

# **Lessons learned from the first on-line international course on Nuclear Safeguards and Non-proliferation (ESARDA course) under the pandemic context**

**K. Abbas<sup>1\*</sup>, F. Raiola<sup>2</sup>, R. Rossa<sup>3</sup> and I. Maschio<sup>1</sup>**

<sup>1</sup> European Commission, Joint Research Centre, Nuclear Safety and Security Directorate, Nuclear Security and Safeguards Department, Nuclear Security Unit, Ispra (VA), Italy

<sup>2</sup> NUVIA Italia, Via Fermi, Ispra (VA).

<sup>3</sup> SCK CEN Belgian Nuclear Research Centre, Mol, Belgium

## **Abstract**

Education and training programmes are playing an important role in raising awareness about the international safeguards and non-proliferation framework and in supporting states towards the implementation of their international obligations. The International Atomic Energy Agency (IAEA) together with other organizations such as the US Department of Energy (US DoE), the Japanese Atomic Energy Agency (JAEA) and others are playing a major role in this respect.

The Nuclear Security Unit of the Joint Research Centre (JRC), European Commission, is yearly organising since two decades in Ispra (Italy) a full week course on nuclear safeguards and non-proliferation. The organisation of this course is the contribution of the JRC to the Training and Knowledge Management working group (TKM) of the European Safeguards and Research and Development Association (ESARDA). This so-called ESARDA Course did not take place in 2020 due to the Covid-19 pandemic. The 2021 edition of the course was delivered in April 12<sup>th</sup>-16<sup>th</sup> on-line as the pandemic persisted.

The virtual nature of the course required adjustments with respect to the traditional course delivered in-person in Ispra. Nevertheless, this first on-line edition of the course kept its traditional broad offer with combinations of lectures, group exercises, case studies, lab visits (conducted virtually), quizzes, and exam. This paper reports lessons learned from this first experience of ESARDA course delivered on-line with discussions for future perspectives.

## **Introduction**

Besides its activities on R&D on nuclear security and safeguards, the work programme of the Nuclear Security Unit, of the Joint Research Centre (JRC) of the European Commission (EC) runs an important training program in nuclear security and safeguards. Additionally, JRC support activities of partners EC Directorate Generals (DGs) such as ENER, INTPA (ex DEVCO), TRADE and also of other partner international organizations such as IAEA, DoE, JAEA, etc [1, 2].

Under the nuclear safeguards training programme, the Nuclear Security Unit delivers a large number of training courses for nuclear inspectors of both EURATOM and IAEA, covering many technologies and skills. Moreover, over the last almost two decades, JRC has delivered in close collaboration with the Training and Knowledge Management Working Group (TKM) of the European Safeguards Research and Development Association (ESARDA) a yearly one-week well-established specialized training on nuclear safeguards and non-proliferation, the so-called ESARDA course [3].

This paper reports lessons learned from the first experience of ESARDA course delivered on-line in 2021 under the pandemic context and including ways forwards and perspectives. The virtual nature of the 2021 ESARDA course required some adjustments with respect to the traditional course delivered in presence in Ispra however the course has kept its original broad content offer with combinations of lectures, group exercises, case studies, lab visits (now conducted virtually), quizzes and exam.

## **Education and Training under ESARDA**

Presently ESARDA runs several working groups (WG):

- Destructive Assay (DA)
- Non-Destructive Assay (NDA)
- Containment and Surveillance (C/S)
- Material Balance Evaluation (MBE)
- Final Disposal (FD)
- Implementation of Safeguards (IS)
- Verification Technologies and Methodologies (VTM)
- Export Control (EXP)
- Training and Knowledge Management (TKM)
- Editorial Committee (Ed-Ctee)

The Final Disposal is the most recent WG; it is established in 2020 to consider approaches for management of spent fuel and high-level waste. The TKM WG was created in order to manage and update the knowledge in safeguards and non-proliferation, including education, training and R&D. The main objectives of TKM are to promote nuclear safeguards and non-proliferation education and training, supervise the ESARDA course on nuclear safeguards and non-proliferation and finally to manage the ESARDA portal.

The ESARDA course is yearly organized since 2005. Typically, this course takes place in Ispra (Italy) and is open to audiences of an average of 50 students from all over the world. The ESARDA course in Ispra targets mostly master's degree students, in particular nuclear engineering students, but also young professionals and international relations or law students. It aims at complementing nuclear engineering studies by including nuclear safeguards and non-proliferation in the academic curriculum. The ESARDA Course Syllabus is published as a book, which is distributed to participants of the ESARDA course [4]. The ESARDA course offers the students to take an exam, which includes two parts: an online exam and an essay on a topic linked to nuclear safeguards or non-proliferation. Students who pass the exam receive four ECTS credits (European Credit Transfer and accumulation System) recognized by the European Nuclear Higher Education Network.

The standard ESARDA course covers the following topics:

- Concept of international nuclear safeguards
  - o Non-Proliferation Treaty
  - o Safeguards agreements
  - o Additional protocol
  - o Safeguards conclusions at state level including exercise
- Implementation of international nuclear safeguards
  - o Nuclear fuel cycle and related activities
  - o Measurement of nuclear materials
  - o Containment, surveillance and verification technologies
  - o Environmental sampling, satellite imagery, open-source information
- Controlling sensitive technologies (direct and/or dual-use capabilities)
  - o Export control systems
  - o Implementing trade regulations
- Combating illicit trafficking of radioactive and nuclear materials
  - o Physical protection of RN materials & radioactive source security
  - o Second line of defense (detection), nuclear forensics

Experts from nuclear regulators or operators as well as from the academia and international organization such as IAEA, JAEA, INMM etc. commit themselves as lecturers of the course. The course has shown an increase in quality and contents thanks to its continuous improvements over

the years, taking into consideration the results of the course evaluation by the participants at the end of each course.

Over the last two decades and until 2019, the ESARDA training course was organized in person for master degree students, in particular nuclear engineering students but also to young professionals in nuclear regulations or operations and international relations. This so-called “ESARDA course” aims at complementing not only nuclear engineering study programmes by including nuclear safeguards and non-proliferation in the academic curriculum in Europe but also to contribute to efforts of European and international organizations such as EURATOM, IAEA or JAEA in order to enhance and harmonize safeguards and non-proliferation approaches.

Due to its success, the course was reached-out over several worldwide regions such as Asia and Africa [1], thanks to the financial support of EC DG INTPA. In Africa, two regional courses based on ESARDA course were successfully organized in 2018, the first in Pretoria for South African countries (13 countries) in February 2018 and a second in Algiers for north African and Sahel countries (9 countries) in October 2018. In Asia, two regional courses were organized for South East Asian countries, the first in Bangkok (Thailand) in June 2013 and the second in Kuala Lumpur (Malaysia) in November 2015. A third course for Asia was organized for China, it took place at Tsinghua University in Beijing with about 80 participants from 18 Chinese universities and six private companies in September 2017.

The outreach ESARDA course constituted an important evolution with respect to classical ESARDA course, which is organized in presence in JRC Ispra (Italy).

In 2020 the ESARDA course did not take place due to the Covid-19 pandemic although the preparation work for the course was accomplished.

The 2021 course edition was delivered on-line (April 12-16) as the pandemic persisted. This first experience of course being fully on-line and virtual nature of the 2021 ESARDA course required some adjustments with respect to the traditional course delivered in presence. Nevertheless, this first on-line edition of the ESARDA course 2021 kept its traditional broad offer with combinations of lectures, group exercises, case studies, lab visits (conducted virtually), quizzes and exam. This paper reports this first on-line experience under the pandemic context of the course by presenting its preparation, delivery, lessons learned and way forward. The successful first experience in an on-line organization of the ESARDA course represents a second important evolution of the course. This success is characterized not only from view points of the organization features and content of the course but also for having tripled the audience with respect to those courses organized in person.

## **ESARDA course 2021**

### **Preparation**

The preparation of an ESARDA course begins at least six months ahead the week of the course, which starts by contacting the lecturers for their availabilities, drafting the programme and announcement of the course mainly in the ESARDA portal. Also EU and international partners are invited to draw the course to the attention of their organizations (e.g. EURATOM, IAEA, AFCONE). Then follows the drafting of the course program, which takes into account availabilities of each of the lecturers, the planning of the lab visits ... The first experience of the on-line ESARDA course of 2021 required specific preparation and several points were put for discussion with respect to the traditional in person course. They concern:

- **The content and duration with respect to the course in person**

Can the full and comprehensive topics of course in person be maintained for a full on-line week course? A compromise was found by maintaining all the topics. However, it was requested to limit the lecturers to maximum 30 minutes instead of 45 in order to allow more time for interactions, questions and discussions with the trainees. 23 lectures (live/recorded), 3 group exercises (breakout in 12 groups) and 3 virtual lab visits constituted the content of the course.

- **The IT platform, connectivity stability and security**  
During COVID pandemic, numerous powerful virtual event platforms for organizers, speakers and attendees (such as MS TEAMS, WebEx, Zoom, Skype) were experienced. They all offer features for efficient and effective organization of virtual events such as courses, trainings, or meetings. MS TEAMS was chosen for the on-line ESARDA Course 2021 as it fulfils with more flexibility the requirements of this particular on-line event. The lecturers of the online ESARDA course accepted to provide beforehand their lecture materials not only in written format (PPT/Word) but also as recorded lectures (in PPT or in MP4 formats). The recorded course material was initially foreseen to be used in case of connectivity issue that could happen during a live presentation. But in the end, most of the recorded presentations were used, which limited live interventions of the lecturers. The lecturers were spotted out during their bibliography introduction and at the end of the recorded lecture for questions and answer sessions.
  
- **The audience**  
As mentioned above the course targeted audience of students in nuclear fields and young professionals in nuclear operation, regulations and international relations. The applicants to the course filled-in forms indicating their studies and/or professional background and motivations and submitted them to the JRC NS registration portal. After the examination of their registration files, the selected trainees are first notified for confirmation of their registrations to the course. Then they received the necessary information on the course and more importantly, connectivity procedures and connectivity tests plan to the MS TEAMS Group of the course.
  
- **Organisation of the lab visits, the group exercises, case study and quizzes/exam**  
In addition to the research laboratories, which are visited during the course in person, nuclear decommissioning facilities in JRC Ispra site were virtually organized using novel technologies based on virtual and augmented realities. Three group exercises that include a case study were successfully delivered despite of the extra high participation to the course (185 registrations) thanks to the feature of MS TEAMS software that allows with a couple of clicks to make as many groups as a lecturer requires with also desired group sizes to allow an efficient and independent group work. A group exercise includes three steps:
  - Introduction of the group exercise in a plenary and attribution of tasks to groups
  - Group work in individual virtual rooms where the lecturer can access to ensure an efficient work progress in the group.
  - Finally, all the groups reconvened in a plenary for presentation of their findings and for concluding remarks of the group exercise.

## **Participation**

With respect to the ESARDA Course in presence, the on-line course 2021 tripled its registration. 185 registrations from 55 countries out of four continents; Europe, Africa, America (North and South) and Asia were filed in for the course (see Figures 1 and 2). The participation from Africa to the course (40%) was high and was close to that from Europe. This high African participation is principally due to AFCONE (African Nuclear Energy Commission), which efficiently brought the course to the attention of the African nuclear organizations and universities. In fact, AFCONE and ESARDA has signed recently a closer partnership agreement, which is also in line with the European Commission priority towards Africa.

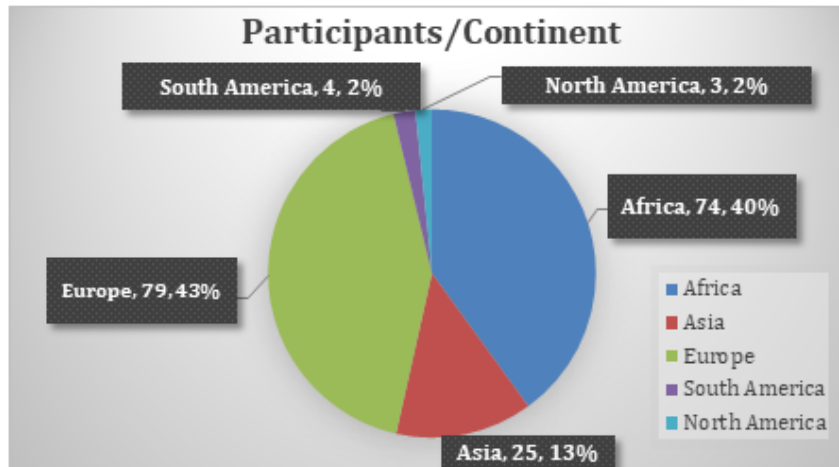


Figure 1: Participation per continent to the first experience of the ESARDA Course being fully on-line (April 12-16, 2021)

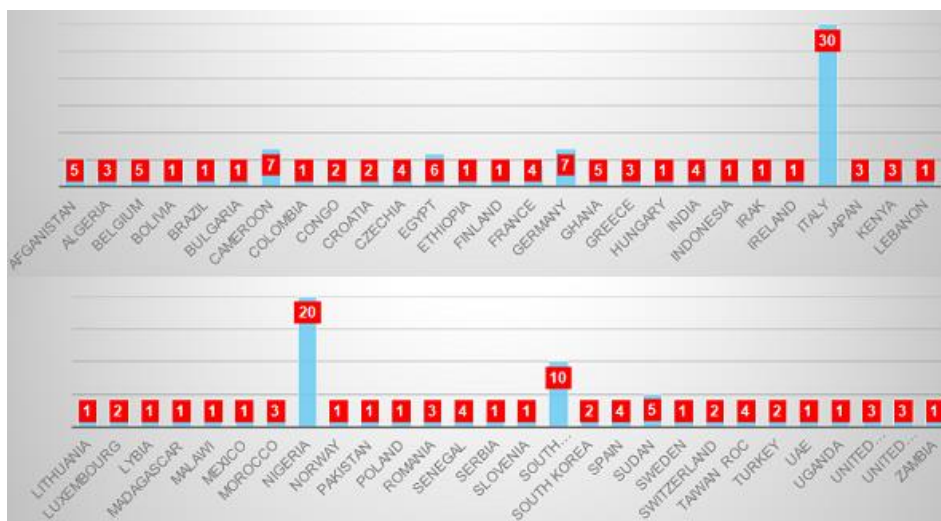


Figure 2: Participation per country to the 1<sup>st</sup> experience of the online ESARDA Course

### Course schedule and exam

As already mentioned, this first experience on an online ESARDA Course kept the full content as in the course in person. The detailed schedule of the course [3] included:

- Opening and closing,
- Lectures, group exercises and case study,
- Virtual lab visits,
- Quizzes,
- and Course evaluation by the participants.

The quizzes were planned every morning covering topics of the previous days, which were posted in the TEAMS group of the course. They are based on online multiple-choices questionnaires (MCQs) made of an average of three questions for each lecture. The filled-in MCQs are evaluated automatically and the correct answers are shared after finishing the quizzes.

A certificate of attendance is delivered to participants who regularly attended a least 75% of the duration of the course. A derogation is made for those participants from regions of time zone out of the range GMT  $\pm$  6. Figure 3 shows a template of such a certificate.

The exam is made of two steps

1 - **Accomplishing successfully the quizzes meaning having a mark of least 50% of correct answers of the 55 questions.** The participants who did not reach this threshold mark were not allowed to continue the exam.

## 2 - Writing an essay on a topic that regards nuclear safeguards and non-proliferation.

Some of topics for essays are suggested to the participants however, a trainee can freely propose any other safeguards topic for approval by the ESARDA Course organizer.

High school and university students who pass successfully the exam receive not only an equivalent to four ECTS credits points (European Credit Transfer and accumulation System) recognized by the European Nuclear Higher Education Network but also a possibility to publish their essays in the periodic scientific journal of ESARDA [5].



Figure 3: The template of the ESARDA Course 2021 attendance certificate

### Virtual Lab visits

In this first experience of the on-line ESARDA Course and in collaboration with the JRC Nuclear Decommissioning unit (Ispra), important efforts were deployed for the exploration of innovative digital technologies to replace as realistically as possible the physical laboratory visits, which are usually organized in the previous ESARDA courses. Such virtual lab visits are an important part of the course from the view point of content from one side and to reduce attention pressure on the participants from a busy whole week on-line course. These virtual lab visits, which were well appreciated by the attendees, were made for research laboratories and facilities in JRC Ispra such as:

- PERLA (Performance laboratory), a Non-Destructive Assay research lab where also some hands-on training for EURATOM safeguards inspector trainings are organized
- AS3ML (Advanced Safeguards Measurement, Monitoring and Modelling Laboratory) for testing and developing innovative and integrated solutions for the implementation of safeguards in the different types of nuclear installations
- SILab (Sealing and Identification Laboratory) for the development, testing and commissioning of security and safeguards systems such as seals and other systems for containment and surveillance. Training on application of seals is delivered in SILab for IAEA/EURATOM safeguards inspectors.
- 3D Laboratory dedicated to R&D and training on laser based identification and verification systems for containment and surveillance for safeguards and security.
- The Scanditronix model Cyclotron (under decommissioning) with the virtual access to the important sections of the facility such as the accelerator vault and the different beam-lines, target systems and control room were made possible.
- A virtual platform developed by the Nuclear Decommissioning unit not only for visits and training but also as a work tool for nuclear decommissioning and waste management.

Figure 4 presents some of screenshots (sequences of MP4 videos) of the virtual lab visit sessions including a sub-group photo of the course attendees.



*A training station in PERLA (Ispra)*



*$\gamma$ -ray spectrometers in PERLA*



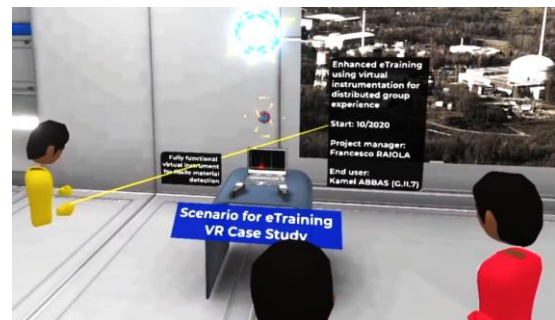
*JRC Cyclotron (cyclotron and bending magnet)*



*Two JRC cyclotron beam lines and target facilities*



*ND Hub; a virtual reality platform for e-learning and e-working in nuclear decommissioning and waste management*



*A virtual training session on  $\gamma$ -ray spectrometry for nuclear material analysis. Two HM5 are visible in a front of the laptop displaying  $\gamma$ -ray spectrometry*



*Virtual visit of the ESSOR research reactor control room (Ispra)*



*A sub-group photo of 49 attendees of the ESARDA Course 2021*

*Figure 4: An overview of some of the virtual lab visits organized in the ESARDA Course 2021*

### **Quizzes and evaluation of the course by the participants**

A quiz file for each day of the course was prepared and submitted to the participants. The quiz was planned for every morning and considered lectures of a previous day. The results of the quizzes are very positive as shown in Table 1, which indicated the high quality of the highly knowledgeable lecturers of the course, who made a tremendous work not only for lecturing but most importantly for the preparation work such as preparing the questions for the quizzes, recording the lectures, being always available for any request from the





ESARDA course organized by EC JRC Nuclear Security unit under ESARDA TKM working group is an example of the yearly achievement of ESARDA in collaboration with EC JRC. The ESARDA Course 2021 presented in this paper continues a big evolution step of the course as it is successfully organized for the first time fully on-line due to the COVID pandemic. The participation of this course has tripled with respect to those organized in person. This course demonstrated that there is a high interest from Africa as seen from its large audience (40%), which is close to that of Europe (43%). This on-line ESARDA course is accessible from all regions of the World thus such kind of course will certainly boost capacity building worldwide to enable states to fulfill their safeguards and non-proliferation obligations.

The success of the ESARDA course 2021 has enhanced our resilience under the pandemic restrictions consequently the sustainability to support international community in the nuclear safeguards and non-proliferation capacity building. The organization of ESARDA Course on-line using available high information and communication technology tools and hardware/software would certainly attract participants from those countries in which travel possibilities are limited or not at all offered. Therefore, regardless the evolution of the COVID pandemic, the option for an on-line organization of the ESARDA course is under discussion. Consequently, future editions of the ESARDA course may lead to on-line or hybrid (in person and on-line) format.

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