ESARDA
European Safeguards Research & Development Association

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Connector

Issue 2 | Spring 2020

EDITORIAL

by Willem Janssens (ESARDA President)

Dear ESARDA Friends,

It is a pleasure and honour to address you to introduce the second edition of our ESARDA Connector. The colleagues working on this “newsletter” have done a great job in the last months to collect up-to-date information and I therefore would like to thank wholeheartedly both the editing teams and all contributors to the Connector. Reading the presentations of new members, associated parties and/or those organisations with which we signed an MoU, flipping through the news and the reporting of the working groups, or reading one of the featured articles, is an inspiring activity, even more so in these days where almost all of us are working from home.

The end of 2019 and early start of 2020 have been very dynamic with various meetings, discussions and interactions relevant to ESARDA, many of which I will shortly cover below. One particular item I would like to highlight

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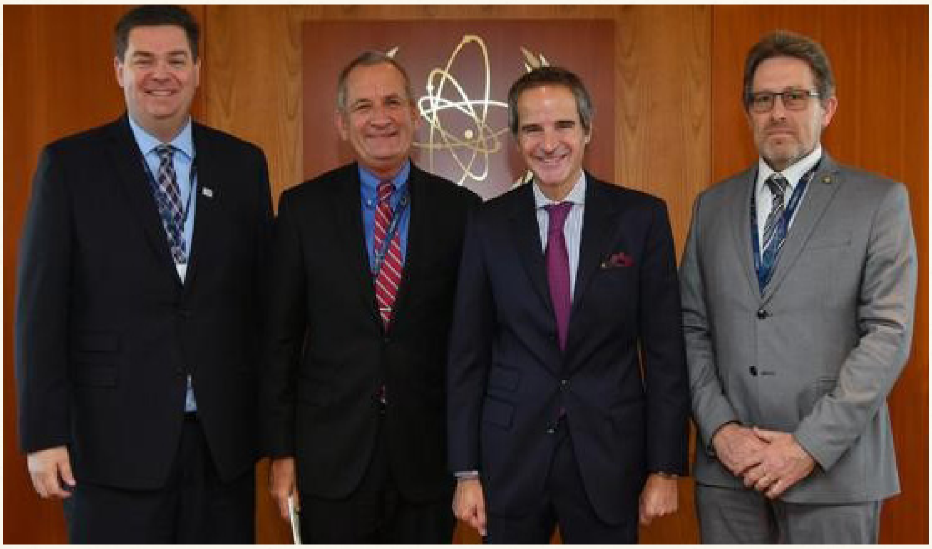


from left to right: C. Crawford (INMM President), L. Satkowiak (INMM past president), R.M. Grossi (IAEA DG), W. Janssens (ESARDA President)

upfront is the meeting with Rafael Mariano Grossi, Director-General of the International Atomic Energy Agency (IAEA) on 13 February 2020, together with the management of the Institute for Nuclear Materials Management (INMM) to discuss the upcoming joint ESARDA/INMM meeting in August 2021. The IAEA DG expressed particularly high appreciation for the effort to organise this meeting in Vienna and welcomed the opportunity that this will provide for other IAEA Divisions, beyond Nuclear Safeguards, to also interact closer with ESARDA and INMM. He recommended also to reach out to the Delegations in Vienna of both traditional, but also potential future new partners for ESARDA and INMM, to assure a sufficiently high level of visibility for this meeting and thus the potential to further raise the profile of the organisations. From the ESARDA side, Julie Oddou, ESARDA Vice-President, Irmgard Niemeyer, ESARDA former-president and myself are following this up closely and will report back to you at regular intervals on the progress made in this direction.

ESARDA's 50th Anniversary and beyond

When you are reading this editorial, you will recall that at this very same time last year, preparations were at full speed to celebrate the 50th anniversary of our Association and lots of added-value products were created by the entire team for and during the 50th Anniversary Symposium. The ESARDA Historical Review, the Reflection Group Paper, the World Cafe Report and the output of the many discussions, panels and side-meetings we had in Stresa, continue to feed the organisation with inspiration, continuous developments and planning for the future. These products were conceived to be living documents which can be fed with input, reporting on the achievements of specific milestones and contributions on the progress made with the implementation of the ESARDA Strategic Plan. During the last ESARDA Executive Board, all WG chairs were asked to regularly report also w.r.t. their contributions to the above activities as foreseen in the World Cafe Report.

Implications of the COVID-19 pandemic

This is even more important as we go all together through this very strange period, late winter and early spring 2020, where a worldwide pandemic paralyses many activities. It was clear at the end of March, that we had to cancel the ESARDA meeting in Luxembourg, scheduled for early May. We are pleased to announce the opportunity to organise a similar meeting in autumn 2020, combined with a Steering Committee and Executive Board meeting, in order to both "recuperate" the preparation and to assure that we keep a certain rhythm in our scientific/technical exchanges, in line with the ESARDA tradition. I am very grateful that IRSN has offered its location to host this 42nd Annual ESARDA meeting from November 16 to 19, 2020 in their head office at Fontenay-aux-Roses. This is a convenient timing, seen that the next open ESARDA Symposium will be organised late August 2021, in Vienna, jointly with INMM. It will also allow us to jointly discuss some key issues from which DG ENER and IAEA could benefit (and that were scheduled to be presented in the May 2020 meeting). In preparatory discussions with DG ENER we touched upon such topics as the security on information technology, the exploitation of large data sets and the termination criteria for safeguards. With IAEA colleagues we discussed issues related to both the reinforcement of the State System for Accounting and Control (SSAC) in small/middle size countries (w.r.t nuclear activities) and the even more urgent the contributions ESARDA could deliver to the adaptations and modernisation of the IAEA Safeguards Implementation Reports (SIR). I thus look forward to us meeting soon altogether to be able to provide ESARDA's scientific/technical input and operational insights to these important issues.

This year we obviously had to cancel also the traditional ESARDA Course on Safeguards and Non-Proliferation. The 19th edition was planned to take place in Ispra from 30 March to 3 April. We hope that most of the around 50 enrolled students will have the opportunity to attend the 2021 edition of the course. We had to also cancel an analogous course, scheduled from 16-20 March 2020 in Cape Town, South Africa, where 45 participants from 15

African countries were already registered. We hope also in this case to be able to reschedule such a course during next year, with the support of the European Nuclear Education Network (ENEN), which was contracted by the EC DG DEVCO to pursue the organisation of short courses on Nuclear Safeguards outside Europe. Also under ENEN responsibility, you might be interested to know that a curriculum will be developed for a Master's Degree on Nuclear Safeguards, to be organised in the academic year 2021/22, and to which quite a few ESARDA members will be invited to contribute.

ESARDA President, W. Janssens giving a speech at ICONS2020

Progress in european and international collaboration

Coming back briefly to the African continent, most of you will know that also at the level of the European Union (EU), in its programme for the next seven years, as established under the new European Commission (EC) President Ursula Von der Leyen, the enhanced engagement with the African Union (AU) is a key priority. This is also in line with a request, which was sent by R. Grossi, IAEA DG to the EC Presidency, to request from the EU an enhanced support for the use of nuclear and radiological technologies in the AU in the areas of Health, Agriculture, Environment and Climate Change. R. Grossi explicitly mentioned the already excellent collaboration in the areas of Nuclear Safety, Security and Safeguards, to which ESARDA also contributes significantly. It might therefore be interesting to analyse which contributions ESARDA could deliver to deal with this additional dimension (e.g. related to radioactive source security, dosimetry, reference materials, nuclear measurements, etc) in the medium-term future. Most of you will remember the presentation in Stresa by the African Commission for Nuclear Energy (AFCONE) which has the ambition to assure that the Nuclear Safeguards and Non-Proliferation aspects and obligations are given due attention on the African Continent. In a meeting with 30+ African States that I was able to attend in South Africa at the end of February 2020, AFCONE announced the plans to coordinate closely in the future also with the Forum of Nuclear Regulatory Bodies in Africa (FNRBA) and the Africa Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology (AFRA), the latter having a branch called African Network for Education in Nuclear Science and Technology (AFRANEST), which could be most interesting for evaluating the opportunities for collaboration with ESARDA, if supported by the ESARDA members. Very similar plans and ambitions of enhanced nuclear collaboration and coordination in the areas of Nuclear Safety, Security and Safeguards, were also presented in a meeting at the Vienna Centre for Disarmament and Non-Proliferation (VCDNP), jointly organised with the International Centre for Science and Technology (ISTC) on 12 February 2020.

Potential synergies between nuclear safety, security and safeguards

Some of the above considerations are also related to the contributions from the ESARDA community to the broader area of nuclear security, recognising both that the latter is the full responsibility of individual states and that international collaboration can provide meaningful contributions and be essential in some areas. This was confirmed also in the Ministerial Declaration, signed on 10 February 2020 in Vienna during the International Conference on Nuclear Security (ICONS) to which quite a few ESARDA participants also effectively contributed. Several panel discussions focussed on the synergies (technical, organisational, legal, etc) between safety, security and safeguards and this again is even more relevant for nuclear newcomers or aspirational states. Similar considerations apply when analysing the challenges in "new" facilities or activities like during decommissioning and waste management and clearance, during the design/conception of encapsulation plants of spent fuel, as well as the future operation of final geological disposal sites. Another area where links with ESARDA (can) exist are in Hybrid Threats, protection of critical infrastructure and the contributions to the creation and enhancement of adequate nuclear security culture.

Strengthening the ESARDA-INMM liaison

A similar discussion on the relevance of the organisation for emerging or future-intended nuclear countries and synergies with other (nuclear) disciplines, is currently taking place within INMM, where both Irmie Niemeyer, ESARDA immediate past-president, and myself participate actively to both the Executive Committee and the follow-up of the INMM Strategic Plan. In fact, based on the Letter of Intent between ESARDA and INMM, we keep each other closely informed about strategic developments, new contacts, joint work for our stakeholders (like IAEA) and already started some concrete planning for the Joint Annual Meeting in 2021, in close coordination with Julie Oddou, the ESARDA vice-president. In the meantime, I am in close contact with Cary Crawford, the INMM president, w.r.t. the programming and preparation for the INMM Annual Meeting, scheduled in July 2020 in Baltimore. This meeting is still on the calendar and we sincerely hope that it will not have to be cancelled due to the Corona Virus pandemic.

Contributing to emerging technologies

A quite inspiring meeting that is highly relevant to ESARDA and took place from 27 to 29 January in Vienna, was the Emerging Technologies Workshop 2020, to explore new and developing technologies that have the potential to affect the IAEA's verification mission. Topics covered included artificial intelligence, machine learning, advanced nuclear material surveillance analysis and enhanced visualisation tools. "Coping with technological developments and trends is expected of us, and exploiting new technological opportunities is required," said Massimo Aparo, IAEA Deputy Director General and Head of the Department of Safeguards. "By bringing together a diverse range of external experts – with people who are engaged with similar challenges – and by focusing on specific tasks, we want to reveal untapped ideas and uncover new ways of understanding how to strengthen our approaches and technologies." A similar message can in fact be provided to the entire ESARDA community and a presentation on the outcome of this workshop, while being very much in line with the ESARDA Strategic Plan, is foreseen for our next ESARDA Meeting.

Brexit

Another highly-important event that took place since the publication of the first ESARDA Connector, with a profound impact on the European Union, was the BREXIT date, 1 February 2020. Although we are still in a transition phase, including w.r.t. the application of Euratom Safeguards to the UK facilities, ESARDA had to start the process of the change in membership status of most of our UK parties to the associated membership status (amongst other solutions). This was a little slowed down due to the teleworking conditions, but will be picked up and completed soon after, so that all our UK friends can stay fully on board with ESARDA also in the future.

Looking ahead

In the same way the discussion with the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) to prepare an MoU are on hold but will be pursued before the next ESARDA Steering Committee Meeting. Another operational issue that was discussed in the last ESARDA Executive Board, held early in February 2020, related to the creation of a new Working Group (WG). The previously approved new ESARDA WG on Final Disposal held a very well attended and highly interesting kick-off meeting in Mol, Belgium on 6-7 February. Lively interactions took place and many suggestions were provided for the future work-plan of this WG, so I am really excited about the start and evolution of this new Working Group and I invite all colleagues with relevant contributions, also from the other ESARDA WGs, to take active part as well in this WG, dealing with a key and imminent challenge for the Nuclear Safeguards authorities. In the meantime, we all know that the 2020 Review Meeting of the Non-Proliferation Treaty (NPT) cannot take place as foreseen, and even if a bulk part of this meeting is highly political, we did discuss shortly in February, what kind of contributions the ESARDA members can and do make, which is an issue we might want to further elaborate in the future.

Finally, and most importantly for the organisation also, is the opportunity for the ESARDA membership to come forward and propose candidates for the next term of the ESARDA Vice-Presidency, for the period 2021-22, where we hope to collect good suggestions in the near future, in order that the Steering Committee can evaluate the candidates and vote on the nomination of this position, to be filled as of 1 January 2021. It is recalled that the Vice-President then normally serves as President of ESARDA (in this case for the period 2023-24) and stays an active member also of the ESARDA Executive Board as immediate past-president (period 2025-26).

I sincerely hope that the current Connector issue and the elements of this editorial, mixing short-term priorities with long-term plans for the Association, inspire you in these particular times and allow you to further shape the contribution of each of you to the success of ESARDA, for which I thank you very strongly in the name of the entire ESARDA community and I look forward to your continued engagement.

Take good care and stay healthy!

news & events

Keeping you up to date with all the latest news of the association and its partners, as well as all the upcoming events in the near future.

NEWS

ESARDA 42nd Annual Meeting New Dates and Venue

Following the cancellation of the May event in Luxembourg, due to the COVID-19 outbreak, ESARDA is pleased to announce that the 2020 ESARDA Annual Meeting will be held at the IRSN head office, 31 avenue de la Division Leclerc 92260 Fontenay-aux-Roses, from 16-19 November 2020. As usual it will be a closed meeting reserved to ESARDA Steering Committee, Executive Board and Working Groups' members, i.e. Parties, Associated and Individual members and ad hoc contributors, as agreed by WG Chairs. The registration form will be made available shortly on the ESARDA website.

IRSN Headquarters in Fontenay-aux-Roses

ANNETTE Workshop in Ispra

The Belgian nuclear research centre SCK CEN organized a workshop on "Proliferation resistance methodologies for nuclear installations" in the frame of the Horizon2020 ANNETTE project. The workshop was held on 3-4 December 2019 at JRC-Ispra (Italy) in connection with the ESARDA Working Group meetings.

Two generic nuclear installations were presented in the workshop, a Pressurized Water Reactor (PWR) and a Fast Breeder Reactor (FBR) cooled by liquid metal. For both installations the workshop participants were asked to apply some sections of the TOPS, PR&PP, and INPRO proliferation resistance methodologies. These methodologies were developed by Pacific Northwest National Laboratory (PNNL), the GEN IV International Forum (GIF) and the International Atomic Energy Agency (IAEA), respectively. Due to time limitations and lack of detailed information on the nuclear installations, only a generic application of the proliferation resistance methodologies was possible. Nevertheless, the participants were able to grasp the essential basic aspects of the methodologies and differences between the methodologies. In addition they had the possibility to discuss the strengths and limitations of each approach.

There were 9 participants in the workshop, and they were all actively involved in the activities and in the discussions during the exercises. For most of the exercises the participants were divided into two groups and this stimulated the participation of each participant. The combination of students, young professionals, and participants with more experience in the application of safeguards helped in the execution of the exercises. The opinions of the participants were very different at certain times, but a positive attitude towards discussion allowed a successful completion of the workshop. The differences in the final results could be attributed partly on the semantic interpretation of the parameters used in the methodologies. A more extensive explanation would help overcome such issues.

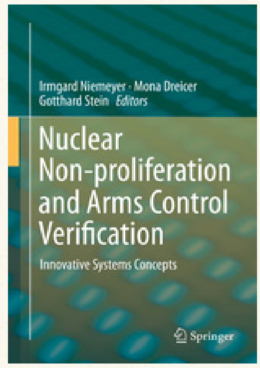
ANNETTE Training in Jülich

The second week of the ANNETTE Training Course on Nuclear Safeguards was held from November 11-15, 2019 at Forschungszentrum Jülich GmbH. It was planned as a continuation of the first week of the ANNETTE course that took place on February 4-8, 2019 at SCK CEN, Mol, Belgium. Six people from Austria, Netherlands, UK, Italy, France, and Egypt participated, with quite different backgrounds: Nuclear Engineering, Earth Sciences, History

and Civilization, Material Science, Physics with Theoretical Astrophysics, and International Law. Only one of the participants also attended the first ANNETTE week in Mol.
The course started with a summary of the first ANNETTE week in order to bring the participants to the same level – a challenge considering their different backgrounds. After this refresher part, the following topics were taught: “Implementation of safeguards”, “Physical protection”, “Export control”, “Microparticle reference materials production in Jülich”, “Probabilistic, statistical and game theoretical methods for nuclear safeguards”, “Destructive analysis for EURATOM and IAEA safeguards”, “Mass metrology”, “Nuclear chemistry (separations) and mass spectrometry”, “Containment and surveillance”, “Safeguarding German spent fuel storage facilities”, “Novel technologies, approaches and methodologies”, and “Upcoming challenges”. The lectures were complemented by two hands-on exercises: “Weighing and uncertainty estimation” and “IDMS (Isotope Dilution Mass Spectrometry) and uncertainty estimation”. Also a technical visit at JEN (Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH) and in the Safeguards laboratory were carried through.
All participants were highly engaged in the discussions during lectures and exercises. Especially their different backgrounds supported a stimulating discussion.
This second week of the ANNETTE course could not have taken place without the great support of R. Rossa (SCK CEN, Belgium), X. Arnes-Novau and C. Bergonzi (JRC, Ispra, Italy), R. Jakopic, U. Jacobsson and S. Richter (JRC-Geel, Belgium), and Th. Krieger, K. Aymanns, I. Niemeyer, S. Neumeier, P. Kegler (Jülich).

Nuclear Non-proliferation and Arms Control Verification Book has Been Released

This book takes stock of current achievements and existing challenges in nuclear verification and identifies the available information as well as existing gaps that can act as drivers for exploring new approaches to verification strategies and technologies. With the practical application of the systems concept to nuclear nonproliferation scenarios and other, non-nuclear verification fields, it investigates, where greater transparency and confidence could be achieved in pursuit of new national or international nonproliferation and arms reduction efforts. A final discussion looks at how, in the absence of formal government-to-government negotiations, experts can take practical steps to advance the technical development of these concepts.



Springer book cover

The book was made possible thanks to significant input from the European Safeguards Research and Development Association (ESARDA), especially the ESARDA Working Group on Verification Technologies and Methodologies (VTM) and the Institute of Nuclear Materials Management (INMM), particularly the INMM Nonproliferation and Arms Control Technical Division.
Read more:
https://www.springer.com/gp/book/9783030295363

ESARDA Publications Indexing Update

The Editorial Committee and its editors have been very busy in the past few months following the launch of the last Connector issue. Since then we have officially welcomed Joshua Rutkowski, of Sandia National Lab, as co-editor of the Connector Editorial Team, together with Guido Renda and Simone Cagno, of the JRC. On top of assisting us in achieving the highest standard of the content received, Joshua will be helping us connect with our counterparts over the Atlantic, providing us with news and information in due time.

New ESARDA Bulletin cover

14th January was the deadline to receive a confirmation from SCOPUS regarding the indexation of the ESARDA Bulletin. Unfortunately no communication has been received, and after having sent an email we were told that they will be needing more time as the SCOPUS Review Board still has to meet on the matter.
In the meantime, we decided to submit the Bulletin also to other indexing databases: Directory of Open Access Journals (DOAJ), The Web of Science and the Open Academic Journals Index (OAJI).
The DOAJ got back to us stating that the Bulletin cannot be indexed as it is, because one of their criteria is to have an assigned DOI number for each article. We are yet to receive confirmation of the latter two. We are now valuating together with the Publications team at the JRC whether we can start assigning an individual DOI number for each article submitted to the Bulletin.

The next issue of the Bulletin will be released in June this year, when hopefully we will have more news to give you on the matter of indexation.

INMM OSGI Working Group Webinar

On March 12, 2020, the INMM International Safeguards Technical Division’s Open Source and Geospatial Information Working Group (OSGI WG) hosted a web-based Technical Exchange. Nearly two dozen participants, including from the International Atomic Energy Agency, the European Commission’s Joint Research Centre, U.S. DOE national laboratories, private companies, and universities, joined a Skype video teleconference, to share news and developments related to open source and geospatial information, update the OSGI WG on their research, and discuss upcoming events, recent publications, or other potential interests to the group. OSGI WG co-chair Zoe Gastelum (Sandia National Laboratories) discussed the recently launched ESARDA Open Source Data Analytics Challenge. Melissa Hanham (Open Nuclear Network at One Earth Future) introduced the Datayo open source data platform used to help identify, track, understand and address emerging threats. Frank Pabian (consultant on geospatial information analysis) provided an update on the latest DPRK- and Iran-related geospatial analysis research. Joshua Rutkowski (Sandia National Laboratories) invited the group to consider publishing their researching the ESARDA Bulletin and the ESARDA Connector. OSGI WG co-chair Yana Feldman (Lawrence Livermore National Laboratory) shared web resources available for learning and practicing open source analysis skills. The feedback to the event was overwhelmingly positive, and the group looks forward to hosting more technical exchanges in the future. The OSGI WG LinkedIn https://www.linkedin.com/groups/4037205/ page serves as a forum for sharing ideas, resources, and information, about open source data and software, citizen sensors, geospatial information, remote sensing, aerial imagery, and satellite imagery as it applies to International Nuclear Safeguards.

EVENTS

2020
March April
30-3

30th March - 3rd April 2020

19th ESARDA Course

CANCELLED

Joint Research Centre of the European Commission, Ispra (VA), Italy

The JRC announces the 19th ESARDA COURSE on Nuclear Safeguards and Non Proliferation to be held in spring 2020. Organised by the Training, Knowledge Management Working Group. [Read more]

2020
May
4-7

4th - 7th May 2020

42nd ESARDA Annual Meeting

CANCELLED

Luxembourg Congrès, Luxembourg

The 2020 ESARDA Annual Meeting will be held at the Luxembourg Congress Conference Centre, Luxembourg, from 4-7 May 2020. As usual it will be a closed meeting reserved for the ESARDA Steering Committee, Executive Board and Working Groups' members. [Read more]

2020
July
12-16

12th - 16th July 2020

INMM 61st Annual Meeting

Baltimore Marriott Waterfront, Baltimore, Maryland, USA

The INMM is a nonprofit technical organisation with worldwide membership of engineers, scientists, technicians, managers, policymakers, analysts, commercial vendors, educators, and students. [Read more]

INMM
INSTITUTE OF
NUCLEAR MATERIALS
MANAGEMENT

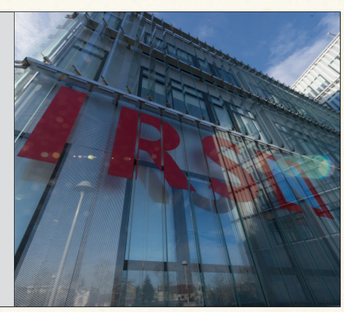
2020
November
16-19

16th - 19th November 2020

42nd ESARDA Annual Meeting

IRSN Head Office, Fontenay-aux-Roses, France

The 2020 ESARDA Annual Meeting will be held at the IRSN head office, 31 avenue de la Division Leclerc 92260 Fontenay-aux-Roses, from 16-19 November 2020. The meeting will be closed to the Steering Committee, Executive Board and Working Group members. [Read more]



2021
August
21-26

21st - 26th August 2021

INMM & ESARDA Joint Annual Meetings

Vienna, Austria

The INMM and ESARDA joint annual meetings provides a unique opportunity for research organisations, safeguards authorities and nuclear plant operators to exchange information on new aspects of international safeguards and non-proliferation, as well as recent developments in nuclear safeguards and non-proliferation related research activities and their implications for the safeguards community. [Read more]

WEBINARS AND ONLINE COURSES

2020
June
24

24th June 2020

Comparison of 16 reactors neutronic performance in closed Th-U and U-Pu cycles

Presenter: Dr. Jiri Krepel, PSI, Switzerland

[Register]

2020
July
29

29th July 2020

Overview of Small Modular Reactor Technology Development

Presenter: Dr. Frederik Reitsma, IAEA, Austria

[Register]

2020
October
28

28th October 2020

Global potential for small and micro reactor systems to provide electricity access

Presenter: Prof. Amy Schweikert, Colorado School of Mines, USA

[Register]

No Date Limitation

Short Course

Nuclear Non-Proliferation and Disarmament

in cooperation with the James Martin Center for Nonproliferation Studies (CNS)

The Vienna Center for Disarmament and Non-Proliferation offers an E-Learning module with "readings, videos and tutorials on topics ranging from the basics of the nuclear fuel cycle to the Nuclear Non-Proliferation Treaty (NPT) and its review process, safeguards, arms control, and regional issues." [Register]

No Date Limitation

Online Course

EU Non-Proliferation and Disarmament E-Learning Course

Course designed by the EU Non-Proliferation Consortium

The course aims to provide a comprehensive knowledge resource for practitioners and scholars interested in arms control, non-proliferation and disarmament, and EU policies in these fields. The course was designed, developed and launched by of 10 March 2014. [Register]

No Date Limitation	Online Course **IAEA** **Learning Management System** The IAEA offer vast online resources, including training courses, covering many different topics, such as nuclear energy, nuclear safety and security, safeguards and verification. Most training courses can be accessed after free registration with a NUCLEUS account. [Register]	IAEA
No Date Limitation	Online Course **Nuclear Non-Proliferation Technical Primer** **The Institute for Science and International Security** The online course focuses on the technical underpinnings of nuclear nonproliferation with a special focus on Iran, North Korea, and trafficking in nuclear commodities. [Register]	ISIS

new partners

New partners have the opportunity to present their organisation's activities and how they can cotribute to ESARDA.

View of the ”courtyard” area in the central campus, KTH Royal Institute of Technology

KTH - Royal Institute of Technology

KTH
Royal Institute of Technology

KTH Royal Institute of Technology in Stockholm has grown to become one of Europe's leading technical and engineering universities, as well as a key centre of intellectual talent and innovation. We are Sweden's largest technical research and learning institution and home to students, researchers and faculty from around the world. Our research and education covers a wide area of natural sciences, all branches of engineering, as well as architecture, industrial management, urban planning, history and philosophy. Research and teaching conducted at the Department of Physics span from fundamental science topics in condensed matter physics, mathematical physics, nuclear, particle, and astroparticle physics to applied areas such as medical imaging, nuclear safeguards and non-proliferation, nuclear security, nuclear power safety, nuclear reactor physics and technology. Hence, research in the Department covers many aspects of the 3S - safeguards, safety, and security – in the technological foundations of nuclear governance.

The nuclear science and energy related research conducted at KTH includes a large diversity of areas such as the development of tools for risk assessment in nuclear power plants, development of radiation detection systems for nuclear safeguards, security and environmental monitoring, design of Gen-IV small modular reactors, development of a supercritical water test loop for thermal hydraulics and heat transfer studies, development of computational methods and tools for coupled simulations based on Monte Carlo methods, and studies of advanced nuclear fuel materials, radiation-tolerant steels and other materials. This provides a dynamic research and teaching environment which includes an international Master's programme in Nuclear Energy Engineering.

Our research in nuclear safeguards and security receives external funding from the Swedish Radiation Safety Autority (SSM) as a national competence center, the Swedish Research Council (VR), and the Swedish Agency for Innovation (Vinnova). The research group, which was started by the Nuclear Physics Division in 2017, currently includes three senior staff members, one PhD student, and two Master´s students. The main objectives of the research activities in nuclear safeguards and security at KTH are to develop new detection techniques and methodologies for improving the systems currently used in spent fuel verification and nuclear security and to come up with new solutions and strategies in these fields. The foundation for this research is laid by the cutting-edge expertise in advanced radiation detection that is associated with the research activities in fundamental nuclear physics within the Division of Nuclear Physics. This applies in particular to detection systems for gamma radiation and fast neutrons developed for studies of exotic atomic nuclei far from the beta-stability line, providing interesting synergies and opportunities for spin-off from the basic research to its applications. As an example, a nuclear security project for development of radiation portal monitors with enhanced sensitivity for detecting and imaging special nuclear materials is currently receiving support from the technology transfer centre KTH Innovation and from Vinnova.

FANC - Federal Agency for Nuclear Control

FANC
federaal agentschap voor nucleaire controle

The Federal Agency for Nuclear Control (FANC) is the nuclear regulatory body in Belgium, responsible for safety, security and safeguards matters. Its mission is to assure adequate protection of the population, the workers and the environment against the hazards of ionising radiation. In this regard, FANC monitors in Belgium the nuclear industry, the industrial and medical uses of ionising radiation, the naturally occurring radiation and the transport and import of radioactive material. FANC also works continuously to improve regulations so that they reflect reality, draws up guidelines and launches regulatory initiatives with the help of national and international expert groups. Indeed, the Belgian Authority is also very active at the international level, and is member, among others, of ESARDA, ENSRA, ENSREG and WENRA.

Operational since 2001, its Board of Directors and the Director General are assigned by the King. It is an independent public institution that reports to the parliament and interacts with the Government via the Minister of Home Affairs. The Belgian nuclear regulatory body has its own budget, which contributes to giving it a large degree of independence and enables the institution to fulfil its responsibilities towards society in an impartial fashion. FANC has 4 departments: Establishments & Waste, Security & Transport, Health & Environment and Support. In addition, it also has a number of staff services that report directly to the Director General. In its daily activities, FANC is supported by Bel V (the Technical Support Organisation) and by the Scientific Council.

Nuclear safeguards matters are dealt with in the Nuclear Security Service within the Security & Transport Department. FANC has always been very active in the safeguards implementation field in Belgium. The safeguards provisions of the Law of 15 April 1994, that describes the FANC's legal duties in the field of radiation protection, nuclear safety, nuclear security, nuclear safeguards and radiological surveillance, ensure the authority's possibility to play a very (pro)active role in this field. In this regard, last years have witnessed very efficient exchanges between FANC, IAEA and Euratom on safeguards matters that led to the implementation of new inspections schemes (including the introduction in Belgium of the unannounced inspections regime) and to the Belgian State Level Approach review. In particular, FANC is currently strongly involved in the discussions relating to the future implementation in Belgium of Remote Data Transmission technologies.

In this perspective, FANC quickly understood the need to contribute to the mission and values of ESARDA. While FANC has always been active within this association, particularly by regularly providing experts to attend and to contribute to the Implementation of Safeguards working group sessions, by taking part in numerous ESARDA annual meetings, and by sending numerous of its experts to the ESARDA course on nuclear safeguards and non-proliferation, the Belgian Agency has only been an official member of the European association since May 2019. The accession of FANC to the status of Party of the association was enacted during the 41st ESARDA symposium organised in the beautiful city of Stresa, in Italy, thus formalising an old efficient partnership.

FANC is deeply convinced of the important role and the added values of ESARDA and is willing to continue to actively contribute to the association's mission.

AFCONE Executive Secretary and ESARDA President signing collaboration agreement during the 2019 Symposium in Stresa, Italy

AFCONE - The African Commission on Nuclear Energy

As part of their efforts to strengthen their security, stability and development, the Parties to the African Nuclear Weapon Free Zone (Pelindaba Treaty, of which the African Union Commission (AUC) is the Depositary) undertake to promote individually and collectively the use of nuclear science and technology for economic and social development. The Treaty also requires maintaining the highest standards of physical protection of nuclear material, facilities and equipment, which are to be used exclusively for peaceful purposes. To this end, the 41 Parties to the Treaty undertake to establish and strengthen mechanisms for cooperation at the bilateral, sub regional and regional levels. The Treaty requires all parties to apply full-scope International Atomic Energy Agency safeguards to all their peaceful nuclear activities.

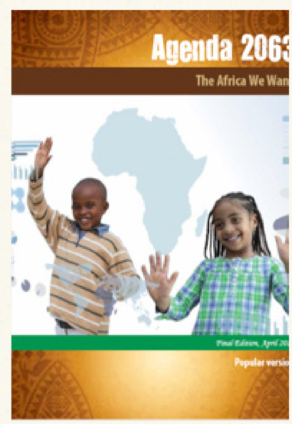
For the purpose of ensuring compliance with their undertakings under this Treaty, the Parties agreed to establish the African Commission on Nuclear Energy (AFCONE). AFCONE, as the African Nuclear-Weapon-Free-Zone Treaty Body, is the AU Specialised Agency for nuclear activities on the continent. The AFCONE Strategy adopted by the 4th Conference of States Parties in 2018 focus its attention on: the most pressing needs of the States Parties, capacity building in Africa, full use of the infrastructure already available in Africa, optimal synergy and maximum cooperation with all regional and international partners.

AFCONE works to promote and enhance the peaceful application of nuclear science and technology for socio-economic development, and to foster regional and international cooperation in peaceful applications as well as nuclear disarmament and non-proliferation. In 2019, AFCONE implemented several activities including developing strategic plans, building capacity in safeguards and contributing to the regional efforts towards promoting peaceful and safe uses of nuclear energy and global non-proliferation and disarmament agenda.

AFCONE formalised, through Practical Agreements (PAs) and Memorandums of Understanding (MoUs), its cooperation and partnership programmes with several international and regional Organisations. These include the International Atomic Energy Agency (IAEA), the European Safeguards Research and Development Association (ESARDA) and the International Science and Technology Center (ISTC).

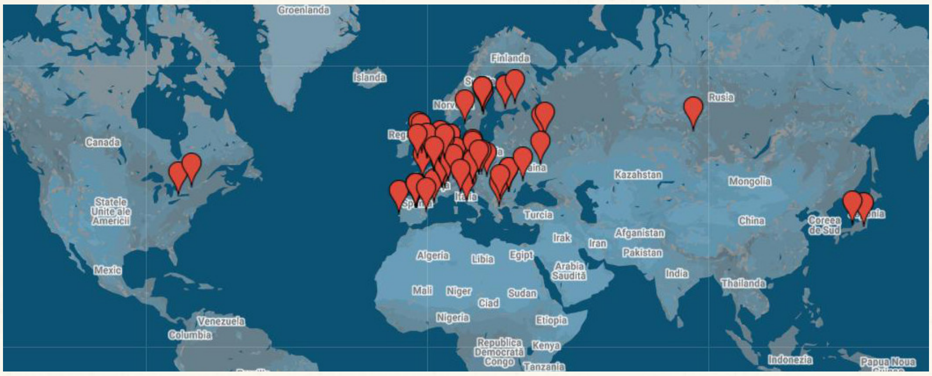
AFCONE and ESARDA decided to collaborate mainly in Research and Development, training on safeguards, joint organisation of conferences, symposia, courses, workshops, exhibitions. AFCONE will also explore the feasibility & cost-effectiveness of creating an arrangement modelled on "EURATOM" for Cooperation, Regulation and Control in Africa. Cooperation Agreements will be signed soon with several African Union Strategic Partners, including Russia, India and China. Additional consultations will be continued in 2020 with the other AU Strategic Partners: European Union, United States of America, Japan, Korea, Turkey.

Additional MoUs are currently under advanced discussions with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the Regional Agreement AFRA & the African Regulators Forum "FNRBA".



In the face of the challenges met, and based on the findings of the MDGs achievements and remaining gaps in the region, as described in the AU "Common African Position (CAP) on the post-2015 Development Agenda", AFCONE, AFRA and FNRBA have decided, with the full support of the IAEA and other Development Partners, to address collectively the most pressing needs and to overcome the persistent challenges which are still hindering the impact of Nuclear Science & Technology in the region.

In order to foster the cooperation and strengthen the coordination with the other Nuclear Weapon Free Zones, AFCONE is currently consulting OPANAL (Treaty of Tlatelolco Agency) and Kazakhstan (Chair/Treaty of Semipalatinsk) for the Signature of Memorandum of Cooperation.
(https://www.afcone.org)



ENEN Members and Partners

ENEN - European Nuclear Education Network

The European Nuclear Education Network, (ENEN) is an in ternational nonprofit organization (aisbl) established in 2018 under the Belgian law. The main purpose of the ENEN Association is the preservation and the further development of expertise in the nuclear fields by higher education and training in Europe.
After September 28th 2018, European Nuclear Education Network aisbl absorbed the activities of the Réseau Européen pour l'Enseignement des Sciences Nucléaires – ENEN, taking place at the same time the conclusion of the activity of the latest. Réseau Européen pour l'Enseignement des Sciences Nucléaires, the former ENEN was established on 22 September 2003 under the French Law.

ENEN's main objective is the preservation and the further development of expertise in the nuclear fields through higher education and training. This objective is realized through the co-operation between universities, research organizations, regulatory bodies, the industry and any other organizations involved in the application of nuclear science and ionizing radiation

Today, ENEN has 79 Members and Partners from 25 countries, consisting of a wide range of types of entities: 5 Research Centers, 9 Companies, 55 Universities, 1 TSO and 9 international institutions.

In 2020, ENEN added to its team new members and following the General Assembly elections Prof. Joerg Starflinger, University of Stuttgart, Germany was chosen to follow Prof. Leon Cizelj, Josef Stefan Institute, Slovenia as President of ENEN after a period of more than 4 years.

Currently, ENEN is leading two EC funded projects, ENEN+(ongoing) and TOUR (starting in Autumn 2020 and it is member in six other projects:

SaTE -
(Safeguards Education and Training);

ARIEL -
(Availability and use of nuclear data Research Infrastructures for Education and Learning);

MEET-CINCH
(A Modular European Education and Training Concept In Nuclear and RadioCHemistry);

A-CINCH
(Augmented Cooperation IN education and training in nuclear and radioCHemistry);

ECC_SMART
(Joint European Canadian Chinese development of Small Modular Reactor Technology)

GRE@T PIONEer
(Graduate education alliance for teaching the physics and safety of nuclear reactors).

In 2017 the ENEN+ project was launched with the aim of reviving the interest of the young generations to the nuclear sector. It established a mobility fund of about 1.000.000 EUR that financed the career in nuclear of about 600 people. Several actions were developed to attract the youngsters, mobility funds were offered to students and researchers to support their education and training activities and also important support was offered to professionals in helping to retain them in the nuclear area.
In 2019 the four year long SaTE project started, a project dedicated to implementation of several actions in the Safeguards field to the third countries. The project must set up education and training short courses for people residing outside European Union and offers them financial support to participate in those courses. The main activity of the project consists in developing a Master Program in Safeguards that should be offered by an accredited European University. At the end of the program the attendee can obtain an EU recognized diploma following the standards and quality of higher-education qualifications imposed by the Bologna Process in Europe. The program is open to EU students and it offers financial support to students coming from third countries. ENEN is targeting to involve as many specialists as possible for the development and implementation of the actions.

left to right: J. Starflinger (ENEN President), F.S. Ortiz (Project Manager & Finance Coordinator), Shaminder (Projects and Administrative Controller), G. Pavel (Executive Director), L. Cizelj (former ENEN President)

working group reports

This section of the Connector has the objective to inform the ESARDA Community about the latest undertaking of the Working Groups' activities during the last six months. Each Working Group Chair has been invited to provide a brief article describing their findings in their fields of interest.

CONTAINMENT & SURVEILLANCE WORKING GROUP (C/S)

by Katharina Aymanns
(C/S Working Group Chair)

At the end of last year, the second C/S WG meeting in 2019 took place on the 4th December at the JRC Ispra attended by eighteen colleagues. On this occasion, Ms. Heidi Smartt, expert for safeguards technologies at the Sandia National Laboratories (SNL), was elected as new co-chair of the group. Further Ms. Katharina Aymanns, safeguards coordinator at the Research Centre Jülich (FZJ), took over the chair from Mr. Juha Pekkarinen (Euratom DG ENER-E).

The WG's mission is to provide the safeguards community with expert advice on containment and surveillance (C/S) instruments and methods as well as acting as a forum for exchange of information of these. In this context, the following topics were addressed and discussed during this meeting:

NGSR video review and VideoZoom development

As a follow up to the presentation at the C/S WG meeting held in Stresa in May 2019 the New Generation Surveillance Review (NGSR) software was presented and it`s functionalities explained. The NGSR software is a joint IAEA/EC review software for NGSS and DCM-14 image data. Foreseen to replace the General Advanced Review Stations (GARS) software the NGSR undergoes currently testing.

Colleagues from the JRC are developing the video summarization VideoZoom for safeguards reviews. VideoZoom detects scene changes overall an image plane. During the image review, the sequence of summaries are presented on screen like a storyboard.

Video summarization of VideoZoom

The key feature of VideoZoom is its ability to preview scene changes for the inspector to decide what to look at and what to skip as well as to show potential events of interest outside Areas of Interest. The software undergoes currently testing by Euratom and IAEA. Plans are to integrate VideoZoom into NGSR to give more review options to the inspector.

Concept on new safeguards techniques for SFSF

A joint project to investigate new safeguards techniques for dry spent fuel storage facilities was established between IAEA, Euratom DG ENER-E and Germany. The projects goal is to develop a toolbox for more efficient safeguards techniques including re-verification methods for dry storage casks. Candidate technologies currently under discussion are laser based systems, Ultra Optical Sealing Bolts (UOSB) as well as muon tomography and fast neutron imaging for re-verification of spent fuel casks. In a next step, field trials in German spent fuel storage facilities are planned to explore the potential techniques.

Dry storage casks

C/S within a Geological Repository:

The progress and current status at the Olkiluoto site was presented. The Encapsulation Plant is under construction therefore, the Safeguards-by-Design process is ongoing. The commissioning of the repository is foreseen in 2024 -2025. Beforehand it´s planned to build a test tunnel to carry out cold tests. The needed safeguards equipment for monitoring the repository is partly still under discussion.

In addition, the group had the opportunity to visit the Advanced Safeguards Measurement, Monitoring and Modelling Laboratory (AS3ML) and to discuss new and current developments such as a COTS surveillance camera prototype, the 3-D laser system, the multi-seal reader and the Ultrasonic Optical Sealing Bolt (UOSB) with colleagues from JRC.

IMPLEMENTATION OF SAFEGUARDS WORKING GROUP (IS)

by Walid M'Rad Dali
(IS Working Group Chair) and
Marko Hämäläinen
(IS Working Group Vice-Chair)

The Implementation of Safeguards group (IS WG) is a horizontal issues working group of ESARDA. Its objective is to provide to the Safeguards Community proposals and expert advice on the implementation of safeguards concepts, methodologies and approaches aiming at enhancing the effectiveness and efficiency of safeguards on all levels. This WG is also a forum for exchange of information and experiences on safeguards implementation.

IS WG organizes at least twice a year two full days meetings. This year, the group was supposed to meet on the margins of the 42nd ESARDA annual meeting that was originally intended to be held in Luxembourg from 4 May 2020 to 7 May 2020. Unfortunately, the meeting was cancelled due to the COVID-19 pandemic.

The last meeting of the WG was hosted by the Hungarian nuclear regulatory body (the HAEA) in Budapest on 19 and 20 November 2019. More than thirty people took actively part to the discussions and work sessions, including to the discussions relating to the two following main themes addressed thoroughly by the group since 2019:

Inspection regime in "ESARDA countries": The goal for this theme would be to present and to share with the safeguards community information on the different safeguards inspections models that exist throughout the world (mainly Europe) and to underline the most important existing trends in the different safeguards inspections regimes. The group has finalized a questionnaire that will be sent soon to the nuclear regulatory bodies of numerous countries.

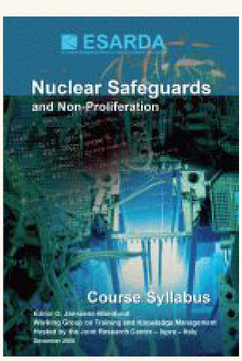
Safeguards by Design in "ESARDA countries": The goal for this theme would be to present and to share with the safeguards community information on the different way SBD concepts and principles are considered and applied throughout the world (mainly Europe) and to underline the most important existing trends in the different countries.

The group is currently finalizing a questionnaire to the attention of nuclear regulatory bodies of numerous countries. The output of these works will be one or multiple papers on the underlined trends and on the main observations. The 2021 ESARDA/INMM symposium could be seen as an opportunity to provide a good visibility to the output of these works.

This meeting was also the opportunity to discuss on the feedback of the Reflection Group 2017-2019, and of the successful World Café organized during the last ESARDA Symposium held in Stresa. IS WG is clearly willing to raise awareness on the need to implement the identified actions.

The next meeting will be planned as soon as practicable taking into account though the current pandemic. IS WG will also seek an opportunity to hold a joint meeting with other ESARDA WGs on the nuclear waste safeguards topic, especially considering the content of Policy Paper 14 and its potential consequences in terms of safeguards verifications activities applied on the nuclear wastes.

Finally, IS WG is coordinating, at the demand of the Executive Board and the Training and Knowledge Management working group, the drafting process of a new State Level Concept chapter for the next edition of the ESARDA Syllabus currently under revision. This drafting process, conducted in collaboration with the TKM WG, has been launched very recently.



ESARDA Course Syllabus cover

VERIFICATION TECHNOLOGIES AND METHODOLOGIES WORKING GROUP (VTM)

by Keir Allen
(VTM Working Group Chair) and
Zoe Gastelum
(VTM Working Group Vice-Chair)

On December 5, 2019, the ESARDA Verification Technologies and Methodologies (VTM) working group held a day-long technical meeting, focusing on the topic of data analytics research and development among working group participant organizations. The meeting focused on three major themes: data and systems, visualization and machine learning, and a data analytics challenge. The working group meeting included 26 participants from 13 different institutions. It also included updates about recent and upcoming ESARDA activities including notices of the recent World Café report now available via the ESARDA website, the new ESARDA Connector newsletter, plans for the ESARDA annual meeting in Luxembourg in May (now postponed), and a new ESARDA working group of final disposal which had its first meeting in February 2020.

Presentations in the area of data and systems included:

Olli Okko (STUK) on Geological Data. There are multiple data streams available relevant to geological repository data, such as rock mechanics, hydrology, and water chemistry. Several have direct relevance to the safeguards mission, and should be considered how, and at what timeframe, they might be used.

Zoe Gastelum (SNL) on Human-data Interactions. Data analytics systems require that human users interpret the outputs from new algorithms, some of which will include errors. New research is evaluating how users respond to errors to better understand which types of models or systems need the best performance.

Ian Stewart (KCL) on Nonproliferation Use Cases for Machine Learning. The large datasets required for machine learning can pose a challenge and need to consider analyst workflows. New research is using semantic webs to classify text documents, and transfer learning can be used with only a small number (17 to 292) of labeled images relevant for the domain.

Presentations on the topics of visualization and machine learning included:

Rita Borgo (KCL) on Data Visualization and Data Analytics. Nonproliferation scenarios require integration of multiple sources of information, including human expertise. Gamification is being used to create scenarios and challenge solutions relevant to the IPNDV exercises.

Cristina Versino (JRC) on the Dark Side of Information Visualization. Charts can be misleading due to poor design, incorrect data, showing too much or too little data, concealing or confusing uncertainty, suggesting misleading patterns, or pandering to expectations or prejudice. Most data visualization for IAEA safeguards is being done in Claude Norman's group, which consists of statisticians.

Ross Peel (KCL) on Ontologies for Nuclear Non-proliferation. Ontologies can be used to structure how data is stored for deep learning, based on structured relationships that are more complex than traditional hierarchies. Ontologies for nuclear nonproliferation should incorporate information across multiple modalities (e.g., trade information, news, technical publications) across the fuel cycle as well as the broader nonproliferation landscape.

Riccardo Rossa (SCK-CEN) on Machine Learning in the Framework of Spent Fuel Verification. Machine learning research for SNF verification is using databases that include simulated and real measurements, including potential diversion scenarios. Training with subject matter expert-informed data stratification increases model performance.

Sophie Grape (UU) on Machine Learning for Applied Nuclear Physics. Simulated gamma radiation measurements were used to create a Pressurized Water Reactor fuel library, which was used to train a machine learning model for burn-up predictions and cooling times. Using only gamma measurements proved difficult to predict for long-cooled fuels, but the addition of neutron signatures increased performance.

Erik Wolfart (JRC) on Machine Learning and Robotics for Safeguards. Commercially available technologies such as autonomous robots, indoor drones programmed to follow a route, virtual and augmented reality, and tracking and localization all have potential relevance for safeguards applications. Current research is exploring how to use 3D mapping of a facility to help inspectors determine their location and direction they are facing.

The VTM working group meeting concluded with a brain storming session on the development of a data analytics challenge that would allow ESARDA participants to work on a consolidated group of datasets but apply their own unique methods or approaches and share results with the community. More information on the data analytics challenge is published in a stand-alone article in this issue of the Connector.

EXPORT CONTOL WORKING GROUP (EXP)

by Christos Charatsis
(Export Control Working Group Chair)

The 12th meeting of the ESARDA Export Control Working Group (EXP-WG) was held in Ispra, on 4 December 2019. This was the second meeting in 2019. A diverse audience of more than 25 practitioners from nuclear regulators to non-proliferation academics, from nuclear service providers to export control experts participated in the discussion centred on the usefulness of export control data and systematic approaches for implementing risk-based trade controls and targeted capacity building activities.

More particularly, the following topics were addressed 1) Methodologies for assessing trade control systems and prioritising capacity building efforts; 2) Data management to the benefit of both safeguards and trade controls implementation and 3) Data mining examples for Customs targeting and profiling.
The meeting provided also an opportunity to consider options for future research initiatives to be taken in the framework of the ESARDA EXP-WG. An official communication report summarising the different interventions and exchanges was circulated among the ESARDA community.

The 13th ESARDA EXP-WG will be organised on the occasion of the 42nd ESARDA Annual Meeting, in the fall of 2020.

TRAINING AND KNOWELEDGE MANAGEMENT WORKING GROUP (TKM)

by Kamel Abbas
(TKM Working Group Chair)

The ESARDA Course, an international course in nuclear safeguards and non-proliferation.

Over the last 15 years, the ESARDA course has been taking place in Ispra (Italy) and is open to an audience of an average of 50 participants, including students and young professionals. The course aims at complementing not only nuclear engineering studies by including nuclear safeguards and non-proliferation in the academic curriculum in Europe, but also to contribute to efforts of international and regional organisations such as IAEA, JAEA to enhance and harmonise safeguards and non-proliferation approaches.

Due to the Covid-19 pandemic, the ESARDA Course 2020, which was planned to be held in Ispra from 30 March – 3 April was cancelled.

ESARDA Course outreach programme.

Two Outreach ESARDA courses were successfully organised in South Africa for 13 countries of the Southern Africa region in February 2018 and in Algeria for 9 countries of the Northern Africa and Sahel regions. A second edition of the Outreach ESARDA course was planned in Cape Town (South Africa) from 9-13 March, 2020 but was cancelled in extremis due to the Covid 19 pandemic.

Partnership enhancement of ESARDA with the European Nuclear Education Network Association (ENEN).

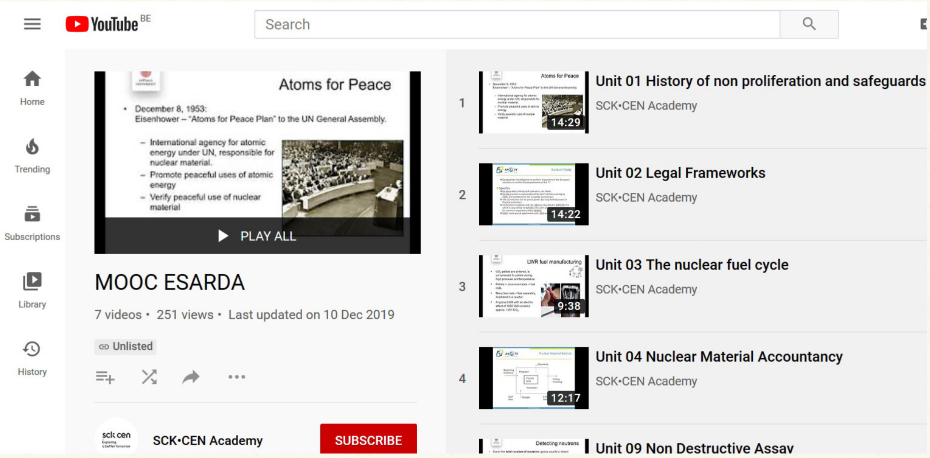
Multiple actions have been undertaken to build a collaboration platform in the Education and Training field between ESARDA and ENEN. As a result, a project funded by DG DEVCO was set with ENEN to assess the development of a master programme in nuclear safeguards and non-proliferation to overcome the lack of this discipline in the academic curricula.

Preparation of a new edition of the ESARDA Course syllabus.

The status on the preparation of the new edition of the ESARDA course syllabus is presented in all ESARDA TKM and Executive Board Meetings. The last update was given in the ESARDA TKM WG meeting in December 2019 and in the Executive Board hosted by SCK-CEN in Mol, Belgium, on 4-5 February, 2020.

The new edition will contain 14 updated chapters (from the previous edition) and 7 new chapters.

The new edition of the ESARDA Course syllabus will be finalised for formatting and editing as the soon as the two missing chapters,



ESARDA Course Outreach Programme screengrab from YouTube namely “SLC/A” and “CS”, are delivered to TKM.

Summary of the December 2019 TKM WG Meeting

The last TKM meeting was held in Ispra on 6 December 2019 and attended by 10 participants. The meeting was structured in 5 items. The first part was dedicated to the tour de table then to the welcome of Prof. Matteo Gerlini (University of Rome) and Gabriel Pavel (ENEN) for their first participation. The ESARDA President (Willem Janssens) discussed the successful ESARDA Symposium (Stresa, March 2019) and gave an overview on the ESARDA World Café initiative that serves the implementation of the ESARDA Reflection Group 2019 (RG2019) ten priority actions.

The second part of the meeting was dedicated to the Safeguards project funded by DEVCO and to be implemented by ENEN. Mr. Gabriel Pavel presented the main tasks of the projects as well as the major implementation steps.
In the third part of the meeting, Riccardo Rossa presented the ESARDA contributions in terms of trainings in safeguards, organisation of thematic workshops and promotion of safeguards via the Massive Open On-line Course (MOOC). Riccardo Rossa is in charge of the coordination of MOOCs and has indicated that unfortunately seven contributions have not been delivered yet. Available MOOCs are posted on the YouTube SCK CEN Academy.

The fourth part of the meeting was dedicated to a short presentation on the ESARDA Course 2019 held in April with a participation of 50 students. The 2019 course included for the first time new topics in its programme, namely the State Level Concept (SLC) and Physical Model lectured by IAEA. Also for the first time, an App was adapted and used for the organisation of the course. The results of the ESARDA Course 2019 exam were presented. The very interesting subjects delivered by the students in their essays were underlined.

The last point of the meeting was dedicated to the presentation of the work achieved for the preparation of the new edition of the ESARDA Course Syllabus. The agenda is posted in the ESARDA website.

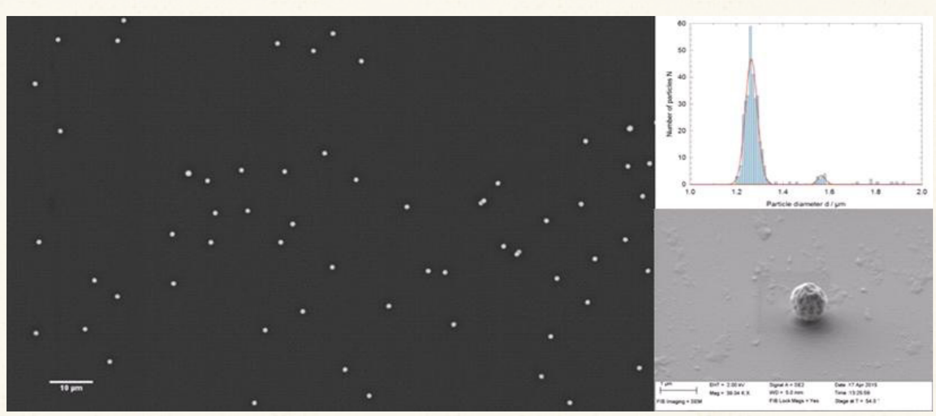
STANDARDS AND TECHNIQUES FOR DESTRUCTIVE ANALYSIS WORKING GROUP (DA)

by Rožle Jakopič
(DA Working Group Chair)

The task of the ESARDA Working Group on Standards and Techniques for Destructive Analysis (WG DA) is to provide the Safeguards Community with an expert advice on reference standards, procedures and analytical techniques for the analysis of a wide range of safeguards samples. In particular, the WG DA increasingly supports activities for the development and improvement of methods for the determination of nuclear signatures in environmental and “special” samples, emphasising the technical convergence of nuclear safeguards, forensics and security.

For verifying the absence of undeclared nuclear materials and activities, measurements of uranium isotope ratios in particles containing uranium collected in environmental swipe samples at nuclear facilities during inspections are performed. These analyses are carried out by Networks of analytical laboratories subjected to rigorous quality management requirements. For this purpose, appropriate certified reference materials (CRMs) and quality control samples at the particle level are required.
The Joint Research Centre (JRC) of the European Commission, Forschungszentrum Jülich (FZJ, Germany) and the Safeguards Analytical Service of the International Atomic Energy Agency (IAEA-SGAS, Austria) joined efforts to produce IRMM-2329P, the first uranium oxide (U3O8) micro-particle reference material certified for major and minor uranium isotope ratios and uranium mass per particle. These micro-meter sized particles were produced using a vibrating orifice aerosol generator (VOAG) from a certified uranium nitrate base solution and characterised by the state-of-the art mass spectrometric techniques. The IRMM-2329P was tested, before being released, for conformity assessment of safeguards laboratories and laboratories in the field through the NUSIMEP-9 inter-laboratory comparison (ILC) programme.

The chair of the WG DA participated in the annual ESARDA Executive Board (EB) meeting (Mol, Belgium) to present the overview of the group’s activities. The EB acknowledged the good work carried out by this working group and the cooperation with the NDA WG on the revision of the International Target Values (ITV) for measurement uncertainties in safeguarding nuclear materials. The WG DA will meet in autumn 2020 (date and place to be confirmed). The discussions will be put forward regarding the implementation of findings of the ESARDA 2019 Reflection Group and actions identified by the participants of the World Café during the 2019 ESARDA Symposium in Stresa.



IRMM-2329P uranium oxide (U3O8) micro-particle reference material

featured articles

This section presents prominent articles on the latest news and topics of interest in the safeguards community

Group picture of the INMM/ESARDA Workshop participants in Tokyo

INMM/ESARDA WORKSHOP TOKYO

by J. Oddou, I. Niemeyer and W. Janssens

The 9th INMM/ESARDA Workshop was entitled "Future Challenges for the Enhancement of International Safeguards and Nuclear Security".

It was the third workshop hosted by the INMM Japan Chapter. Through the presentations made by the Japanese representatives and the IAEA Tokyo Office, it gave the opportunity to all the participants to learn a lot about the challenges and achievements in the Japanese facilities and especially the huge work achieved the decommissioning of Fukushima Daiichi NPP.

Thus decommissioning and waste management were key topics discussed during the workshop together with new technologies and knowledge management retention.

The program was featured 4 working groups, each of them organized by 2 co-chairs:

WG-1: International Safeguards - M. Hori (JAEA) and J. Oddou (CTE)

WG-2: Nuclear Security - Y. Naoi (JAEA) and A. Atkins (DOE)

WG-3: Nonproliferation and Arms Control - K. Naito (JEF) and M. Dreicer (LLNL)

WG-4: Nuclear Knowledge Retention - D. H. Hanks (NRC) and W. Janssens (JRC)

Main topics and questions addressed by WG-1 on International Safeguards

The presenters were asked to look at how technological advancements pose challenges and create opportunities in planning for and implementing international safeguards, especially in the field of:

1) data handling;
2) advanced reactors and new fuel cycles; and
3) facility decommissioning and waste management.

Based on the 19 submitted abstracts the working group was organized in 5 sessions.

Questions addressed during Session 1 were related to data handling and information management and especially how do we make the link between the data sciences and the end user for safeguards purposes. A focused technical session was dedicated to nuclear data needs for safeguards and the possible improvement in nuclear data and measurements uncertainties.

The session 2 focusing on safeguards preparedness for new types of reactors and fuel cycles discussed how the IAEA can meet the challenges of new fuel cycle technologies and the transition from the old to the new approaches.

The session 3 was the one about effective and efficient safeguards for facility decommissioning and long-term waste management and addressed the following questions: How do we define "decommissioned for safeguards purposes"? How to verify this non-accessible spent fuel and waste? How to safeguards retrievable repository?

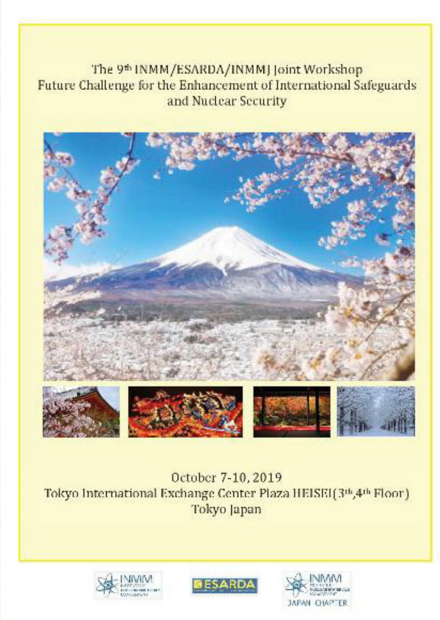
A short final technical session about enhancing communication on international safeguards with new partners and industries tried to identify means to engage new partners and industries and also benefits from safety, security and safeguards interactions.

Other working group sessions related to interactions with safeguards

Many presentations of the WG-2 were also linked to synergies between nuclear security and safeguards.

Some new technologies were presented such as virtual reality tools and how they can be used for Safeguards&Security-by-Design (SSBD). The participants also exchanged about the use of modelling flowsheet and their applications to the field of either security or safeguards. Synergies between safeguards and security were also discussed concerning design for advanced fuel cycles, decommissioning and, as the main area of interface, material control and accountancy.

Many discussions on the importance for establishing, implementing, and sustaining a process hold-up measurement program were held and concurred than it can support both nuclear security and safeguards for bulk processing facilities. The group also identify some institutional difficulties in sharing safeguards and physical protection data due to the confi-



dentiality of related information.

WG-3 explored the common challenges across existing verification regimes, and looked at how to exploit new technical opportunities to improve verification practices in support of future arms control, non proliferation and safeguards treaties and agreements. Five main themes were covered :
Leveraging Existing Regimes for Future Arms Control Verification; Similarities Between Non-proliferation and Arms Control Challenges; Emerging Technologies, Big Data Sets and New Data Processing and Analysis Techniques; Strategic Trade Controls; Inspection Modelling and Planning; Suggestions for Future Directions

A special WG-4 dedicated to Nuclear Knowledge Retention

WG-4 on Nuclear Knowledge Retention for nuclear safeguards and non-proliferation aimed to use the collective know-how of all INMM/ESARDA workshop participants to discuss, establish and start to fill out a reference structure for collecting, storing, accessing and updating knowledge and experience with respect to real, historical, nuclear proliferation verification or "crisis cases". The final aim would be to ensure that this essential knowledge is retained, available for and embraced and practiced by future generations.

The work was split in two parts:
Part 1: Knowledge Retention - approaches, experience, lessons learned, recommendations
Part 2: Develop and test out a Knowledge Retention reference structure based on a real (and closed) proliferation event- the Iraqi case presented by Jacques Baute.
In each phase, several types of knowledge from multiple disciplines were analyzed and collected, i.e. legal (international treaties, national/regional agreements, IAEA mandates etc.), technical (inspection tools, available technologies, safeguards approaches), political (geopolitical situations, geographical influences, culture, history, perceived threats, …).
The WG-4 collectively identified many ways to learn from each other. One presenter described knowledge management as capturing critical information and making the right information available to the right people at the right time. This can be done by multiple ways such as: mentoring, seminars, databases, electronic reading rooms, formal and informal training, interviews, procedures, desk references, communities of practice, websites and portals. The main challenge is how to organise and create the tools for this to be integrated in the operational workflows as the final step before closing a file/an event/a proliferation crisis.

Outcome and next steps

The discussions during the joint workshop allowed exchanges among technology developers, safeguards/security practitioners and policy makers from all over the world in key areas of current and dynamic change.

Based on the conclusions some relevant contributions were identified for the future work of INMM and ESARDA:

Visitors to Fukushima

- Continue to (jointly) visit and promote the application of new technologies, especially continue to raise awareness about distributed ledger technologies (DLT), further DLT-related studies and its potential application for safeguards purposes, as there is no well-established interface between developers and end-users.
- Joint work among a variety of partners, for example through lfuture technical workshops to link different communities
- ESARDA DA and NDA WG to raise awareness about revising nuclear data and measurements uncertainties for safeguards purposes :
- Encourage safeguards users to question the source of the data
- Establish benchmark measurements for safeguards data
- ESARDA and INMM to work on uncertainties in bulk handling facilities (e.g. within the new ESARDA WG on Material Balance Evaluation)
- ESARDA/INMM to allow interaction between peers all over the world
- Joint INMM/ESARDA Annual Meeting in 2021: bridge with other networks/organizations
- ESARDA and INMM to work on safeguarding facilities under decommissioning, repositories and waste management facilities (e.g. within the new ESARDA WG on Final Disposal), can also help in improving terminology of facility decommissioning status and waste measurement technologies for safeguards purposes (including termination of safeguards), where further refinement and understanding is needed.
- Share experience and good practices of spent fuel and waste management: INMM and ESARDA are very useful for this purpose
- Human/brain factor studied: contribution of soft sciences in safeguards/security? How to interact with data and equipment?
- Educating vendors and designers in SSBD

Company image can be an incentive
International market "saleability"
Also to be included in licence requirements
Possibly topic for future ESARDA/VTM and INMM/NAC meetings: creation of a data analytics repository?

IAEA HOSTS EMERGING TECHNOLOGIES WORKSHOP FOR NUCLEAR SAFEGUARDS

Chad C. Haddal
(IAEA, Department of Safeguards)

For international nuclear safeguards, the complex and dynamic global technology environment is fraught with challenges, but also filled with opportunities. To ensure that it remains effective and efficient in its mission, the International Atomic Energy Agency's (IAEA) Department of Safeguards must maintain a current awareness of those new and forthcoming technologies and approaches—including the novel application of existing tools –that could impact its mission.

It is against this backdrop that the IAEA gathered over 100 staff, some 25 external technology experts, and over 40 observers from the Member State Support Programmes (MSSPs) to IAEA Safeguards for its Emerging Technologies Workshop from 27-29 January 2020, held at IAEA headquarters in Vienna, Austria.

Unlike the quadriennial International Safeguards Symposium, the biennial Emerging Technologies Workshop is mainly an internal event for the Department to identify technologies that may affect safeguards or help improve verification effectiveness and/or efficiency. Moreover, it provides an opportunity for the IAEA to engage MSSPs early on forthcoming R&D needs.

The IAEA project team responsible for organizing the event eschewed the conventional technology-centric organization of similar events to create a problem-driven event that featured technologies according to their solution potential for each respective problem.

Through consultations with staff, leadership, and select stakeholders, the project team identified five challenges to anchor the event, focusing on how the Department of Safeguards might:

incorporate artificial intelligence and machine learning advances into safeguards surveillance;

leverage technologies and approaches from industries with analogous challenges to rethink approaches to spent fuel verification;

enhance analysis, interpretation and communication of safeguards data and information;

more fully leverage imagery and multimedia data streams for better detection of undeclared nuclear material and activities; and

adjust safeguards assumptions and acquisition path analysis to account for advances in additive manufacturing.

Participants engaged in facilitated problem solving sessions to identify actionable ideas and solution pathways for consideration. Informing these discussions were presentations on general technology developments, case studies from industries with similar challenges, such as the diamond industry, and the perspectives of additional non-presenting subject matter experts from diverse safeguards-related fields.

Enthusiastic discussion produced dozens of concrete measures for consideration. Of these, several ideas emerged that could prove game-changing for the Department, including partnership-based pilot project ideas on 1) expanding artificial intelligence and distributed ledger technologies capabilities, 2) a digital-first approach to external communications, and 3) leveraging additional open source sensors for more in-depth contextual analysis.

This Spring, the Department will publish a publically available report summarizing the technological updates, group discussions, key takeaways, and actionable ideas that the Workshop produced.

The Workshop results will be used for preparedness efforts within the IAEA. In addition to the pilot projects, Workshop ideas will also inform updates of various strategic planning documents setting out the directions and capabilities required to meet the Department's strategic objectives.

An equally critical outcome of the Emerging Technologies Workshop was the innovative precedent it set for future IAEA events. Engaging with industries with similar challenges allowed the Department to learn from their experiences and perspectives. And by focusing on participant engagement in finding solutions to specific challenges, the Workshop revealed untapped ideas and uncovered new ways of understanding opportunities to enhance safeguards effectiveness and efficiency.

Panel discussion during the workshop

ESARDA'S VERIFICATION TECHNOLOGIES AND METHODOLOGIES WORKING GROUP DATA ANALYTICS CHALLENGE

Zoe N. Gastelum[1], Keir Allen[2]
1) Sandia National Laboratories, Albuquerque, NM, USA
2) Atomic Weapons Establishment, Aldermaston, Reading, UK

In response to an overwhelming call for data analytics to be considered in part of ESARDA's research agenda via the ESARDA 2019 Reflections report, as well as strong interest from the Verification Technologies and Methodologies (VTM) working group members, VTM is developing a data analytics challenge that will be open to working group members as well as the entire ESARDA community. The objectives of the data analytics challenge are two-fold:

Objective 1: Provide a centralized repository of data that can be accessed by all researchers associated with ESARDA who are interested in this area to apply their techniques or algorithms so that we can, as an integrated research community, discuss issues of data cleansing and processing, performance of certain types of analytic activities, and comparisons of different approaches on identical data sets.

Objective 2: Discover opportunities to move the fields of safeguards and nonproliferation forward through novel applications of data analytics techniques.

At the 2019 VTM working group meeting, participants brainstormed regarding topics on which to focus joint research in support of Objective 1. Due to the long timelines associated with acquisition and processing of new datasets, VTM participants discussed data sets that are open and available at the same time, so that data availability would shape the focus area of the challenge.

For our first phase of the data analytics challenge, the group decided to focus on knowledge management of the organization, and for the broader nuclear nonproliferation community. Knowledge management was selected as a topic that should be relevant to ESARDA participants across all ESARDA working groups, home institutions, and research specialties. Specific research foci surrounding knowledge management are still be defined by VTM members, and can also be defined by individuals per their own research interests.

Some preliminary research questions included:

What are the recent and historical trends in research within our community?
How has discussion of certain research topics shifted over the years?
Who are the thought leader institutions and authors in our domain?
How have researchers used common datasets such as gamma spectra libraries in the past, and how have they published their results?

VTM members identified three datasets of interest, for which access is either readily available or deemed within reasonable reach. The datasets are: archives of full text papers from the ESARDA Symposia and ESARDA Bulletin, archives of abstracts and bibliographic information from ESARDA's partner organization the Institute of Nuclear Materials Management (INMM) annual meeting, and a collection of uranium and plutonium reference spectra.

Further planning, including detailed descriptions of the data and how to access them, will occur at the next VTM working group meeting (dates to be determined pending international travel and health restrictions resulting from the covid-19 pandemic).

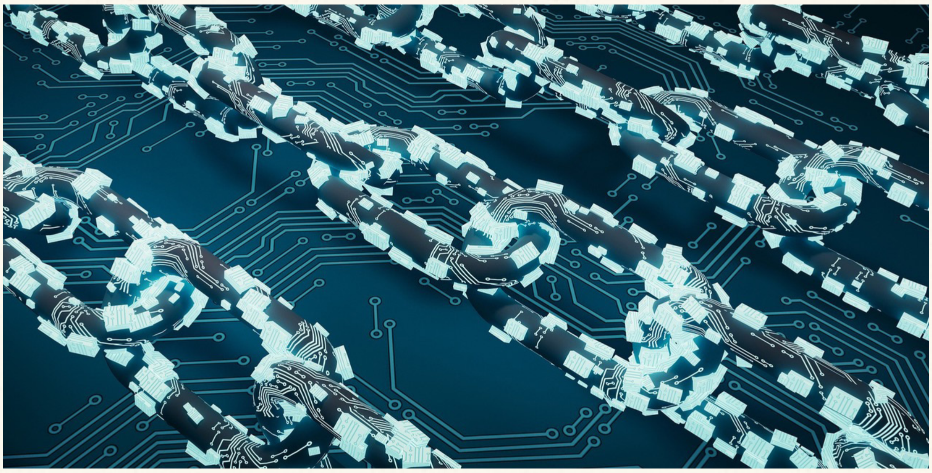
To address Objective 2 of the data analytics challenge, VTM will convene a special session to discuss how we think safeguards and nonproliferation motoring could be enhanced by using data analytics methods, what those methods might be, and how we could access real or proxy data to test our hypotheses.

technical articles

Technical articles covering the latest findings of our community of experts on fundamental issues

BLOCKCHAIN-BASED PUBLIC KEY INFRASTRUCTURE TO STRENGTHEN NUCLEAR SAFEGUARDS

by Roberto Spigolon; Marco Sachy; Stefan Nonneman; Ricardo Neisse; Isabella Maschio; Igor Nai Fovino.
(European Commission
Joint Research Centre
Ispra, Italy)



Abstract

This paper demonstrates for the first time the potential of the application of Blockchain technology for managing a Public Key Infrastructure (PKI) for Nuclear Safeguards process monitoring. Asymmetric cryptography (based on the use of private and public keys) is the basis of a Public Key Infrastructure and is widely used to prove the authenticity of data through digital signatures. In the case of sensors, the output data is signed with the private key of the sensor and everybody can verify with the corresponding public key the authenticity of that data. A certificate signed by a trusted Certificate Authority, or a trusted master list of public keys, guarantees the identity of the sensor associated to the public key. Nevertheless, even trusted processes may be hit by cyberattacks: in fact, malicious actors impersonating authorized personnel, or colluded system administrators, could potentially either issue a new unauthorized certificate or modify an entry in a public key master list to disrupt normal process monitoring operations. We demonstrate here how Blockchain technology can discourage attacks aiming at stealing the identity of devices. The scenario we consider consists of cameras deployed for the surveillance of a nuclear plant. As a first security layer, video frames are digitally signed and the camera's public key is embedded in the transmitted file. A second layer of security, uses a public Blockchain to record the hashes of the cameras' public keys, enabling inspectors to verify the authenticity of both the video and the camera. This second layer, compared to a traditional master list, makes it practically unfeasible for a public key to be added or modified without leaving traces. In this paper we present the experimental results obtained using Bitcoin and Ethereum blockchains. We discuss strengths and limits, and we compare this approach with traditional and log-based PKI approaches. We demonstrate that Blockchain-based PKI can enhance security in Nuclear Safeguards. We conclude that using Blockchain for managing PKI cannot block fraudulent behaviours, but that the attacker cannot avoid leaving traces.

Introduction and use case description

Traditionally, asymmetric cryptography (founded on the use of private and public keys) is the basis of PKI, a digital infrastructure widely used to prove the authenticity of data through digital signatures [1]. In the case of sensors, the output data is signed with the private key of the sensor and everybody can verify with the corresponding public key the authenticity of that data. A certificate signed by a trusted Certificate Authority (CA), or a trusted master list of public keys, guarantees the authenticity of the data and the identity of the sensor associated to the public key.

However, when relaying to trusted third parties or centralized components, the verification process is dependent on the adopted protection measures and the absence of errors. Relevant works show that data entry errors or security breaches perpetrated by malicious actors can affect the integrity of PKI operations [2] [3]. For example, impersonation of authorized personnel or collusion among system administrators are attack vectors for either issuing a new unauthorized digital certificate or modifying an entry in a public key master list. These and other similar actions can disrupt normal process monitoring operations, potentially causing great damages especially in very sensitive domains such as Nuclear Safeguards. We demonstrate here how Blockchain-based PKI approaches can structurally discourage attacks targeting the identity of devices.

Indeed, one major drawback of traditional PKI approaches is the lack of transparency and accountability with respect to the certificates issued by a CA. The standard approach of a CA is to issue certificates upon request of an entity after performing some kind of identity verification. After the certificate is issued, any relying party that considers the CA trusted, accepts the certificate. Within traditional PKI there is no way to verify if a certificate has been issued twice or if the CA has behaved correctly.

In order to address this drawback, Blockchain-based PKI approaches [4] [5] [6] [7] provide auditability and traceability with respect to certificate issuance using a public append-only log (the Blockchain) replicated multiples times and kept resilient to unauthorized modification by the so-called consensus mechanism, making it practically immutable if the majority of the replicas are not owned by a single entity or a consortium. Issuing a new certificate would add a specific log entry to the Blockchain showing who issued the certificate, to whom and when. Doing that it is possible for everyone to check if a CA has issued the same certificate to multiple individuals or entities. Moreover, blockchains can be used to store not only the logs of certificates issued

by particular CAs, but also to implement additional certificate validation rules using smart contract functionalities. For example, a smart contract (also replicated and subject as well to the same consensus mechanism to ensure its integrity) can be defined to automatically monitor the log of certificates and trigger certificate management rules to invalidate potentially rogue certificates.
In this work we take advantage of the potential benefits that Blockchain-based PKI may deliver to improve the security of process monitoring in nuclear safeguards applications. In particular, we considered the real scenario of safeguard cameras deployed for the surveillance of a nuclear plant.
Such devices are already provided with sophisticated cryptographic chips on board and are also equipped with anti-tampering detectors. In case of undue manipulation, they trigger a zeroisation circuit to erase the memory containing the cryptographic keys. In particular, these cameras, as a first level of protection, make wide use of the asymmetric cryptography to ensure the authenticity of the produced videos: in each video stream (where a single stream covers a complete day) they sign every single frame with the camera's DSA private key, and the complete video stream with the camera's RSA private key. When the video stream is transmitted, all the signatures, together with the camera's DSA and RSA public keys, are embedded in the stream. The inspectorate is therefore able to verify the correctness of each signature, using the camera's public keys.

Obviously, this verification can detect if the video stream was tampered during the transmission, but does not say anything on the identity of the camera that created it. Such authentication is currently performed via a centrally managed master list of public keys: whenever a new video is received, the system is able to compare the camera's ID and the received public keys to the ones contained on the master list. A mismatch indicates that something happened to the camera, or that a malicious device is trying to impersonate a legitimate camera.

Nevertheless, relying on centralized components, the current solution is potentially prone to internal and external threats: for example, it doesn't prevent the scenario where an attacker impersonating an authorized sysadmin, or a colluded one, modifies the master list substituting the public keys of a specific camera with those of a malicious device.
To address this issue, we added a second layer of security leveraging on public Blockchain properties. This second layer, compared to a traditional master list, makes unfeasible, also for well-funded attackers, to substitute a public key associated to a sensor without leaving traces of the action performed. This additional feature is obtained thanks to the intrinsic immutability of public blockchains. In the next section, we present the experimental results obtained using Bitcoin [8] and Ethereum [9] blockchains for managing PKI in this domain.

Bitcoin and Ethereum Proof of Concepts (PoC)

Bitcoin-based Proof of Concept

Our first proof of concept is based on the Bitcoin public Blockchain. Within Bitcoin the OP_RETURN operator permits to store 83 bytes (since Bitcoin Core version 0.12.0) of custom data in a single transaction. While this size does not allow to store a complete public key, it is enough to memorize a SHA256 hash. For easiness of development, we put together a utf-8 encoded string formed by an application identifier, the camera's ID (10 bytes), the combined hash of the camera's DSA and RSA public keys (64 bytes in the utf-8 encoding) and separators. Figure 1 shows the data structure.

Whenever a new camera is deployed in the field, the authorized inspector retrieves the camera's public keys, calculates the combined hash and publishes it on the Bitcoin public Blockchain together with the camera's ID. To do so the inspector has to sign the transaction with its own Bitcoin account's private key. Pointers to the generated transaction are sent to a central database within the inspectorate. Four relevant data are therefore stored in a practically immutable way on the Blockchain: the camera ID, the combined hash of its public keys, a pointer to whom generated the transaction (the authorized inspector) and the timestamp of when the transaction was included in the Blockchain. These last two data are automatically recorded by the Blockchain.

Whenever a registered camera transmits a new video stream to the inspectorate its ID and public keys are embedded in the video stream together with all the digital signatures, as described before (step 1). The management software on the inspectorate, relying on a central DB, retrieves the pointers to the transaction where the public keys combined hash was stored (step 2) and, through a local Bitcoin node, retrieve such hash (step 3). In this way the software can verify if the public keys embedded in the received video stream are correct and verify the correctness of all the signatures, thus guaranteeing that a) the video has not been tampered and b) the video comes from an authorized camera. Figure 2 shows the described workflow where the steps 1, 2, and 3 are depicted.

We verified that this approach does not add significant overhead in comparison to a traditional approach based on a centralized master list of public keys. It is important to note, however, that with the Bitcoin approach we are still relying on a centralized component: the DB containing the transaction pointers. Without such a repository, searching directly into the Blockchain for the right information could add a significant overhead to the verification process. This is due to the fact that the Bitcoin Blockchain, as it is currently implemented, does not have any accessory index-like structure that could enable the searching for OP_RETURN information without having to sequentially access the whole Blockchain. One important aspect has nevertheless to be taken into account: even in the case that

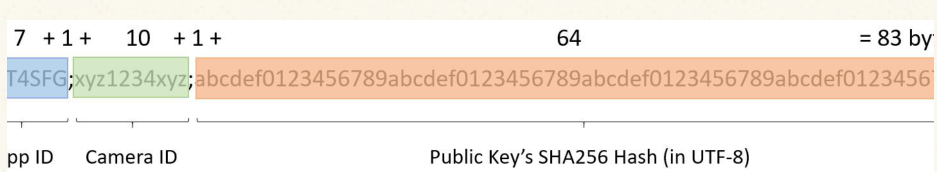


Fig.1 OP_RETURN data format

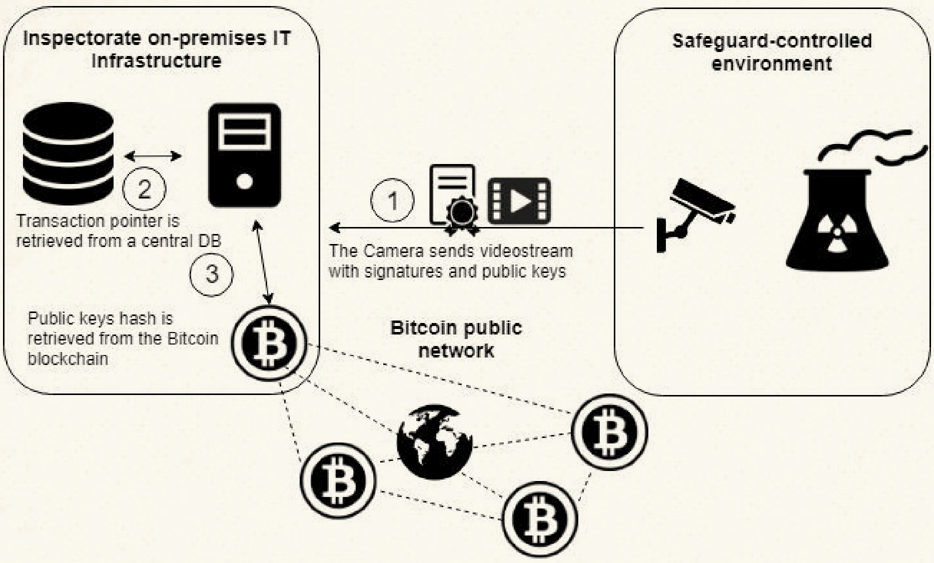


Fig.2 Video stream verification workflow

someone is able to modify a transaction pointer with a new one pointing to a different transaction where the same camera's ID is related to a different public keys hash, two data could still reveal that a manipulation occurred: the Bitcoin account from which the new transaction has been sent and the timestamp. A cross check with information related to authorised maintenance on the camera's site (i.e: time of execution and personnel involved) may reveal if a transaction is suspicious.

Ethereum-based Proof of Concept

The main problem faced in the Bitcoin PoC, namely the difficulties in retrieving information from the Blockchain without pointers, is easily solved in Ethereum thanks to its native support for Smart Contract.

Smart Contracts, briefly described as event-based scripts directly deployed (stored) on the Ethereum Blockchain and executed by every node that participates to the network, provide more flexibility and enable the implementation of several functionalities directly "on the Blockchain", without having to rely on third components. In our PoC, to demonstrate such possibility, we deployed a smart contract containing the following functions:

- authorizeOperator: allowed to be triggered only by the smart contract's creator, this function inserts the specified Ethereum account on the list of approved operators that can register a new camera

- removeAuthorization: the opposite of the authorizeOperator function

- registerNewCamera: the camera's ID and the public keys' combined hash is registered on the smart contract storage. This function can be called only by authorized operators

- getPublicKeyHash: retrieve the public keys' combined hash of the camera whose ID correspond to the requested one.

The camera registration and video verification workflows are quite similar to what already explained for the Bitcoin PoC, with the difference that no centralized component is needed (Figure 3). The "data search" issue is here automatically solved by the smart contract implementation: all the information sent to a smart contract via Ethereum transactions are also stored in the smart contract's internal storage, a reserved area of memory in the Ethereum Virtual Machine (a component of each Ethereum node where the smart contracts are executed) directly accessible by the smart contract. Contrariwise to the "pointers" on the Bitcoin PoC, the smart contract's internal memory cannot be locally manipulated as doing so would break the consensus mechanism of the Ethereum network. Such memory, as the whole smart contract implementation, is indeed replicated on all the network's nodes as a result of the smart contract transactions processed, and a modification on a single node, thanks to the consensus mechanism, would automatically exclude such node from the network because the contract state would become invalid.

Comparing the two PoCs within each other and with the traditional master list approach, we can derive the following results.

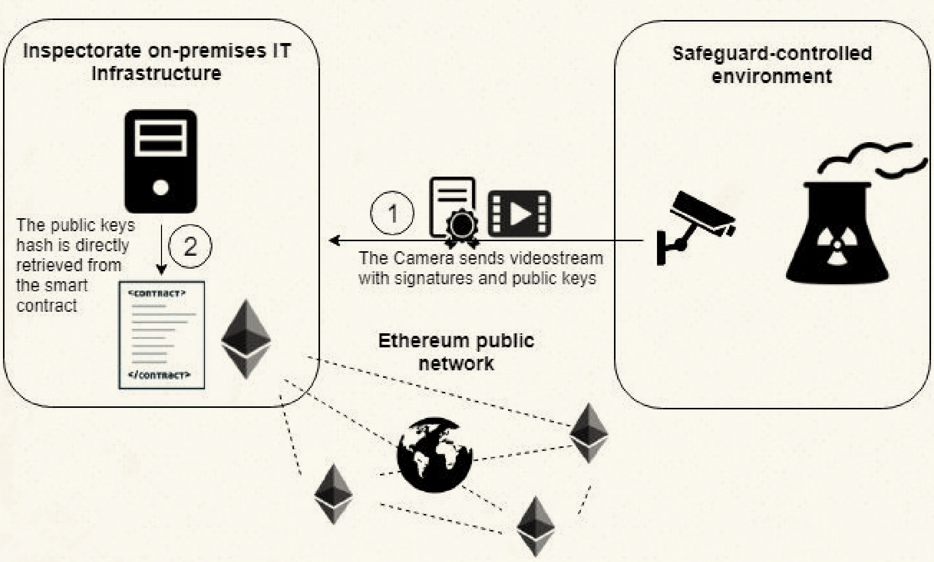


Fig.3 Video stream verification workflow within the Ethereum Proof of Concept

Performance: In terms of computational performance, the Ethereum-based proof of concept is comparable with a traditional master-list approach. This is due to the fact that the smart contract enable the fast retrieval of information, as explained before. With the Bitcoin-based PoC, the same performance can be achieved only using an accessory central database where pointers to the relevant transactions on the Blockchain are stored.

Operational Costs: While we can neglect the setup cost as there is basically no relevant infrastructure needed in both PoCs, we have to consider that registering information on a public Blockchain usually does not come for free: who creates a transaction has to pay a fee to remunerate the work of nodes (i.e. miners) which create new blocks of transactions to be added to the chain. Currently (mid of March 2020), a Bitcoin transaction with an OP_RETURN operator has an average fee of 0,00017 Bitcoin (0,77€). This means that registering each single camera will costs 0,77€. Once the camera is registered, retrieving its information is always free since it's a read only operation. Within Ethereum, the fee calculation for each transaction that invokes a smart contract depends on the computation performed. In our case, we verified that each camera registration has a cost of 0,002 ETH (0,20 €). As with Bitcoin, retrieving information is always free.

Conclusion Remarks

In this work we demonstrated how Blockchain technology can be leveraged to manage a PKI to increase the security for Nuclear Safeguards process monitoring. Considering the real world scenario of safeguards cameras deployed at nuclear plants, we developed two PoCs to analyse how the two most widespread public Blockchain (Bitcoin and Ethereum) can be leveraged to ensure the integrity and authenticity of video streams. The traditional master list approach, currently used, is already able to authenticate a video stream and the relative camera, but it is vulnerable to internal and external threats that could modify the master list deleting all logs of the operation, making such alteration very difficult if not impossible to spot. The public Blockchain approach makes unfeasible to perform such an attack without leaving any trace of it. The Bitcoin PoC however needs to rely on a centralized pointers repository to have acceptable performance, and such component needs to be secured to avoid unauthorized alterations of the pointers. In the case such an attack happens, it is always possible to identify that something has happened analysing the Blockchain. The Ethereum PoC, instead, does not have this vulnerability since it does not need any custom centralized component to guarantee a fast information retrieval. However, two requirements need to be satisfied: the smart contract code shall not contain vulnerabilities, and the "owner" account has to be secured from hijacking. In our future works we will analyse if the same approach can be extended to other sensors in the nuclear safeguards domain like laser scanners and canisters' seals.

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BENEFITS AND DRAWBACKS OF REMOTE MONITORING BY SATELLITE IMAGERY AND WIDE ENVIRONMENTAL SAMPLING.

by David PÉREZ GONZÁLEZ
(RWTH Technical University Aachen, Germany)
(Participant of the 18th ESARDA Course, selected student essay)

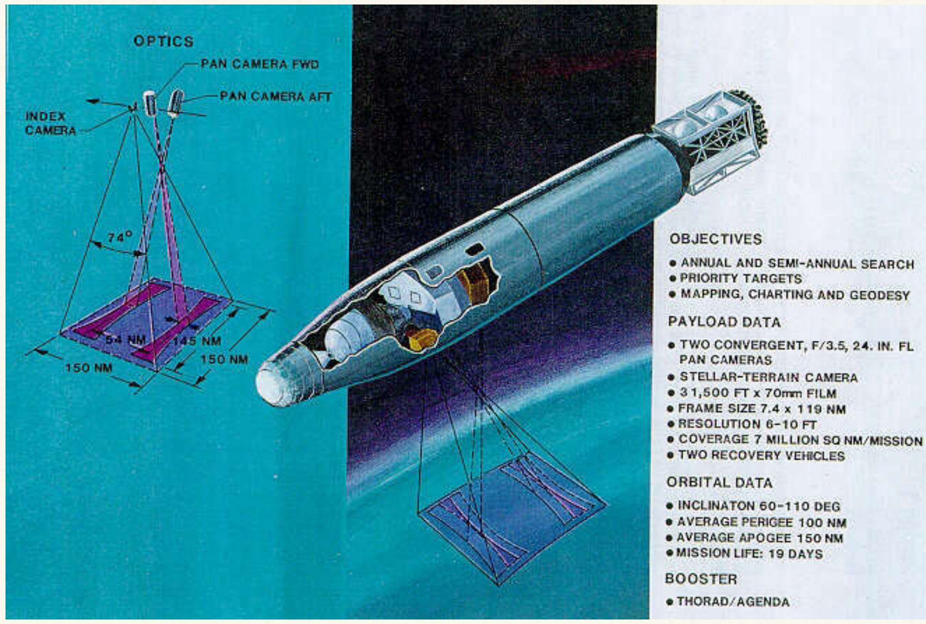


Fig.1 KH-4HB Corona Satellite (source: Wikipedia)

Abstract

Remote monitoring is the process of supervising systems, such as facilities or regions by agents that can be remotely accessed by a management service provider.

Satellite remote sensing technology has revolutionized global change and environmental monitoring research by exponentially expanding our knowledge of the terrestrial environment. The technology provides environmental scientists with quantities of quality information and data that could not be obtained by any other data-gathering methods. The argument for satellite remote sensing technology includes the fact that it collects data in a timely, cheaper, and more efficient way than the conventional one. Satellite data is readily and uniquely suitable to automated analysis in microcomputers. The synergy of advances in both satellite remote sensing and computer technologies, certainly, controls our present approach to environmental research and will, most probably, continue to shape our environmental research direction and agenda in the future. [1]

For wide environmental sampling, the preparation of a sampling plan, goals, strategies, and methods must be considered in conjunction with an understanding of the target environment, including the physical, chemical, and biological variables and processes involved. Existing knowledge of the environment is used to help develop the monitoring plan. [2]

The increase of the demand of both techniques made possible their prompt development. In short term, these techniques have improved their efficiency incredibly. It is well known that their benefits contribute to a better confidence in treaties. However, their drawbacks are also playing an important role on that. It will be discussed those facts that made both techniques suitable or not for verification purposes.

Introduction

Satellite remote sensing systems are useful for collecting information on environmental variables such as climatic and atmospheric radiation and chemistry, ocean dynamics and productivity properties, geographic and topographic locations, and land-biosphere characteristics. Specific information derivable from satellite remote sensing include land use and land cover (including urban infrastructure and vegetation types), land surface temperature, soils, soil moisture, vegetation stress, chlorophyll concentration and plant biomass, sea surface temperature, bathymetry, and ocean biochemistry, color and surface characteristics, atmospheric temperature, humidity, wind speed, precipitation, cloud and aerosol properties; volcanic effects, and snow, sea, and polar ice distribution and thickness, etc. Satellite sensors estimate most of these variables only indirectly and quasi quantitatively, and the processes of interpreting and converting remote sensing signals to actual parameter values are potentially fraught with significant errors. So, here we will discuss the benefits of it and possible issues from those errors. [1]

Environmental sampling (ES) was first introduced as a safeguards-strengthening measure in 1996. It is now in routine use and is a powerful tool for detecting undeclared nuclear material and activities at declared facilities or at undeclared locations. ES involves collecting samples from the environment in order to analyse them for traces of materials that can reveal information about nuclear material handled or activities conducted. The majority of samples collected for safeguards are swipes of equipment surfaces and building structures. Thousands of such samples have been collected during routine inspection and design information visits and during complementary access under additional protocols. A whole new infrastructure has been designed, established and put into operation for ES. Sampling kits have been created and detailed instructions have been developed for sample collection and handling. Tools have also been devised to help with the evaluation of analytical results and a dedicated database records the collection, processing, analysis and evaluation of the samples taken. We go through the benefits that this technique has brought with it to the field of verification and its main drawbacks. [3]

Finally, this work is meant to be mainly a bibliographical study, so the facts included as well as the possible outcome of it are made based on the references found.

Satellite Imagery

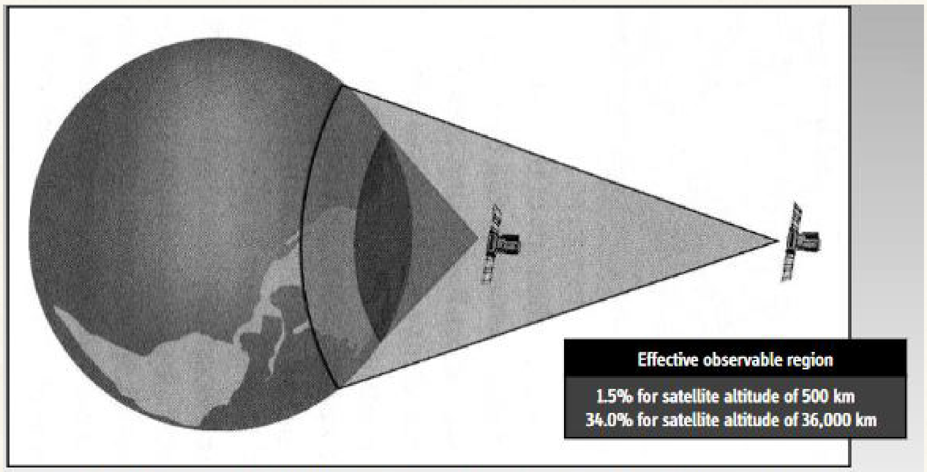
This concept starts to become popular in the last century with the launch of the Sputnik 1 (1957) and later (1959) with the launch of the

CORONA series (Figure 1), known as the first reconnaissance satellite. Additionally, one of the first successful electronic imaging satellites and the one which popularity is as long as its distance with earth is the Hubble Space Telescope (1990).
From then on, the satellite missions have acquired a wide range from communication or navigation until earth observation, or science in general (especially astronomy). However, the most interesting one for the scope of our work is the IMINT (Imagery Intelligence) and other special reconnaissance together with remote sensing.
Nowadays, the total amount of satellites in orbit is about thousands (operative and inoperative). Thanks to that, the variety of uses is huge and the possibilities behind even larger.

2.1 Capabilities

All the satellites have an orbital period time (how long it takes for the satellite to fly around the Earth one single round) related to the altitude mainly, when they are in orbit. For example, for an altitude of around 1000 km the orbital period is about 1 hour and 45 minutes. There are also geostationary satellites (altitude of 36000 km) which orbital period coincides with the Earth. With that possibility, they can focus on one area all the time, but they are minority. With that, one has to take into account the maximum observable ground area from the satellite point of view that it is well explained in the Figure 2:

Nevertheless, to be able to cover such areas, they need to have enough ground resolution of imagery to obtain sensitive information. Also, what we are looking for/with is important, since the wavelength of the information we want to get affects the resolution. For example, when the lens or mirror that the satellite includes is 0.5 m diameter and the satellite is 1000 km, for a wavelength of 550 nm (visible light), the ground resolution is 130 cm. For a satellite at 36000 km from Earth with the same lens, it would be 48 m. When we want to look for thermal infrared imagery (10000 nm), the resolution is approximately 20 times poorer.
As it was said, it always depends on what one wants to look at. In the table from Figure 4, it is shown the ground resolution requirements for various interpretation tasks.
Satellites as a remote monitoring system for Arms-Control-Treaty Verification.
For the scope of this work, we will focus now on the benefits that the satellite imagery has brought to the field of verification, reminding at the end the caveats we need to consider.
It is worth to mention the Vela Satellite Program which was part of the "national technical means" to monitor compliance with the 1963 Limited Test Ban Treaty. This program consisted of satellites which used non-imaging photodiodes to monitor light levels. Thanks to that technology, a nuclear explosion could be detected by the light flash that it produces. This statement was proved by a 19-kt atmospheric nuclear test conducted in Nevada (1952) as we can see in the Figure 5.



Source: D. Wright, L. Grego, and L. Gronlund, *The Physics of Space Security. A Reference Manual*, American Academy of Arts & Sciences, 2005

Fig.2 Maximum observable ground area

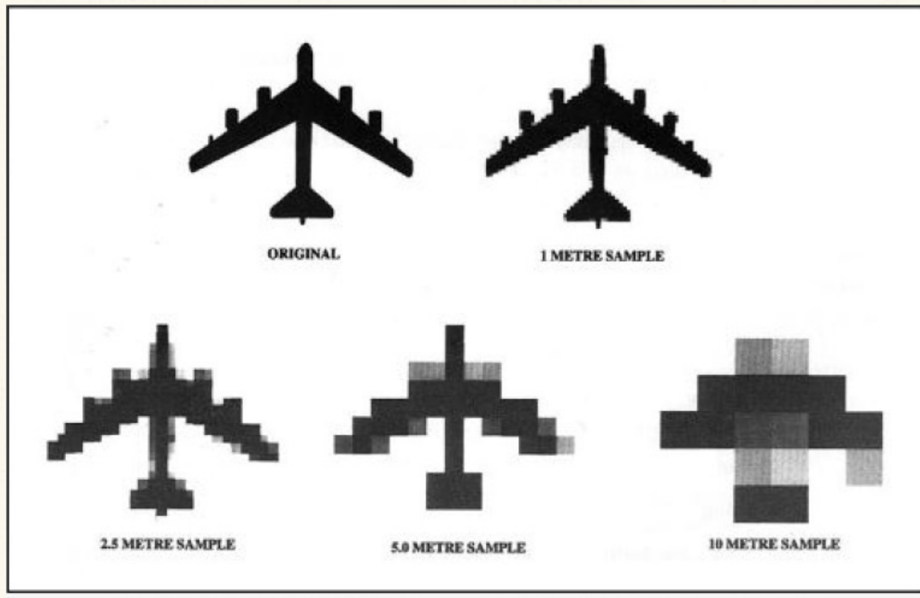
However, this method has good chances of high uncertainties, namely the possibility that a signal appears from an artefact of a meteoroid hitting the satellite and sunlight reflecting off particles ejected as a result of the collision. This was actually what happened (more likely) in the VELA incident where it was thought that a covert test was conducted by some nation, particularly South Africa or Israel.[4]

Despite this incident, the development of the technology for satellite imagery was so large that it was seriously considered as a remote monitoring system of provisions such as deployment of additional missiles and bombers, tests of new strategic weapons or modifications of existing weapon-system into more advanced modifications in the 1972 SALT I Treaty.
At the beginning of this century, more advantages of the satellite imagery were upcoming. Thanks to its commercialization (Google Earth, DigitalGlobe, GeoEye, etc.), they started to become better and better improving the remote monitoring so much that nowadays, whole nuclear facilities can be monitored with an impressive level of detail.
An example of the benefits of it, it is the recognition of the plutonium production chain thanks to the analysis of satellite images of the facilities.

With all this information, is the satellite imagery suitable for Nuclear Safeguards? The answer is clear, all the benefits that satellite imagery can contribute with as a remote monitoring system are more than the possible issues. Some of them are the following: verification of declarations to the IAEA/EURATOM safeguards inspectorates and up-to-date inspection aids (with enough satellites and different orbital period, it is possible to cover any area from Earth within minutes up to hours), operational status of nuclear facilities (especially of nuclear reactors and large enrichment plants of certain types, new possible construction activities and change-detection in facilities or even indirect detection of (clandestine) facilities via detection of passive and active security features typically associated with "strategic assets" (multiple perimeter fences, active defensive systems, etc.).[5]

On the other hand, there are still some issues

that need to be faced. One of them is purely political, bilateral versus multilateral/international monitoring. Many unresolved issues regarding the “appropriate use” of satellite imagery lead to the question: What is considered “sensitive” and what “non-sensitive” data?
Additionally, the risk of uncertainties is still there. Certain regions are really hard to monitor, including the possibility of bad weather with the consequence use of other techniques that are not as precise.



Source: B. Jasani and G. Stein, *Commercial Satellite Imagery. A Tactic in Nuclear Weapon Deterrence*, Springer, 2002

Fig. 3 Satellite image of a B-52 Bomber

Object / Target	Detection	General ID	Precise ID	Description
Urban area	60 m	30 m	3.0 m	3.0 m
Ports and harbors	30 m	15 m	6.0 m	3.0 m
Surfaced submarine	30 m	6 m	1.5 m	0.9 m
Roads	9.0 m	6.0 m	1.8 m	0.6 m
Surface ships	7.5 m	4.5 m	0.6 m	0.3 m
Bridge	6.0 m	4.5 m	1.5 m	0.9 m
Aircraft	4.5 m	1.5 m	0.9 m	0.15 m
Missile sites (SSM, SAM)	3.0 m	1.5 m	0.6 m	0.30 m
Nuclear-Weapon Components	2.4 m	1.5 m	0.3 m	0.03 m
Vehicles	1.5 m	0.6 m	0.3 m	0.05 m

Source: D. Schroeer, *Science, Technology, and the Arms Race*, John Wiley & Sons, 1984
Selected data from a NASA Authorization Hearing before the U.S. Senate Committee on Commerce, Science, and Transportation

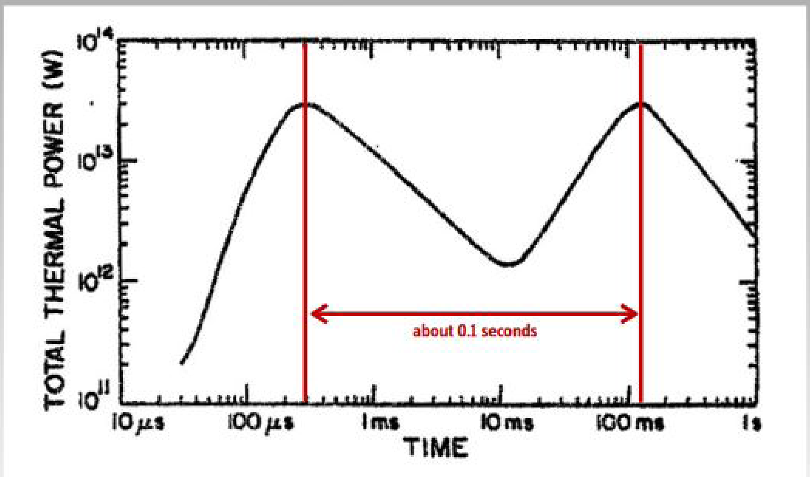
Fig. 4 Ground resolution requirements

Wide Environmental Sampling

The scope of environmental sampling can be illustrated by the following steps: a sampling is planned (“conceived”), a sampling point is identified, the sample is collected (“born”), the sample is transferred to the laboratory and the sample is analyzed. However, many questions arise: where, when or how to take the samples, how many of them, how often and how to preserve. [6]
Many thinks of field sampling as simply going out to the field and getting some material, then bringing it back to a lab for analysis. The choice of where and when is basically based on statistics.
The restrictions from the devices chosen for the sampling can derive in poor statistics. Furthermore, the way the sampling is analyzed determines if we are able to certify a conclusion or if it is not possible to make a statement about it.
For that reason, a lot of new techniques have raised. In the 1950s gravimetric methods were primarily used, although colorimetric and spectroscopic methods were being developed and offered a greater precision. They were followed by wet-chemistry-based methods, but they were still tedious and imprecise. Soon, chromatographic methods were applied to the sampling with gas and high-performance liquids resolving individual components from complex mixtures or quantifying how much of an individual substance is present in the mixed component sample.
Nevertheless, mass spectroscopy in the 80s dramatically enhanced the scope of detection with the possibility of being quite precise.
On the other hand, treaties play an important role on this work since they limit the possible range of solutions for the problems formulated above. If we look closer to the provisions of the Model Protocol Additional to the Agreement(s) Between State(s) and the IAEA for the Application of Safeguards (i.e., the Additional Protocol, INFCIRC/540c), we can see that it foresees environmental sampling of air, water, vegetation, soil, and smears, in order to draw conclusions about the absence of undeclared nuclear activities over wide areas.
The benefit of it is the possibility of acquiring data remotely about areas and objects that are of public domain (or basically if one country does not allow you to make samplings, you may ask the neighbour countries in order to obtain that data).
Setting facilities which main goal is the monitor of environmental sampling does not only help on verification, but to the governments in order to control certain areas in case of natural disaster, accidents or simply the climate change.

Conclusions

In conclusion, both satellite imagery and wide environmental sampling monitoring have the advantage of such small intrusiveness that it is not only of paramount importance for



Light flash produced by a 19-kiloton atmospheric nuclear test conducted in Nevada, 1 May 1952

G. E. Barasch, *Light Flash Produced by an Atmospheric Nuclear Explosion*
Los Alamos Scientific Laboratory, LASL-79-84, November 1979

Fig. 5 Signature of a Nuclear Explosion

nuclear safeguards but also for other verification regimes. The other positive aspect of these technologies is the huge technological future potential and therefore the overwhelming perspectives, namely through improving resolution of multispectral satellite imagery or through improved particle analysis for environmental monitoring. With that, it is clear from the references read that the benefits overcome the drawbacks in both methods.

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Supported by the ESARDA Executive Board

European Commission, Joint Research Centre,
Directorate G - Nuclear Safety and Security
Nuclear Security Unit G.II.7
T.P. 800, I-21027 Ispra (VA), Italy
Tel. +39 0332-786182
EC-ESARDA-CONNECTOR@ec.europa.eu

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Contributions are to be sent to the Editors (EC-ESARDA-CONNECTOR@ec.europa.eu)

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