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ESARDA strategic developments and continued evolution

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ABSTRACT

The European Safeguards Research and Development Association (ESARDA), while celebrating its 50th Anniversary in 2019, opened up several new strategic lines of development and continues to grow both in membership and topics. This paper will present the motivation, the current status of strategic developments, and include a short outlook for the future.
A number of steps were undertaken in the recent past to prepare ESARDA for the challenges and opportunities of the next decade. A pillar of the ESARDA development and evolution is the Reflection Group Report that was finalized in 2019 and that looked at the short and medium priorities and activities and at some internal operational and organizational aspects. The outcome of this report was translated into a large set of concrete actions through the organization of a World Café in 2019. One year after, at its 2020 symposium, ESARDA took stock of where it stood w.r.t. implementation of actions. Each Working Group (WG) of ESARDA reported specifically on the work that was implemented in the preceding year. Concrete examples of this follow-up, such as the creation of new ESARDA WGs to deal with specific topics (Final Disposal, Material Balance Evaluation), the publication of a peer reviewed journal that is now fully SCOPUS indexed, and the outreach to new partners will be described in the paper.
To illustrate further the position of ESARDA in the international safeguards and non-proliferation landscape a specific effort was made to compare the strategic priorities of ESARDA with those of the closest partners INMM and IAEA organizations, including input e.g. from the latest IAEA Safeguards Symposium, the IAEA Emerging Technology Workshops, the IAEA International Conference on Nuclear Security and others. This resulted in a multi-point comparison of which activities are being pursued by the different players and can also serve to identify opportunities for further collaboration and synergies. Some input from third organizations has also been included. The overview could be used as a living document to pursue future strategic developments in nuclear safeguards and non-proliferation, with some links to e.g. nuclear security and strategic trade control.

INTRODUCTION

Chapter 7 of the Euratom Treaty addresses nuclear safeguards and requires the European Commission to satisfy itself that, in the territories of Member States:

- nuclear materials from civilian applications are not diverted from their intended uses as declared by the users (Article 77 (a));
- the provisions relating to supply and any particular safeguards obligations assumed by the Euratom Community under an agreement concluded with a third State or an international organisation are complied with (Article 77 (b)).

These tasks are entrusted to the European Safeguards Directorate (Euratom safeguards) of the General Directorate Energy (DG ENER). Underpinning R&D and technical support with the European Commission is provided by the Joint Research Centre (JRC), Nuclear Safety and Security Directorate.

At international level, nuclear safeguards are implemented through a variety of safeguards agreements between individual European Union States and the International Atomic Energy Agency (IAEA) to which Euratom is always a party. A special partnership agreement has also been made between IAEA and Euratom Safeguards, recognizing its role as a regional system for implementing safeguards. Also, the European Commission, through JRC coordination, operates an extensive Support Programme to the

IAEA Safeguards Department in which many R&D tasks and technological support activities are embedded. The same holds true for many Member States of the IAEA and there is in general a good coordination and contacts between the different Support Programmes to the IAEA Safeguards.

As the successful implementation of nuclear safeguards requires both a collaboration of a variety of players (inspectorates, authorities, regulators, operators, facilities etc.) and a sound scientific and technical support (bringing in technical support organizations, research centers, academia etc.), it was decided early on, in the European Union, to establish the European Safeguards Research and Development Association (ESARDA). The organization, which runs on a fully voluntary basis without budget or treasury, has been constantly evolving over the years [1,2] both in content and partnership and in the mean-time has a strong international footprint also. Both through dedicated meetings of the many ESARDA WGs and through its annual scientific symposia, all partners are regularly updated on new issues, R&D results, joint exercises, new safeguards approaches etc. Due to the continuingly varying safeguards challenges, the expansion of the nuclear fuel cycle (e.g. soon including final geological disposal of spent nuclear fuel) and the evolving technology it was felt that at the mature age of 50, an important analysis on the ESARDA future strategy was appropriate. Short, medium and longer term priorities have been established in the resulting ESARDA 2019 Strategy Paper [3] and detailed action plans were elaborated to implement the different priorities.[4] The process and outcome of these efforts are described in this paper.

At the international level, the IAEA Nuclear Safeguards Department organizes a Safeguards Symposium every 4 years, to take stock of the latest developments [5]. In parallel to the input from the different support programmes to nuclear safeguards, this allows IAEA to constantly be informed on the latest safeguards-relevant research and developments and establish also new priorities for R&D in the years to come [6]. The content of these plans will be shortly referred to in this paper also.

Also at international level, the Institute for Nuclear Materials Management (INMM) makes very substantial contributions to both the R&D and the implementation of Nuclear Safeguards, both at domestic and international level. Existing since over 60 years now, INMM regularly takes stock of the latest developments and analyses the key challenges for the future. The latest INMM strategic plan [7] documents these challenges and corresponding actions and it is regularly reviewed and updated by the INMM Strategic Planning Committee. The key actions will be described in this paper alongside those of IAEA and ESARDA mentioned above.

Because there is a substantial potential for synergies in the implementation of nuclear safeguards with other nuclear disciplines, like nuclear security, some of the key R&D challenges that have been identified in the nuclear security area (by IAEA, NTI, WINS and others) [8,9,10] are also included in this paper. This will allow both the R&D partners and those responsible for the implementation of both nuclear safeguards and nuclear security, to benefit from parallel and/or joint developments to enhance both effectiveness and efficiency of the implementation.

As novel technologies developed in fully different areas, and especially those developed under the enhanced push for digitalization, have a large potential for being deployed also in the nuclear safeguards area, such input is also referred to in this paper. In fact, the IAEA Safeguards Department in recent years developed several "Novel Technologies" Workshop, exactly aiming at bringing in novel expertise, new developments and innovative tools to the safeguards world [11,12], and in parallel IAEA is developing what is called "non-traditional partnership agreements" with a variety of players (including INMM and ESARDA) to take these initiatives even a step further. Some of the input collected through these initiatives is therefore also reported in this paper.

DEVELOPMENT AND IMPLEMENTATION OF THE ESARDA 2019 STRATEGY PAPER

The ESARDA Reflection Group 2019 (RG2019) was established in January 2017 with the objectives to develop a roadmap to improve and enhance the quality, effectiveness and efficiency of safeguards and

non-proliferation in Europe and abroad; and to ensure that the future activities of ESARDA are both consistent with the Association's purpose, as stated in the ESARDA Agreement, and address the needs of the ESARDA members and/or stakeholders.

To fulfil these objectives, three specific goals were identified: First, to establish short term ESARDA priorities (2019 to 2024) and prepare a roadmap (what?); second, to define ESARDA's medium-term future (2019-2029) activities based on the new landscape in Europe and internationally; and third, to review the ESARDA organization, and discuss how ESARDA can implement/achieve the identified objectives and implement the identified roadmap.

Volunteers contributed to the Reflection Group from across the ESARDA Membership, including WG Chairs, Steering Committee and Executive Board members and ESARDA participants of both long-standing and recent activities. Outreach to the wider ESARDA community was achieved through a questionnaire and discussions within regular meetings of the ESARDA WGs and the 2018 Annual Meeting in Luxembourg, in order to ensure that the views of all those who drew benefit from the activities of ESARDA were considered and that all stakeholders, including operators, authorities and scientific institutions, could achieve ownership and influence the future of ESARDA.

The Reflection Group itself undertook its work through five dedicated meetings between October 2017 and January 2019, with considerable work undertaken in the interim by individuals and groups of members. The RG2019 identified, debated and analyzed future requirements for ESARDA and agreed to present ten priorities from which to develop actions within a roadmap. Each priority is described in the RG paper with a short introduction and context and then a number of focus points are provided including the actions retained for the Roadmap. The comparative table in the last section of this paper has more details on the actions.

ESARDA's short term priorities (2019-2024):

The short-term priorities for ESARDA are driven by the requirements of current EC safeguards policy and its evolution, and resource constraints in implementing safeguards. The overall goal for the short-term activities of ESARDA is to develop and facilitate the implementation of further improvements in safeguards effectiveness and efficiency at all levels:

1. Strengthen the focus on development, pilot-testing and evaluation of safeguards approaches for the back-end of the fuel cycle (including encapsulation plants and final repositories)
2. Fully exploit the potential of remote data transfer, remote observation and control, artificial intelligence and machine learning for enhancing the implementation of safeguards measurements and data evaluation, duly taking into account (cyber) security considerations
3. Enhance the use of modern business analytics/intelligence and data science tools to reach higher quality findings from current and future nuclear safeguards relevant data (all types)
4. Attract the young generation to and implement knowledge transfer from the field of nuclear safeguards and non-proliferation
5. Enhance the awareness and visibility of nuclear safeguards at the public and political level

Progress on the implementation of the short term priorities is reviewed during each Executive Board meeting and reported at each annual meeting to the ESARDA members. Similarly, the ESARDA WG chairs regularly report on the implementation of the respective roadmap actions at the bi-annual meetings hosted by DG ENER and during the Executive Board review meetings. Achievements in the implementation of short term priorities are also shared with the membership via the ESARDA Connector.

ESARDA's medium term priorities (2019-2029):

Any action in the medium term vision of the medium term priorities will require review depending upon the results of the shorter term actions. Assuming that safeguards and non-proliferation related activities, in the next 10 to 30 years, will be very strongly influenced by further technological developments, the medium term priorities were identified as:

6. Continued safeguards enhancement based on R&D (key role for ESARDA)
7. Further changes in nuclear fuel cycle strategies and operations in Europe

8. Contribute safeguards expertise to major nuclear developments outside Europe

Progress on the implementation of the medium term priorities is also reviewed during each Executive Board meeting and reported during each "internal" bi-annual meeting hosted by DG ENER in Luxembourg.

ESARDA's structure and operation:

The RG2019 recommends two types of activities in regard to the structure and operation of ESARDA.

9. Procedural, to make sure the rules and procedures and the ESARDA Agreement are up to date and adequate to the current and future composition and working methods of the associations
10. Operational with an emphasis on enhanced interaction between ESARDA WGs (e.g. through joint meetings) and with IAEA (in line with the non-traditional partnership agreement currently under preparation)

Some key elements decided under these headers were the need for enhanced communication (e.g., ESARDA Connector), establishing a peer reviewed and indexed scientific journal (International Journal for Nuclear Safeguards and Non-Proliferation) and assuring follow-up of the RG recommendations (see World Café, amongst other)

ESARDA Reflection Group World Café

As a first step to take ownership of the ESARDA RG roadmap, an interactive World Café was held at the ESARDA Symposium 2019. The ultimate goal of the World Café was that participants not only take ownership of the RG2019 actions but contribute actively to their future implementation, ideally taking an action in their personal agenda. The results of the World Café were summarized in an extra report, which is also available via the ESARDA website.

Complementary to the detailed commitments that were identified under each of the 10 challenges, some other key findings are reported here:

- The World Café participants strongly envisaged establishing a new dedicated WG on advanced business data analysis and visualization.
- Additionally, ESARDA should invest more joint (research) efforts to overcome political and technical limitations, fostering communication, education, and share technologies to unlock the 3S potential.
- Synergies on several dimensions – between safeguards authorities, nuclear and non-nuclear research institutions, regulators, operators, industry and safety and security – are considered indispensable for keeping ESARDA abreast of developing technologies in a changing world.
- Finally, ESARDA as a European Association must be aware of and take into account the political context and public concerns throughout the planning and execution of its R&D activities.

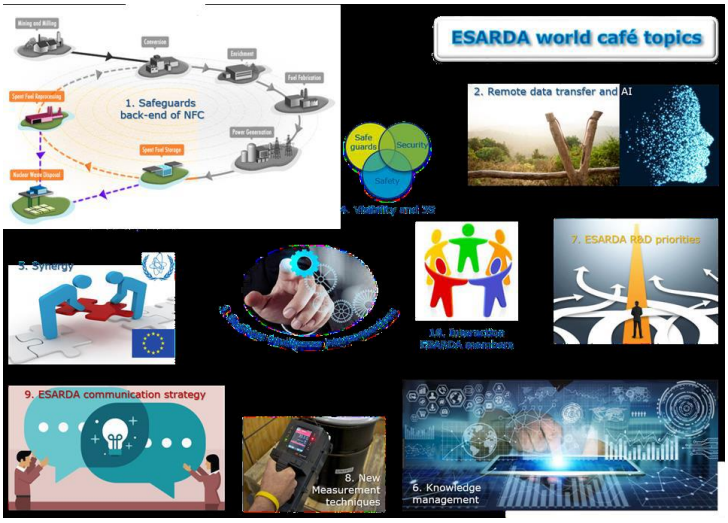

Figure 1: The 10 World Café topics are identified as the most salient challenges

A few concrete examples are presented here that illustrate the follow-up of both the RG and World Café.

New WG on Final Disposal

Considerations on the safeguards for the back-end of the fuel cycle started many years ago and multiple world-wide expert groups discussed this topic at length, the last one being e.g. the ASTOR group under guidance of IAEA. However, recently these groups came to an end or were less active. Because of the pressing needs to have ready-to-use solutions, especially for safeguarding some of the newest installations, i.e. in Finland and Sweden, which will be operational in the near future, ESARDA felt the requirement to establish a new WG on Final Disposal, which in the meantime has already met several times since its creation early 2020. This "facility oriented" WG works in close collaboration with other ESARDA WGs like Implementation of Safeguards and Containment and Surveillance, and attracts considerable interest also from other international participants. The scope is to understand better the challenges and jointly work out solutions for those challenges counting on the input from R&D, the insights from the operators and the contributions from the inspectorates, i.e. to utilize to the full extent the potential of the ESARDA community.

The importance of the back-end of the fuel cycle for ESARDA is further illustrated by two of its latest members:

- Andra is the agency responsible for the management of all the nuclear waste generated in French facilities,
- Posiva Oy (Posiva) is a nuclear waste management company in Finland whose main task is the disposal of the spent fuel of its owners' NPPs. The current ESARDA Vice-President, Mari Lahti works at Posiva Oy.

New WG on Material Balance Evaluation

During the 42nd ESARDA annual meeting in November, ESARDA launched a new WG related to Material Balance Evaluation in bulk handling facilities, focusing on the determination of the related uncertainties and their interpretation.

The main objectives of this WG are in short to establish some reference, methodology and guidelines on Material Balance Evaluation, through the identification and sharing of best practices and knowledge within the safeguards community (operators and inspectorates). This WG will also contribute to international reference through guidelines and ESARDA publications. It will provide a basis for relevant education and training.

The tasks of this WG will be distributed in 4 sub-WGs

1. Regulations for Material Balance Evaluation
2. Methodologies and statistical assumptions for Material Balance Evaluation as well as uncertainties, examples and tools
3. Best practices for Material Balance Evaluation, Material Balance monitoring and Material Balance accuracy improvement
4. NRTA / Near Real Time Accountancy studies and perspectives, including machine learning algorithms and the mathematical methods for combining physical models and statistical models.

Dealing with business analytics and handling of big data sets

Recent advances in data analytics have the potential to make significant contributions to the fields of nuclear safeguards and non-proliferation. ESARDA has recognized this potential, and specifically called out topics relevant to data analytics including business intelligence and artificial intelligence in the 2019 World Café. Even before that the ESARDA Verification Technologies and Methodologies (VTM) WG has taken active interest in further exploring data analytics applications for safeguards and non-proliferation, including several topical sessions focused on data analytics research being conducted within the community. On March 19th 2021, a new recurring segment to the WG meetings called "what is…" took place offering explanations of methods being discussed for safeguards, and ongoing planning for a data analytics challenge. A detailed description of the outcome is included in the latest ESARDA Connector Issue. In order to provide a single forum for the latest research and development on data analytics for nuclear safeguards and non-proliferation, the VTM WG is organizing a special topical issue of the ESARDA Bulletin on data analytics focusing on R&D and use cases.

Peer reviewed journal

Since end of 2020, ESARDA is proud to have achieved the full indexing by SCOPUS of the peer reviewed ESARDA Bulletin, having now the main title of the International Journal on Nuclear Safeguards and Non-Proliferation. The comments of the reviewers were very positive, confirming that articles published in the journal are "scientifically sound and relevant to an international academic or professional audience" in the field of Nuclear Safeguards and Non-Proliferation.

Figure 2 : ESARDA Bulletin and ESARDA Connector

ESARDA Connector

In Autumn 2019 the first issue of the semi-annual ESARDA Connector was published. The Connector contains a message from the president, news, events, and dedicated presentations of the new partners of ESARDA and an overall update on the ESARDA developments through the reports of the WGs. Featured articles, like e.g. from the students of the ESARDA Course, and other technical articles are also included. All issues can be downloaded freely from the ESARDA website.

Reaching out to the young generation through Education and Training

The 19th ESARDA Nuclear Safeguards and Non Proliferation organized by the JRC is a wonderful example of agility and adaptation. For the first time, it was a fully online course, which succeeded in arousing the interest of a high number of attendees all over the world, including from Africa and Asia. More than 150 participants attended the course.

Figure 3 : 19th ESARDA Course on nuclear safeguards and non-proliferation

Based on a MoU signed between ESARDA and ENEN and the fact that ENEN received a contract from the European Commission to foster training and education on nuclear safeguards outside Europe, the ENEN colleagues with support of JRC reached out to a number of regions outside Europe. In the outreach for the course, we also benefit from the active participation of another new partner of ESARDA, i.e. The African Commission on Nuclear Energy (AFCONE). The joint effort of AFCONE, ENEN and

the JRC contributed to make a big success of this 19th ESARDA Course. For the future and starting from September 2021, again under contract with ENEN and the Polytechnic University of Milan, the newest academic ESARDA partner, funded by the EC and with support from ESARDA and JRC, the first ever full-fledged master course on nuclear safeguards will be organised (mainly virtually) at academic level (for a full duration of 12 months). This initiative is presented in a separate paper in the INMM/ESARDA 2021 Joint Annual Meeting.

ESARDA R&D CHALLENGES IN THE BROADER INTERNATIONAL CONTEXT WITH OTHER STAKEHOLDERS AND PARTNERS.

To illustrate further the position of ESARDA in the international safeguards and non-proliferation landscape a specific effort was made to compare the strategic priorities of ESARDA with those of the closest partners INMM and IAEA organizations, including input e.g. from the latest IAEA Safeguards Symposium, the IAEA Emerging Technology Workshops, the IAEA International Conference on Nuclear Security and others. This resulted in a multi-point comparison of which activities are being pursued by the different players and can also serve to identify opportunities for further collaboration and synergies. Some input from third organizations has also been included. The overview could be used as a living document to pursue future strategic developments in nuclear safeguards and non-proliferation, with some links to e.g. nuclear security and strategic trade control.

CONCLUDING REMARKS

Despite its more than 60 years of effective implementation, the field of nuclear safeguards and non-proliferation continues to evolve strongly and calls upon the latest R&D results and achievements to modernize, optimize, make more efficient and in general enhance further the quality of the safeguards implementation and conclusions. This paper illustrated both how ESARDA contributes to this endeavor and how the international collaboration with other partners, both in the same disciplines and beyond, allows to further nurture the safeguards community and address the identified challenges.

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IAEA SG Symposium 2018 Outcome	IAEA Symposium Action Plan	ESARDA Reflection Group Outcome	ESARDA RG / World Café Actions	INMM Closing Plenary 2018 outcome : taken those above 10% of POLL	INMM Actions defined for follow-up suggested by SPC analysis	ICONS2020	IAEA ETW 2020	INMM/ESARDA JAPAN 2019	NTI Security Index	WINS
1. Rethink spent fuel verification for optimized safeguards	Consider nuclear fuel designs, with respect to diversion and misuse scenarios in terms of evolving factors, including: —Reduced self-protection during long-term spent fuel storage; —Modern fuel designs offering pin replacement/substitution options; —New nuclear fuel compositions; and —Improvements to measurement capabilities of spent fuel in casks.	1. Strengthen the focus on development, pilot-testing and evaluation of safeguards approaches for the back-end of the fuel cycle (incl. encapsulation plants and final repositories)	1.1. Enhance techniques for verification and characterisation of spent fuel (e.g. passive gamma emission tomography)	2.D NP Challenge/Risk/Threat of Lack of options for the back-end of the fuel cycle (12%)	2.D.1. Support work on dry cask storage with physical security and safeguards technologies	Slightly related is the importance given to the nuclear security considerations on separated Pu	A specific session was dedicated to How might we leverage technologies and approaches from industries with analogous challenges to rethink your approach to spent fuel verification	WG 1 on International Safeguards discussed facility decommissioning and waste management	Reduction of countries with weapons usable materials has halted (i.e. not further reduced since 2016)	Security during decommissioning and security of the back end of the fuel cycle is a key strategic priority for WINS over the next 5 years.
	Explore areas for technology development that could enhance spent fuel verification, including measurement accuracy and reliability.		1.2. Enhance the development of smart safeguards approaches for encapsulation plants (e.g. multispectral cameras, smart seals, identification of canisters, etc.)			ICONS also discussed the lack of IAEA Nuclear Security Series guidance on activities such as disposal, decommissioning of facilities, spent fuel and waste				WINS has held workshops and has developed best practice guidance on security during decommissioning and security of spent fuel
			1.3. Give attention to proper safeguards for the transport of loaded final storage containers			A special session was also dedicated to the minimization of HEU within civilian stocks				
			1.4. Develop technologies for (re)verification of loaded spent fuel canisters (e.g. muon tomography)			Along the same lines as seeking alternatives for HEU, also the replacement of radio isotopic irradiators with alternative technologies is a point of interest				
			1.5. Improve and evaluate the approaches for safeguarding of deep geological repositories, including long-term storage of data and the use of special verification technique			Also technologies to deal with final disposal of radiation sources were discussed (e.g. borehole disposal and melt processing)				
		7. Further changes of nuclear fuel cycle strategies and operations in Europe	7.1. Evaluate techniques to screen final disposal sites after closure							
			7.2. Develop, validate and promote the application of characterisation techniques that are of mutual benefit for safeguards, decommissioning and waste management, which might lead one day to the definition of exemption levels of fissile materials from safeguards							
2. Reinforce implementation of multisource data visualization for better integration, analysis and use of safeguards information	Establish or enhance collaboration between the IAEA, Member States and competent partners to identify and explore the most favourable means to utilize visualizations, including tools and best practices from other organizations;	2. Fully exploit the potential of remote data transfer, remote observation and control, artificial intelligence and machine learning for enhancing the implementation of safeguards measurements and data evaluation, duly taking into account (cyber) security considerations	2.1 Develop and promote enhanced inspection and sampling schemes to optimize the use of human and other resources through remote operations and control	5.A.Cyberthreat : Cyber vulnerabilities of nuclear security systems at sites (17%)	5.A.1.Organise dedicated session in future AMon this with NTI and the new INMM cyber/physical security integration committee	Support from the Emerging Technologies and Digital Age High Level Panel	A specific session was dedicated to how we might incorporate artificial intelligence and machine learning advances into safeguards surveillance	WG 1 on International Safeguards discussed data handling and information management		WINS has held workshops, events and written reports on data analytics for nuclear security
	Make use of relevant existing, and/or develop customized, software based on well-defined Safeguards needs;		2.2 Pursue the deployment of smart process-monitoring and remote monitoring for a variety of fuel cycle facilities, including the use of advanced statistics, quality control, machine learning, artificial intelligence etc.	5.B. Cyber threat : Vulnerability of MC&A Systems (11%)		Proposed strong public-private partnerships and with vendors	A specific session was dedicated to how we might enhance our analysis, interpretation and communication of safeguards data and information	WG 2 on nuclear security discussed cyber security and information security		
	Deploy relevant crowdsourcing to maximize opportunities from external perspectives;		2.3 Address security issues, in particular cybersecurity, data traceability and immutability in the collection, transfer, storage and handling of safeguards-relevant data	5.C.Cyberthreat : Operational security (11%)		Emerging technologies like AI, Big Data etc. have applications in detection, delay and response to nuclear security events	A specific session was dedicated to how we might more fully leverage imagery and multimedia data streams for better detection of undeclared nuclear material and activities	WG 3 on Non Proliferation and Arms Control discussed new/emerging verification methods, technologies and techniques		
	Develop training for State Evaluation Groups and managers that accounts for aspects of behavioural science and human cognition in making decisions that use information from automated visualization tools	3. Enhance the use of modern business analytics/intelligence and data science tools to reach higher quality findings from current and future nuclear safeguards relevant data (all types)	3.1. Reach out to the business intelligence and data science community and seek for expertise, tools and insights to apply to safeguards.	5.E.Cyberthreat : Ability to interfere with safety systems at facilities (31%)	5.E.1. New cyber/physical security integration committee	Request for development of national computer security regulations (incl. computer security threat profiling and risk mitigation)		WG 3 on Non Proliferation and Arms Control discussed the integration of strategic export control data		
			3.2. Consider the benefits of using geographic information systems & enhanced data visualisation and interconnected databases for mapping, storing, presenting, analysing safeguards data (with due attention to the sensitivity and/or classification of certain types of information)	7.A. Game changer : Artificial Intelligence/Machine Learning (29%)	7.A.1. Analyse tremendous impact (illustrated by referring to hypersonic delivery systems of nuclear weapons reducing strongly the decision time frame to react…)	Computer security risk analysis was highlighted as requiring extra attention incl developing technical defence architectures and the benefit of doing cybersecurity threat assessments and exercises. Simulation tools were also requested		WG 3 on Non Proliferation and Arms Control discussed data analytics and integration of information		
			3.3. Consider establishing a new sub-working group in ESARDA on modern business analytics, and data science and in general analytical tools in support of the safeguards analyst	7.G. Game changer : Information analysis / Big Data (15%)	7.G.1. INMM to engage more membership expertise in these areas (reference to first Exascale computer by ANL)	Potential use of blockchain technology was mentioned in the area of NMAC for both nuclear and radioactive materials				
		6. Continued Safeguards enhancement based on R&D	6.2.Explore to what extent the internet of things, distributed and self-organising networks of sensors, smart data and equipment, and the use of distributed ledger technology etc. are suitable tools to support the implementation of nuclear safeguards with less inspector	7.H. Game changer : Remote sensing (21%)						
			6.3. Develop and promote the use of augmented reality, ambient intelligence, enhanced self-localisation, virtual reality tools, next generation of robotics, for future in-field inspections							
			6.4. Investigate the potential of future and emerging technologies such as artificial intelligence, enhanced cognitive systems, data analysis, block chain, robotics, biotechnologies, new materials, nanotechnologies, quantum technologies, 'green' technologies, etc. to support safeguards evaluations and approaches.							

3. Build national safeguards capacity by supporting the improvement of SSAC performance	Further support SRAs with self-assessment tools and procedures for comparing against the requirements and obligations under their safeguards agreements	8. The major nuclear developments are expected to happen outside Europe	8.1. Support and exchange with 'nuclear newcomer' countries i.e. those without pre-existing nuclear safeguards infrastructure.	2.F. NP Challenge/Risk/Threat of the Ability of IAEA to implement safeguards (11%)		Support expressed from IAEA Nuclear Security Plan (next 2022-2025) and strengthened IAEA role, including synergies between security and safety			The rate of improvement in nuclear security regulations and laws has reduced significantly since the end of the 2016 Nuclear Security Summit Series	WINS has held and is holding workshops on capacity building for nuclear security in newcomer countries
	Use SSAC self-assessments and surveys to identify training needs and develop tools, such as the State Declarations Portal (SDP), to support SSACs in meeting their obligations;	5. Enhance the awareness and visibility of nuclear safeguards at the public and political level	5.2. Address the technical synergies between safeguards and safety / security	3.C. NS Challenge/Risk/Threat of Implementation/Security practices at the sites	3.C.1. Study impact of drones and cybersecurity on the physical security of sensitive nuclear sites	In the nuclear security area, a similar request is formulated through the development of Integrated Nuclear Security Support Plans (Incl. self-assessment)			Countries without relevant nuclear materials (but with radioactive sources), have not done enough to support the global nuclear security architecture	
	Promote the good practice of requesting IAEA SSAC Advisory Service (ISSAS) missions and implementation of follow up actions;		5.3. Promote the collaboration between inspectorates and State authorities, e.g. also in the area of characterization of waste from nuclear decommissioning and with small holders.		3.C.2. Stimulate major technology development programme to replace decade-old technologies in the security infrastructure	The importance of evaluating and performance testing (incl modelling and simulation) of Physical Protection Systems was stressed				
	Continue to develop and deploy new e-learning tools and other innovative ways to support SSAC personnel;		5.4. Contribute to the transparent and recognized positioning of European safeguards in the policy context with EU Member States	3.E. NS Challenge/Risk/Threat of Many high activity radiological sources in many locations	3.E.1. Can INMM play a role in the follow-up of the efforts of the Nuclear Security Summits (2010-2016) that focussed on these topics ?	IPPAS (International Physical Protection Advisory Service) was praised for providing support to states w.r.t. content and prioritisation of activities				
	Encourage collaboration between stakeholders (States, regional networks, non-traditional partners) to enhance SSACs' capacity-building, possibly with some role for the IAEA;		5.5. Support the liaison between Euratom and IAEA on safeguards implementation	3.F. NS Challenge/Risk/Threat of Material in Transport		Enhancing capabilities (e.g. border detection), improve collaboration between multiple agencies and also internationally on detection/response/forensics				
	Promote the development of 'Centres of Excellence' and 'Safeguards Champions' to generate sustainable momentum in capacity building.			3.G. NS Challenge/Risk/Threat of Potential for sabotage of a nuclear facility leading to release	3.G.1. Include aspects of the aftermath of a release with respect to emergency management and the attendant public response to a release	The importance of a nuclear security architecture was stressed with technical reachback capabilities				
4. Bolster safeguards education to build the next generation of safeguards experts	Support the development of a robust curriculum on international safeguards and nuclear non-proliferation that could be offered to academia throughout the world	4. Attract the young generation to and implement knowledge transfer from the field of nuclear safeguards and non-proliferation	4.1 Launch specific outreach activities to other (nuclear) communities and networks such as European Nuclear Society, International Young Nuclear Congress, etc. to promote R&D and careers in nuclear safeguards and non-proliferation, and increase the diversity of the ESARDA Membership	6.D. Top INIMM Focus : Helping improve processes and resources for education, training, knowledge etc. (16%)	6.D.1. WINS challenge to INMM	Strong support for E&T and capacity building expressed in the high level panel on National nuclear security regimes with a special role also for IAEA		T	IAEA nuclear security series / INFCIRC adoption is to be further improved	WINS put forward a challenge to the INMM Membership at the 2018 Annual meeting for INMM members to develop certificated training programmes in their areas of specialization.
	Introduce proven concepts and analytical techniques from behavioural science, as appropriate, into the curriculum to provide future safeguards practitioners with a broader skill set for application to diverse challenges		4.2 Review, revise and implement the initial concept of operating a Young Generation Initiative within ESARDA		6.D.2. Identify other institutions of higher education to host similar events (like the Texas A&M "capston" session "Policy and Technical Fundamentals of International Nuclear Safeguards" at the INMM AM	ICONS stressed the need for developing and sustaining human resources for national nuclear security inspections				A proposal for a safeguards and NDA certification programme was developed by Dan Johnson from WINS, Jeff Chapman from NNSA, and Cary Crawford from ORNL. This proposal was presented to the SPC in 2019.
	Foster increased gender and geographic diversity in STEM education, in order to attract new generation to careers in the nuclear field, including international safeguards		4.3 Continue to give and develop training courses on safeguards and enhance outreach activities in close collaboration with the IAEA and other players (e.g. ENEN at European level) in both education and training, if possible including external funding		6.D.3. Create a student-based challenge program (Student Chapters offer suggestions for challenging research project and the winning suggestion being used for a competition among the other Student Chapters)	Leadership development needs to include the evaluation and increase of the quality and effectiveness of nuclear security training				
	Develop a forum to exchange experience about professional courses and the development of learning material for academia;		4.4 To assure knowledge transfer from the retiring generation to the young generation through the development of an effective knowledge management concept.	8.D INMM increase attention : Historical analysis, including incidents and lessons learned (15%)	8.D.1. Support the work of the newly created "Historian" function at INMM to capture as much information as possible before the aging population of the institute is lost.	Nuclear Security Support Centres are important w.r.t. sustaining a State's nuclear security regime (through capacity building, networking, train the trainer activities etc.)				
	Expand safeguards education partnerships by facilitating interactions between SSACs/other stakeholders and academic establishments									
5. Proactively engage industry to ensure the early incorporation of safeguards requirements into nuclear projects	Further develop safeguards awareness-raising initiatives among stakeholders (e.g. designers, vendors, operators, and new comer countries), and provide relevant training;	7. Further changes of nuclear fuel cycle strategies and operations in Europe	7.3. Keep ESARDA's R&D appraised of possible new and or advanced concepts of nuclear facilities which might require adapted or new safeguards approaches (e.g. small modular reactors, Generation IV, and safeguards for accelerator driven systems like Myrrha)	2.B. NP Challenge/Risk/Threat on Spread of Uranium Enrichment for the civil nuclear fuel cycle to new countries (18 %)	2.B.1. Support (with NP/NS expertise) the development of SMRs not requiring HEU	Support in this area was expressed by the high level panel on International cooperation in information exchange, sharing of good practices and broader experience to enhance nuclear security	A specific session was dedicated to how we might adjust our safeguards assumptions and acquisition path analysis to account for advances in additive manufacturing	WG 1 on international safeguards discussed safeguards preparedness for new types of reactors and fuel cycles		WINS has just published a special report, in collaboration with NTI, on Security of Advanced Reactors. The report has been drafted to encourage advanced reactor developers, supported by their regulators, to incorporate security into their designs as early as possible.
	Identify lessons learned from other industries and regulators on how to engage vendors, including how to ensure confidentiality of design aspects and develop effective approaches supporting safeguards by design	8. The major nuclear developments are expected to happen outside Europe	8.2. Follow-up closely in which aspects ESARDA could support (new) sensitive nuclear fuel cycles from a safeguards and non-proliferation point of view, including transportable NPPs, pyroprocessing, molten salt reactors etc.		2.B.2. Enhance the capability to detect the harbingers of enrichment and remotely detect the by-products through National Technical Means	Security by design and for newcomers was stressed, alongside safety and safeguards				Security and safeguards considerations must be jointly taken into consideration early in the design of a new reactor.
	Enhance active cooperation between the IAEA Departments (e.g. Department of Safeguards,				2.B.3. Enhance further use of Big Data and Data Analytics to ensure compliance to Treaties	In transportation challenges, the important role of industry was emphasized (transport container development in line with regulatory frameworks etc.)				
	Department of Nuclear Energy, and Department of Nuclear Safety and Security), and ensure effective engagement of relevant national and regional stakeholders and partners			8.F. INMM increase attention: Outreach to industry (19%)	8.F.1. Analyse how stronger engagement with industry can be achieved (see earlier Facilities operations division and possibly use marketing expertise of AH)					

6. Develop tailored communication on the role and importance of safeguards	Develop tailored communication, which targets multiple audience types for building awareness about the purpose and value of safeguards;	5. Enhance the awareness and visibility of nuclear safeguards at the public and political level	5.1. Engage with external partners/organisations/academia/policy-makers to increase awareness and visibility of ESARDA (nuclear safeguards and non-proliferation); including promotion, communication, dissemination, continuation and foresight of ESARDA success stories	6.F. Top INMM focus : Increasing public awareness, engagement, education about materials management (13%)	6.F.1. Evaluate whether INMM should stay "silent" with respect to public announcements ; and find staff with professional experience in public relations in case the decision is taken to create a more public presence, esp. on controversial public issues and policies	Support in this area was expressed by the high level panel on International cooperation in information exchange, sharing of good practices and broader experience to enhance nuclear security				As side recommendation, the participation of very high level delegations to the ICONS meetings and CPNMM review meetings are recommended to assure sufficient visibility for nuclear security is maintained
	Actively approach various audience types such as newcomer countries, vendors, States holding small quantities of nuclear material, operators of locations outside facilities and the R&D community, to ensure they are properly informed about international safeguards	9. Procedural	9.2. Develop and implement an ESARDA (internal and external) communication strategy; including short communications to attract new members; improved use of the website, the ESARDA document repository CIRCABC and social media	8.G. INMM increase attention : Impact of culture (16%)	8.G.1. Seek continuity of the investment done through partnering previously with PNS to attract non-US chapters and further encourage contributions of the international community on safeguards/security (focusing on cultural diversity)					
	Create and use simpler, less technical, messages that are understandable by public at large, and make full use of diverse media channels and modern presentation techniques to disseminate these messages.		9.3. Evaluate the opportunities of a peer-reviewed, SCOPUS indexed, open-access journal supplementary to a monthly/bi-annual ESARDA Newsletter/Report	8.H. INMM increase attention : Media outreach (15%)	8.H.1. Seek for experienced resources to gain recognition in the public/policy sector					
7. Expand and leverage non-traditional partnerships to broaden political, financial and technical support to the safeguards mission	Develop means for engagement with non-traditional partners, drawing upon the IAEA's experience and best practices from other relevant sectors	6. Continued Safeguards enhancement based on R&D	6.5. Stimulate 'out-of-the box' thinking and encourage engaging with global system science, behavioural sciences, social media, crowdsourcing, all-information analysis, arts & science, etc. to bring in new ideas into safeguards	2.G. NP Challenge/Risk/Threat of Lack of political progress on nuclear disarmament (26%)	2.G.1. Re-engage with Russia	The need and value of regional collaboration in nuclear security was stressed				WINS is engaged actively with WANO to develop peer review for cybersecurity of nuclear facilities
	Develop and set up a framework for mobilizing and directing support from non-traditional partners towards the IAEA's strategic priorities and needs	10. Operational	10.1. Envisage modernisation approaches for the open ESARDA symposium, such as the use of live-web streaming and interactive/participatory session formats and tools		2.G.2. Educational efforts w.r.t. Arms Control, Verification and Disarmament	Reference was made to the security and safety interface e.g. w.r.t. physical protection, material transport				WINS collaborated with a number of advanced reactor developers in the development of the aforementioned report on Security of Advanced Reactors
	Further develop crowdsourcing pilot outreach projects, such as the recent IAEA robotics challenge, to mobilize expertise and research that address specific IAEA needs		10.2. Encourage EURATOM safeguards and the IAEA upfront of the closed ESARDA meetings (even years) to propose specific topics for the ESARDA WGs to reflect and work on		2.G.3. Can INMM still become more truly international / global (e.g. including China, India, Pakistan etc.)					Engagement with India is opening up and growing
			10.4. Continue the successful series of joint workshops on dedicated topics, of interest to multiple ESARDA WGs but also to invited experts beyond the safeguards and/or nuclear field, to further provide integrated solutions and advice to safeguards stakeholders	6.G. Top INMM focus : Connecting policy and technical communities to develop solutions (26%)	6.G.1. Continue outreach to / engagement with NTI, Carnegie, ESARDA, WINS...					
				8.E. INMM increase attention: Partnerships with other civil society organizations (11%)						
OTHER inputs that could be connected to the above or be handled separately				5.D. Cyberthreat : Risk to command and control of military nuclear weapons	?					WINS has several guides and a WINS Academy training course on cybersecurity for nuclear facilities
				6.C. Top INMM focus : Supporting nuclear arms control and disarmament, including policy discussions (11%)						WINS has held several workshops and events on cybersecurity for nuclear facilities.
				7.C. Game changer : Additive Manufacturing (17%)	7.C.1. Consider within INMM to create "Advanced Technologies" Committee that might help to focus emerging technologies for the technical divisions					