3D Printing Are Two Different Things*, Additive Manufacturing, https://www.additivemanufacturing.media/columns/additive-manufacturing-and-3d-printing-are-two-different-things.

[124] Jones, K. (2015). Additive Manufacturing: A New Piece in the Proliferation Puzzle? *Annual Meeting Proceedings of Institute of Nuclear Materials Management*, pp. 2-3, https://www.inmm.org/INMM/media/Archives/Annual%20Meeting%20Proceedings/2015/a230_1.pdf.

[125] Shaw, R., Dalnoki-Veress, F., Cotton, S., Pollack, J., Toki, M., Russell, R., Vassalotti, O. and Altaf, S. G. (2017). *Evaluating WMD Proliferation Risks at the Nexus of 3D Printing and Do-It-Yourself (DIY) Communities*, CNS Occasional Paper No. 33, James Martin Center for Nonproliferation Studies – Middlebury Institute of International Studies at Monterey, USA, p. 9. http://www.nonproliferation.org/wp-content/uploads/2017/10/op33-wmd-proliferation-risks-at-the-nexus-of-3d-printing-and-diy-communities.pdf.

[126] Jones, K., *Additive Manufacturing*, pp. 4 and 6.

the list owing to their “high strength to density ratio, ductility, high tensile strength, resistance to heat, corrosion, creep and generally extreme and caustic environments, which provide for their utility in nuclear fuel cycle components, notably in the construction of nuclear enrichment centrifuges”.[127] Moreover, there are active efforts to improve current designs of 3D printers so that the size of a printable object would not be “a significant limitation in 3D printing”.[128]

In terms of the controllability and significance of additive manufacturing, the NSG jury is still out. Greater emphasis has been placed on the production of weapons delivery systems, rather than on the weapons or weapons-usable material production. Safeguards (and export control) approaches must differentiate between the machines themselves, the powders used in the processes and the technology itself. Transfer of the technology is more significant than the item itself from a proliferation point of view.

Similar concerns, but less widely discussed, surround the use of nanotechnology.

2.1. Recommendation and Assessment

Recommendation:

38. The IAEA should establish a dialogue with the NSG with a view to assessing the proliferation challenges associated with additive manufacturing, laser technology and other dual-use technologies, as well as their implications for safeguards and export controls.

[127] *Ibid*., p. 7, and Oelrich, I. and Barzashka, I (2013). Centrifuges and Nuclear Weapon Proliferation, *Federation of American Scientists*, http://fas.org/programs/ssp/nukes/fuelcycle/centrifuges/proliferation.html.
[128] Shaw, R. et al., *Evaluating WMD Proliferation Risks at the Nexus of 3D Printing and Do-It-Yourself (DIY)* Communities, p. 10.

Chapter IV: Opportunities Offered by New Tools and Emerging Technologies

Paragraph 6 of INFCIRC/153 obliges the IAEA, in implementing safeguards pursuant to a CSA, to "take full account of technological developments in the field of safeguards". In operative paragraph 32 of GC(62)/RES/10, the General Conference encouraged the IAEA "to enhance its technical capabilities and keep abreast of scientific and technological innovations that hold promising potential for safeguards purposes, and to continue building effective partnerships with States in this regard".

For many years, the IAEA has been using "high resolution commercial satellite imagery to improve its ability to monitor nuclear facilities and sites in support of its safeguards activities."[129] Opportunities for the use of remote analysis have expanded dramatically, including through the availability of multi- and hyperspectral imagery, synthetic aperture radar capable of providing three-dimensional reconstructions of objects regardless of the time of day or atmospheric conditions, high-frequency collection of images and automated change detection. In addition to enhanced imagery, extensive small satellite constellations and satellite-based, high-resolution video have the potential to enhance the safeguards analytical process.

In recent years, we have witnessed rapid development in other technologies that could also be used during in-field activities and in the collection, processing and analysing of information at IAEA headquarters.

1. Headquarters Activities

Between 2010 and 2017, the amount of nuclear material under safeguards increased by over 20 per cent and the IAEA collected tens of thousands of pieces of open source information per year.[130] Together with information obtained during verification activities and from State reports, this massive quantity of information needed to be effectively organized and archived. In 2015, the IAEA initiated the MOSAIC (Modernization of Safeguards Information Technology) project aimed at providing a single integrated and secure environment for all safeguards information as well as new reporting and data visualization tools, new applications and processes that eliminate paper-based steps, and data analytics supporting the preparation of the SIR. There may still be challenges associated with capturing the vast amount of historical data collected decades ago and in turning that data into comprehensive and organized information in order to facilitate knowledge management.[131,132]

[129] IAEA, *GC(62)/8*, para. 29.
[130] IAEA (2018). IAEA Completes 3-Year Project to Modernize Safeguards IT System, Press Release, https://www.iaea.org/newscenter/pressreleases/iaea-completes-3-year-project-to-modernize-safeguards-it-system.
[131] VCDNP and CNS (2014). New Technologies for Information Analysis to Support Non-Proliferation and Disarmament Verification, *Workshop Report*, p. 7.

The IAEA should nevertheless continue exploring new sources of safeguards-relevant information, such as targeted social media searches and online social network analysis offer other valuable sources of information for safeguards analytics. In particular, analysis of nuclear-related research communities may help identify tacit knowledge capacity within a State and ascertain indigenous capabilities, as well as detect alignment with stated nuclear development objectives.[133]

Exploring new ways to process and analyse data is an important task for the IAEA. There are a number of emerging technologies and approaches that might provide significant assistance in accomplishing those tasks. As described below, they may help protect the confidentiality of data, present information in ways that offer greater insight for safeguards inspectors and analysts, be useful in identifying patterns and deviations and automatically extract data from non-text based media.

1.1. Distributed Ledger Technology

Guaranteeing the confidentiality of information has always been of utmost importance to the IAEA. Pursuant to Article VII.F of its Statute, the Director General and IAEA staff members are prohibited from disclosing "any industrial secret or other confidential information coming to their knowledge by reason of their official duties for the Agency", an obligation echoed in paragraph 5 of INFCIRC/153. Article 15 of the Model Additional Protocol also imposes an obligation on the IAEA to "maintain a stringent regime to ensure effective protection against disclosure of commercial, technological and industrial secrets and other confidential information coming to its knowledge, including such information coming to the Agency's knowledge in the implementation of this Protocol".

Currently, the most commonly used method for protecting information provided by a State is through the use of encrypted files, submitted as attachments to a specified email address and the encrypted web-based system State Declaration Portal (SDP).[134] The SDP offers States and regional authorities a secure and efficient mechanism for submitting declarations and communicating with the Department of Safeguards. The portal also keeps track of communications, reducing paper-based processes and manual data entry.

Distributed ledger technology (DLT) might offer an additional layer of protection for confidential data. DLT is relatively new and, consequently, neither its definition nor its possible applications are well understood.[135] Among the most comprehensive definitions of DLT is one suggested by Michel Rauchs, *et al*:

> DLT system is a system of electronic records that: (i) enables a network of independent participants to establish a consensus around (ii) the authoritative ordering of cryptographically-validated ('signed') transactions. These records

[132] For example, the total number of records processed by the safeguards information system in 1977 was 180,000; in 1978 – 370,000; in 1980 – 1,000,000; and in 1981 – 1,187,100. See Dell'Acqua, F. (n. d.). *The development and function of the IAEA's safeguards information system*, IAEA Bulletin, Vol. 23, No. 4, p.21, https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull23-4/23403452125.pdf.

[133] Baxter, P. (2018). Epistemic Communities and Knowledge Transfer Networks: Examining Capacity through Network Analysis, *Presentation made at VCDNP International Workshop on the Applicability of New Tools and Technologies for Non-Proliferation*, Vienna.

[134] Li, J. (2017). *New Web-Based System Streamlines Safeguards Information Exchange with IAEA*, IAEA News, https://www.iaea.org/newscenter/news/new-web-based-system-streamlines-safeguards-information-exchange-with-iaea.

[135] Rauchs, M., Glidden, A., Gordon, B., Pieters, G., Recanatini, M., Rostand, F., Vagneur, K. and Zhang, B. (2018). *Distributed Ledger Technology Systems: A Conceptual Framework*, University of Cambridge, UK, p. 19, https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2018-10-26-conceptualising-dlt-systems.pdf.

> are made (iii) persistent by replicating the data across multiple nodes, and (iv) tamper-evident by linking them by cryptographic hashes. (v) The shared result of the reconciliation/consensus process – the 'ledger' – serves as the authoritative version for these records.[136]

Some of the particularly valuable aspects of DLT relate to its "authoritative", "persistent" and "tamper-evident" nature.

Its authoritative aspect allows for a set of records that all network participants agree upon, and which cannot be altered without consensus. Its persistence is reflected in the ability to ensure survival of records after the loss of a number of entries, or nodes. "Tamper-evident" refers to the ability of participants to easily detect changes to records. In terms of access to participation, DLT systems may be of two types: not permissioned (open) and permissioned (private/closed). In the former, anyone may participate in the consensus process by downloading the code and "starting to run a public node on their device validating transactions".[137] This guarantees the transparency of transactions and anonymity of participants. In the permissioned DLT system, there is a gatekeeper, or central authority, that determines which participants may access the system and "what functions and tasks a participant can perform, who can read data, and how data is diffused among participants".[138]

A permissioned DLT system with the IAEA, a State or a regional authority or a facility serving as central authority, could be used for information exchange among them.[139] DLT would allow all relevant parties to see the transaction history and be assured that "data is not corrupted or accessed by anyone other than the SSAC and the IAEA".[140] The IAEA has already identified the need to "monitor the potential utility of block chain technology for safeguards applications (e.g. nuclear material accounting)".[141]

During the 2018 IAEA International Symposium of Safeguards,[142] a presentation was made on a study initiated in 2016 on "Identifying Safeguards Use Cases for Blockchain Technology".[143] The authors found that DLT (also referred to as shared ledger technology (SLT)) could offer some benefits to the safeguards system, promoting efficient, effective, accurate and timely reporting, and increase transparency in the safeguards system without sacrificing confidentiality of safeguards data. According to the authors, increased transparency and involvement of Member States in certain safeguards transactions could lead to increased trust and cooperation among States and the public further strengthening the international safeguards system. In 2018, they undertook additional research to understand the precise safeguards problem that would most benefit from a DLT solution. Among the possible uses is in facilitating transit matching, tracking inventory change reports and material balance reports, nuclear material shipment tracking and possibly a "living SIR". The results of that study suggest, however, that while DLT offers a spectrum of benefits to the safeguards system (in terms of promoting efficient, effective

[136] *Ibid*., p. 24.
[137] BlockchainHub (n. d.). *Blockchains & Distributed Ledger Technologies*, https://blockchainhub.net/blockchains-and-distributed-ledger-technologies-in-general/.
[138] Vestergaard, C. (2018). *Better Than a Floppy: The Potential of Distributed Ledger Technology for Nuclear Safeguards Information Management*, The Stanley Foundation, p. 2, https://www.stimson.org/sites/default/files/file-attachments/Vestergaard%20PAB%201018-final.pdf.
[139] *Ibid*., p. 4.
[140] *Ibid*.
[141] IAEA, *Research and Development Plan*, p. 15.
[142] IAEA (2018). *Symposium on International Safeguards: Building Future Safeguards Capabilities. Programme*, Vienna, p. 45, https://www.iaea.org/sites/default/files/18/11/cn-267-programme.pdf.
[143] The paper, which was presented by Sarah Frazar of Pacific Northwest National Laboratories (PNNL), was so-authored by PNNL colleagues Amanda Sayre, Cliff Joslin and Sean Kreyling, and Mark Schanfein of Idaho National Laboratory. The presentation is available at https://conferences.iaea.org/indico/event/150/contributions/5422/.

and timely reporting), DLT is not unique in offering this solution. Modern databases and information technology solutions may be just as effective, if not more so, in advancing these objectives. However, DLT solutions *are* unique in their ability to increase transparency in the safeguards system without sacrificing confidentiality of safeguards data.

Another researcher who has written extensively about safeguards applications for DLT came to somewhat similar conclusions:

> Proof of concepts will be the first step to understanding the plausibility of DLT for safeguards information management. It would not be difficult to configure a permissioned DLT to meet specifications of the organizations involved, whether national, bilateral, multilateral, or within the IAEA. The bigger hurdles to adoption will be acceptance by member states, with each having its own policies for information exchange and technology practices, as well as different ideas on how to create greater resource efficiencies within the IAEA and different lead times in adoption of emerging technologies.
>
> The application of DLT to nuclear safeguards information management will not displace the essential role of the IAEA as a central authority nor diminish the importance of its work. Instead, it could add layers of security and traceability to better control and streamline data that in turn can facilitate more-effective safeguards implementation. The technology therefore will not radically transform the safeguards information ecosystem, but it will allow operations to be refined and adapted to an evolving safeguards system. The technology is still maturing, but there is promise in its use among actors that mistrust one another. It may not solve every problem, but it is much better than the floppy.[144]

1.2. Data Visualisation

Another useful tool for data processing is data visualisation, whereby data is presented through graphical tools in order to produce insight and evidence while analysing or communicating data. Exploring new ways of displaying large datasets is different from the use of artificial intelligence, discussed below, insofar as the former supports pattern recognition by humans rather than by machines. Data visualisation could help analysts "formulate the right questions, rather than address specific predefined issues or expectations".[145]

Three-dimensional (3D) visualization often makes information more comprehensible and lively than dense text or two-dimensional images, offering more possibilities for the analysis of significant amounts and different types of data. A number of other advantages makes this technology attractive: low costs of many tools, including some technology in the public domain with no proprietary rights; the ability to increase detail and accuracy of models depending on the need; and ease of learning.

Virtual reality and 3D modelling are also useful training tools for IAEA inspectors. One benefit of its use could be training on complicated and potentially dangerous scenarios in an inclusive, cost-effective manner with no risk to safety or security. These technologies

[144] Cindy Verstergaard, "Better than a Floppy: The Potential of Distributed Ledger Technology for Nuclear Safeguards Information Management", Stimson Center, October 2018, available at https://www.stimson.org/sites/default/files/file-attachments/Vestergaard%20PAB%201018-final.pdf.

[145] VCDNP and CNS, *New Technologies for Information Analysis to Support Non-Proliferation and Disarmament Verification*, p. 14.

could also provide complete visualization of facility and design information-relevant infrastructure for safeguards verification, integration of 3D models with game engines for facility walk-throughs and/or interactions and conducting simulations in order to test verification solutions.[146] While the IAEA already uses these techniques for training purposes, it does not map out real facilities in Member States due to security and confidentiality concerns. Combining publicly available information from both satellite imagery and online photo and video footage of facilities or locations could permit even greater detail for 3D models.

1.3. Artificial Intelligence and Machine Learning

Artificial intelligence (AI) and machine learning (ML) could be a next step in achieving further efficiency in the analysis of large amounts of information. AI is defined as the ability of a digital computer or computer-controlled robot to perform tasks usually associated with humans and characterised by the "ability to reason, discover meaning, generalize or learn from past experience".[147] As a branch of AI, ML is the use of computer algorithms that "learn" by examining and comparing data to find common patterns and explore nuances without being explicitly programmed.[148] ML can be of two types: supervised and unsupervised. The former requires classification or "input data sets containing examples with labels of each possible output category", while the latter does not need labels but instead tries to determine clusters, groupings and relationships through the data structure.[149]

These autonomous technologies could be employed, for example, to reduce repetitive tasks for analysts, maintain continuity of knowledge on nuclear material and/or identify anomalies and patterns in large amounts of data, thus enabling analysts to focus on value added tasks.[150] Of particular consideration are advances in algorithms for image detection and classification to describe non-text-based sources and multilingual speech-to-text capabilities.[151]

The IAEA is already using AI and ML techniques on its collaborative analysis platform (CAP) in connection with the collection of large amounts of data for purposes of:

- Categorization of data: weaning out relevant publications from vast collections of academic articles; website crawling; collecting relevant images;
- Change detection: reviewing satellite imagery and/or the surveillance camera images to identify changes to a facility; and
- Natural language processing.

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[146] See, for example, WNN (2019). *Wolsong 1 simulator to be repurposed for use at unit 3*, http://www.world-nuclear-news.org/Articles/Wolsong-1-simulator-to-be-repurposed-for-use-at-un.
[147] Encyclopædia Britannica (n. d.). *Artificial intelligence*, https://www.britannica.com/technology/artificial-intelligence.
[148] Iriondo, R. (2018). *Differences Between AI and Machine Learning and Why it Matters*, https://medium.com/datadriveninvestor/differences-between-ai-and-machine-learning-and-why-it-matters-1255b182fc6.
[149] Shoman, N. and Cipiti, B. B. (2018). Unsupervised Machine Learning for Nuclear Safeguards, *Annual Meeting Proceedings of Institute of Nuclear Materials Management*, https://www.inmm.org/INMM/media/Archives/Annual%20Meeting%20Proceedings/2018/a125_1.pdf.
[150] See, for example, Shoman, N. and Cipiti, B. B., *Unsupervised Machine Learning for Nuclear Safeguards*.
[151] See, for example, Barber, G. (2018). *AI Can Recognize Images. But Can It Understand This Headline?* Wired, https://www.wired.com/story/ai-can-recognize-images-but-understand-headline/, Olafenwa, M. (2018).*Train Image Recognition AI with 5 Lines of Code*, Towards Data Science, https://towardsdatascience.com/train-image-recognition-ai-with-5-lines-of-code-8ed0bdd8d9ba; and Szegedy, C. (2014), "Building a deeper understanding of images", *Google AI Blog*, https://ai.googleblog.com/2014/09/building-deeper-understanding-of-images.html.

However, the accuracy of the results of machine learning tend to be relatively poor, since large datasets are necessary to "put things in the right box". This is likely to improve with time. In addition, it is possible to spoof machine learning, although ML can be trained to detect spoofed content.

The important take-away from ML is that, while it can be used to channel data to the analysts, it cannot replace them.

1.4. Crowdsourcing

Crowdsourcing – defined in the Oxford Dictionary as "obtaining information or input into a task by using the services of a large number of people, either paid or unpaid, typically via the internet" – may provide additional value to verification applications. In particular, crowdsourcing may be used for online information collection, mass deployment of mobile radiation sensors and/or public engagement challenges. It increasingly provides more capabilities given the ubiquity of cell phones as sensor platforms, new algorithms that can maximize the efficiency of network analysis, the appearance of more open online data fora and communities and the increasing popularity of gaming challenges, through which the public can be engaged as an information source and workforce.[152]

The IAEA has already used this approach to support hardware and software development, most recently in the 2018 crowdsourcing challenge for visualization, analysis and simulation of materials to build fusion reactors,[153] and a series of challenges aimed at the discovery of new robotics technologies that could be used to enhance the IAEA's work.[154]

1.5. Recommendations and Assessments

The technologies described above have the potential to help the IAEA to better utilize the massive quantities of data it receives in a more effective and targeted fashion. However, the driver for new technologies should remain whether they offer new and necessary capabilities or can enhance a current capability by making it more efficient and effective. Some of these technologies are already in use by the IAEA; expanded application of these technologies will benefit from collaboration between the IAEA, Member States and industry.

Recommendations:

39. IAEA staff should receive more training on data literacy so that they are able to make the most efficient use of both data processing technologies and the data itself, in particular on how to interpret and communicate information provided by such data.
40. The IAEA should continue to invest in knowledge management, as it has done with MOSAIC and other new systems, with the support and collaboration from Member

[152] VCDNP and CNS, *New Technologies for Information Analysis to Support Non-Proliferation and Disarmament Verification*, p. 17.
[153] Hill, C. and Peeva, A. (2018). *Winners of the IAEA Crowdsourcing Challenge for Materials for Fusion Technology Announced*", IAEA News, https://www.iaea.org/newscenter/news/winners-of-the-iaea-crowdsourcing-challenge-for-materials-for-fusion-technology-announced.
[154] Dubertrand, M. (2018). *Robotics in Nuclear Verification: Sparking Innovation through Crowdsourcing*, IAEA News, https://www.iaea.org/newscenter/news/robotics-in-nuclear-verification-sparking-innovation-through-crowdsourcing.

States.

41. DLT may offer benefits in the protection of data and increasing transparency between the IAEA and its Member States. Further exploration of the possible use of DLT in the context of safeguards should be conducted, with the support of Member States, with a view to ascertaining whether the technology would provide greater benefits and if so how best to utilize it.
42. The IAEA should continue to invest in data visualization and virtual reality training. Member States should consider providing the IAEA with 3D models of facilities for training and inspection preparation purposes.
43. The IAEA and Member States should adopt a holistic approach to new technologies, and not become over-reliant on AI and ML. AI and ML are not substitutes for human analysts but rather an efficient aide for analysts to do their jobs better and more efficiently.

2. In-Field Activities

Many new technologies are being commercialized that may offer opportunities for the IAEA to more effectively and efficiently implement safeguards. These technologies could include unmanned aerial vehicles (UAVs), wearable technology, ground-penetrating radar and robotics, just to name a few. They could be used to:

- Provide on-demand, location-based information;
- Automatize simple tasks (e.g. item counting, data acquisition);
- Reduce the need for inspector presence at facilities;
- Reduce the effort required for data review; and
- Improve data analysis.

Some of the more obvious opportunities could include the use of UAVs or other technologies to make wide-area environmental sampling more cost-effective, or the use of “smart glasses” by an inspector in the field to assist in geo-referencing, allowing him or her to determine precise locations and possibly connect to the internet.

However, as for new Headquarters tools, the focus on these new technologies should not be about acquiring the newest “shiny tool” in verification technologies, but rather on assessing whether the new technology provides either a new and required capability or improves the efficiency of an existing capability.

Implementation of new technologies may come with new risks as well. For example, some experts consider that additive manufacturing might be useful for creating ad hoc spare parts for IAEA equipment thus saving time before a substitute arrives.[155] On the other hand, additive manufacturing technology could potentially be used by States to undermine containment measures employed by the IAEA, for example, to replicate complex patterns used to authenticate IAEA seals.[156]

In terms of verification activities, the IAEA and its Member States face other challenges in the cyber domain: given the IAEA special requirements for its safeguards equipment, the pace of authorisation procedures lags behind technological progress; interception or falsification of safeguards information needs to be guarded against; systems vulnerability

[155] IAEA, *Emerging Technologies Workshop*, p. 17.
[156] IAEA, *Emerging Technologies Workshop*, p. 17.

analyses could be corrupted (with a special threat posed by "zero-day probability" (i.e., if malware is not yet known, how can protections against it be built in?); an attacker might gain access to sensors or systems at the equipment supply stage or disable hardware through a software system if it is an open network.

An important issue in the use of these technologies will be in demonstrating their cost-effectiveness and addressing possible State concerns about the impact of such technologies on safety at nuclear sites and their implications for security (both nuclear security and national security). While easing the burden on facility operators could be another benefit, especially when considering remote applications of these technologies, it is important to recognize that the IAEA's added value to international verification rests in the presence of inspectors on the ground.

The following section touches on just a few of these technologies and their possible applications.

2.1. Drones

UAVs, or drones, might be used to improve current safeguards practices, providing more information to safeguards inspectors than can be obtained through satellite imagery or ground measurements. Drones could be especially useful for verification in areas that are too dangerous or difficult for inspectors to reach, e.g., high radiation areas or building exteriors.[157] By way of example, Tokyo Electric Power Company already uses drones to assess the condition of the containment vessels of the damaged reactors at the Fukushima Daiichi nuclear power plant thereby reducing the risk of human exposure to the still highly radioactive environment.[158] A wide variety of currently available drone technologies would enable the building of UAVs specifically tailored to particular safeguards activities, as described below.

During a CA, IAEA inspectors may evaluate the function of buildings on a site, typically using a site map and a general description of each building on the site, its use and its contents provided by the State under Article 2.a.(iii) of INFCIRC/540. A drone with a mounted camera could provide additional visibility as well as high resolution geo-referenced site images, and be utilised to effectively verify site declarations.[159] Adding infrared, radiation or other sensors to the drone could also be helpful in mapping of the site.

Similarly, drones could be used during DIVs. Drones equipped with high-resolution cameras, 3D laser range finders and other detectors or sensing technology could complement existing laser mapping tools. To boost the efficiency of information collection, swarms of small drones might be deployed.[160]

Drones equipped with geo-referenced cameras could also reduce the time needed for an inspector to survey uranium mines, as well as uranium or thorium concentration activities, which are required to be declared under APs. Mounting more advanced

[157] Hackett, A. and Hayward, J. (2016). Safeguards Use of Unmanned Aerial Vehicles, *Annual Meeting Proceedings of Institute of Nuclear Materials Management,* https://www.inmm.org/INMM/media/Archives/Annual%20Meeting%20Proceedings/2016/a181_1.pdf.

[158] World Nuclear News – WNN (2018). *Drones to venture into Fukushima containment vessels*, http://www.world-nuclear-news.org/Articles/Drones-to-venture-into-Fukushima-containment-vesse.

[159] Boldon, L., Reed, J. K., Gastelum, Z. N., Smart, J. E. and Disser, J. (2017). Unmanned Aerial Systems Applications for International Nuclear Safeguards, *Annual Meeting Proceedings of Institute of Nuclear Materials Management*, https://www.inmm.org/INMM/media/Archives/Annual%20Meeting%20Proceedings/2017/a271_1.pdf.

[160] *Ibid*.

equipment onto a drone, such as hyperspectral sensors or spectrometers and laser-ranging, could help complete the picture by identifying the composition of stockpile materials and providing more accurate volumetric measurements of the material.[161]

Another potential use of drones is the counting of containers at large storage yards at enrichment facilities, detecting if any changes have occurred and, using a gamma detector, identifying empty containers.[162] A drone carrying a digital Cherenkov viewing device (CVD) might also be deployed for monitoring spent fuel in spent nuclear fuel wet storage facilities. Drones could also be used to follow and track items while in transit, and remotely send data in real time to the IAEA.[163]

Drones may be suitable for taking environmental samples as well. As suggested above, their use could contribute to a re-evaluation of the costs and benefits of wide-area environmental sampling, as contemplated in Article 9 of the Model Additional Protocol. Rather than serving as “eyes in the sky”, they might carry special attachments to take surface swipes, and air and liquid samples.[164]

The use of drones can potentially entail considerable challenges, not the least of which is the acceptance by Member States of their use, especially as the relevant legal requirements may differ from country to country. Another risk associated with the use of drones relates to possible liability and safety concerns in the event of the crashing of a UAV. Drones could also become contaminated through their use in high radiation areas, a problem that could be overcome with the use of low cost disposable drones.[165]

Other technologies that could help inspectors attain higher levels of effectiveness and efficiency include ground-penetrating radar to detect hidden facilities and robotics, which might take repetitive measurements and give inspectors more time for analysing data or substitute them in places of difficult access or with safety and security concerns.

An excellent example of the innovative use of unmanned mobile robotics for safeguards purposes is the alternative to the current hand-held CVD developed by a small Hungarian company, Datastart, to improve the verification of spent fuel at spent fuel ponds. The device is a “Roomba”-like robot equipped with the technology to detect the Cherenkov glow that crawls (or swims, if you like) on the surface of spent fuel ponds. Unlike the traditional CVDs, the robot is also able to store the data and create unified maps of the spent fuel ponds. It is transportable, reusable, de-contaminable, autonomous, is extremely stable and can be operated either tethered or wirelessly. The result is a much more effective and efficient way to verify spent fuel, reducing inspector and operator time and increasing the accuracy of the detection capability.

The other unusual aspect of this equipment is how it came to be used: the company that developed the robot was the winner of an innovative crowd-sourcing competition, the third of its kind convened by the IAEA, and aimed at discovering new technologies that could be used to enhance the IAEA’s work in nuclear safeguards and verification, referred to above.[166]

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[161] *Ibid.*
[162] *Ibid.*
[163] *Ibid.*
[164] Hackett, A. and Hayward, J. (2016). Safeguards Use of Unmanned Aerial Vehicles, *Annual Meeting Proceedings of Institute of Nuclear Materials Management*, https://www.inmm.org/INMM/media/Archives/Annual%20Meeting%20Proceedings/2016/a181_1.pdf, and Boldon, L. et al, *Unmanned Aerial Systems Applications for International Nuclear Safeguards*.
[165] Boldon, L. et al, *Unmanned Aerial Systems Applications for International Nuclear Safeguards.*
[166] See footnote 149.

2.2. Wearable Technology

There have been considerable developments in wearable technology from which inspectors might also be able to benefit. So-called “smart glasses” have been developed that can project information either alongside or onto the picture that a wearer sees.[167] Smart glasses might also be able to show a map of an inspected area and include geo-referencing allowing an inspector to know his or her precise location and determine places not yet inspected. Smart glasses connected to the Internet could facilitate external conversations, for example, with headquarters or a field office. They could also save an inspector considerable time by instantly facilitating access to information and, if they include a voice command function, would give an inspector an “extra hand” for carrying out verification tasks.[168]

Smart glasses could even provide for a function of augmented reality through the projection of data onto the inspector’s field of vision. This feature could be helpful in illustrating, for example, the swipe sampling of different centrifuges within an inspected zone[169] or for training purposes.

The possible deployment of wearable technology is likely to meet with objections on the part of States and facility operators, who may have concerns about information collection and the protection of confidential information. The IAEA will also need to consider the issue of data security during transmission of data to and from wearable gadgets.

2.3. Recommendations and Assessments

Advances in new technology should provide either a new and required capability or improve the efficiency of an existing capability. While open-ended research is a positive and necessary aspect of any programme, advancement for the sake of advancement does not necessarily contribute to the betterment of safeguards implementation.

Another key consideration will be whether approval by the Board of Governors is required for the implementation of new in-field verification measures.

Under a CSA, the IAEA has a right to carry out two types of in-field access: DIVs[170] and inspections.[171] Paragraph 74 of INFCIRC/153 authorizes the IAEA, in carrying out inspections, to use a variety of specific techniques and measures, and to “use other objective measures which have been demonstrated to be technically feasible”.[172] INFCIRC/153 contains no limitations on the types of activities in which the IAEA may engage for the purposes of verifying design information. The use of location-specific environmental sampling, first developed in the early 1990s, did not require Board approval prior to its use. However, the IAEA carried out numerous field trials, in

[167] See, for example, Baldwin, R. (2012). *6 Glasses With Integrated Displays That You Can Buy Today*, Wired, https://www.wired.com/2012/04/6-glasses-with-integrated-displays-that-you-can-buy-today/, and Sumra, H. (2019). *The best augmented reality glasses 2019: Snap, Vuzix, Microsoft, North & more*, Wearable, https://www.wareable.com/ar/the-best-smartglasses-google-glass-and-the-rest.

[168] Mascareñas, D., Katko, B., Bleck, B., Green, A., Dasari, S., Gertsen, H., Morales, J., Yang, Y., Blackhart, C., Cattaneo, A., Trujillo, J., Farrar, C., Wysong, A. and Harden, T. (n. d.). *Augmented Reality Tools for Criticality Safety, Documentation, Material Moves, and Material Accountability in Nuclear Facilities*, Los Alamos National Laboratory, USA, https://www.inmm.org/INMM/media/Documents/Presenations/Novel%20Technologies%20Workshop/0829_1015_Mascarenas.pdf.

[169] *Ibid*.

[170] INFCIRC/153, para. 48.

[171] INFCIRC/153, paras 70-84.

[172] INFCIRC/153, para. 74(e).

cooperation with Member States, before introducing it on a routine basis for inspections and DIVs.

Under an AP, the IAEA has a third type of access: complementary access.[173] Articles 6.a., 6.b. and 6.c. of INFCIRC/540 contain language similar to that used in paragraph 74 of INFCIRC/153, but build in a requirement for agreement by the Board of Governors consultations between the Agency and the State concerned for the use of “other objective measures which have been demonstrated to be technically feasible”.[174] The Model Additional Protocol includes a specific article concerning the use of wide-area environmental sampling, conditioning its use on Board approval of its use and on the procedural arrangements therefor, as well as consultations between the IAEA and the State concerned.

The Model Additional Protocol also includes in Article 9 assurances of the IAEA’s right to free communications for official purposes between Agency inspectors in the field and IAEA Headquarters and/or Regional Offices, including through attended and unattended transmission of information generated by Agency containment and/or surveillance or measurement devices. It also guarantees the IAEA, in consultation with the State concerned, “the right to make use of internationally established systems of direct communications, including satellite systems and other forms of telecommunication, not in use in the State”. However, Article 9 requires that such communication and transmission of information “take due account of the need to protect proprietary or commercially sensitive information or design information considered by the State as being of particular sensitivity. Such issues might arise, for example, with the use of wearable technology that involves the transmission of data or access to the Internet while the inspector is on site.

While it may be concluded that the introduction of new technologies for use in connection with DIVs or inspections does not, as a legal matter, require Board approval (e.g. use of the advanced robotic CVD for verification of spent fuel), implementation in the field of some of these new technologies may be complicated, and attention will have to be paid to State and operator sensitivities, including safety and security considerations. Engagement of Member States before deployment would enhance the prospects of deploying new technologies for use in safeguards. Both in terms of practice and optics, the IAEA needs to ensure that Member States are kept in the loop.

It should be recognized that the argument that advanced technologies might reduce the footprint of IAEA inspectors in the field has its limits. While they might supplement on-site verification activities, they cannot replace the IAEA’s most valuable asset: inspectors on the ground.

[173] INFCIRC/540, Articles 4-10.

[174] Articles 6.a., 6.b. and 6.c. refer to access requested under Articles 5.a. or 5.b. to locations required to be declared by the State. Under Article 6.d., however, Board agreement” is not required for the use of “other objective measures” in connection with access requested under Article 5.c. to “any locations specified by the Agency, other than locations referred to in paragraphs a. and b. [of Article 6]”. In the latter instance, the implementation of such measures requires only agreement by the State and the Agency.

Recommendations:

44. Given that authentication of new equipment is often a complicated and lengthy process, the IAEA should consider using either off-the-shelf equipment or deploying in the field technologies and equipment developed for other purposes (such as the unmanned robot used for spent fuel verification).
45. In all prospects for the deployment of new technology, the IAEA must prioritise ensuring the integrity of transmitted data and authentication of equipment.
46. The IAEA should include in its future research and development plans notional budgets for the development of new technologies.
47. Ensuring acceptance by Member States and operators is critical to the deployment of IAEA equipment and technology. In developing use cases for new technology, safety, security and safeguards all need to be kept in mind.

Chapter V: Conclusions

Drawing from the research conducted by the VCDNP and the results of the workshop convened by the VCDNP, this final chapter is intended to summarize the recommendations and offer commentary on the feasibility of their implementation.

There were many ideas and recommendations offered by the participants. While some of them are immediately feasible, others are desirable but may not be immediately feasible given the immediate political environment; a few may be still longer-term. Upon review of these ideas and recommendations, the following four broad categories emerged:

- Outreach and Communications;
- Balancing Independence and Transparency;
- Evolution of Safeguards; and
- Applications of Emerging Technology.

1.1. Outreach and Communication[175]

Within almost all of the topical areas, the workshop participants focussed on recommendations related to new or enhanced outreach and communications activities. The majority of these recommendations should be feasible in the short term, given that they necessitate neither policy changes nor increased budget allocations.

Several recommendations emphasised the need for outreach activities that the IAEA, Member States and non-governmental organisations could implement in relation to States that lack information or resources to conclude or effectively implement a CSA or an AP thereto, or to amend or rescind SQPs, where relevant. States that have not yet concluded an AP or modified an SQP for other reasons should also remain among the outreach priorities. The IAEA should develop sustainable solutions and place emphasize the benefits of concluding or amending those instruments, as appropriate.[176]

In the context of the IAEA's legal authority, the participants offered some novel recommendations on how to encourage those States that have yet to conclude their required CSAs to do so, in particular with respect to differentiated treatment using a regional approach.[177] Regionally tailored outreach could include bilateral and multilateral meetings, as well as the creation of a forum for SRAs/SSACs to exchange experiences and best practices.[178]

As most of the IAEA's outreach activities rely on extrabudgetary funding, it was suggested that the IAEA could enhance its communication with Member States by more clearly outlining what should be funded.[179] Moreover, when outreach is conducted by actors other than the IAEA, e.g., Member States or non-governmental organisations, it is useful to invite IAEA representatives to participate.[180] Such participation not only ensures proper messaging, but also highlights the importance that the IAEA places on such activities.

[175] Corresponding Recommendations: 1, 2, 3, 4, 5, 6, 7, 8, 12, 16, 17, 18, 19, 27, 32, 33, 34
[176] Recommendation 6.
[177] Recommendations 1 and 7.
[178] Recommendations 18 and 19.
[179] Recommendation 2.
[180] Recommendation 3.

In terms of broader outreach efforts, the IAEA should include in its training for staff members and new diplomats in Vienna sessions on the history of safeguards.[181] Similar training could be extended throughout the nuclear field to promote better understanding of the IAEA's safeguards activities and generate greater diversity in applicants for IAEA staff positions.[182] The general public would also benefit from additional knowledge about IAEA verification activities, for example, through the publication of short briefs on issues important to the IAEA.[183] Examples of topics for such issue briefs include advanced nuclear technologies, new types of reactors and fuels, new verification equipment and technology and the importance of cooperation between the IAEA, Member States and technology developers.

The participants highlighted the importance of IAEA outreach to all stakeholders in order to promote safeguards by design, elaborate new verification approaches and secure acceptance by States and operators in the deployment of new verification tools.[184] Outreach to industry could play a particularly meaningful role, given that many reactor designers are now non-governmental.[185]

While the above measures constitute changes in focus or strategy in outreach and communications, other recommendations focussed on actions that States might undertake either on their own or within other international organisations. Among these suggestions were the creation of a regional SRA for Pacific Island States or entrusting existing regional safeguards, safety or security organisations with the SRA functions.[186] Another recommendation focussed on adding safeguards and non-proliferation issues to the Organisation for Economic Co-operation and Development's definition of development to reframe and associate safeguards with development.[187] Two other, and perhaps even more challenging, recommendations advocated for: a linkage between IAEA safeguards, Member States and the 1540 Committee for capacity building purposes; and increased transparency among NWSs and as between NWSs and the other parties to the NPT with a view to encouraging the conclusion of APs by States that have yet to do so because of policy reasons rather than capacity.[188] As these measures depend largely on the will and economic capabilities of Member States, they may be less feasible in the near term. However, stakeholders should still bear in mind the positive impact these measures could have.

1.2. Balancing Independence and Transparency[189]

The Member States of the IAEA have delegated to the Director General and to the Secretariat the responsibility for the day-to-day implementation of IAEA safeguards. However, that responsibility is not absolute, and the Secretariat remains subject to the wishes of the Member States. Independence and transparency need not be viewed as mutually exclusive qualities, but rather as complementary ones.

One of the key issues raised in this context is support for the IAEA's existing legal authority. As noted above, seeking reaffirmation of the IAEA's rights and obligations

[181] Recommendation 16.
[182] Recommendation 27
[183] Recommendation 17
[184] Recommendations 32 and 34
[185] Recommendation 33
[186] Recommendation 4
[187] Recommendation 5
[188] Recommendations 8 and 12
[189] Corresponding Recommendations: 13, 14, 15, 20, 22, 28, 30

under CSAs would not come without some risk, especially in the highly politicized atmosphere that currently prevails. Moreover, there already is general consensus on these issues, as reflected in the annual General Conference resolution on safeguards and the NPT Review Conference outcome documents. However, all stakeholders, including, the Secretariat must be willing to challenge false assertions and mischaracterizations regarding the IAEA's safeguards authority, and ensure that historical achievements are not lost.[190]

While comparatively few recommendations touched on these issues, they are critical factors in how the IAEA operates. Unlike the recommendations discussed in the previous section, many of these recommendations are likely long-term goals. What is possible in the short term is for the Secretariat to adopt an open policy based on transparency as a priority with the aim of reframing its relationship with Member States as a partnership.[191] An increase in the frequency of consultations and more openness about the decisions taken by the Secretariat have worked well to address concerns raised in the context of the SLC discussions, and have been demonstrated to be simple and feasible ways to increase trust. This would be especially desirable with regard communications about how the IAEA protects sensitive information.[192]

However, other recommendations on independence and transparency may be longer-term goals. For example, extrabudgetary funding will likely continue to come with preconditions attached and, as the regular budget is not likely to see comprehensive reform in the near future, Member States should be encouraged to offer voluntary contributions without such preconditions.[193] Moreover, increased transparency on the budget overall, including about the drivers of increased costs and future projections, could ease tensions on requests for budget increases.[194]

Two other, long-term goals for strengthening the relationship between the IAEA's independence and transparency/accountability to the Member States: publication of the SIR and changing the mandate of SAGSI. These would both be quite challenging in the near term.

The SIR could conceivably be used as a transparency tool for Member States if it contained more information about the performance of individual States and also evaluated the performance of the Secretariat. Conversely, the public release of the SIR could be contemplated, as it does not contain any truly safeguards-sensitive information.[195] While the SIR is the report of the Director General, and thus modifiable by the Secretariat, a decision to publish the SIR would need to be taken by the Board of Governors.

Changing the role of SAGSI might also have merit. The Director General could consider revising SAGSI's role so that, in addition to its traditional advisory role, it would have an authoritative public face.[196] SAGSI could use this public face to help challenge false assertions about safeguards, offer independent opinions on safeguards issues to the public and to the Board and produce reports. Such a group, in principle independent but informed, could help elevate the transparency of the IAEA, while better informing choices about safeguards implementation. This endeavour would be challenging since it

[190] Recommendation 14
[191] Recommendation 13
[192] Recommendation 22
[193] Recommendation 30
[194] Recommendation 28
[195] Recommendation 20
[196] Recommendation 15

would involve changing SAGSI's terms of reference and might lead to politicising discussions in the group, among other things.

1.3. Evolution of Safeguards[197]

The safeguards system has evolved considerably through the years to adapt to a changing international environment and the priorities of its Member States. The safeguards system should continue to evolve as these factors continue to change.

Among the recommendations that could be implemented in the near term are those focused on the acquisition and retention of qualified staff. On a basic level, the IAEA could enhance training for staff, particularly safeguards inspectors, on data literacy and social sciences.[198] Ensuring that staff have the best command of data, interpersonal skills and cultural awareness is a relatively inexpensive way to heighten job performance, and thus their work on implementing safeguards. Member States could participate in administering this training, as well as in some pre-training of safeguards staff, including potential inspectors.[199] This could reduce the time it takes inspectors to become operational.

A more challenging issue is the matter of staff rotation. As there is no absolute rule compelling the existing rotation policy, the current practice could be modified with immediate effect.[200] However, given the competing interests in its implementation, prior to undertaking such modification, the IAEA could consider conducting a study of staffing practices that could inform its staffing policies in the future.[201] This is especially pertinent to the question of staff performance reviews and contract extensions. The IAEA could also consider addressing the needs that the rotation policy is meant to address by offering long-term leave or sabbaticals for staff to work, for example, in nuclear facilities.[202] This would give staff the opportunity to acquire fresh perspectives on scientific and safeguards issues at a national level, while ensuring that the IAEA retains the institutional memory of qualified staff.

One long-term issue is that of the IAEA's budget, which affects the IAEA's ability to implement effective and efficient safeguards. Comprehensive budget reform certainly represents a long-term goal for the IAEA. A more immediately feasible recommendation would be for the IAEA to commission a study identifying what drives the budget, prioritizing demands and exploring different approaches to optimising the budget.[203] Future research could also include notional budgets for the development of new technologies.[204] This would allow the IAEA and Member States to take a fresh look at how budgeting practices might be optimized.

Though many recommendations involve action on the part of the IAEA, a few reflect actions that Member States could take. In particular, Member States could work with industry to develop a code of conduct for the export of new reactor designs in order to ensure their "safeguardability".[205]

[197] Corresponding Recommendations: 9, 10, 11, 21, 23, 24, 25, 26, 29, 31, 35, 39, 46
[198] Recommendations 21 and 39
[199] Recommendation 26
[200] Recommendation 23
[201] Recommendation 24
[202] Recommendation 25
[203] Recommendations 29 and 31
[204] Recommendation 46
[205] Recommendation 35

One of the likely least immediately feasible recommendations, although it still bears mentioning, is the modification of the Annexes to the Model Additional Protocol.[206] It might be more feasible to establish an open-ended working group under Article 16 of the Model Additional Protocol to discuss the Annexes on an on-going basis at regular intervals, rather than requiring it to produce recommendations for amendment of the Annexes.[207] Input by representatives of the NSG and those who contributed to the most recent EU export control lists would be useful, although more challenging due to institutional sensitivities. Alternatively, and likely also challenging, the IAEA and Member States could shift attention to strengthening the implementation of APs by encouraging information sharing, on a voluntary basis, about export license denials and other pertinent information.[208]

1.4. Applications of Emerging Technology[209]

Although this entire body of work focuses on how the IAEA and Member States can stay ahead of the game in safeguards, emerging and commercialising technologies pose some of the greatest challenges while possibly offering the greatest opportunities. There are many "known unknowns" about the potential or expanded use of these technologies, but there are undoubtedly more "unknown unknowns". As such, many of the recommendations about challenges and opportunities concern not what should be done with emerging technologies, but rather how stakeholders should view them.

Many of the recommendations concerning emerging technologies could and should be implemented in the near term. On-going and enhanced focus on cyber vulnerabilities, knowledge management, laser technology, additive manufacturing, DLT, data visualisation, AI, machine learning and other emerging technologies will be critical for all stakeholders.[210] Additionally, the IAEA should consider revisiting the current situation with respect to alternative nuclear materials and the impact of emerging technologies on potential transmutation activities.[211]

On-going collaboration between the IAEA and Member States in that regard is not only feasible today, but is extremely important. A collaborative environment would also help to ensure that safety, security and safeguards all factor into new technologies. Stakeholders should bear in mind that new technologies will supplement the work of inspectors in the field, not replace them. Thus, a holistic approach to emerging technologies will be required in order to effectively integrate them into existing processes.

Given the speed at which technology is developing, the IAEA could take advantage of off the shelf equipment and technologies for safeguards applications.[212] This could help streamline the production process for the introduction of new technologies by obviating the need for in-house design and development of specialized safeguards equipment. In addition, because authentication of equipment used by the IAEA is a complex and often lengthy process, it is recommended that the Agency, in observing the technologies being produced, try to develop a more forward looking strategy in order to help predict its

[206] Recommendation 9
[207] Recommendation 10
[208] Recommendation 11
[209] Corresponding Recommendations: 36, 37, 38, 40, 41, 42, 43, 44, 45, 47
[210] Recommendations 36, 38, 40, 41, 42 and 43
[211] Recommendation 37
[212] Recommendation 44

future needs and increase the shelf life of new equipment and technologies for safeguards.[213]

Despite the increase in the development of new tools and equipment, the need to assess the applicability of such tools to the overall objective of safeguards cannot be understated. Any tools, equipment or technology to be applied to IAEA safeguards should provide either a new and required capability or improve the efficiency of an existing capability. While open-ended research is a positive and necessary aspect of any programme, advancement for the sake of advancement does not necessarily contribute to the betterment of safeguards implementation. Engagement of Member States before deployment would enhance the prospects of deploying new technologies for use in safeguards. Both in terms of practice and optics, the IAEA needs to ensure that Member States' legitimate concerns about safety and security are taken into account.

Caution must be used when increasing one's reliance on new and (re)emerging technologies as those technologies may also have vulnerabilities. The need to constantly review and reassess the accuracy and authentication of technologies being used for safeguards must be a priority to ensure an optimal combination of inspectors on the ground and the use of new tools.[214] It should be recognized that the argument that advanced technologies might reduce the footprint of IAEA inspectors in the field has its limits. While they might supplement on-site verification activities, they cannot replace the IAEA's most valuable asset: inspectors on the ground.

[213] Recommendation 47
[214] Recommendation 45

Recommendations by Topic

CHAPTER II: Current Challenges

1. Legal Framework

Recommendations regarding the conclusion of CSAs and modification/rescission of SQPs

1. Noting that many of the States that have yet to conclude the required CSA, and/or have not yet modified or rescinded their respective SQP, are located either in the Pacific region or sub-Saharan Africa, differentiated approaches to outreach activities, on a regional basis, could be effective. The IAEA and interested Member States could contribute with regional approaches through increased frequency of bilateral and multilateral meetings, and through sustained engagement with relevant stakeholders. It is important to listen to ideas and initiatives coming from within the regions to ensure their commitment.
2. Because the IAEA primarily funds outreach activities through extrabudgetary funding, outreach is dependent on Member States' contributions. The IAEA's outreach activities would benefit from enhanced communication to Member States about its funding priorities.
3. IAEA staff should participate in Member State outreach efforts whenever possible. While Member States appreciate the efforts of the Director General to maximize staff days in the office, the positive impact of the presence of IAEA staff in such outreach activities cannot be overestimated.
4. Given the minimal resources available to the Pacific Island States, a regional entity could be established that would be responsible for the implementation of safeguards in those States. This could be achieved by creating a new entity, leveraging already established safeguards, safety and/or security organisations or networks and/or through the Global Partnership for Effective Development Cooperation.
5. Safeguards should be seen as an essential contributor to development, as their application is one guarantor of the provision of technical cooperation in the IAEA. Member States participating in the Organisation for Economic Co-operation and Development's (OECD) Development Assistance Committee (DAC) should seek an expanded definition of "development" to include, as a priority, the development of relevant non-proliferation infrastructure.

Recommendations regarding the conclusion of APs

6. As regards States that are unwilling to conclude an AP, closing the gap has been more challenging. Better and proactive messaging by the IAEA, which focusses less on "identifying bad actors" and more on the benefits to the States, should be pursued.
7. For those States that are unaware of the requirements to effectively implement an AP and for those who are aware, but are simply unable to do so, regional approaches might bear results (such as those in the style of the "Friends of the Additional Protocol").
8. Momentum in support of APs among the unwilling group could also be engendered by an increase in transparency among the NWSs, and also as between the NWSs and the other parties to the NPT, particularly in the area of arms control and disarmament.

Recommendations regarding updating the Model Additional Protocol Annexes

9. While updating the Annexes to the Model Additional Protocol is an important measure to keep safeguards "ahead of the game", it may not be feasible in the near or medium term given the current political environment. However, initial conversations could be undertaken within SAGSI and among Member States.

10. There may be merit in the establishment of a standing Open-Ended Working Group under Article 16 of the Model Additional Protocol, much as the NSG has done with its Consultative Group (CG).[215] This would alleviate the pressure of requiring that a conclusion be drawn within a given timeframe, while providing a forum for discussion of issues related to the Annexes. The group that updated the NSG lists between 2010 and 2013 could offer valuable input into this process. The EU list could also provide a good basis for better understanding the advantages and challenges of catch-all controls as opposed to list-based controls.

11. A more feasible course of action might be to identify ways to strengthen the implementation of APs as they enter into force (e.g., encouraging the voluntary provision to the IAEA of information on export license denials or requiring an AP as a condition of supply). This could help avoid a "race to the bottom" by vendors and suppliers.

12. Capacity building is essential for better implementation. To that end, Member States and the IAEA could explore a link between the UN Security Council resolution 1540 and safeguards as a way to increase capacity building.

2. Strengthening Support for the IAEA's Authority

13. Challenges to the IAEA's authority stemming from States' mistrust of the Secretariat can be ameliorated with transparency, consultations and messaging that underscores a safeguards relationship characterized by partnership rather than contestation.

14. False assertions regarding the IAEA's legal authority should be challenged by Member States and by the Secretariat.

15. The Director General could consider revising the role of the Standing Advisory Group on Safeguards Implementation (SAGSI) so that, in addition to its traditional role of advising the Director General, it would give the group a public face. The idea is that SAGSI would use this public face to help challenge false statements about safeguards, offer independent opinions on safeguards issues to the public and to the Board. Such a group, independent but informed, could help elevate the transparency of the IAEA.

16. Training for new diplomats and new staff, whether conducted by the IAEA, by Member States or by non-governmental organizations, should include historical briefings on issues surrounding the IAEA's safeguards authority, e.g., correctness and completeness.

17. The IAEA should engage in enhanced communication with the broader public in respect of its verification activities. Specifically, the IAEA could publish short

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[215] In 2013, the NSG also established a Technical Experts Group (TEG), which, at the request of the CG, is tasked with ensuring that the NSG control lists are complete and up-to-date with technical advancements. It meets to discuss and make recommendations to the CG on all technical questions referred to it by the CG on an as needed basis. For further information, see http://www.nuclearsuppliersgroup.org/en/about-nsg/organisation-information.

"school briefs" on safeguards, offering concise and clear answers to commonly asked questions, such as why and how the IAEA must concern itself with undeclared activities.

3. Implementation Challenges

18. SRA/SSAC operations would benefit from more outreach to State entities, policymakers, SRAs and operators by the IAEA, Member States and non-governmental organisations. However, it is important to coordinate outreach efforts with the IAEA, ensuring that the IAEA is aware of the activities and inviting IAEA staff to participate in them. A focus of such outreach should be to help States understand what safeguards are through SRA training at the national, regional and international level.

19. The IAEA should facilitate the creation of a forum for networks of SRAs to exchange views on the implementation of SSACs. Although the IAEA already conducts high-level policy dialogues with States on safeguards implementation, opportunities for the SRAs to exchange experiences on a regional level could be especially useful.

20. The SIR should include more information on the performance of the Secretariat as well as on individual States. Public release of the entire SIR might be contemplated, as it does not currently include any information that is safeguards sensitive. In that vein, the IAEA could consider releasing the Safeguards Technical Report (STR), which used to accompany the SIR and was made available to Permanent Missions upon request. The STR provided technical and statistical data on facilities and materials under safeguards, but was rarely requested and thus discontinued.

21. The IAEA should enhance training for inspectors to help them in the field, especially knowing what they may and may not ask for and how to ask, i.e. how to interact with operators and local authorities (i.e., behavioural sciences; negotiation skills). Training should focus on communication in the field to promote a culture of cooperation.

22. The IAEA could improve communication to its Member States on how it maintains sensitive information and who has access to those details. This could decrease tensions and misunderstandings between the Agency and its Member States.

4. Administrative Challenges

Recommendations regarding the rotation policy

23. While there are merits to a rotation policy, the strict implementation of the seven-year rotation policy for all staff should be reconsidered. Certain posts requiring specialized training and institutional memory that merit longer-term engagement should be identified. However, this should be premised on performance-based assessments: those who continue to demonstrate their value should receive contract extensions, while those who do not should not receive extensions. This will require that the performance review process be implemented more strictly and that the criteria for granting extensions be transparent.

24. The IAEA should conduct a formal study of staffing practices, including the negative impact of ad hoc safeguards requirements that might leave some divisions understaffed.

25. Cultivating staff is important, but mobility and acquisition of fresh scientific perspectives should be encouraged, e.g., through mandatory or voluntary sabbatical leave to work. This would not only benefit the IAEA and Member States but the staff members, offering opportunities for new experiences. To that end, the IAEA should establish formal relationships with national nuclear facilities to host IAEA staff members.
26. Member States could reduce the time necessary to have fully trained inspectors by offering joint training and pre-training of inspector candidates.
27. The IAEA, in collaboration with relevant stakeholders, should promote work in the nuclear field through career talks and briefings in order to increase interest in operational positions. This will assist in increasing the pool and diversity of applicants.

Recommendations regarding funding

28. The IAEA should consider enhancing transparency regarding the IAEA's budget and the drivers of increased costs, and a better sense of where the budget currently stands. More projections based on timeframes of when more resources are needed.
29. The IAEA should consider engaging an external management company to carry out a robust risk analysis to help clarify the drivers of the safeguards budget and prioritise the demands on the budget.
30. The IAEA should have to rely less on extrabudgetary funds as such funding often comes with preconditions for its use. However, until such time as the regular budget is meaningfully increased, Member States should be encouraged to offer voluntary contributions without such preconditions, or with less specific preconditions.
31. A study should be conducted on the feasibility and possible impact of employing alternative approaches to funding for safeguards activities.

CHAPTER III: Emerging and Future Challenges

1. New Types of Facilities and Materials

32. Member States, designers, vendors and the IAEA should be actively promoting safeguards by design to all stakeholders, but especially to reactor designers, taking into account the timeline for possible deployment of these new reactors. This would allow the IAEA and Member States to narrow the gap between the commercialization of the new facility types and the time needed for the IAEA to ensure that it possesses the requisite equipment and technology to safeguard the new facilities.
33. Outreach to private enterprise reactor designers should be emphasized with a view to informing them of the importance of safeguards. In some States new reactor designers are working with national laboratories on reactor prototypes. Such engagement among non-government designers and government entities should be encouraged, promoted and standardized to help raise awareness of the importance of engaging the IAEA at an early stage.
34. The IAEA and its Member States should actively cooperate now in order to ensure that safeguards concerns are addressed with advanced reactor designs and alternative nuclear fuels. There are a number of safeguards questions that do not yet have answers, including but not limited to accountancy issues with MSRs and PBMRs. In

particular, the IAEA should initiate discussions with the NWSs about arrangements for the verification of facility design information in the early stages of construction of new reactors that will be built in NWSs and subsequently exported.

35. Member States and industry should develop a code of conduct for the export of new reactor designs with a view to ensuring their "safeguardability" (e.g., early consultation with the IAEA about IAEA access and design information verification).

36. The IAEA, Member States and industry need to address cyber vulnerabilities, especially in supply chains and decommissioned facilities. Given the rapid change in technology, these vulnerabilities need to be reassessed constantly and security measures implemented accordingly.

37. The IAEA should evaluate the current situation with respect to alternative nuclear materials and the implications for safeguards of further transmutation activities involving emerging technologies.

2. New and Emerging Dual-Use Technologies

38. The IAEA should establish a dialogue with the NSG with a view to assessing the proliferation challenges associated with additive manufacturing, laser technology and other dual-use technologies, as well as their implications for safeguards and export controls.

CHAPTER IV: Opportunities Offered by New Tools and Emerging Technologies

1. Headquarters Activities

39. IAEA staff should receive more training on data literacy so that they are able to make the most efficient use of both data processing technologies and the data itself, in particular on how to interpret and communicate information provided by such data.

40. The IAEA should continue to invest in knowledge management, as it has done with MOSAIC and other new systems, with the support and collaboration from Member States.

41. DLT may offer benefits in the protection of data and increasing transparency between the IAEA and its Member States. Further exploration of the possible use of DLT in the context of safeguards should be conducted, with the support of Member States, with a view to ascertaining whether the technology would provide greater benefits and if so how best to utilize it.

42. The IAEA should continue to invest in data visualization and virtual reality training. Member States should consider providing the IAEA with 3D models of facilities for training and inspection preparation purposes.

43. The IAEA and Member States should adopt a holistic approach to new technologies, and not become over-reliant on AI and ML. AI and ML are not substitutes for human analysts but rather an efficient aide for analysts to do their jobs better and more efficiently.

2. In-Field Activities

44. Given that authentication of new equipment is often a complicated and lengthy process, the IAEA should consider using either off-the-shelf equipment or deploying in the field technologies and equipment developed for other purposes (such as the unmanned robot used for spent fuel verification).

45. In all prospects for the deployment of new technology, the IAEA must prioritise ensuring the integrity of transmitted data and authentication of equipment.

46. The IAEA should include in its future research and development plans notional budgets for the development of new technologies.

47. Ensuring acceptance by Member States and operators is critical to the deployment of IAEA equipment and technology. In developing use cases for new technology, safety, security and safeguards all need to be kept in mind.

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The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 300 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

Strålsäkerhetsmyndigheten
Swedish Radiation Safety Authority

SE-171 16 Stockholm
Solna strandväg 96

Tel: +46 8 799 40 00
Fax: +46 8 799 40 10

E-mail: registrator@ssm.se
Web: stralsakerhetsmyndigheten.se

Ale Tryckteam AB, Bohus, 2019