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Table of contents

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KEYWORDS: nuclear security detection architecture, RN detection by instrument

Summary

The Finnish national CBRNE (Chemical, Biological, Radiological, Nuclear, Explosives) strategy was published in December 2017. The aim of the strategy is to continuously improve the prevention of and preparedness for CBRNE threats and incidents to safeguard society and secure the functions vital to society. The CBRNE strategy launched the revision process of the national Nuclear Security Detection Architecture (NSDA) document, which was published in 2013. The updated NSDA aims to enforce the CBRNE strategy in terms of RN (Radiological and Nuclear) detection, including the identified research and development topics.

The revised NSDA also provides a public summary concerning the national RN detection principles. The NSDA is expected to save resources and increase authority effectiveness in countering RN criminality and terrorism. Even though the CBRNE strategy and the NSDA derived from it are primarily concentrating on crime prevention, the development of crime-scene investigation and nuclear forensics techniques and processes are also included in them.

A national coordinating CBRNE committee and expert group were established in 2019. Both the CBRNE committee (31 August 2021) and the expert group (7 December 2020) have reviewed and approved the NSDA.

Introduction

In Finland, multiple authorities and actors from the private sector are contributing to the nuclear security detection efforts. The development of authority cooperation related to the detection of nuclear and other radioactive material out of regulatory control has arisen from practical needs. As an example, in-field measurement activities taken place within the interior of a state and associated information processing were initially developed by committed experts of the Helsinki Police Department, the Helsinki City Rescue Department, the Finnish Defence Forces and STUK – Finnish Radiation and Nuclear Safety Authority.

The first Nuclear Security Detection Architecture (NSDA) was formulated in 2012–2013 in the REPO (RElocatable POrtal monitor) project that was partly funded by TEKES, the Finnish Funding Agency for Innovation. Information sharing is the cornerstone of authority activities, it was concluded in the REPO project. The goal is to address issues in a comprehensive manner while considering the points of view of all authorities.

The Finnish National CBRNE (Chemical, Biological, Radiological, Nuclear, Explosives) Strategy was published in December 2017 (Ministry of the Interior 2017). The strategy aims to continuously improve the prevention of and preparedness for CBRNE threats and incidents to safeguard society and secure the functions vital to society. Appendix 2 on the strategy lists the key CBRNE operators and their responsibilities. The CBRNE strategy tightens the linkage between the nuclear security RN detection efforts and the overall national security. The National Counter-Terrorism Strategy is also related to this. The CBRNE strategy lists topics requiring research and development (R&D). It also triggered the revision project of the detection architecture. The updated detection architecture aims to enforce the CBRNE strategy in terms of RN detection, including the identified R&D topics. While knowledge-based detection and intelligence assessment are also important elements of detection, the detection architecture described in this document focuses more on detection by instrument. Detection measures carried out by private licensees are not addressed in this document. Even after these emphases and limitations, the detection architecture contains a wealth of information.

Revised detection architecture also provides a public summary concerning the national RN detection principles. It exploits the relevant RN detection-related IAEA (International Atomic Energy Agency) and GICNT (Global Initiative to Combat Nuclear Terrorism) guidelines and best practices. Due to the structure of the architecture, the identified R&D topics are not introduced in the same order as in the Finnish National CBRNE Strategy. The architecture is expected to save resources and increase authority effectiveness in countering RN criminality and terrorism. The authorities listed in Appendix 2 of the CBRNE strategy are responsible for the development and maintenance of more detailed RN detection plans and capabilities in accordance with these general documents.

Even though the CBRNE strategy and the detection architecture derived from it are primarily concentrating on crime prevention, they also include the development of crime-scene investigation and nuclear forensics techniques and processes. Additionally, a national monitoring strategy for radiation measurements in emergency situations is currently being developed under the leadership of the Ministry of Interior. It is important to note that the CBRNE and the upcoming monitoring strategy for radiation measurements in emergency situations overlap in malevolently caused RN emergencies.

A national coordinating CBRNE committee and an expert group were established in 2019. Both the CBRNE committee (31 August 2021) and the expert group (7 December 2020) have reviewed and approved the revised detection architecture.

Abbreviations

CBRNE	Chemical, Biological, Radiological, Nuclear, Explosives
CORES	Finnish Consortium for Radiation Safety Research
GICNT	Global Initiative to Combat Nuclear Terrorism
HIP	Helsinki Institute of Physics
IAEA	International Atomic Energy Agency
R&D	Research and development
REACHBACK	Remote Expert Support
REPO PROJECT	Abbreviated from RElocatable POrtal monitor
RN	Radiological and Nuclear
TRL	Technology Readiness Level
VTT	Technical Research Center of Finland Ltd.

1 Basis of the detection architecture design is the prevention of criminal acts against society and management of various threat situations

The IAEA has defined the three fundamental pillars of nuclear security:

1. Prevention
2. Detection and
3. Response

The primary objective for nuclear security activities is crime prevention. The cost-benefit ratio of preventive measures is generally considered the best. Preventive activities include counter-radicalization measures, such as measures for prevention of social exclusion. Prevention also includes activities that increase deterrence such as visible security measures.

To support the prevention, there must also be capacity to detect abnormal events and to respond to them. An integral part of nuclear security detection by technical means is the assessment and processing of radiation alarms. The IAEA defines two activities for this purpose: the initial assessment of the instrument alarms and the assessment process which determines the security significance of the observation. The person who reacts to the alarm in the field should receive support from a radiation expert in the interpretation of data or radiation protection, if necessary.

Detection efforts may lead to nuclear forensics investigation. Especially the development of nuclear forensics capabilities of high-activity radioactive sources (R) requires further work. In this, the VTT (VTT Technical Research Centre of Finland Ltd) Centre for Nuclear Safety plays a key role. In terms of nuclear materials (N), the development of non-destructive analysis capabilities should be continued. The most advanced nuclear material analyses can be performed at the European Commission's Joint Research Centre (JRC), Karlsruhe, Germany. Neither VTT or JRC are mentioned in the national CBRNE strategy. The development of general RN investigation process should also be continued in the future.

What, where, when, how and who are the questions of central importance for each pillar above. These questions also highlight why the cooperation of different authorities and other operators is important when ensuring and building comprehensive nuclear security. Each party uses these questions to consider nuclear security from their own point of view. Thus, a multi-functional vision for implementing nuclear security can be obtained.

The IAEA defines risk as the combined effect of the likelihood and the consequences of threat realization (IAEA 2015). The likelihood describes the probability of threat realization and is influenced by both the threat and the vulnerability (Figure 1, page 10). Behind each threat is a scenario, the most important aspect is the adversary that threatens society: criminals, terrorists or perpetrators of vandalism or disruption. Also, the availability of RN materials and the target itself influence the scenario.

There are two components affecting the security assessment of a particular case: the assessment of the immediate threat and the assessment of the consequences that result from the threat. The former is carried out by the police, with STUK's support. The latter has the character of a consequence analysis, and regarding the assessment of radiation hazard, STUK carries the responsibility.

The long-term assessment of nuclear security risks directs the development of the detection systems and response. The risk-informed approach defined by the IAEA is applied to this task.

The ultimate risk is the use of a nuclear weapon. On the other hand, the threat can be vandalism or threatening or disruptive behaviour with harmless or only slightly radioactive material.

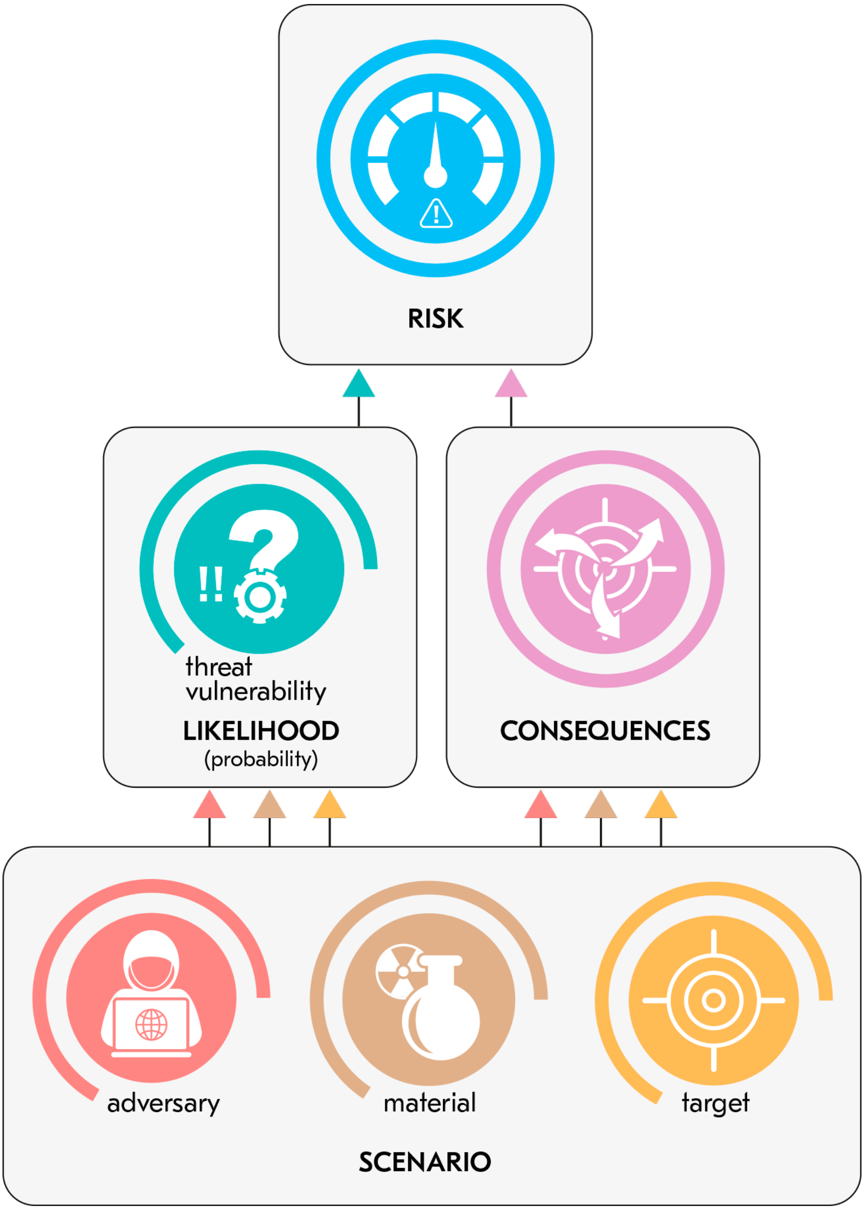

FIGURE 1. The relationship between the risk, threat and consequences as defined by the IAEA. The threat and the vulnerability define the likelihood (probability) of an incident. Risk is the combined effect (product) of the likelihood and the consequences of the incident. Note that even when a threat is high, the risk can be low, if the vulnerability is low or the consequences have been minimized.

2 Information sharing is one of the cornerstones of cooperation between the authorities

Efficient distribution and utilization of correct information enable timely and properly targeted authority activities. Many types of information users are connected to the detection architecture, all of them having their own individual information needs. Providing correct information to the relevant users at the right time is of paramount importance to the success of nuclear security tasks.
For example, correct information about the presence of hazardous substances should rapidly reach the first responders. Commitment to good information security is essential in all areas of the detection architecture to maintain confidence in cooperation and information integrity, while making information available to those who need it. The local, isolated use of surveillance equipment limits the efficiency of the whole process.

3 Detection systems are evaluated and optimized for various areas of nuclear security

According to the IAEA and GICNT, the comprehensive detection architecture considers nine areas of nuclear security where the authorities can have an influence on threat reduction (IAEA 2013, GICNT 2009). These areas can be grouped into three sets: foreign countries, cross-border and domestic (Figure 2., page 14).

Exterior:

1 Nuclear facilities or facilities that handle radioactive materials in foreign countries
2 Transport between facilities and border crossings in foreign countries
3 Border crossings in foreign countries

Border:

4 Transport from the source country to the destination country
5 Border crossing point

Interior:

6 Domestic nuclear facilities or facilities that handle radioactive substances
7 Nationwide observations – transport, transport hubs
8 Detection systems at a stand-off distance from the target
9 Target (could be, for example, a major public event)

Knowledge-based detection and intelligence assessment are important elements of RN detection. However, the detection architecture described in this document focuses more on radiation detection by instrument. The detection architecture is based on a layered approach. Hazardous substances can be detected at several different stages before they are used for criminal purposes. It is important to carefully consider all these stages and associated economic and other realities. Detection measures carried out by private licensees are not discussed in this document.

With a comprehensive architecture, the different detection systems and response can be developed to be nationally as cost-effective as possible. The aim is to make the resources function as a whole, in accordance with the needs of different authorities at any given time. This requires that the technology is interoperable and the data transfer occurs in real time, regardless of where the activities are taking place. The future target is to develop instrument specifications shared between the authorities, perform joint competitive biddings and make common framework agreements with companies. The coordinating role of the CBRNE committee and expert group is the key here.

Since technical systems are often expensive, it is important to comprehensively evaluate whether the planned purchases are rational and well-functioning. Frequently changing monitoring environments, such as airports and harbours, pose their own additional challenges. Defining thoroughly the needs and performance requirements of the authorities is an essential part of the procurement process. Whenever technical modifications are planned, their potential impact on the Concepts of Operation and Standard Operating Procedures also need to be considered.

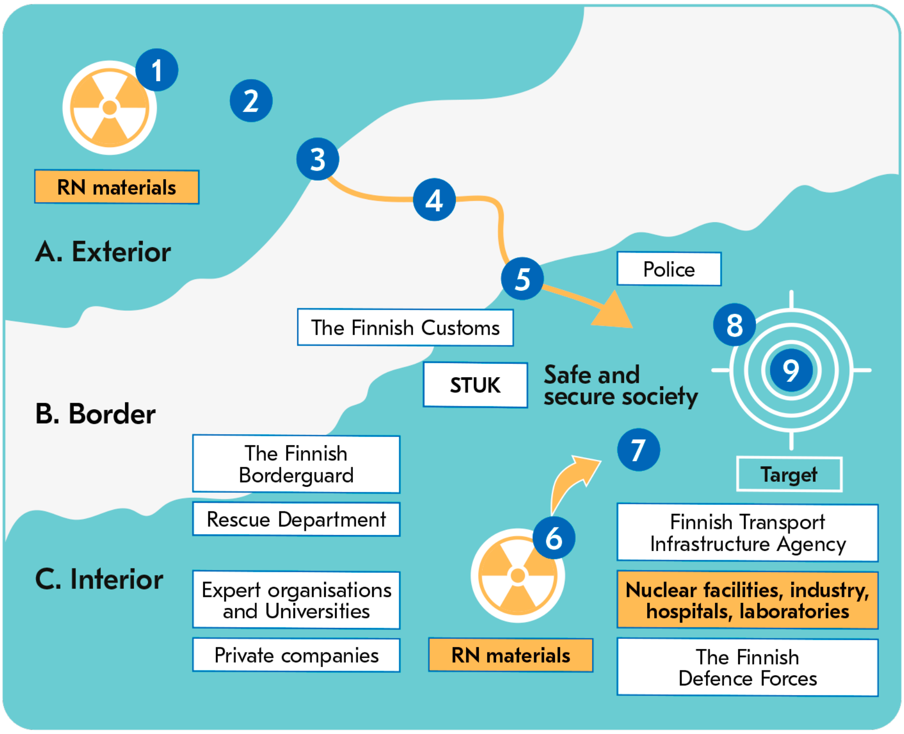

FIGURE 2. A layered approach to the nuclear security detection architecture. Layers are explained in the main text (part 3).

4 Radiation measurements, analyses and data management are integrated

Within nuclear security, the purpose of radiation measurements and analyses is the early detection of threats and the assessment of their significance, in order to use the gathered information for a correctly targeted and dimensioned response. The response must be neither over- nor under-dimensioned. The possibility that the situation will escalate and/or be prolonged as well as the potential international dimensions must be considered. Therefore, the deployment of all the specialized experts and measurement equipment at once should be carefully considered. The division of work between different authorities must be clear and the safety of all people must be ensured. Adequate human and instrument resources as well as agility and flexibility in applying them are key to a successful response.

In the detection architecture, mobile and relocatable radiation measurement systems are used alongside fixed detection systems, as necessary. Fixed and relocatable detection systems are often employed for continuous 24/7 monitoring of people, cargo and critical spaces. Mobile measurements are made to complement the fixed and relocatable monitoring systems and to increase the unpredictability of detection activities. They can be carried out nearly everywhere and in all conditions. It is worth mentioning that in mobile measurements, the variation of the natural radiation may be significant. Spectrometric detection systems are currently quite common in nuclear security measurement activities. Spectrometers can, in addition to detecting radiation, better identify and characterize objects emitting radiation. Note that even the weak signals may be highly significant in terms of nuclear security. Therefore, the largest and most effective radiation detectors are often used in nuclear security activities. In mobile measurements, efficient use of different manned and unmanned platforms requires further research and development. Response measures in case of alarms from the remotely monitored detection systems require extra planning beforehand. Effective alarm adjudication typically requires supporting information generated by other technical systems, such as video cameras. The further development of remote monitoring concepts is needed. The application of imaging detectors and detectors capable of determining the direction of incoming radiation in different areas of nuclear security call for further research and development.

Several authorities carry out nuclear security-related radiation measurements. Not all the authorities have in-house RN experts who can reliably interpret the observations. Therefore, cooperation between authorities is the foundation of effective nuclear security. In order to ensure rapidity and cost-efficiency, expert assistance is primarily provided remotely. Radiation experts are also sent to the field, as necessary. In Finland, STUK and the Finnish Defence Forces Technical Research Centre have expertise on analysis of spectrometric measurements done in field conditions.

Remote expert support (reachback) services are being developed in diverse ways to better match the needs of different authorities. The remote expert support includes both real-time assistance in operative measurement activities as well as separate analyses and other support measures requested by the authorities. Key technical components required for the successful remote expert support cooperation include secure and reliable data transfer and communication channels as well as data management and analysis tools tailored for the purpose. It is important to continuously maintain and develop these tools.

As the number of detectors capable of sending data is increasing, also the need for remote expert support is growing. Since it is not possible to fully compensate the growing need by increasing the number of subject matter experts, the role of digitalization and automation must be increased in the future.

The graphical user interfaces of the RN situation assessment systems of different authorities and reachback centers will be further developed. The further development of manual and automatic analysis tools also plays a crucially important role. They speed up the alarm adjudication process, standardize the quality of analyses and increase the number of detectors that one analyst can monitor simultaneously. A reachback center needs to be able to effectively process multiple simultaneous alarms in different locations or handle the information generated by multiple detectors in one location to form the radiation situation overview. Rapid source localization techniques are important.

In addition to first responders, remote expert support services are also available for radiation experts operating in field. In conclusion, reliable and effective reachback is a significant cross-cutting element of the national nuclear security detection architecture.

5 Sustainability and continuous development of detection activities is an integral part of the architecture

There are detection systems in different stages of their life-cycle in operational use in Finland, as in many other countries. In addition to the use, the authorities are involved in the maintenance, quality control and quality assurance of systems and, if necessary, in their further development together with companies.

The testing and/or calibration processes of several detection systems continue to need further development. International and university cooperation is utilized in nuclear security detection research and development work, whenever possible. The importance of computer simulations in system development is continuously growing. System maintenance tasks are mainly outsourced to companies.

During the past years, the technical outcomes of the REPO project have significantly contributed to the systematic development of detection capabilities.

5.1 Systematic training and exercises for authorities

Training and exercises for authorities and their development are part of the national CBRNE strategy. Essential elements of training and exercise activities are threat awareness, various methods, protective equipment and detection instruments, exercises, their evaluation and implementing the observations in training and further in operational activities. The aim is to continuously maintain and develop competence in this area.

A major challenge in authority training is the basic education of the front-line officers. They are the first on the event scene and they can easily become victims, unless they have a basic knowledge and skills concerning the CBRNE threats and personal protection. Awareness of the CBRNE materials, including their potential criminal or unauthorized use as well as the response from the authorities in various situations, must be integrated into the training of the front-line officers.

In our RN detection architecture, the personnel of, for example, the Rescue Services, the Police, the Finnish Defence Forces, the Border Guard and the Customs, in addition to radiation experts, operate the radiation detectors in the field. STUK cooperates actively with these authorities in RN training and exercises. The optimization and continuous development of national RN training and exercise activities require centralized coordination and planning. The principle of Train the Trainers is applied when educating the larger masses of authorities.

5.2 Research and development are implemented based on the national needs for nuclear security

In order to secure the continuity of the RN research and development work in Finland, STUK together with the Finnish universities established a consortium, Cores – Finnish Consortium for Radiation Safety Research in 2016. STUK has also joined with Helsinki Institute of Physics (HIP) for a fixed period. Promising detection technology can be researched and developed together with the universities to technology readiness levels (TRL) between 4 and 7. After that, private sector partners are sought to turn the technology concept into products in a well-controlled manner, by raising the TRL level one step at a time. This procedure ensures that the desired goal will be reached before larger investments are made.

6 Raising nuclear security awareness of the public with communications – Detection by information becomes more effective

The violent events of recent years in Finland and elsewhere in the world have created fear and insecurity, as well as highlighted the importance of communication before and during different types of crises. Awareness of malicious RN threat scenarios builds a solid foundation for various authorities to provide relevant information and education to the public. The well-planned and implemented provision of information by the authorities can increase the threshold for initiating malicious RN activity.

The public has abundant information but does not necessarily understand the meaning of the information. This can be influenced by the means of communications. A relevant question is how the threshold for reporting a strange occurrence or observation can be made as low as possible. For example, the "Nettivinkki" ("Internet tip") service launched by the Finnish police serves this purpose. Tips through this service arrive at the shared Operation Centre of the police, the Customs and the Border Guard for processing.

Authority announcements, recommendations and exhortations to the public during abnormal events may go unnoticed if they are not distributed through the optimal channels. Therefore, the authorities must have varied means available for active and easily understandable communication to the public, including social media. Coordination and systematic sharing of information between different authorities is also required to ensure that all the authorities have a uniform understanding on the prevailing situation. The development of different aspects of authority communications will continue.

7 Active participation to international nuclear security efforts

National nuclear security becomes comprehensive only if it considers sufficiently the international threats connected to RN materials and the consequences of threat realization. This requires bilateral and multilateral (regional and international) cooperation, such as joint exercises. International cooperation can also be used to develop and harmonize national activities. The significance of nuclear security is increasingly acknowledged, and its development is widely considered crucial. This trend is also clearly visible in the IAEA, Interpol and GICNT activities as well as in the EU funding programmes. Finland has extensive experience from various nuclear security areas. This gives us a good basis to participate in the international nuclear security cooperation.

Influencing the development of the nuclear security detection field can be pursued in many ways. Participation in bilateral, regional or international projects is considered on a case-by-case basis, within the limits of possibilities and priorities.

8 Actions and recommendations

1. Continuing the development of RN investigation processes and techniques. In this, VTT also plays a significant role.
2. Developing RN instrument specifications shared between the authorities, performing joint competitive biddings and making common framework agreements with companies.
3. Continuing the development of databases, graphical user interfaces of the RN situation assessment and remote expert support systems and secure data transfer and communication channels.
4. Further research and development are needed in mobile measurements, to use more efficiently different manned and unmanned platforms.
5. Further research and development are needed in remote monitoring technology and concepts, detector networks, imaging detectors and detectors capable of determining the direction of incoming radiation.
6. Continuing to develop the manual and automatic analysis algorithms and software.
7. Continuing to develop further the testing and calibration processes of detection systems.
8. Continuing to systematically develop authority RN training, exercises and evaluation and improve the overall national coordination.
9. Continuing to develop communication with the public and participation in international nuclear security activities.

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