



Investigative report: excerpt

Date: 2018-09-20

Ref. no: SSM2017-134

Document no: SSM2017-134-23

Head investigator: Anneli Hällgren

Approved by: Mats Persson

Laying the foundation for long-term knowledge management in the field of nuclear safety and radiation protection

Summary

As commissioned by the Swedish Government, the Swedish Radiation Safety Authority (SSM) has investigated the prerequisites for maintaining national competence in the Authority's area of responsibility, not only internally at the Authority, but also on the part of other applicable stakeholders on a national level.

SSM has, by means of communication analyses and horizon scanning, gained situational awareness of needs and potential relating to securing of competence in the field of nuclear safety and radiation protection. Status reports were compiled in co-operation with industry, institutions of higher education and other relevant stakeholders. The focus of the data is on these perspectives: the needs and requirements of licensees and of SSM in terms of competence, higher education programmes, and the potential of academia to maintain scientific expertise.

Thereafter, the Authority analysed the situational awareness material and identified weaknesses in the knowledge management framework for securing competence. The Authority also identified sources of funding for research and education in the field, and subsequently suggests approaches to interaction on impending areas of focus. Based on this analysis and the shortcomings identified, this Inquiry suggests measures to ensure that Sweden has access to appropriate competence in the field of nuclear safety and radiation protection. These suggestions are made on the basis of the requirements identified during the investigation: not only the needs of today, but also the requirements of tomorrow.

Summary analysis

SSM has established that there is a need to strengthen the national framework for knowledge management in areas relating to radiation safety, both for the purpose of meeting today's needed competence, and for anticipating needs arising in the years to come. One of the root causes of this vulnerability in the knowledge management system nationally is the present underfunding of several areas of research that are critical to society. This situation is due to a number of factors, for instance the following:



- Parts of the research conducted in the field of nuclear safety and radiation protection are (for example) considered by the Swedish Research Council, a major source of national research funding, as being of low scientific interest. Consequently, funding from the national framework for research funding is relatively inaccessible.
- Certain competencies in radiation protection are needed in connection with e.g. emergencies; however, these professional skills are only in low demand by employers for their day-to-day operations. This makes it difficult for research projects of this kind to find matching sources of funding. Another aspect is that students are not attracted to the area of knowledge.
- The nuclear power industry is subject to great financial pressure. As a result, the industry has scaled down its programmes for support of nuclear research.

This is in addition to a lack of incentives for central government sources of research funding to liaise on concerted investment for the purpose of sustaining dynamic research environments relating to radiation safety.

National trends of declining interest in engineering programmes, and county councils' difficulty in recruiting people to occupations in the care sector, also have an impact on the flow of students to programmes in the field of nuclear safety and radiation protection. In the assessment of SSM, the decisions of industry to shut down four reactors have also affected the level of interest in courses in the nuclear field, with reduced enrolment in nuclear engineering programmes as a consequence. For this reason, two out of three nuclear engineering programmes are not currently offered. At the same time, the broad energy agreement between political parties is in effect, bringing about stable political assumptions on the part of the nuclear power industry. This signifies that the sector needs to achieve long-term knowledge management to ensure safe operation of the remaining reactors in operation.

Faced with weak research funding and weak enrolment, institutions of higher education have difficulties in sustaining the programmes and courses that will continue to be needed given the existing operations in Sweden and in other countries in the region whose work, and associated hazards, relate to radiation. Correspondingly, with a lack of incentives for strengthening underfunded research environments, there is a lack of impetus directed at institutions of higher education to have them sustain research and education programmes that are essential to ensure that Sweden has the capability to maintain good radiation protection on a national level, and that Sweden fully complies with its international commitments in the field.

However, it is not enough to invest in research and education for the purpose of establishing a system for knowledge management that is sustainable over the long term in the field of nuclear safety and radiation protection. Good prospects for the future in terms of job availability is another prerequisite for attracting students and postgraduate students to a certain field.

An additional key component of the system for knowledge management is ongoing professional development programmes at the workplace in the form of courses and work experience. At the present time, Sweden has efficient systems and high-quality entities for continuing education and in-service training in the field of nuclear safety and radiation protection.

SSM's investigation has also revealed the problems resulting from today's mixed radiation safety sector and that the knowledge management framework in the areas relating to nuclear safety and radiation protection cannot be comprehensively examined or controlled in a straightforward way. For this reason, influencing education programmes in



the field of nuclear safety and radiation protection presupposes the involvement of several different stakeholders. An additional challenge is that the perspective of nuclear safety and radiation protection only constitutes part of the licensees' areas of responsibility, alongside areas such as electrical power production and medical practices. Viewed from this aspect, matters relating to nuclear safety and radiation protection may to some extent compete with the licensees' other objectives and requirements (occupational health and safety management, earnings targets, etc.).

Another way of viewing this problem is that the areas of expertise relating to nuclear safety and radiation protection are not only own disciplines within the basic sciences having several cross-disciplinary links; what's more, they are often categorised into different basic sciences belonging to technical and natural sciences. For instance, nuclear engineering belongs to the sciences of physics and engineering, radiation biology is a subdiscipline of biology, and dosimetry is a subdiscipline of medicine, and so on. Complicated matching also takes place between the activities requiring competence (nuclear activities, medical practices, as well as other activities in areas such as industry or veterinary practices) and the competencies that are needed (e.g. reactor physics, radioecology and radiation biology).

Consequently, the assessment of the Authority is that the knowledge management framework in relation to the field of nuclear safety and radiation protection requires reinforcement as follows:

- A comprehensive national strategy with coordinated efforts is a prerequisite for achieving a higher level of effectiveness in the knowledge management system.
- Increase the funding provided to the critical core of research environments needed to maintain the knowledge management system and to meet needs in Sweden, given the activities relating to radiation that are conducted nationally and abroad, today and in the years to come. Today's inadequate funding to these research environments has made this component of the knowledge management system all too vulnerable and dependent on the knowledge of individuals.
- Formalise the interaction between stakeholders in the system for central government research funding to guarantee that the relevant research environments as described above will be sustained.
- Ensure that education programmes critical to society in the field of nuclear safety and radiation protection can be run, and that the content of courses relating to the field is given defined objectives as necessary and subjected to quality assurance.
- Several stakeholders should run campaigns and issue communication for the purpose of attracting students so that they enrol in nuclear safety and radiation protection education programmes and choose occupations in the field.

Summary account of measures proposed to the Swedish Government

Based on the analysis conducted by SSM, the Authority suggests that the Government implement the following measures:

National liaison and coordinated control

For more straightforward control over the knowledge management system in the field of nuclear safety and radiation protection, this area needs to be dealt with in a way that is more strategic and coordinated than is currently the case. Among other things, key stakeholders need to have a shared approach to this system.



Measures

For the purpose of achieving improved interaction for, and control over, the system for knowledge management, SSM hereby suggests that the Government:

1. Establish a separate chapter covering the field of nuclear safety and radiation protection to recur in the government's research bill.
2. Task SSM with the assignment of producing and maintaining a national strategy for knowledge management. This mandate should be expressly stated in SSM's Instructions.
3. Task SSM and central government research councils with the assignment of liaising on distribution of funding and shared strategies as part of research activities relating to nuclear safety and radiation protection. Such liaison should be expressly stated in the government instructions of the respective authorities, or in their appropriation directions.

Reinforced funding for critical areas of research

A critical core of research areas requires funding in order to ensure a minimum national level of scientific expertise with skills applicable to the activities and practices involving radiation conducted in Sweden, while also having capacity to provide instruction to students, leading to their recruitment to key positions in different sectors. SSM has established that there is a need to secure competencies in six areas of research:

- Nuclear engineering, including reactor physics, thermal hydraulics, and nuclear data
- Severe accidents and nuclear chemistry
- Safeguards and non-proliferation
- Radiation biology
- Radioecology
- Radiation protection dosimetry.

Measures

Parts of the Authority's research grants are already being used for this purpose; however, to prevent these areas from continuing to be underfunded, SSM suggests that the Government:

1. Bolster SSM's research grants by SEK 24 million so that the Authority's total research grants amount to SEK 100 million.

The competence needs of the Swedish total defence system

The need for radiation protection competence brought about by the higher level of national security tension is not encompassed by this investigation. Consequently, SSM suggests that the Government task the Authority with the assignment of liaising with other competent authorities to look into required radiation protection expertise as part of total defence planning and qualifications required for site area emergencies and heightened states of alert, and proposing as necessary how competence needs should be met. This kind of assignment could, for example, be given in the form of a separate government assignment, or as part of the civil defence assignment contained in the annual appropriation directions.

Measures

1. SSM suggests that the Government task the Authority with the assignment of liaising with other competent authorities to look into required radiation protection expertise as part of total defence planning and qualifications required for site area emergencies and heightened states of alert.



Communication to the public regarding occupations and competencies in the field of nuclear safety and radiation protection

The number of applications to nuclear engineering programmes is dropping, meaning that two out of three programmes are no longer offered. The conclusion drawn from the data compiled for this investigation is that the competencies relating to nuclear safety and radiation protection are characterised by medical training programmes as being subject to future labour shortages.

Measures

In order to increase the attractiveness of course programmes relating to nuclear safety and radiation protection and to increase enrolment, and thus ultimately benefit future employers, SSM suggests that the Government:

1. Give SSM the means to communicate both in the long term, and systematically, about the wealth of possible occupations nationally in activities relating to radiation.

Further on in this chapter, within the parameters of this investigation, a recommendation on this theme is directed at licensees.

Guaranteed availability of education programmes that are critical to society

Given the activities relating to radiation that are conducted in Sweden, there is a need for a certain availability of course and programme offerings so that the activities will have access to the competencies needed. There are currently no incentives for institutions of higher education to sustain these programmes in the field when student enrolment declines.

Measures

In order to guarantee the availability of education programmes critical to society in the field of nuclear safety and radiation protection, the Authority suggests that the Government:

1. Task SSM with the assignment of performing further investigations into which education programmes need to have guaranteed availability, and which institutions of higher education should offer them, as well as proposing amendments to the government instructions to the relevant institutions of higher education.
2. Following the investigation suggested above, task the institutions of higher education with sustaining education programmes that are critical to society, and that have a link to radiation safety in Sweden. It is suggested that this may be expressed in the government instructions issued to the institutions of higher education.

Quality assured content of medical training programmes relating to nuclear safety and radiation protection

The division of responsibility between different public bodies, including institutions of higher education, should be defined more clearly in terms of education programme content directed at occupational categories involving radiation. Here, it is also possible that certain components will require quality assurance and development.

Measures

In order to clarify the division of responsibility, as well as to ensure the quality of content of medical training programmes relating to nuclear safety and radiation protection, the Authority suggests the following measures:



1. The Government tasking the National Board of Health and Welfare with the assignment of looking into the division of responsibility between public bodies, including institutions of higher education, in terms of education programme content covering radiation competence.
2. The Government, following the suggested investigation, tasking the public body in charge with the assignment of developing forms of interaction for quality assurance of modules relating to nuclear safety and radiation protection that are a part of medical training programmes.
3. Having the qualification descriptors defined by the Higher Education Ordinance (1993:100) for doctors and dentists supplemented by core learning outcomes relating to medical radiological procedures.

SSM's planned measures

Interaction platform for maintaining dialogue with key stakeholders

With the aim of improving the interaction between key stakeholders in the field of nuclear safety and radiation protection, SSM plans to establish a platform for continual interaction. This forum for stakeholders is to facilitate relevant discussions on pertinent topics.¹

Measures

SSM plans to:

- Compile annual updates of the current status of the knowledge management system, and report back to the Government and the interaction platform
- On the interaction platform, conduct dialogue on consultation responses received regarding the government bill on research strategies
- On the interaction platform, conduct dialogue on the national strategy for knowledge management.

SSM is also considering resumption of the Authority's participation in SKC, the Swedish Centre for Nuclear Technology. The purpose of the Centre is to support education, research and development programmes in disciplines with nuclear applications at KTH (Royal Institute of Technology), Chalmers University of Technology, and Uppsala University.

In parallel with the interaction platform, SSM plans to initiate dialogue with the Swedish Energy Agency concerning the potential to have the Agency's research budget also provide funding for nuclear research.

Standardisation for improving the dynamics of the labour market

With the exception of certified medical training courses, the labour market in the field of nuclear safety and radiation protection is characterised by a low level of standardisation in terms of occupational titles and qualifications. Standardisation to a certain extent of titles and qualifications may be conducive to the employability of candidates and make it clear to students that there is a wealth of career paths encompassed by the activities relating to radiation.

¹ From the outset, SSM will convene a reference group that contributed to the parameters of the government assignment, and shall supplement this group in pace with a growing number of relevant stakeholders registering their interest.



Measures

1. SSM plans to suggest this area as a topic of discussion on the interaction platform, and as needed, report back to the Government on proposed next steps.

Recommendations for licensees with competence needs

Enrolment in radiation-related courses as part of nuclear engineering programmes is declining, with two out of three programmes no longer being offered. In the assessment of SSM, this is due to the nuclear power industry being portrayed as shutting down, and thus having lost its attractiveness. Here, the nuclear power industry is facing a challenge in communicating the image of an industry that has a need for skilled personnel over the period of time of planned operation of the remaining reactors, in parallel with decommissioning of the reactors taken out of operation.

In-house opportunities for continuing education, transfer of knowledge, and professional development within the framework of one's day-to-day tasks comprise an essential component of the nuclear power industry's knowledge management. For this reason, employers need to continue developing this focus. In themselves, these opportunities can also be perceived as attractive to people who are planning to apply for jobs in the nuclear power industry or enrol in nuclear engineering programmes.

Recommendations

Consequently, within the parameters of this investigation, this recommendation is issued to licensees needing competencies relating to radiation in the nuclear engineering sector:

1. Licensees should run campaigns to increase the attractiveness of jobs in the sector, and
2. Licensees should continue to develop opportunities for relevant employees to maintain and develop in-depth skills concerning specific facilities.

1. Foreword

On 22 December 2016, the Swedish Radiation Safety Authority (SSM) was tasked with a government assignment on long-term knowledge management [1], with the latest reporting date of 30 September 2018. The Authority was tasked with:

“...investigating the prerequisites for maintaining national competence in the Authority's area of responsibility, not only internally at the Authority, but also on the part of other applicable stakeholders. The Authority has the task of analysing the present framework for knowledge management, and forecasting future developments, as well as identifying areas where there is a shortage of skills, or where such shortage might arise. The Authority also has the task of identifying stakeholders that provide funding for research and education in relevant areas. Subsequently, the Authority is to identify approaches to interaction on future areas of investment.

In dialogue with industry, institutions of higher education, and other relevant stakeholders, the Swedish Radiation Safety Authority is tasked with identifying the stakeholders' potential to, in the short and the long term, recruit staff having sufficient qualifications. As necessary, the Swedish Radiation Safety Authority has the task of preparing proposals for measures that are needed to ensure the availability of expertise and that this competence is utilised as part of the relevant organisations and activities.”



Two main background factors are given that describe this government assignment:

- The international requirements that the Authority must fully comply with in terms of relevant education programmes and national competence in the area, in addition to the international peer review (IRRS) which, in 2016, showed that Sweden does not fully comply with IAEA standards for maintaining competence in radiation protection and nuclear safety.
- The decisions of the nuclear power industry to shut down four nuclear power reactors up to and including 2020, comprising changed circumstances which may have an impact on knowledge management not only in the nuclear power sector, but also in relevant education programmes.

A robust system for knowledge management and securing competence is a crucial aspect of guaranteeing that radiation safety continues to show progress in Sweden, and, as stated by the assignment, the Government is consequently of the assessment that the preconditions for maintaining and developing national competence in the field should be reviewed and reinforced as necessary. It is also stated by the Government that building up, maintaining and developing competence are long-term efforts that presuppose a forward-looking approach that demonstrates continuity.

1.1. Introduction

In Sweden, radiation is used in activities that have links to nuclear power, and to medical and dental care, in addition to veterinary practices, research, commerce and industry. These activities relating to radiation, which are conducted throughout the country, have a major impact on defining the parameters of the professional skills required in the field. Unpredictable changes or events that take place in the external environment comprise another factor that can influence competence needs.

Incorrect use of radiation can lead to detriment to human health or the environment. Accidents are one of the most common causes of events involving radiation that bring about human injury. Minimising the risk of mistakes, and the consequences of events, accidents and emergencies involving radiation, presupposes a certain level of professional skills among all the parties involved.

An additional perspective is that autonomous stakeholders have different responsibilities and roles relating to activities involving radiation. These stakeholders may have legislative mandates, executive mandates, or supervisory mandates.

The following is a breakdown of the stakeholders involved:

- Industry develops technology where radiation serves as a component. Industrial companies also build facilities intended for activities involving radiation.
- The private sector and public sector, including county councils, utilise technology relating to nuclear safety and radiation protection, and operate facilities intended for activities and practices involving radiation.
- Inspection bodies perform standard inspections of activities and practices involving radiation in relation to public sector requirements.
- Regulators impose requirements to ensure nuclear safety and radiation protection in the form of regulations, supervisory work, and issuing authorisation.
- Regulatory bodies, municipal authorities, county councils and licensees deal with the consequences of events and accidents that occur.
- The Riksdag passes legislation relating to nuclear safety and radiation protection.
- Institutions of higher education provide instruction and conduct research in the areas of knowledge with links to radiation. Academia also has the task of

communicating objective and expert-based analyses of risk assessments, measures and responsibilities.

- The largest sources of research funding from central government are among the bodies that consider research projects and provide funding for research. These sources include the Swedish Research Council, Vinnova, the Swedish Foundation for Strategic Research, Formas (Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning), and the Swedish Energy Agency.
- Special interest groups monitor activities and practices involving radiation from a public safety perspective.

An additional factor that influences the professional skills that are in demand in Sweden is the existence abroad of nuclear activities which, in the event of an accident, might bring about consequences for our country. Competence needs are also influenced by the threat of nuclear weapons use and the risk of terrorist acts. National competence is needed to enable Sweden to take part in international work, mainly for the purpose of influencing future directives, for example those issued by the European Union in the field of nuclear safety and radiation protection. The aim is to have circumstances in Sweden taken into account. Our maintaining this competence is also an urgent element of our country's total defence system.

Competence is fostered through research and education programmes alike. Education and professional development are available not only through institutions of higher education, but also in the form of in-house courses and as part of one's daily work. Research creates new awareness to benefit industry, the care sector and public authorities, while also maintaining the dynamics of learning environments. Without the continual advancement of knowledge, learning and understanding, there is a high risk of stagnation on the part of levels of learning and expertise, followed by their decline.

1.1.1. The three perspectives of national competence

National competence in the field of nuclear safety and radiation protection can be described and defined in several ways. This investigatory report is based on the following breakdown:

1. The competence needs of employers
2. Programmes of institutions of higher education
3. Society's need for scientific expertise.

Employers whose activities or practices involve radiation have competence needs relating to radiation. In this way, their operations and competence needs shape the parameters of the national system for knowledge management. Institutions of higher education provide instruction to students and thus provide future employers with skilled human resources. An additional perspective is that the higher education system is closely linked to the potential to maintain relevant research environments, as these environments are a fundamental component of the higher education system. Research environments are a source of national scientific expertise. This expertise maintains an autonomous and scientific level of knowledge, while also contributing to crucial assessments when considering the balance between the benefit and risk of exposure. Scientific expertise also contributes to securing of instruction at institutions of higher education, on the part of both teachers and programmes. This expertise is also an independent source of information and scrutiny. It also contributes to trustworthy decision making.

Figure 1 illustrates two perspectives of the knowledge management system for securing competence in the field of nuclear safety and radiation protection:

- Employers' competence needs for activities and practices involving radiation

- Area of knowledge.

Links between these perspectives are complex in nature. Several areas of knowledge are prerequisites for individual operations, while other areas of knowledge are shared by all undertakings and organisations. The data compiled during this investigation is mainly categorised by the competence needs per area of activity. At the same time, this categorisation into areas of knowledge was a key part of the work to define the competencies needed by the various activities.

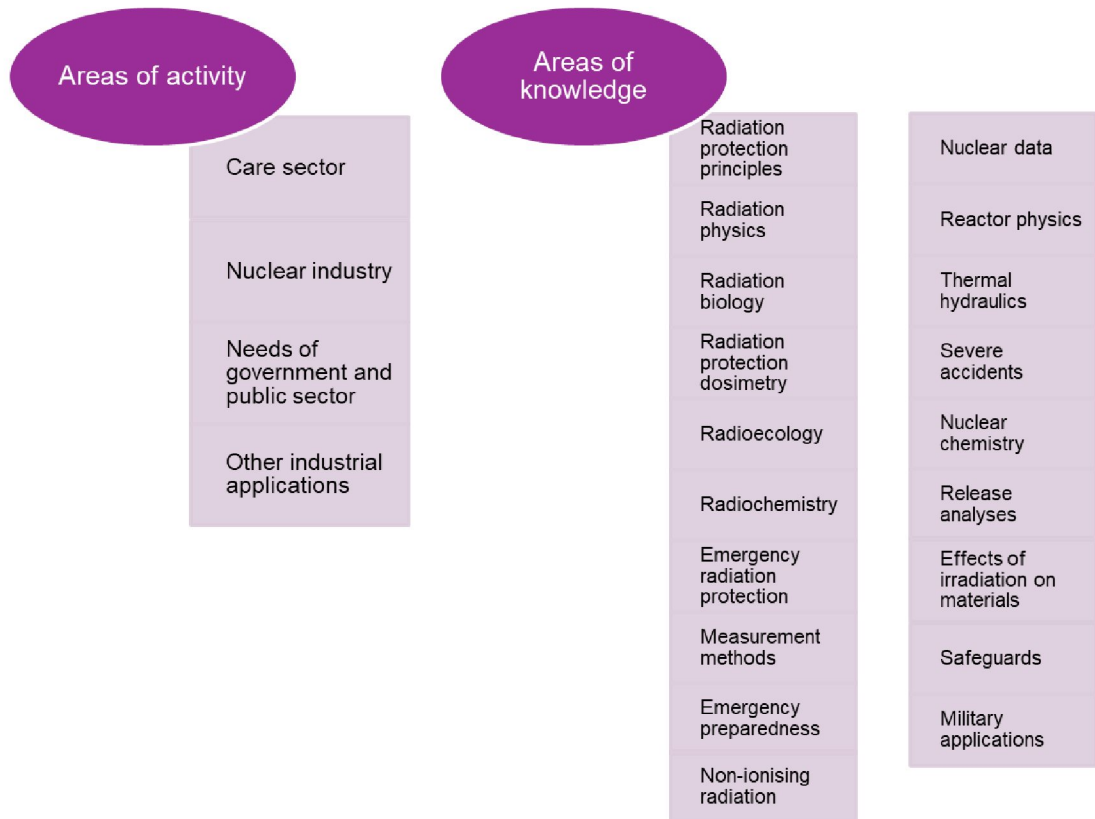


Figure 1 Two perspectives of the knowledge management system for securing competence in nuclear safety and radiation protection, with a special focus on activities where competence is needed, presented per area of knowledge. The areas of knowledge illustrated do not represent a comprehensive list.

1.2. Approach and method

This government assignment was carried out by an internal project organisation at SSM. The assignment was broken down into several phases to ensure a structured approach on the basis of the system's management direction, needs and offerings. The assignment's division into phases is illustrated schematically in *Figure 2*. External participation by relevant stakeholders was ensured by convening a reference group comprising attendees from the nuclear power industry, health and medical services, competent authorities, and universities. This reference group met on four occasions for dialogue.



Figure 2 Activity categories as part of this investigation.

The data compiled included:

- A compilation of government assignments carried out in the 2000s regarding knowledge management in Sweden
- A compilation of professional skills assessments carried out by major licensees of nuclear facilities and by competent authorities
- Statistical data on the number of employees of licensees that have a defined level of professional skills
- Questionnaire responses from approximately 2,000 licensees and operations subject to obligatory notification
- Interviews with representatives of the relevant institutions of higher education.

This assessment of future needs was conducted during a reference group meeting that convened on 6 and 7 December 2017, as well as during brief interviews held with a random selection of attendees of SSM's annual conference on nuclear safety and radiation protection, held 22-23 November 2017.

During a reference group meeting that convened on 15 February 2018, the attendees identified areas that risk facing inadequacies.

The proposed measures were agreed upon in-house at the Authority on the basis of the investigation's findings. The measures were presented to the reference group at the last reference group meeting held on 16 May 2018.

1.3. Consultation procedure

A version of the final report was circulated for comment among the attendees of the reference group. The consultation version was published on the Authority's website to give those that did not participate in the reference group's work an opportunity to submit comments. The period for submitting comments was between 15 June and 13 August.

1.4. Delimitations

Activities and practices involving radiation encompass many areas of knowledge, see *Figure 1*. For the purpose of defining the parameters of this investigation, it was decided that the focus should only be on areas of knowledge in which SSM has its main role as the regulator in charge of this field. Consequently, this investigation is limited to the following parameters:

- Ionising and non-ionising radiation
- Nuclear non-proliferation (safeguards, export control and illicit trafficking) to some extent
- Materials, including effects of irradiation and ageing effects due to radiation.

Financial control, physical protection and information security are excluded because training in these areas does not have nuclear safety and radiation protection as the main focus. The qualifications required for shipments of active components, in addition to geoscientific disciplines that are key to final disposal work, are also encompassed by other education programmes.



The need to consider the competencies required by the public authorities subject to the needs of the Swedish total defence system in the field of nuclear safety and radiation protection was noted most significantly once the investigation was already in progress. Therefore, this area is outside the scope of this investigation. For more information, refer to the measures suggested for further investigation.