Emerging Technologies Workshop

Insights and Actionable Ideas for Key Safeguards Challenges

Workshop Report

IAEA

Safeguards

27–29 January 2020
Vienna, Austria

STR-397

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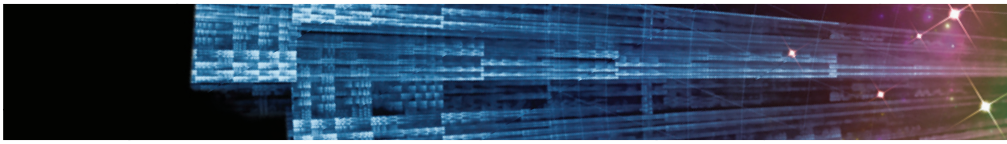


Executive Summary

From 27-29 January 2020 in Vienna, Austria, the International Atomic Energy Agency's (IAEA's) Department of Safeguards (hereafter referred to as 'Department') held its biennial Emerging Technologies Workshop, which gathered participants from the Department, Member States Support Programmes (MSSP), industry, non-governmental organizations (NGOs), and academia. The event aimed at increasing the Department's awareness about and preparedness for addressing the challenges and opportunities of emerging technologies from both nuclear and non-nuclear sectors. Using a problem-driven, solution-oriented structure, Workshop participants focused on the following challenges:

1. How might we incorporate artificial intelligence and machine learning advances into safeguards surveillance?
2. How might we leverage technologies and approaches from industries with analogous challenges to rethink our approach to spent fuel verification?
3. How might we enhance our analysis, interpretation and communication of safeguards data and information?
4. How might we more fully leverage imagery and multimedia data streams for better detection of undeclared nuclear material and activities?
5. How might we adjust our safeguards assumptions and acquisition path analysis to account for advances in additive manufacturing?

This report summarizes the technological trends and updates, group discussions, key insights, and actionable ideas that the Workshop produced.

Themes

Exploration of the problem statements addressed in the five technical incubators revealed that some of the greatest challenges to safeguards are not only technological, but also include a combination of regulatory requirements and restrictions, limitations in financial resources and human knowledge, as well as challenges in change management.

The ideas and insights that emerged for solutions formed three broad themes:

- **Partner** — enhancing existing partnerships and establishing new partnerships especially in areas where the Department lacks expertise – i.e. with individuals/entities deeply immersed in modern technology to leverage their knowledge and eagerness to assist the IAEA – to accelerate innovation in the safeguards field.
- **Pilot** — taking advantage of technological opportunities and creating a culture that embraces small experiments, allows some risk taking, and builds on the successful pilots to foster larger scale change.
- **Prepare** — monitoring closely and preparing for technology trends that could challenge the IAEA's detection capabilities.

Game-changing Ideas

Some of the game-changing ideas that emerged from the workshop and a facilitated working dinner between external experts and senior management included:

- Starting small-scale pilot projects to e.g., incorporate artificial intelligence (AI) and machine learning (ML) into safeguards video surveillance review, to liberate analysts and inspectors from more mundane and tedious tasks of surveillance review; and to apply distributed ledger technologies (DLT/blockchain) to handle States' nuclear material accounting data.
- Instituting a 'digital-first' initiative on reports to Member States to modernize, measure and maximize the impact of communication, using effective visualization.
- Leveraging the expanded variety and volume of open source data for detection of undeclared nuclear material and activities, taking advantage of advances in various sensors.

Looking Forward

Although any decision to pursue new ideas would require careful consideration and review by IAEA Safeguards leadership, several potential future development and implementation ideas emerged, which might enhance the prospects of seizing the ideas and opportunities outlined in the workshop. Some of the ideas that might warrant further consideration are:

- Reaching out to the science and technology (S&T) community to form **new partnerships** to address the Department's needs, using the IAEA's framework for non-traditional partnerships.
- Collaborate with research and development (R&D) experts, including from the private sectors, to develop **pilot projects** in the areas where the IAEA lacks expertise (e.g. artificial intelligence (AI), robotics, and DLT).
- Bring in new perspectives by building a **network of S&T visionaries and experts** that would propose new safeguards solutions leveraging emerging technologies.

Introduction

Emerging technologies have played an important role for the IAEA Department of Safeguards for many years as it has successfully exploited them for safeguards implementation. Indeed, the IAEA is legally obliged under safeguards agreements to "take full account of technological developments in the field of safeguards." As challenges to safeguards have evolved, the Department of Safeguards has always worked to mitigate these challenges by advancing its technical capabilities and harnessing new technologies and novel technology applications.

Our work has enormous global importance, and in order for us to be effective and efficient in a complex and rapidly evolving world we need to be prepared. Prepared to seize new opportunities; prepared to address new challenges; prepared to adapt for the benefit of the safeguards mission. Preparedness for tomorrow helps us make better decisions today.

Therese Renis
Director, Division of Concepts and Planning, Department of Safeguards

The safeguards system must continue to be responsive to the IAEA's ever more complex and dynamic operating environment. Monitoring such changes is an integral part of the strategic planning activities in the Department of Safeguards.

It is against this backdrop that the Department organized its biennial Emerging Technologies Workshop from 27-29 January 2020 in Vienna, Austria. At the workshop, staff members from the Department, the private sector, NGOs, academia and Member States Support Programmes worked to increase the Department's awareness about and preparedness for addressing the challenges and opportunities of emerging technologies – nuclear and non-nuclear. Using a problem-driven, solution-oriented structure, the Workshop focused on the following challenges:

1. How might we incorporate artificial intelligence and machine learning advances into safeguards surveillance?
2. How might we leverage technologies and approaches from industries with analogous challenges to rethink our approach to spent fuel verification?
3. How might we enhance our analysis, interpretation and communication of safeguards data and information?
4. How might we more fully leverage imagery and multimedia data streams for better detection of undeclared nuclear material and activities?
5. How might we adjust our safeguards assumptions and acquisition path analysis to account for advances in additive manufacturing?

This report summarizes the technological updates, group discussions, key insights, and actionable ideas that the Workshop produced. It will — inter alia — inform a series of pilot projects to address the outlined challenges and inform the Department's strategic planning.

Welcoming Remarks

In opening the Workshop, Deputy Director General and Head of the Department of Safeguards, Massimo Aparo conveyed the following remarks to staff and other participants:

Massimo Aparo
Deputy Director General and Head of the Department of Safeguards

"It is my pleasure to welcome you to the Emerging Technologies Workshop of the IAEA's Department of Safeguards. I am also pleased to welcome observers from our Member State Support Programmes as well as from other IAEA Departments. We really appreciate your support in carrying out our crucial mission.

So what do we expect from this workshop? Let me provide some context about the conversations that we are expecting during the workshop.

Our mission is our mantra: "Atoms for Peace and Development." The Agency is part of a global system that ensures that humankind can enjoy the benefits of nuclear power without the fear of nuclear material and technology being diverted to weapons of mass destruction. As staff in the Department of Safeguards, you sit at the very heart of that mission. Coping with technological developments and trends is expected of us and exploiting new technological opportunities is required of us.

This workshop comes at a crucial time for our Department and our Agency. The global environment continues to present challenges to the safeguards mission, and we are increasingly being asked to do more with less. Thus, we need to think differently to ensure that we remain effective. Innovating and leveraging technologies is part of the answer.

The best place to find new and creative solutions is with you: the people closest to the challenges. By bringing you together with a diverse range of external experts – with people engaged with similar challenges – and by focusing your energies on specific tasks, we want to reveal untapped ideas and uncover new ways of understanding how to strengthen our approaches and technologies.

When engaging with one other and with our invited experts, I want you to bring an open mind. But I also want you to think critically from a safeguards perspective. Continuously question your assumptions and ask yourself the following questions:

- How could we do things differently?
- Which technologies could transform the way we work?
- Which technologies could challenge safeguards?

Finding answers should enable us to become both more efficient and effective in our verification mission.

I see that you have an excellent work programme in front of you, with prominent experts for you to learn from and engage with. The workshop sessions address some key challenges that emerging technologies could help us solve — including new approaches and novel applications of existing technologies. We have high expectations that a number of practical ideas and proposals will emerge from your discussions, which we will be able to follow up in the months and years ahead. Also, please make use of this opportunity to establish new contacts with our invited experts.

I want to thank you once again for your active participation, I wish this workshop every success and I very much look forward to hearing about positive outcomes."

Workshop Opening

The opening of the 2020 Emerging Technologies Workshop (ETW) featured strategic design expert *Marco Steinberg* (Finland) of *Snowcone and Haystack* as the keynote speaker. Steinberg focused on how to create organizational change while maintaining mission delivery — reflecting the point that preparing for and adapting to technological trends and circumstances is necessary for those factors to be meaningful.

Keynote speaker **Marco Steinberg**, Founder and CEO of Snowcone & Haystack

In today's complex and dynamic technological environment, incremental changes are insufficient. Governance systems for organizations and larger systems were designed for previous eras where information, ideas, and technical capabilities evolved more slowly. When organizations have a slow, reactive posture to external circumstances, they are unable to anticipate or provide effective timely responses to the external challenges that emerge. Consequently, to remain vibrant and vital in the 21st century, institutions need to move beyond 20th century governance models, Steinberg argued.

While many organizations attempt to adapt through gradual evolution, Steinberg considered this approach as ineffective and advocated for transformative action instead. In essence, such transformation entails shedding legacy burdens from processes, structures, and culture to build better approaches. In this regard, he encouraged participants to pursue transformational change in the Department by asking: *If you had to redesign the solution from scratch, how would you do it?*

Steinberg encouraged participants to take a holistic and interdisciplinary view of the challenges under consideration. Cross-functional teams are at the core of innovation. By emulating such teams to identify and address the intersection of influencing factors — not the separate factors in isolation — participants could avoid perpetuating an ineffective stovepipe approach to developing sustainable solutions.

He also cautioned against the "*institutional reflex*" of reverting to fundamental behaviors favoring the organization's status quo. The danger this reflex creates is *overestimating the risk of changing and underestimating the risk of not changing*. Such a bias will quickly punish any unsuccessful efforts to change and innovate. Combatting this reflex requires a change in leadership style and mindset. At lower organizational levels, individual staff must take the leadership reins for initiating change, Steinberg advised. Senior organization leaders should in turn accept the possibility that some change efforts may fail.

Finally, Steinberg called upon all organizational levels to help carefully define what change-based success looks like in a dynamic technological environment, and to consider whether the organization is asking the right questions. Becoming more innovative may not necessarily entail technological transformation, but could instead entail re-designing the organization for better human interactions. In other words, for safeguards challenges, Steinberg advised the Department to carefully examine whether technology is indeed the necessary solution for a problem, or whether the problem could be addressed through better human approaches instead. Gaining clarity on those questions is the first step for successful transformational change towards becoming a 21st Century institution.

Key Insights

- Embrace a transformational approach to organizational change
- Recognize that risk of not changing is as significant as risk of change

Incubator 1:
How might we incorporate artificial intelligence (AI) and machine learning (ML) advances into safeguards surveillance?

For inspectors, video surveillance review represents an important, but tedious and labor-intensive task. Their responsibility is: confirming that recorded activities align with State declarations, as well as detecting any potential indications of materials diversion at the declared facility. Yet, most footage is largely static and events of interest are infrequent. Moreover, the soon-to-be-completed upgrading of all safeguards surveillance systems is now improving the quantity and quality of data which provides opportunities to develop new algorithms but may increase inspector workload. The Department has been pursuing learning-based algorithms to help automate detecting and tracking events of interest to free up inspector time for more complex tasks. However, the data sharing restrictions and lack of annotations to train learning-based algorithms is limiting the Department's ability to leverage AI technologies for safeguards video surveillance analysis.

PROBLEM STATEMENT

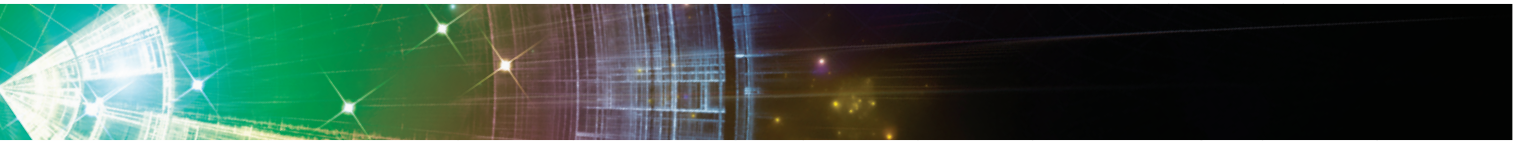
Using learning-based algorithms to help the Department be more efficient and effective with video surveillance analysis is challenged by the requirements of the unique safeguards mission space, lack of datasets for some scenarios, sparseness of events within the data, and limited resources to label training data.

"Better data beats complex AI."

– Olivier Salvado

Presenter Summary

Olivier Salvado (Australia) of *Commonwealth Scientific and Industrial Research Organisation (CSIRO)*, provided an overview of the computer vision technologies generally involved in surveillance review activities. He highlighted recent advances in ML and AI research to develop algorithms to detect rare events. These advances focus on enhancing privacy-preserving techniques, developing a synthetic data generation platform, utilizing self-supervised learning, and improving data compression (such as encoder-decoder approaches). Yet, despite these advances, Salvado cautioned against the ability of algorithms to overcome such issues as having too little data for training or using poor quality data.



The incubator included two case studies. The first case study, by *Saimir Baci* (Sweden) of *Ivadolabs*, leveraged his experience from the autonomous driving industry and discussed how a different approach is needed for algorithms to cope with unexpected and exceedingly rare events, especially when those events are of the highest consequence. He outlined the development of algorithms that, while not necessarily well equipped to understand the environment or context that they are analyzing, nonetheless excel at detecting items of interest that are out of the ordinary. He noted that an ongoing challenge for algorithms remains to distinguish unusual or outlier observations (anomalies) from altogether new behaviors in the environment (novelties), and how to appropriately adapt to such unusual observations.

> *"Think beyond just video sensors. There is a plethora of sensors to inform the system."*
>
> *– Saimir Baci*

The second case study, by *Peter Klimek* (Austria) of *Medical University of Vienna*, highlighted how the medical community in Austria had explored new ways to fuse together different types of data for high confidence detection of medical events that can lead to catastrophic outcomes. Their approach involved feeding these massive data into deep learning algorithms, which are designed to imitate the way decision-making in the human brain develops, and visualizing the results. While this approach proved fruitful for the medical community, the speaker noted that the approach was resource-intensive, and his team spent over 90 percent of their project time preparing the data for use by the algorithms — a significant and general challenge he said impedes progress in deploying AI tools and ML in any field.

Group Work

Irmgard Niemeyer (Germany) of *Forschungszentrum Jülich* and *Bernhard Petermeier* (Austria) of *Institute of Science and Technology Austria (IST Austria)* helped facilitate group work, much of which focused on how to improve the data needed for training algorithms. Participants discussed options to advance partnerships with nuclear operators for data acquisition and for dealing with challenges related to its confidential nature. They also discussed the possibilities of combining video surveillance with data streams from other sensors (e.g. lasers, noise detectors) for a more holistic and integrated perspective, thereby increasing overall confidence.

The discussion suggested that data confidentiality and the lack of a standardized agreement from States on using surveillance data for algorithm development create significant safeguards obstacles. Moreover, building inspector trust in these algorithms would take time, regardless of the algorithm's effectiveness. Participants agreed that while algorithms could generate efficiencies for inspectors to focus on more complex tasks, current regulatory requirements and human factors may slow the pace of progress — and the ability of emerging technologies to circumvent those constraints is limited. Therefore, moving forward would require consideration of both policy and human resource aspects. The external subject matter experts urged 'starting with a small problem' and a gradual piloting approach to ensure successful development of ML and AI algorithms as both a surveillance review tool and a broader strategic organizational capability.

> *"Everyone in the organization needs a common understanding of what AI is."*
>
> *– Peter Klimek*

Key Insights

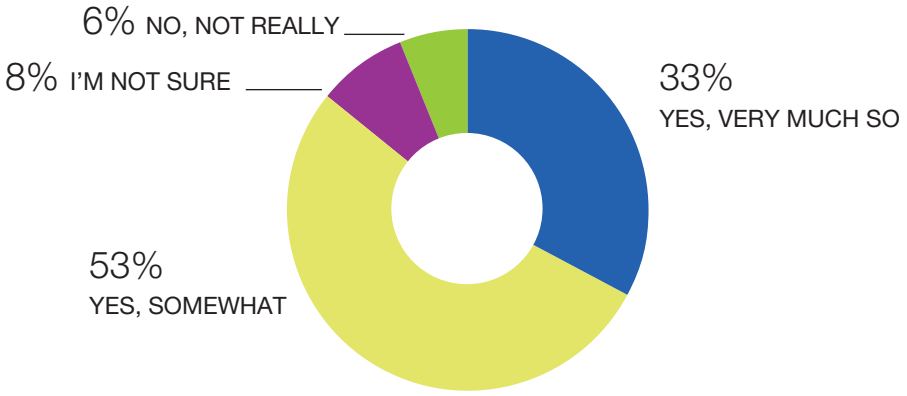
The incubator focused on understanding the limits of ML and AI capabilities, as well as on the process for yielding better results from their use. The key insights were:

- AI is a strategic capability requiring
  - a common organizational understanding of AI and how best use it
  - appropriate human resources dedicated to AI integration
- The application of ML cannot 'beat', or substitute for, better data quality and strong subject matter expertise
- AI algorithms can be very good at solving niche problems, but may not yet be ready for our more complex, multi-step problems
- AI should in the near term be applied for those parts of the process that are tedious and well defined
- New partnerships may provide opportunities for new data and resources

Actionable Ideas for Consideration

- Develop tools for labeling pictures by inspectors while conducting surveillance review
- Partner with States, operators, companies, and S&T community to:
  - test ideas and equipment
  - obtain old data to train algorithms
  - learn from other industries
- Build a small, cross-cutting team focused on developing, implementing, and supporting AI and ML
- Pilot a small, well-understood safeguards surveillance problem that we know can be solved
- Explore development of simulated data or declassification of older data to overcome data confidentiality restrictions
- Use field trials from supportive State(s) for constructing algorithm training data sets

Poll: Are you optimistic about the prospect of AI and ML to help the Department in safeguards surveillance?



Incubator 2:
How might we more fully leverage imagery and multimedia data streams for better detection of undeclared nuclear material and activities?

As part of its efforts to detect any undeclared nuclear material and activities and to complement other safeguards relevant information, the IAEA collects and analyses a variety of openly available information in a diversity of formats including text-based information photographs, and satellite imagery. In response to changes in the overall information landscape in recent years, it has also strengthened its capabilities to utilize multimedia-based information. But the growing volumes and increasing diversity of open source information are challenging the Department's ability to utilize such information in an efficient and effective way, making the labor-intensive processes for processing and analyzing open source imagery and multimedia data increasingly unsustainable. While the Department has made strides in terms of automated processing for text-based data, factors such as lack of data to train learning-based algorithms and niche subject matter expertise has limited its ability to build non-text automated data processing tools.

PROBLEM STATEMENT

Growing volumes and increasing diversity of open source information are challenging the Department's ability to efficiently and effectively utilize such information for the detection of undeclared nuclear material and activities. Labor-intensive processes for processing and analyzing open source imagery and multimedia data are increasingly unsustainable.

"IAEA staff need to be empowered to pursue new technologies and approaches."

– Melissa Hanham

Presenter Summary

Melissa Hanham (United States) of *Open Nuclear Network*, described some of the advances in open source and satellite imagery in a safeguards context. Satellite hardware and the automated processing of imagery have made great technological strides in recent years. Unlike installed cameras in facilities, satellites are not regulated. Imagery is particularly useful for change detection and object identification. There are significant advances for satellite imagery in both synthetic data and change detection, as well as new ways of using shape and spectral

signatures for object detection. Leveraging these features in conjunction with one another could richly enhance contextual understanding for a geographic area of interest. Describing her own work, Hanham's team has been collecting and processing large volumes of images and leveraging crowdsourcing for the cleaning and tagging of data for analysis. However, she acknowledged that the Department faces significant regulatory obstacles for detecting undeclared materials and activities, and that even for Open Nuclear Network's own efforts a significant number of legal issues arise in terms of data usage.

> *"Everyone from startups to universities, NGOs, and government agencies have satellites and sensors."*
>
> *– Tim Kelton*

In the first case study, *Tim Kelton* (United States) of *Descartes Labs* discussed his firm's commercial platform that ingests 100 terabytes per day of open source data from diverse sensor types and uses it to do predictive modeling across multiple industries (e.g. agriculture, shipping, etc.). This private sector capability is possible due to the major inflection in the number of open source sensors in space, which has dropped the cost of data significantly. Using custom-built algorithms for data processing, the platform is able to develop patterns-of-life analytics on a given satellite observation area, as well as predictions on future patterns. Kelton gave an example of the platform detecting forest fires prior to them being spotted by authorities. Nevertheless, despite exceptional capabilities, the growing volume and variety of data means it is still challenging to ensure that the platform is able to rapidly mix and match the data for meaningful and actionable results.

> *"Better data integration is more important than better AI."*
>
> *– Craig Desjardin*

The second case study, by *Craig Desjardin* (United States) of *Striveworks*, provided a look at his company's approach to organizational integration of AI tools in light of the technology's evolution. Outlining the three "waves of AI development" — rules-based; statistical; contextual — he highlighted how the latest wave offered significant opportunities to leverage expert insights and reduce risks inherent in some data sets. Striveworks conducts their algorithm development by physically co-locating data scientists with subject matter expert end users for 6-months to 1 year. Embedding their staff in the customer environment enables the company to develop bespoke AI solutions by understanding the customer's workflow, their challenges, and where in the process that AI will be most effective.

As a final case study, the ETW team presented information provided by *Bernd Bickel* (Austria) of *IST Austria* on recent advancements in the development of deep fake technologies, highlighting the threats posed by technological advances. Describing work led by Professor Hao Li at the University of Southern California and presented at the 2020 session of the World Economic Forum in Davos the previous week, the ETW team showed videos illustrating deep fake technologies spoofing individuals in real time and with as little as one image input to create a credible rendering. The videos demonstrated the technology's potential for use in deception, blackmail, and mass disruption through technologies that are openly and easily available. This technology could affect the safeguards community because: 1) deep fakes can spoof a wide variety of data, 2) the technology is becoming cheap and accessible, and 3) criminals have already used the technology to infiltrate and disrupt other organizations.

Group Work

Irmgard Niemeyer (Germany) of *Forschungszentrum Jülich* and *Bernhard Petermeier* (Austria) of *IST Austria* helped facilitate group work. Most of it focused on the utility of satellite imagery, how it is changing, dropping in price, and how higher volumes are available, which could improve nuclear verification if done in conjunction with automated change detection and/or object identification. There was also discussion on other types of open source data and AI capabilities to help with e.g. pattern recognition and cross-referencing other data sources. Many participants also engaged with the topic of "cleaning" data, pre-processing it or categorizing/tagging it so that it can be more useful in models or analysis. They recognized the need to address this task because it is so very time consuming, but an immediate path forward remained unclear. Finally, several participants flagged the need for education and training to strengthen the Department's human capital in satellite imagery analysis and AI capabilities.

Key Insights

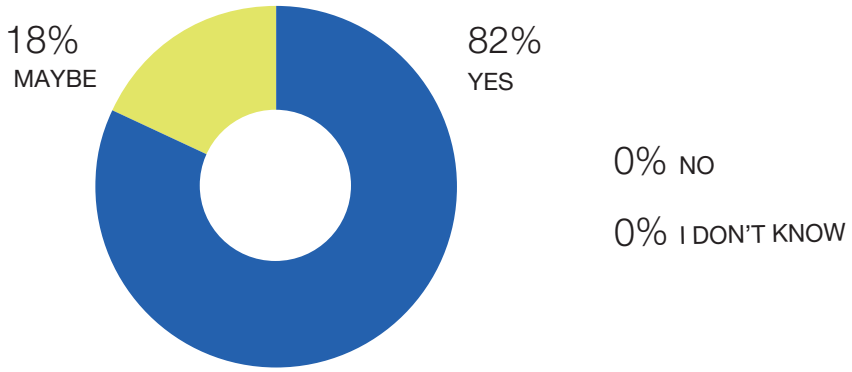
The insights from the incubator tended to focus on leveraging the growing technological capabilities and expanding number of commercial players in the field as well as on how partnerships, small experiments, and improved technological understanding are pathways for improvement in the Department. The key insights were:

- As satellite imagery will continue to play an important role in safeguards it will be important to invest in the associated human competencies
- There are numerous additional types of sensor data to leverage and complement data currently being collected
- Technology democratization is empowering new players to access capabilities previously only available to States; access to technologies is easier and cheaper
- Partnering and competency building is critical for better understanding of AI development needs
- The Department needs a better understanding of ML and AI tools, and their potential application in the field and at headquarters, to ease their adoption
- Start building change by focusing first on small, tedious, but solvable problems, and subsequently build on success
- Technologies threatening information veracity are advancing rapidly

Actionable Ideas for Consideration

- Promote use of pilot projects and experiments across the Department
- Explore how to make broader use of non-optical sensors
- Use annotated login to label unrestricted safeguards data and boost security
- Issue an external safeguards challenge to design an application for AI-based satellite imagery analysis using open source information (similar to robotics challenge)
- Partner to leverage crowdsourced object identification via tagging of satellite imagery
- Further support use of measurement points geolocation for verification purposes
- Save 'peripheral' data as it could still be useful in the future

Poll: Should the Department partner with and leverage external expertise to apply the emerging technologies we have just discussed?



Incubator 3:
How might we leverage technologies and approaches from industries with analogous challenges to rethink our approaches to spent fuel verification?

As part of its inspection activities, the IAEA verifies spent fuel quantities and seals the containers holding the spent fuel to maintain continuity of knowledge. Spent fuel quantities worldwide are growing significantly. This growth is more pronounced and problematic for dry cask storage containers. These casks are not standardized, nor are their storage conditions, which means that passive seals often provide the best option for individually safeguarding each cask. Yet, the casks are also large (frequently four or more meters in height), stored closely together, emitting radioactivity (are hot to touch) — all of which makes passive seal verification physically challenging and labor intensive. Moreover, there are approximately 7 000 of these casks worldwide currently requiring verification, but that number is projected to grow to more than 20 000 by 2030 while budgets for safeguards are not projected to grow at the same pace. The anticipated increase in the number of spent fuel casks, with the current verification approach and seal verification requirements, is likely to overwhelm the existing resources to perform seal verification of dry spent fuel casks. With a number of nuclear power plants reaching the end of their lifetime and others being closed/shut down as a result of political choices, the Department further expects increasing transfers of spent fuel to storage, which will likely require additional resource-intensive verification efforts.

PROBLEM STATEMENT

The projected increase in the number of spent fuel casks, with the current verification approach and seal verification requirements, will overwhelm the existing resources to perform seal verification of dry spent fuel casks. Moreover, with interim storages filling up, the Department expect increasing transfers of spent fuel transfers, the verification of which is resource intensive.

Presenter Summary

Juha Pekkarinen (European Commission) of *Euratom* and *Ken Baird* of *IAEA* together focused on describing current approaches to verify spent fuel, as well as planned and ongoing initiatives to improve verification technologies and approaches. Despite challenging conditions and a lack of methods to re-verify spent fuel in casks, the IAEA is required to maintain 100% continuity of knowledge on declared spent fuel given the high volumes of Plutonium contained therein. While the Department continues to use passive seals, it has also developed active seals and is exploring methods for harvesting energy from the dry casks to extend active seal battery life. Additionally, two newer technologies are in development. The first of these is a hot cell enclosure that lessens the need for continuous surveillance of samples because opening and closing of the enclosure is externally monitored and logged. The other concept under consideration is a laser curtain system that provides a perimeter around and over a large number of casks — thereby shifting from an individual cask sealing approach to a group-based seal. While the idea is promising as a scalable approach to mitigating the need for seals, Pekkarinen and Baird acknowledged its potential limits for outdoor sites due to interference from natural events (e.g. wind-driven debris).

> *"We currently have no 'good' way of verifying fuel already in dry fuel storage."*
>
> *– Juha Pekkarinen*

The first case study, by *Jim Duffy* (United Kingdom) of *Tracr*, focused on the diamond industry's recent embrace of emerging technologies to certify their inventory's provenance, authenticity, and traceability throughout its lifecycle — from producer through manufacturer and retailer to the consumer. Duffy described Tracr's approach of connecting the physical and virtual layers of their system such that they can reinforce the overall certification. In this approach, diamonds are physically scanned to an atomic level to characterize their unique identifiers. The virtual system uses a combination of a distributed ledger technologies (DLT) platform, cyber technologies, and AI to record and track each diamond on an immutable record as it moves from one stage to another, starting from mining and eventually ending up with the consumer. The physical and virtual ledger reinforce each other through a dual accountancy mechanism for detecting diversion or other anomalous activity.

> *"Our stakeholders can view the end-to-end experience of a diamond's lifecycle on an immutable ledger."*
>
> *– Jim Duffy*

Cindy Vestergaard (Denmark) of *Stimson Center* described the second case study on a pilot project in Finland to leverage a blockchain-based system for nuclear materials accountancy and control (SLAFKA project). She described blockchain as a subset of DLT and stressed ledgers could be either public or private. Private/permissioned ledgers require participants to be invited to join (e.g. by a regulatory body) and allow permissions to be customized so as to enable private transactions. Finland is constructing a deep geological repository for which it wants the spent fuel records to be sustainable and trusted after sealing the repositories. Through a partnership with Stimson Center and the University of New South Wales, the Radiation and Nuclear Safety Authority in Finland (STUK) is developing a virtual ledger built on DLT. Vestergaard noted

> *"Finland is building the world's first shared ledger platform for nuclear accountancy."*
>
> *– Cindy Vestergaard*

that DLT was pursued because it could create ledgers that are immutable, and have flexibility for customizing access permissions, provide real-time data updates, and other considerations. She noted that such real-time access to trusted data could lead to faster and more robust safeguards conclusions. However, Vestergaard also noted that DLT is still in its infancy for nuclear applications and that forthcoming testing will further reveal its potential and any shortcomings.

Demonstrations

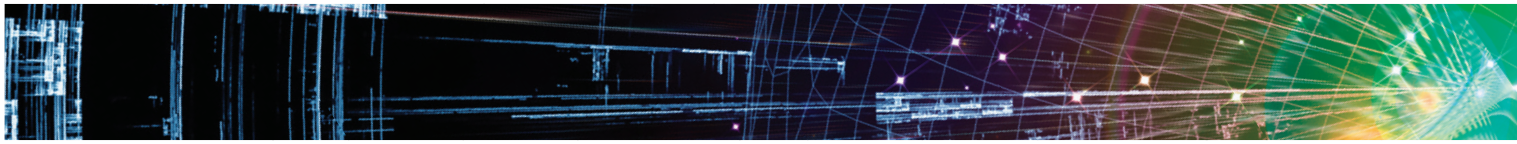
Beyond the featured presentations, the incubator also included three demonstrations of robotics for safeguards. *Ross Dungavell* (Australia) of *CSIRO* brought live demonstration components of a robot used for inspections in confined spaces. CSIRO has developed a tethered robot that carries cameras and sensors for inspection. While promising and effective under favorable conditions, the main challenge remains scaling down equipment size to fit the robots and having the robots navigate difficult conditions (e.g. roaming under misaligned pallets of stored material).

Naoaki Okuzumi (Japan) of *IRID* presented on robotic technologies developed for decommissioning of the Fukushima Daiichi Nuclear Power Station. The robots from International Research Institute for Nuclear Decommissioning (IRID) are submersible and have lighting because their purpose is to investigate and retrieve nuclear material inside the primary containment vessel at the Fukushima Daiichi accident site. For the tethered robot, a wide range of obstacles inside the vessel can limit its movement. Consequently, to overcome this issue the IRID team has needed to develop innovative ways of cable management to ensure proper robot mobility.

Peter Kopias (Hungary) of *Datastart* presented on the robot that had won the IAEA Safeguards Robotics Challenge in late 2017. The robot consists of a tethered robotic floating platform — mounted with a neXt Generation Cerenkov Viewing Device (XCVD) capable of providing digital recording — that autonomously propels itself across the surface of a spent fuel pool. Using this robot reduces the risks to nuclear safeguards inspectors of having an accident at the spent fuel pond. Additionally, by stabilizing the XCVD in a vertical position, the robotic platform can help provide clearer images of spent fuel in a shorter timeframe to aid verification of spent nuclear fuel.

Group Work

Jussi Heinonen (Finland) of *STUK* and *Bernhard Petermeier* of *IST Austria* helped facilitate group work. Most of it focused on how to retrofit current technologies to make nuclear verification easier and faster to overcome Departmental limits on personnel and monetary resources. In this regard, the robotics demonstrations were seen as a pathway for reducing workload and increasing personnel safety for verification inspections. More crowdsourcing using student / innovation contests could open the Department to more ideas and external collaboration. Moreover, such approaches for robotic technologies could expose the Department to new end-to-end approaches beyond retrofitting of existing technologies.



For more emerging technologies, the participants generally felt that DLT had significant potential for transforming spent fuel verification, especially for State specific applications of nuclear material accountancy. However, some also noted that the path forward for Departmental applications was less clear. Overall, there was a consensus that the Department needs to build its understanding of DLT capability, its benefits, and its possible applications in the safeguards realm.

Finally, it was recalled that some years ago researchers conducted an extra-budgetary study for the Department on advanced sealing techniques. While the study deemed most approaches technically unfeasible at that time, participants encouraged the Department to revisit that study and others to determine if their assessments remain accurate in light of technological evolution.

Key Insights

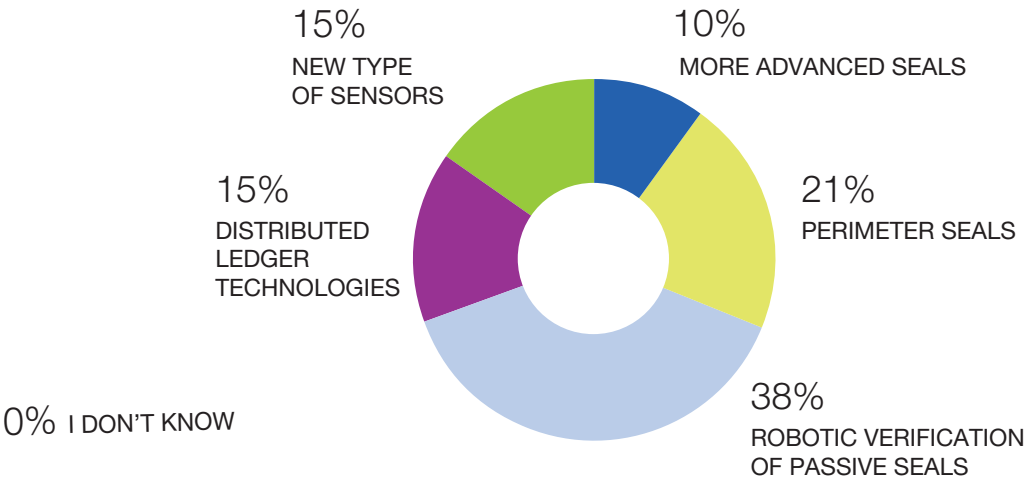
The insights from the session tended to reflect consensus that emerging technologies and novel applications of existing technologies are creating opportunities to rethink spent fuel verification approaches. However, they also suggest that more industries should be engaged to further inform the opportunity space, as well as for identifying potential partners that could help design, test, and implement such transformative measures. The key insights were:

- Distributed Ledger Technology is being adopted by broad variety of sectors which have found it to be highly effective for providing greater data integrity and real time view of supply chain
- DLT has potential for safeguards, but its applications still need to be better understood internally by the Department
- DLT for data records need to be accompanied by ways to uniquely identify spent nuclear fuels
- Robotic technology could be employed to perform some of the more routine tasks currently performed by inspectors to reduce personnel safety risks and allow more time to focus on more non-routine/out of the ordinary tasks
- More standardization for nuclear facilities and equipment is needed to ease inspections in general
- Innovation contests are important to driving newcomers into the discussion and exploring new ideas
- Group containment and surveillance of casks such as laser curtain technology offer a scalable solution to the dry cask challenge, but only for indoor environments
- There might be more to learn from exploring completely new technologies rather than retrofitting existing ones

Actionable Ideas for Consideration

- Closely monitor DLT pilot projects by Member States
- Develop a small in-house working group (with the right expertise) to pilot DLT for a small project
- Conduct more benchmarking of practices by other industries and organizations with similar challenges (e.g. private sector, Organisation for the Prohibition of Chemical Weapons, etc.) and identify novel approaches to solutions. Develop a small in-house working group (with the right expertise) to pilot DLT for a small project
- Engage with other IAEA Departments to identify and participate in working groups on dry fuel storage
- Invite dry fuel storage vendor(s) to participate in the safeguards-by-design process
- Re-examine assessment of findings from MSSP study on advanced sealing techniques
- Establish more 'challenge projects' to crowdsource solutions

Poll: Which technologies are most promising for overcoming the spent fuel dry cask challenge?



Incubator 4:
How might we enhance our analysis, interpretation and communication of safeguards data and information?

Every year the IAEA releases a Safeguards Implementation Report (SIR) that reports conclusions drawn on States' compliance with safeguards agreements. The compilation of this product necessarily has two critical elements: 1) the internal data analysis that underpins the conclusions, and 2) the external communication of those conclusions and other information to stakeholders. Although the SIR has evolved gradually over the years, the format and the process for its production have remained largely unchanged for decades, while the world keeps moving to more visual and effective ways of communication. Despite a suite of powerful new tools within the Department, the growing variety and abundance of safeguards relevant information at large, especially from open sources, continues to make comprehensive analysis challenging. The technical nature of safeguards data creates challenges in communicating trends in and results of safeguards activities effectively to Member States. However, increasing use in the digital realm of both new and well-established approaches to data visualization have raised interest in its potential to help alleviate data analysis, interpretation, and communications challenges in the Department.

PROBLEM STATEMENT

The growing variety and abundance of safeguards data makes fully analyzing it difficult with current resources and approaches. Additionally, the technical nature of safeguards data creates challenges in communicating trends in and results of safeguards activities effectively to external stakeholders.

Presenter Summary

Xaquín Veira Gonzalez (Spain), *Independent Consultant*, focused on creating data driven stories. Leveraging his experience from The New York Times, The Guardian, and National Geographic, he outlined a six-step approach for visual storytelling.

> *"We need to guide our audience on what the data means. Help them digest and understand [the story told by the data]."*
>
> *– Xaquín Veira Gonzalez*

- **Show**: make visually prominent what is otherwise hard to grasp and provide an interface for the data
- **Annotate**: provide context and explanation
- **Connect**: use visceral metaphors so your message reaches your audience's amygdala
- **Simplify**: our brain can only process three to four visual cues at a time before it overloads
- **Surprise**: add delight, because people read many things and an especially insightful wink can make your information more memorable
- **Tell**: weave the visualizations into the story; storytelling is our innate way to interpret reality

Veira Gonzalez noted that storytelling, or messaging, is critical regardless of whether your objective is analytical or communicative because the need for engagement and proper interpretation is evident in both. Moreover, all visualizations carry some element of human judgment in terms of data selection and depiction. Therefore, the Department should account for cognitive biases when developing its visualizations.

> *"The messages are what carries the report, not the visuals."*
>
> *– Kazuki Kitaoka*

The first case study, by *Kazuki Kitaoka* (Japan) of *Food and Agriculture Organization of the United Nations (FAO)*, featured a recent effort by his organization to reach policymakers more effectively with their annual reports. Kitaoka demonstrated how FAO had switched to designing their reports for consumption on digital devices first (rather than hard copy), which required simpler and clearer messaging, but also facilitated the integration of multimedia and interactive graphics into their products. Despite these new communication requirements, Kitaoka stated there was no loss of data and FAO still publish printed versions of their reports. The main challenge and workload associated with the FAO effort had been developing the new concept and the consultation process to get leadership and FAO stakeholders to embrace the effort. Deciding on the very few key messages of the report for conveyance to policymakers was a crucial part of this process. A major benefit of this digitization initiative is the ability to better assess the effectiveness of FAO's communication, through such metrics as number of views, number of report links shared, and time spent viewing the reports – allowing for continual improvement. Stakeholder reaction to FAO's new reports has been positive.

In the second case study, *Heather Krause* (Canada) of *Datassist* provided specific best practices for how to create effective visualizations, and then illustrated those practices through examples using IAEA open source data, including the SIR. To ensure the most effective visualizations, Krause recommended:

1) Choose the specific question you are trying to answer
2) List the information you have to use to answer the question
3) Choose the smallest amount of information possible to answer the question
4) Design that information using basic best practices
5) Add informative title
6) Add details and links to appendices.

For the specific data examples, Krause stressed how the Department could leverage specific techniques that account for limits and tendencies in human cognition to both clarify the interpretation and reinforce the main message of its visualizations. She also advised that the current Departmental visualizations of safeguards data generally depict too much information, diluting their effectiveness.

> *"To transform your storytelling, take small steps to start making people feel successful."*
>
> *– Heather Krause*

Group Work

Cristina Versino (European Commission) of *EC JRC* helped facilitate group work. Overall, participants reflected that the speakers had very well illustrated a path forward for the Department to improve its external communications on safeguards matters. Participants agreed that most reports coming from intergovernmental agencies — including the SIR — are usually a text-based narrative with visuals added on retroactively. In this regard, FAO's experience in modernizing their reports generated significant excitement because of its practical use as a model for the Department (and FAO's similarities to the IAEA in their organizational structure and stakeholders). There was general agreement that the Department should pursue a similar report modernization initiative, and begin the process by pilot testing enhanced storytelling and interactive visualization on a single report.

The incubator highlighted the overall need for more staff with effective visualization skills in the Department of Safeguards. It was felt that the Department does not put an emphasis on skills for exploratory data visualization work to assist with data analysis, and does not currently offer the means for developing them. Although there are data visualizations tools and some trained users of such software, most analysts rely upon rudimentary tools and labor-intensive approaches to both process and visualize data.

A number of participants also noted the variety of internal constraints that restrict more effective, integrated data storytelling. Some of the obstacles include the challenge of data cleaning; conflicting data management and data governance; and some databases that do not work well together. Combined with access restrictions on some data and the overall growing volumes of data, the collective effect is a more limited, compartmentalized use of visualization tools for internal data analysis.

Key Insights

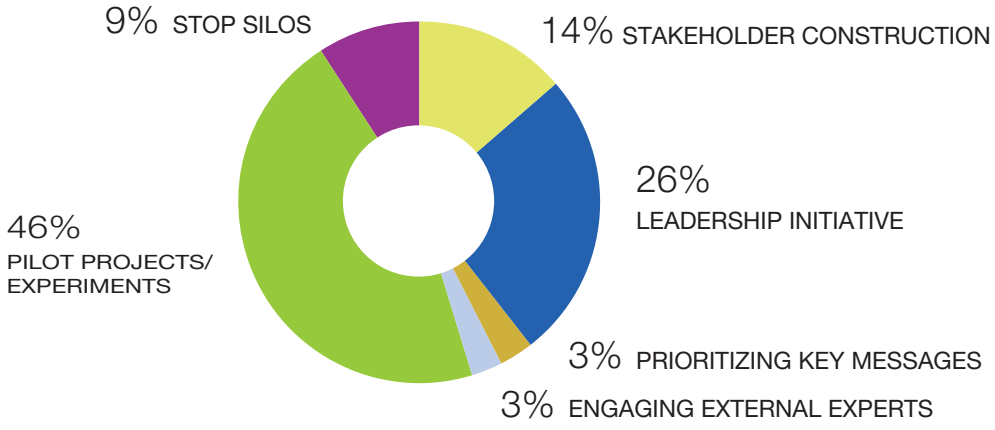
The insights from the incubator focused on the process of creating messages with safeguards data that are more effective. The obstacles to success within the Department also featured prominently. The key insights were:

- Tell the most important story in the most effective way
- Start with prioritization of your messages, not the visualization
- Visual tools lend themselves to interactivity, better engaging your audience
- With visuals, we need to guide the audience and help them digest and understand things, using annotation
- To build competencies, hold workshops to look at the importance of bringing data and emotions together in the reports in a way that it brings right emotions to the right data
- Data confidentiality in data can inhibit identifying key messages
- Technical minds tend to admire the complicated and dismiss the seemingly obvious, which inhibits effective communication
- Successfully changing storytelling approaches requires top management and stakeholder buy-in
- Creating highly effective visualizations is not a quick and easy process

Actionable Ideas for Consideration

- Conduct initial pilot testing of communication changes using a single existing report
- Prioritize and focus on key messages
- Collect new content and key messages from both bottom-up and top-down approaches
- Use more sophisticated visualizations and tools
- Emphasize data visualizations skills through skills recruitment and develop visualization training courses
- Develop and distribute a set of guiding principles for more effective data storytelling

Poll: What would be the most important step to improve communication to stakeholders?



Incubator 5:
How might we adjust our safeguards assumptions and acquisition path analysis to account for advances in additive manufacturing?

In implementing State level safeguards, the IAEA considers a State's nuclear and nuclear-related activities and capabilities as a whole. It develops and implements a customized State-level safeguards approach (SLA) for each State. The SLA is informed by an acquisition path analysis (APA): a structured method used to analyze the plausible paths by which, from a technical point of view, nuclear material suitable for use in a nuclear weapon or other nuclear explosive device could be acquired. The plausibility of such paths depends largely on the State's available technical capabilities. Additive manufacturing (AM), in particular, has shown potential to present new risks as novel techniques and materials are allowing faster, cheaper, and simpler production of increasingly stronger, more diverse materials and designs. Moreover, AM introduces the potential for indigenous production of proliferation-sensitive components that are normally subject to export controls or that would otherwise trigger detection. These technological advances create concerns that AM could introduce new pathways for acquiring nuclear material and capabilities that might challenge current safeguards assumptions and require additional considerations when conducting an acquisition path analysis.

PROBLEM STATEMENT

Advances in additive manufacturing could introduce new pathways for acquiring nuclear material and capabilities that might undermine current safeguards assumptions and acquisition path analysis

Presenter Summary

Grant Christopher (United Kingdom) of *VERTIC* provided an overview of AM methods, as well as some of the recent trends and advancements for the technology. He demonstrated several different manufacturing techniques to clarify the distinct characteristics of AM. Importantly, AM allows for a quick transition from design to production, but currently printing is slow, lacks adequate standards,

and is frequently unreliable (low quality). While the industry is actively working to improve its speed and reliability, and has demonstrated its usefulness in certain specialized tasks, there is not yet an expectation that AM would replace traditional manufacturing in many sectors. From a nuclear applications perspective, Christopher noted that the Department of Energy and national laboratories in the United States are investigating printing nuclear components and fuel. It remains difficult, however, to assess overall how AM might affect proliferation risks, due to the lack of any comprehensive open-source effort to track proliferation-relevant AM capability and application developments.

> *"Because there are so few examples of proliferation-related items being printed, we don't really know what's possible."*
>
> *– Grant Christopher*

A case study by *Andrew Bergeron* (Canada) of *Canadian Nuclear Laboratories* focused on his team's research efforts for the past two years to print nuclear fuels using light-based commercially available AM technology. To date, the team has managed to print thorium-based fuel samples, but so far AM of uranium-based fuel samples remains a challenge for their chosen AM method, although this may not be the case for traditional filament-style AM. For thorium fuels, the team has printed several sample shapes, and through various iterations has achieved significant improvements in surface roughness and porosity. Bergeron noted that their fuel development team sees potential in AM's ability to manufacture complex geometries, potentially allowing optimization of heat transfer surfaces and the creation of hollowed-out pellets for instrumented tests. The team has also worked with the University of Waterloo to apply AM to zirconium, with successful results. Notably, while Bergeron's team had only limited knowledge of AM prior to beginning the project, they were able to provide a successful proof-of-concept with very limited resources. Thus, their success illustrated the low barrier of entry — both financially and operationally — for using AM for novel nuclear purposes of safeguards relevance.

> *"We did our successful proof-of-concept for printing nuclear fuel on a $5000 machine."*
>
> *– Andrew Bergeron*

Group Work

Numerous participants noted their surprise at the capabilities highlighted by the speakers. They stressed that the Department needs to better understand the evolving capabilities, and safeguards relevance, of the AM industry. Some suggested that the Department should attend relevant conferences, trade shows, and standards discussions. Ideas also surfaced about how the Department might collaborate with the greater nuclear community (e.g. Nuclear Suppliers Group) to leverage their expertise for a better understanding and monitoring of this capability. Such strategic engagement would complement the Department's current ad-hoc interactions.

Participants were also concerned about the limited ability of the Department to address this challenge given the rapidly expanding market and lowering barriers of entry for use. Limited export controls on printers, as well as the dangers associated with easy access to digital files containing printing schematics, could pose particular challenges. Moreover, while the combination of AM with AI is already yielding highly efficient and effective new designs, it might also be possible to redirect this capability to the manufacture of components needed for nuclear proliferation, with reduced risks of being detected. Going forward, the AM challenge is not limited to the direct manufacturing capability, but also to the safeguarding of sensitive digital design files.

Although AM-based threats to safeguards have potential for disruption to existing safeguards approaches, it was noted that AM for nuclear applications still very much remains an emerging capability. Some participants also recognized that the capability to print unique shapes and incorporate other materials and devices in the manufacturing process, might actually yield new "safeguards by design" opportunities for nuclear material, or containers storing nuclear material.

Key Insights:

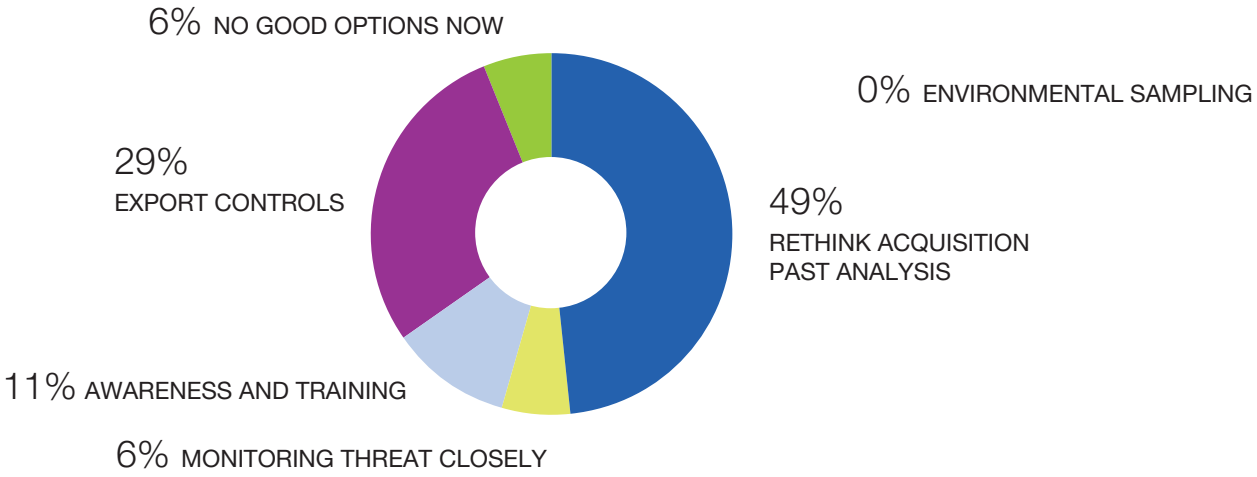
The insights focused on how accessibility, affordability, and connectivity are rapidly 'democratizing' AM printing capabilities, by allowing novices and non-state entities to harness its capability. Additionally, participants focused on ways to mitigate this challenge, and how the use of AM in non-nuclear industries potentially creates a new dual-use technology challenge that would need to be addressed. The key insights were:

- AM hardware, software, services, and usability have increasingly low barriers of entry
- Confluence of AM with AI and other technology might introduce new designs, resulting in new opportunities for safeguards R&D but also new challenges for detecting proliferation sensitive components
- There is seemingly little general knowledge of who is currently researching AM for nuclear applications
- Nuclear material control and accountancy remains a key tool for mitigating the technology threat
- APA assumptions remain viable in the near term, but robustness and timeframe for re-evaluation needs close and frequent monitoring
- Despite the nuclear industry's slow evolution, the Department remains susceptible to technological surprise, demonstrating the value of the intent behind the ETW

Actionable Ideas for Consideration

- Closely monitor advancements in AM — especially through external discussions (e.g. standards meetings, trade shows, etc.) — to stay abreast of developments and assess implications for safeguards
- Create a joint IAEA working group on AM and/or embed safeguards staff on relevant existing working groups
- Identify and engage other research entities that are pursuing AM printing of nuclear fuel and related items
- Develop training for inspectors and analysts on AM capabilities and potential proliferation uses, to raise their awareness
- Gather environmental samples on AM equipment in nuclear facilities, and prioritize further pursuit of wide area sampling technologies
- Revisit the AP annex to determine potential long-term impact of AM upon trade analysis

Poll: Which mitigation approach is most promising for addressing the additive manufacturing challenge?



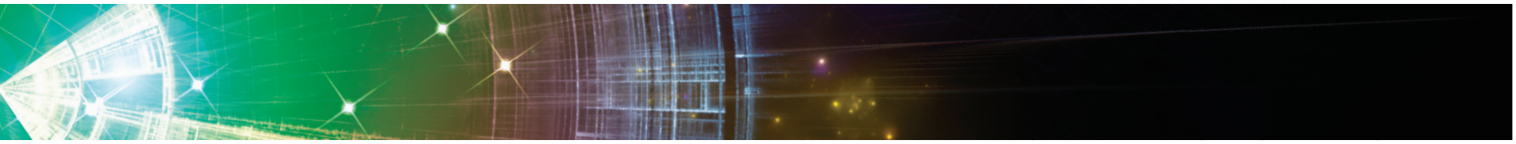
Closing Panel

The closing of the Workshop featured a panel with *Melissa Hanham* of *Open Nuclear Network*, *Tom Weis* (United States) of *Rhode Island School of Design (RISD)*, and *Bernhard Petermeier* of *IST Austria* discussing how to better develop innovation in public sector entities. The moderator, Strategic Planning Team Leader Jenni Rissanen, used the breadth and depth of innovation experience among the panelists to seek key lessons on successful innovation and the panelists' reflections on what they had heard during workshop. What followed was a focused dialogue that reflected the theme of change management from the opening of the Workshop, but that ultimately outlined an approach for building a more innovative organization through new and reimagined partnerships.

In their reflections on the Workshop, the panel acknowledged the complex and challenging tasks embedded in the IAEA's verification mission, and their appreciation that through the Workshop the Department's staff were open to thinking differently about its long-established practices. They stressed that if the Department wants to be more innovative and "forward leaning", it must continue to challenge the status quo with similar efforts that allow people to rethink and take risks. In essence, the Department must find contained ways wherein its staff can experiment and safely fail — and learn from those mistakes to effectively "fail forward."

The implementation of such risk taking on an organization-wide scale would fundamentally involve a structural and cultural shift. Panelists noted that concrete measures would need to result in decreased internal competition and increased cooperation among various Departmental components. They pointed out the need for more effective measures to recognize and retain effective talent. However, the panel also recognized that such internal changes toward innovation become harder with larger organizations due to their bureaucracy protecting status quo interests. Thus, if internally transformative efforts meet too much resistance, the panel recommended keeping innovation grounded within small internal groups working in close collaboration with outside groups.

From the panel's perspective, partnerships with new, non-traditional partner entities can invoke new perspectives and build transformative momentum. Other organizations such as the World Economic Forum organize external panels of influence that include prominent and respected leaders from government, industry, and civil society to help generate public support for change. Moreover, engagements with outside entities provide a multiplier effect for visibility and interaction with target audiences. Indeed, the panelists noted, there is a significant group of non-traditional entities — organizations, groups, individuals — that would be interested in partnerships with the IAEA, given its vital verification mission. Nevertheless, one panelist pointed out that the IAEA lacks a clear mechanism by which these outside entities can approach the organization to understand how to develop a partnership with it and what benefits it could expect in return.



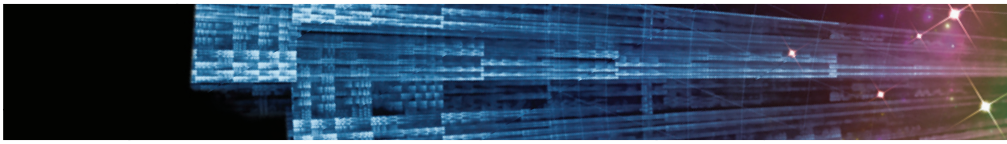
To maximize the appeal of a potential IAEA partnership, panelists argued that each partner must see achievable benefits from partnering. For the IAEA, the panel agreed that its biggest enticement for collaborating is its name and reputation. Indeed, they argued, many organizations would find it compelling to have their brand associated with a Nobel Peace Prize-winning entity.

Going forward, the panel also urged the Department to engage more directly with the public in a transparent manner. Leveraging crowdsourcing challenges issued to the public, the Department could push for additional technology development with specific requirements and cost parameters. Furthermore, by tying its challenges to the United Nations Sustainable Development Goals (UNSDG), a larger number of people might be motivated to participate. This would be especially true of young people, whom the panel argued frequently find a sense of purpose more motivating for engagement than financial rewards. Consequently, by capturing the interest of a younger generation through connections to a sustainable future, the Department could both create new technological solutions for its mission and build better pipelines for safeguards positions among younger talent.

Key Insights

- Avoid the notion that technology can solve all problems
- Better communicate the frameworks for non-traditional entities to partner with the Department
- Create processes that allow staff to experiment and fail with contained risk in a manner that rewards initiative rather than punishes failure
- Embrace the IAEA brand as a valuable asset for building partnerships
- Create open source challenges and tie them to the UNSDG

ANNEX 1: Programme



Monday, 27 January 2020

M2 Conference Room

Opening

Chair: Therese Renis (Director, SGCP)

09:30 – 09:35 Welcome
Therese Renis (Director, Division of Concepts and Planning, Department of Safeguards)

09:35 – 09:45 Opening
Massimo Aparo (Deputy Director General, Department of Safeguards)

09:45 – 10:10 Keynote address on emerging technologies and organizational change
"Plan Z: a Call for Redesign" – *Marco Steinberg (Snowcone & Haystack)*

10:10 – 10:25 Workshop scene setting
Tom Weis & Justin Cook (Rhode Island School of Design), Morgan Matthews (N Square)

Incubator 1: How might we incorporate artificial intelligence (AI) & machine learning (ML) advances into safeguards surveillance?

Problem Statement: Using learning-based algorithms to help the Department be more efficient and effective with video surveillance analysis is challenged by the requirements of the unique safeguards mission space, lack of datasets for some scenarios, sparseness of events within the data, and limited resources to label training data.

10:30 – 10:35 **Internal scene setting**
Maikael Thomas (IAEA)

10:35 –10:55 **Presentation and Q&A session**
"AI for Video Analysis" – *Olivier Salvado (CSIRO)*

10:55 – 11:00 **Lightning round:** IAEA Safeguards staff ideas for incubator 1

11:00 – 11:25 **Example case study and Q&A session**

- "Deep Learning for Safety Critical System" – *Saimir Baci (Ivadolabs)*
- "Insights into Critical Event Detection from Medical Applications" – *Peter Klimek (Medical University of Vienna)*

11:25 – 12:55 **Facilitated problem solving session**
Safeguards staff-members with assistance of external presenters and subject matter experts – Irmgard Niemeyer (Forschungszentrum Jülich) and Bernhard Petermeier (IST Austria)

- What can we learn from the problem definition and external approaches?
- How could advances in AI & ML applications help strengthen SG surveillance functions?
- What are concrete actions that the Department can take in this area?

12:55 – 13:00 **Polling**
Workshop participants to rank the most promising opportunities that emerged from incubator 1

13:00 – 14:00 **Lunch** (catered for external presenters, facilitators and scene setters from 27 Jan)

Monday, 27 January 2020

M2 Conference Room

Incubator 2: How might we more fully leverage imagery and multimedia data streams for better detection of undeclared nuclear material and activities?

Problem statement: Growing volumes and increasing diversity of open source information are challenging the Department's ability to efficiently and effectively utilize such information for the detection of undeclared nuclear material and activities. Labour-intensive processes for processing and analyzing open source imagery and multimedia data are increasingly unsustainable.

14:00 – 14:05 **Internal scene setting**
Katie Spence (IAEA)

14:05 – 14:25 **Presentation and Q&A session**
"Efficient Detection of Undeclared Nuclear Facilities Using Human-Guided Automations" – *Melissa Hanham (One Earth Future Foundation)*

14:25 – 14:30 **Lightning round:** IAEA Safeguards staff ideas for incubator 2

14:30 – 15:00 **Example case studies & Q&A session**

- "GeoSpatial Machine Learning at Scale in 2020" – *Tim Kelton (Decartes Labs)*
- "Structuring Data with Computer Vision" – *Craig Desjardins (Striveworks Inc.)*

15:00 – 15:15 **Break**

15:15 – 17:25 **Facilitated problem solving session (Part I)**
Safeguards staff-members with assistance of external presenters and subject matter experts – Bernhard Petermeier (IST Austria)

- What can we learn from the problem definition and external approaches?
- What are the implications of recent trends in these capabilities, and how might the Department leverage them for more holistic information analysis?
- What are the risks associated with these capabilities?
- What are concrete actions that the Department can take in this area?

17:25 – 17:30 **Polling**
Workshop participants to rank the most promising opportunities that emerged from incubator 2

Reception

Hosted by the Stanley Center for Peace and Security

17:45 – 19:00 M-building ground floor

Tuesday, 28 January 2020

M2, M6, M7 Conferene Rooms

Incubator 3: How might we leverage technologies and approaches from other industries to rethink our approach to spent fuel verification?

Problem statement: The projected increase in the number of spent fuel casks, with the current verification approach and seal verification requirements, will overwhelm the existing resources to perform seal verification of dry spent fuel casks. Moreover, with interim storages filling up, the Department expect increasing transfers of spent fuel transfers, the verification of which is resource intensive.

09:00 – 09:05 **Internal scene setting**
Graham Morris (IAEA)

09:05 – 09:20 **Presentation and Q&A session**
Presentation on the current status of the dual C/S approach and expectations for the future – *Juha Pekkarinen (Euratom), Ken Baird (IAEA)*

09:20 – 09:25 **Lightning round:** IAEA Safeguards staff ideas for incubator 3

09:25 – 10:05 **Example case studies & Q&A session**

- "The Opportunity of Connectivity for the Diamond Value Chain" – *Jim Duffy (TRACR)*
- "Pilot Distributed Ledger Technology (DLT) for Safeguards Data in Finland" – *Cindy Vestergaard (Stimson Center)*

10:05 – 10:20 **Break**

10:20 – 10:50 **Demonstration on robotics for safeguards**

- "Robots for Inspection in Confined Spaces" – *Ross Dungavell (CSIRO)*
- "Robotic Technology Development for Decommissioning of Fukushima Daiichi Nuclear Power Station" – *Naoaki Okuzumi (IRID)*
- "Benefits of Robotics in Spent Fuel Pool Inspection" – *Peter Kopias (Datastart)*

10:50 – 12:55 **Facilitated problem solving session (Part I)**
Safeguards staff-members with assistance of external presenters and subject matter experts – Jussi Heinonen (STUK) and Bernhard Petermeier (IST Austria)

- What can we learn from the definition of the problem? Are there other ways the problem could be framed?
- What can we learn from the industries with analogous challenges?
- Could we rely on entirely new and innovative – and more effective and efficient – safeguards approach(es) based on e.g. C/S applied to wider areas/bigger groups? What complementary other technologies could be applied to such safeguards approaches?
- What entirely new technologies could help address the continuity of knowledge challenges associated with dry spent fuel storage casks?
- What are concrete actions that the Department can take in this area?

12:55 – 13:00 **Polling**
Workshop participants to rank the most promising opportunities that emerged from incubator 3

13:00 – 14:00 **Lunch** (catered for external presenters, subject matter experts, facilitators and scene setters from 28 Jan)

Tuesday, 28 January 2020

M2, M6, M7 Conferene Rooms

Incubator 4: How might we enhance our analysis, interpretation and communication of safeguards data and information?

Problem statement: The growing variety and abundance of safeguards data makes fully analyzing it difficult with current resources and approaches. Additionally, the technical nature of safeguards data creates challenges in communicating trends in and results of safeguards activities effectively to external stakeholders.

14:00 – 14:10 **Internal scene setting**
Antonio Bruno (IAEA), Agatha Walczak-Typke (IAEA)

14:10 – 14:30 **Presentation and Q&A session**
"Show and Tell: Data-Driven Visual Stories" – *Xaquin G.V. (Independent consultant)*

14:30 – 14:35 **Lightning round:** IAEA Safeguards staff ideas for incubator 4

14:35 – 15:25 **Example case study and Q&A session**

- "Using Visualization in Communicating Results: FAO's Experience" – *Kazuki Kitaoka (Food and Agriculture Organization)*
- "Meaningful Data Visuals in Six Steps" – *Heather Krause (Independent data scientist)*

15:25 – 15:40 **Break**

15:40 – 17:25 **Facilitated problem solving session**
Safeguards staff-members with assistance of external presenters and subject matter expert, Cristina Versino (EC JRC)

- What can we learn from the problem definition and external approaches?
- What improvements in analytics and visualizations would help 'identify relevant signals within the noise' and make data processing more efficient and our analysis of safeguards data and information more robust?
- What are our assumptions about how our products will look in the future and which media will be used to view them?
- How might visualization of data and information help us convey our safeguards reports more effectively? What are concrete actions that the Department can take in this area?

17:25 – 17:30 **Polling**
Workshop participants to rank the most promising opportunities that emerged from incubator 4

Senior Leadership Dinner

A working dinner for SG senior leadership and the invited subject matter experts to further explore challenges and opportunities from emerging technologies discussed at the workshop.

18:45 – 21:00 *Invitees: Department of Safeguards' Senior Leadership, external presenters and SMEs*

Wednesday, 29 January 2020

M2 Conferene Rooms

Incubator 5: How might we adjust our safeguards assumptions and acquisition path analysis to account for advances in additive manufacturing?

Problem statement: Advances in additive manufacturing could introduce new pathways for acquiring nuclear material and capabilities that might undermine current safeguards assumptions and acquisition path analysis.

09:00 – 09:05 **Internal scene setting**
John Druce (IAEA)

09:05 – 09:25 **Presentation and Q&A session**
"Recent Trends in Additive Manufacturing" – *Grant Christopher (VERTIC)*

09:25 – 09:30 **Lightning round:** IAEA Safeguards staff ideas for incubator 5

09:30 – 09:50 **Example case studies & Q&A session**
"Progress on Additive Manufacturing of Nuclear Fuels at Canadian Nuclear Laboratories" – *Andrew Bergeron (Canadian Nuclear Laboratories)*

09:50 – 11:45 **Facilitated problem solving session**
Safeguards staff-members with assistance of external presenters and subject matter expert

- What can we learn from the problem definition and external approaches?
- Which capabilities in indigenous production of proliferation sensitive items, especially from metal powders, would change our assumptions regarding acquisition paths and how might we address this challenge?
- What does the evolving ways of spreading of sensitive know-how entail for the Department's future partnering efforts?
- What are concrete actions that the Department can take in this area?

11:45 – 11:50 **Polling**
Workshop participants to assess the significance of recent technological developments to safeguards

11:50 – 12:00 **Break**

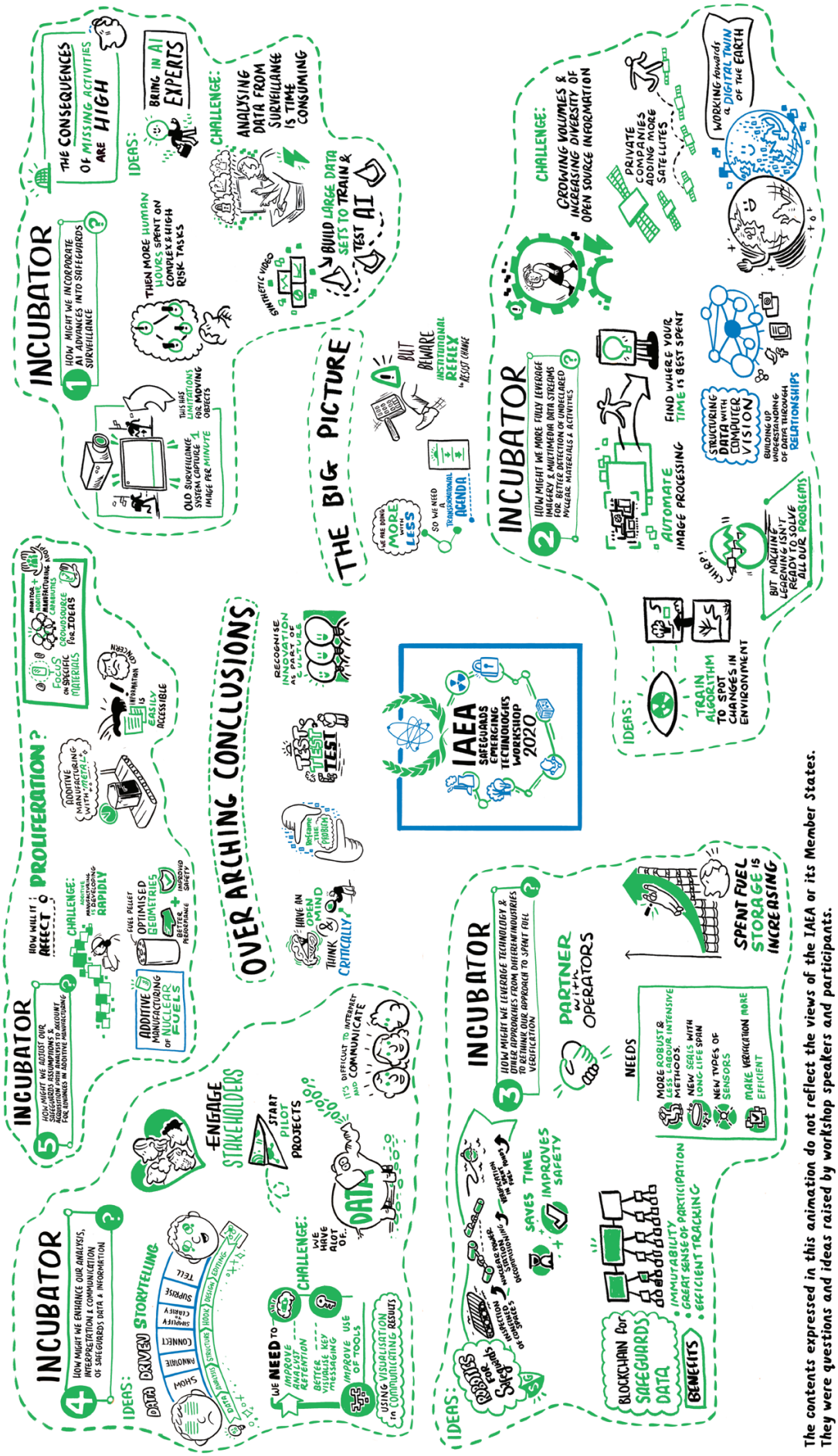
Closing

12:00 – 12:15 **Summary: Key take-aways from the 5 incubators**
Chad Haddal (IAEA)

12:15 – 13:00 **Closing Panel**
A panel of experts to discuss their observations on what they have learned and observed during the workshop, and suggest ways on how public sector entities like the IAEA can become more innovative and leverage emerging technologies.
Moderator: Jenni Rissanen (IAEA)
Panelists: Melissa Hanham (Open Nuclear Network), Bernhard Petermeier (IST Austria), Tom Weis (Rhode Island School of Design)

13:00 – 14:00 **Lunch** (catered for external presenters, subject matter experts, facilitators and scene setters from 29 Jan)

ANNEX 2:
Workshop Summary Illustration



The contents expressed in this animation do not reflect the views of the IAEA or its Member States.
They were questions and ideas raised by workshop speakers and participants.

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