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Finnish Support Programme to the IAEA Safeguards

Annual Report 2019

stuk
SÄTEILYTURVAKESKUS
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Contents

SUMMARY

Radiation and Nuclear Safety Authority (STUK) coordinates and implements Finnish Support Programme to the IAEA safeguards (FINSP). FINPS is financed by Ministry for Foreign Affairs of Finland (MFA). MFA and STUK have made an agreement for implementation of FINSP for the term of three years 2019 – 2021. For 2019 MFA reserved funding of 149 000€. Actual expenditures of the Programme in 2019 was 141 366,89 €.

The results of the FINSP are presented in this report. Main goals of the FINSP are the training of the IAEA inspectors and development of the IAEA safeguards methods and concepts. FINSP had two review meetings with the IAEA in 2019. Annual review meeting was held on 26 April and semi-annual review meeting on 22 October, both in Vienna.

The goals of the programme were achieved as planned. At the end of the year 2019 FINSP has 15 active tasks and one stand-by task. Of the active tasks three are practically completed and waiting for administrative decision and/or final report from the IAEA. Two new task proposals were accepted in 2019 and one is pending. Two tasks were completed during 2019.

1 History and introduction

Member States' Support Programmes are essential for the IAEA safeguards. In 1970's Member States agreed that IAEA safeguards shall not have dedicated budget for research and development activities. IAEA has neither specialized training facilities of its own to train new Safeguards inspectors or to field test emerging technical advances. Instead, IAEA will make use of voluntary support by the Member States. To meet this need, the Support Programme Mechanism was created. The first Member States Support Programme (MSSP) was established in 1978 by the United States of America. In Finland, different kinds of NDA verification methods were developed in the beginning of 1980's and measurement campaigns were organised in Loviisa and Olkiluoto nuclear power plants in cooperation with the IAEA. Officially FINPS was established on 31 May 1988.

The objective of FINSP is to provide the IAEA support in well managed tasks related to development of safeguards verification methods, safeguards concepts and the IAEA inspector training.

At the end of 2019, altogether 20 Member States have a MSSP: Argentina, Australia, Belgium, Brazil, Canada, China, Czech Republic, Spain, Finland, France, Germany, Hungary, Japan, Netherlands, Republic of Korea, South Africa, Russia, Sweden, United Kingdom and United States. In addition, European Commission has one.

2 Administration and Finance

FINSP is financed by Ministry for Foreign Affairs of Finland (MFA) and it is implemented and coordinated by STUK. In 2018 STUK has procured outside consultant services to assist in the implementation of the programme.

Cooperation between other MSSPs takes place in majority of the tasks.

In STUK, FINSP is managed by Director Kaisa Koskinen and coordinated by Tapani Honkamaa.

In 2019, MFA budgeted altogether 149 000 € for FINSP implementation. Actual expenditures were 141 366,89 €. The expenditures were divided in three main categories: Training, development of methods and concepts and overall implementation. Budgeted and realized costs are shown in Table 1.

	Budgeted	Realized	Difference
Training 5550P-003601	10 000,00	9109,62	890,38
Development of concepts and methods 5550P-003602	105 000,00	100 697,09	4 302,92
Implementation costs 5550P-003603	34 000,00	31 560,18	2 439,82
Total	**149 000,00**	**141 366,89**	**7 633,12**

Table 1. Budgeted and realized costs of FINSP in €.

3 Activities and tasks

At the end of December 2019 FINSP has the tasks listed in Table 2. Three tasks (FIN B 1435, FIN DB 1939, FIN B 1949 and FIN D 2330) are related to training and others related to R&D of conceptual or technical development. Training tasks are explained in paragraph 3.1 and R&D tasks in paragraph 3.2.

ID	Title	MSSP POC	Start Date
FIN C 2507	Safeguards by Design for Small Modular Reactors	HONKAMAA	18/12/2019
FIN A 2390	Field-testing of an Unmanned Surface Vehicle and neXt generation Cerenkov Viewing Device	HONKAMAA	26/10/2018
FIN C 2399	Umbrella Task - Technical Assistance on Methodology and Guidance for Implementation of Safeguards at the State-level	MARTIKKA	22/10/2018
FIN C 2307	Support for the 2018 Safeguards Symposium	MARTIKKA	15/08/2017
JNT A 2414 FIN	Support for testing of PGET new functionalities in attended, remote and unattended modes	HONKAMAA	28/12/2018
FIN C 2290	Update of the Physical Model (AUL, CAN, CZ, EC, ESP, FIN, FRA, GER, JPN, ROK, SWE, UK, USA)	HONKAMAA	13/07/2017
FIN D 2330	Creation of e-learning modules, supporting the preparation of State declared information	HONKAMAA	27/11/2017
FIN B 01939	Support for Newcomer States Pursuing a Nuclear Power Programme	MARTIKKA	11/06/2012
JNT C 2383 FIN	Consolidation of SAGOR and ASTOR Tasks Recommendations (BEL, EC, FIN, GER, SWE, USA)	OKKO	11/09/2018
JNT C 2415 FIN	Development of Safeguards Guideline for Facilities Under Decommissioning and Post-Accident Facilities (BEL, CAN, CZ, EC, FIN, FRA, GER, JPN, ROK, RSA, USA)	NIITTYMAKI	28/12/2018
FIN A 01628	Support for Instrumentation Technology Foresight	HONKAMAA	25/07/2006
FIN B 01435	Spent Fuel Verification Training Course	HONKAMAA	02/06/2003
JNT X 2445 FIN	2020 Emerging Technologies Workshop (ETW)	HONKAMAA	16/04/2019
FIN A 2416	Feasibility study: Use of high intensity neutron generator based system for fissile particle detection and identification	HONKAMAA	28/12/2018
FIN D 01996	Digital Declaration Site Maps (DDSM)	HONKAMAA	09/04/2014

Table 2. FINSP active tasks at the end of Dec 2019.

3.1 Training

3.1.1 Spent Fuel Verification Training Course

Spent Fuel Verification Training is elemental part of the training programme of IAEA inspectors. The IAEA training section has established a specific verification course, which includes two field exercise parts: 1) NDA training part and another part relating to Cerenkov observation technologies. NDA training part of the course has been hosted by FINSP and Loviisa NPP in the years 2010, 2011, 2013, 2014, 2015, 2016, 2017 and two courses in 2018. The instructors are provided by the IAEA, but Loviisa and STUK experts follow the conduct of the course and provide their insights about the recommended ways to work safely and efficiently in the NPP environment, share knowledge about the fuel and provide useful information about the related activities in Finland.

The NDA methods used in the course are SFAT, IRAT and FDET[1]. The course is well established. In 2018, Loviisa hosted 2 courses 20–23 Nov and 27–30 Nov 2018. Loviisa NPP was not able to host the course in 2019 due to operational reasons. Plan is to have next course in November 2020. In December 2019 IAEA and STUK agreed to plan 2020 course so that the newest method PGET (Passive Gamma Emission Tomograph, approved for the IAEA use in 2017) will be added into the curriculum.

3.1.2 Support for Newcomers States Pursuing a Nuclear Power Programme

IAEA safeguards is challenged by the fact that new member states are pursuing a Nuclear Power Programme and increasing IAEA safeguards workload, while it is not expected that the IAEA safeguards budget will follow accordingly. To mitigate this challenge, IAEA provides trainings for the State System of Accounting and Control (SSAC) in these States (a.k.a. "Newcomer Countries"). By experience, functional operator-regulator relationship combined with a strong regulatory authority mandate in a State will also make IAEA safeguards implementation more effective and efficient.

Finnish SSAC has a good reputation and STUK is fully established 3S regulatory body. Therefore, IAEA suggested that STUK can be an example how cooperation between the operator, regulator and with the IAEA could be efficiently implemented. This could be best done by arranging a specific training workshops in Finland. As a result, FINSP hosted the first interregional Safety&Security&Safeguards course in STUK and in Olkiluoto in 2014 and another in 2018. The next course will be held in Finland in September 2020. Kick-off meeting of the course planning was held in December 2019.

Practical coordination of the course is on the responsibility of Nuclear Infrastructure Development Section in the Department of Nuclear Energy. IAEA Technical Cooperation Fund provides resources for this task. The course advocates balanced approaches of Safety, Security and Safeguards. In addition, Emergency Preparedness and Public Relations are discussed.

[1] For more information about these methods, please see the IAEA report "Safeguards Techniques and Equipment 2011 Edition" https://www-pub.iaea.org/MTCD/Publications/PDF/nvs1_web.pdf

3.1.3 Specialized Training and Visits to Nuclear Facilities

The task can be utilized for short IAEA staff visits to Finland. In 2019 no visits were arranged but task will be kept as standby for future needs

3.2 R&D of safeguards concepts and verification methods

According to its R&D plan IAEA will "To continually improve the Department's performance and productivity to effectively carry out the Agency's verification mission". This requires that IAEA shall keep up with technology and innovating, with the help of MSSP's. Also, IAEA is facing new demands and challenges. One specific issue important to Finland is safeguards for geological repository, which is challenge for safeguards community.

3.2.1 Support for the 2018 Safeguards Symposium

In November 2018, IAEA arranged safeguards symposium. The symposium was implemented successfully with support from 17 MSSPs. The Symposium Report was released in July 2019 as Safeguards Technical Report (STR-392)[2]. Before the event FINSP contributed to the planning of the event and took part in abstract evaluation. FINSP also actively distributed information about the event within Finland and the Finnish delegation was larger than ever before. During the event, multiple Finnish delegates served as session chairs and presenters. The task is practically completed.

3.2.2 Update of the Physical Model

The Physical Model was developed as a basic technical tool to aid the enhanced information analysis in the context of the strengthened safeguards. The model consists of 10 chapters describing the peaceful use of nuclear energy from mines to disposal. It should have use for preparatory work to aid enhanced information analysis in the evolving 21st century safeguards system. The Physical Model was expected to be a 'work-in-progress' document subject to periodic review and update based on technical advances, experience accumulated through Physical Model application, and new requirements related to the development of State-level safeguards approaches.

The update of the Physical Model is conducted through consultancy meetings and consultations with Member State and IAEA experts. FINSP has taken part in the update of the chapters, where Finland has specific expertise. These include spent fuel handling and waste management.

Upon request, FINSP will review the final versions of the documents in 2020. Otherwise, from FINSP point of view, the task is completed.

[2] https://www.iaea.org/sites/default/files/19/07/cn-267-symposium-report.pdf

3.2.3 Umbrella Task - Technical Assistance on Methodology and Guidance for Implementation of Safeguards at the State-level

The IAEA is gaining experience conducting in-depth acquisition path analysis (APA) and with updating and developing customized State-level Approaches (SLAs). While performing APA and SLA development processes the State evaluation groups (SEGs) and Operations Divisions are identifying aspects that would require further conceptual and/or practical technical assistance.

FINSP accepted this task in November 2018, but in 2019 there were no specific activities. FINSP is preparing to contribute to the February 2020 workshop.

3.2.4 Consolidation of SAGOR and ASTOR Tasks Recommendations

The purpose of the task is to take care of knowledge management at the IAEA and discuss in one document the most relevant questions emerged during the history of 30 years of SAGOR (Safeguards for Geological Repositories) and ASTOR (Application of Safeguards to Repositories) tasks. The document was written in the form of questions and answers. The purpose of the task was not to create any new information, just to consolidate existing information. The final report of the task is not a recommendation and does not express any official position of the IAEA or participating MSSP's.

IAEA organized at the end of April a workshop where the main part of the work was accomplished. The workshop was attended by experts from Finland, Sweden, US, Belgium, Germany and the EC. The Questions and Answers document was finalized later in the year 2019.

FINSP concern relating to final disposal has been that the application of safeguards will become too resource intensive for both inspectorates and operators. FINSP recommends utilizing Additional Protocol measures fully and making use of available national findings as much as possible and minimizing IAEA inspection efforts, as stipulated by Comprehensive Safeguards Agreements.

3.2.5 MSSP Umbrella Task: Support for Instrumentation Technology

The task implements a mechanism through which Member State Support Programmes and staff of IAEA Technology Foresight project may communicate and collaborate with R&D organizations (government and private). Task deals with States' experts on relatively small tasks, including the provision of technical information on various nuclear activity detection subjects, soliciting technical proposals, conducting technical proposal reviews, equipment evaluations, field testing and identifying suitable forms of funding for promising technologies.

Under this task the IAEA arranges so called technical challenges to exploit the idea of expert crowdsourcing, where IAEA announces a competitive challenge and publishes it openly. The winners are provided a monetary prize and commercial agreements may be awarded later with the best solutions.

In 2019 the IAEA arranged a challenge where it sought submissions from the public to enhance the software used to analyse PGET data. FINSP sponsored Rasmus Backholm to

participate in the challenge. The software used and developed by Mr. Backholm was initially written in Helsinki Institute of Physics and later developed in STUK. Mr. Backholm won the 2nd prize in the challenge and provided a presentation at the award ceremony in Vienna on 30th Sep 2019.

Figure 1. Picture taken at the IAEA prize award ceremony of PGET challenge. Rasmus Backholm (STUK/HIP), second on the right.

3.2.6 Field-testing of an Unmanned Surface Vehicle and Next Generation Cerenkov Viewing Device

This task was accepted in October 2018 and in November 2018 a field test was arranged in Loviisa nuclear power plant. IAEA tested 3 floating robots in Loviisa NPP spent fuel storage. During the test robots navigated autonomously in the pool, carrying the payload called XCVD (Expanded Cerenkov viewing device). XCVD is a Camera, which can observe ultraviolet light emanating from the spent fuel in the water. Currently, the IAEA inspectors mostly use the Cerenkov viewing devices handheld, which is labor intensive and not ergonomic. Verification of large storages will take several hours or even days. The use of autonomous robot in these facilities would be real cost saver for the IAEA. With an advanced image recognition algorithm, the XCVD can also do the verification in more reliable way than human eye can do.

In 2019 IAEA wrote technical travel report about the campaign, which was reviewed by FINSP. The test proved that the robots are promising but a deployment of the technology still requires lots of detailed development work.

3.2.7 Performance Evaluation and Implementation Support of Gamma Emission Tomography for Spent-Fuel Verification

A task of the IAEA is to verify the declared nuclear materials by the member states. The largest amount of nuclear material is in the form of spent fuel at nuclear power reactor sites and spent fuel storages. IAEA policy is to verify spent fuel before it is transferred to the difficult to access storages or geological repositories, where the spent fuel becomes "impossible to access".

Passive Gamma Emission Tomography is a method which can detect individual missing pins even from inner parts of a spent fuel assembly. IAEA approved the method in 2017 and is in the process of procuring verification instruments. FINSP has provided support to the IAEA in operationalizing the new method. This included organizing accesses to spent fuel ponds in order to perform the needed testing. In addition, FINSP participated in the tests as observers in order to provide feedback from the regulatory perspective and providing expert support in that regard.

The task arranged campaigns in 2018 in Loviisa and in Olkiluoto. The task was completed on 25 Apr 2019. The work is continued in the task JNT A 2414 FIN "Support for testing of PGET new functionalities in attended, remote and unattended modes".

3.2.8 Support for testing of PGET new functionalities in attended, remote and unattended modes

The task proposal was approved in December 2018. The task arranged a test campaign in Olkiluoto Spent fuel storage in July 2019. The campaign was the first opportunity to verify spent BWR fuel with long (almost 40y) cooling times. PGET was used in modular verification system together with another novel method - PNAR (Passive Neutron Albedo Reactivity). PNAR test campaign results were reported to the IAEA on 14th Nov in connection with EPGR LLLC (Encapsulation Plant Geological Repository Low-Level Liaison) meeting.

FINSP also arranged a meeting in Finland to assist IAEA in the delivery of new commercial PGET instruments. The first commercial PGET unit was delivered to the IAEA in 2019. This instrument is planned to be tested in March 2020 in Loviisa NPP.

Figure 2. Setting up measurement campaign with PGET and PNAR in Olkiluoto Spent fuel Storage, July 2019.

3.2.9 Digital Declarations Site Maps (DDSM)

The task started in 2014. The goal is to establish process through which nuclear operators can report additional protocol site maps in a digital format, which could be directly compatible with the IAEA Geospatial Information Systems (GIS). Digitalization would save significantly IAEA person resources and enhance effectivity and efficiency.

In 2019 STUK provided DDSM as a part of its official declaration to the IAEA in a separate package. The DDMS was also sent to European Commission. The IAEA evaluated the package and only minor issues were found. The practice will continue in 2020.

Current plan is that Olkiluoto Nuclear Operators (TVO NPP operator of 3 reactors and Posiva, the implementer of Final Disposal project) will submit their DDSMs as a part of 2021 declaration.

3.2.10 Creation of E-learning Modules

There were no activities in this task in 2019.

3.2.11 Development of safeguards guideline for facilities under decommissioning and post-accident facilities

The task was accepted in December 2018. The results of the two consultancy meetings held in 2019 continued to improve the revision of existing DIQ templates and fulfilled a major goal to establish draft DIQ completion guideline. The outcome of these two consultancy meetings were positive and objectives were achieved. As results of participants' discussions, some key safeguards considerations were made for facilities under decommissioning. For Finland, and especially considering the Triga Mark II Research Reactor (VTT, FiR1) currently under decommissioning activities, these considerations (e.g. regarding essential equipment) were beneficial. The task continues in 2020 and the third workshop is planned to take place in Vienna on 3-6 Feb 2020. A major goal for that consultancy meeting will be to establish and review an adequate DIQ example for geological repository and spent fuel encapsulation plant.

3.2.12 Feasibility study: Use of high intensity neutron generator based system for fissile particle detection and identification

This project was approved by letter in December 2018. The background to the project proposal is that the Finnish startup *NeutronGate* is developing and commercializing a high-intensity neutron generator. With this device it is possible to make so-called Fission Track analyses, previously mainly available in a reactor. The IAEA analytical laboratory has no reactor at site, therefore the IAEA must procure neutron irradiation services from various research reactors.

Fission Track is one of the analytical methods utilized by the IAEA. An environmental sample is placed on a suitable planchet and exposed to neutron flux. The substrate is chosen so that the halves of the atom born in the fission reaction leave a microscopic trace therein. Based on the traces, the particle can be located and the amount of nuclear material it contains can be estimated.

Until now, Fission Track has required the use of a nuclear reactor because of the high neutron flux required by the process. If a relatively small size neutron generator can replace the nuclear reactor, then analyses can be done entirely in the IAEA laboratory, and time-consuming, risky and cumbersome delivery of samples to the reactors can be completely avoided. Alongside this, the substantially longer irradiation time required by the generator would not be a problem.

In addition, the generator can provide neutrons in short pulses, allowing time-sensitive and camera-based signal acquisition, synchronized with the neutron beam, to perform completely new types of analysis, such as real-time separation of uranium and plutonium particles, particle size scans and analysis of isotope ratios. Accumulation of data can be observed in real time and irradiation can be finished when the desired result is obtained.

The project was discussed in June 2018 with the IAEA and *NeutronGate*. The IAEA's formal interest in development work is expressed in the project proposal.

As part of the first proof-of-concept phase, the IAEA has provided some standard environment samples for irradiation to the *NeutronGate* test facility. The irradiations were conducted in 2019 and initial results were obtained. If a decision to continue the project is made, the equipment will be combined with a radiation detector and camera equipment.

If the project leads to more product development and prototype development of the method, then it will be the responsibility of the developing company and will probably require external money. If *NeutronGate* goes to apply for funding for the development of the method, FINSP and STUK can support the application. The support programme would also be needed at this stage as a framework for cooperation with the IAEA.

3.2.13 2020 Emerging Technologies Workshop (ETW)

The Emerging Technologies Workshop will take place from 27th to 29th of January 2020 (2,5 working days in total). FINSP has participated the planning of the workshop with the IAEA staff. FINSP and STUK will contribute to the ETW with presentation on pilot Digital Legder Technology (DLT)-based system for Safeguards project implemented in Finland, a keynote speaker and one facilitator to a problem-solving session.

3.3 Support programme coordination and implementation

3.3.1 Meetings

Annual review meeting was held on 26th of April 2019 and semiannual meeting on 26th of October 2019, both in Vienna.

3.3.2 Accepted tasks in 2019

FINSP accepted two task proposals in 2019.

1. Safeguards by Design for Small Modular Reactors (SMR)
2. 2020 Emerging technologies workshop (ETW)

The SMR task was offered to FINSP, because there is a lot of interest in SMR's in Finland. Active Finnish SMR practitioners are Lappeenranta University of Technology that is developing a conceptual design for SMR for district heating, Fortum power company and the Technical Research Centre of Finland (VTT). STUK is an active member of SMR

regulators forum. This task will identify the key technical challenges for safeguards implementation involving SMRs, and steps that can be taken to support incorporating Safeguards by Design principles into SMR designs.

3.3.3 Completed tasks in 2019

In 2019 two tasks were completed

1. JNT D 2284 Developing Business Capabilities for the Modernization of Safeguards Information Technology (MOSAIC) 25.4.2019.

2. JNT A 2258 Performance Evaluation and Implementation Support of Gamma Emission Tomography for Spent Fuel Verification (MOSAIC) 25.4.2019.

3.3.4 Pending task proposals

On 1st of July 2019 IAEA proposed a task "19/CTR-003, IAEA Safeguards Traineeship Programme Support". Initial discussions have taken place with IAEA training unit. The task in interesting and FINSP may provide in-kind support to the IAEA, which may include presentations or excursions to the trainees to Finnish Nuclear facilities. Implementation of the trainee programme is not yet acute within the IAEA, and FINSP will consider accepting the task in 2020 if need arises.

In December 2019 the IAEA proposed a task "19-CTR-008, Comprehensive Inspection Exercise (CIE) for New Inspectors". The task proposal is currently under review.