NKS-362
ISBN 978-87-7893-447-5

Nuclear icebreaker traffic and transport of radioactive materials along the Nordic coastline: response systems and cooperation to handle accidents (NORCOP-COAST): Final report

Anna Nalbandyan[1], Øyvind Aas-Hansen[1]
Inger Margrethe H. Eikelmann[1]
Jonas Lindgren[2], Kjartan Guðnason[3]
Tuomas Peltonen[4], Jeppe Vöge Jensen[5]

[1]Norwegian Radiation Protection Authority
[2]Swedish Radiation Safety Authority
[3]Icelandic Radiation Safety Authority
[4] STUK-Radiation and Nuclear Safety Authority in Finland
[5]Danish Emergency Management Agency

March 2016

Abstract

The maritime traffic in the Arctic region is already considerable and expected to increase in the future years.This includes traffic of nuclear icebreakers and transport of radioactive materials along the Nordic coastline. An increase in such traffic will increase potential risks for accidents resulting in spread of radioactive materials into the terrestrial and marine environments. All this put an additional pressure on monitoring and responding authorities, coastguards and rescue services.
In the frames of the NORCOP-COAST project a 2-days workshop was organized in Tromsø, Norway on 13-14 October 2015 where authorities from Norway, Finland, Denmark, Sweden and Iceland as well as Emergency Response Center of ROSATOM from Russia and Incident and Emergency Centre of the IAEA contributed. The joint discussions covered existing emergency preparedness and response systems in each country; possible scenarios and ways of handling the maritime accidents resulting in spread of radioactive substances; national and international laws; notification procedures; interaction between Nordic countries and Russia. This report summarizes results of joint discussions and provides a description of identified challenges and target areas for future cooperation in order to further improve cross-border assistance and handling of maritime accidents both between Nordic countries and between Nordic countries and Russia.

Key words

Nordic coastline, maritime accidents, response systems, notification, radioactive cargo, nuclear icebreaker, nuclear-powered vessels, cross-border preparedness.

NKS-362
ISBN 978-87-7893-447-5
Electronic report, March 2016
NKS Secretariat
P.O. Box 49
DK - 4000 Roskilde, Denmark
Phone +45 4677 4041
www.nks.org
e-mail nks@nks.org

Nuclear icebreaker traffic and transport of radioactive materials along the Nordic coastline: response systems and cooperation to handle accidents

Final Report from the NKS-B Project NORCOP-COAST

(Contract: AFT_NKS-B_2015_7)

Anna Nalbandyan[1], Øyvind Aas-Hansen[1], Inger Margrethe H. Eikelmann[1], Jonas Lindgren[2], Kjartan Guðnason[3], Tuomas Peltonen[4], Jeppe Vöge Jensen[5]

[1]Norwegian Radiation Protection Authority, Section High North, PO Box 6606 Langnes, 9296 Tromsø, Norway
[2]Swedish Radiation Safety Authority, S-171 16, Stockholm, Sweden
[3]Icelandic Radiation Safety Authority, Raudararstigur 10, 150 Reykjavik, Iceland
[4] STUK-Radiation and Nuclear Safety Authority in Finland, PO Box 14, 00881 Helsinki, Finland
[5]Danish Emergency Management Agency, Datavej 16, 3460, Birkerød, Denmark

Table of contents

ACKNOWLEDGEMENTS

The project partners wish to acknowledge the NKS, the participating organisations and all participants of the NORCOP-COAST Workshop for their valuable contributions and support.

NKS conveys its gratitude to all organizations and persons who by means of financial support or contributions in kind have made the work presented in this report possible.

DISCLAIMER

1. Introduction

The maritime traffic in the Arctic region is already considerable and it is expected to increase in the future years.This also includes traffic of nuclear icebreakers and transport of radioactive materials along the Nordic coastline. An increase in such traffic would increase potential risks for accidents resulting in spread of radioactive materials into the terrestrial and marine environments, and thus put additional pressure on monitoring and responding authorities, coastguards and rescue services. Due to the cross-border nature of potential accidents there is a need for direct cooperation between neighboring countries in order to discuss preparedness systems, interaction and potentials for mitigating consequenses of different accidents as well as assissting each other, when needed.

In the frames of the NKS NORCOP-COAST project, a 2-days workshop was organized in the FRAM – High North Research Centre on Climate and the Environment in Tromsø, Norway on 13-14 October 2015 where authorities from Norway (NRPA), Finland (STUK), Denmark (DEMA NUC), Sweden (SSM) and Iceland (IRSA) took part and discussed current and future cooperation within the Nordic emergency preparedness organisations with regard for response and assistance in case of potential maritime incidents or accidents involving radioactivity. From Norway, also the Norwegian Coastal Administration, the Norwegian Defence Research Establishment, the Norwegian Joint Rescue Coordination Centre (North Norway), the Institute of Marine Research and the Northern Research Institute (NORUT) participated in the workshop. In addition, Incident and Emergency Centre of the IAEA and Emergency Response Center of ROSATOM in St. Petersburg, Russia contributed to the workshop.

Figure 1. Participants of the NKS-B NORCOP COAST Workshop at the Fram Centre in Tromsø, Norway (13 October 2015). *Photo: Helge Markusson, Fram Centre.*

The overall objective of the workshop was to improve knowledge on existing response systems and capabilities in each country and to discuss interaction and procedures between countries in case of accidents related to the maritime transport of radioactive materials and traffic of nuclear-powered vessels along the Nordic coastline.
Main topics for discussions included:

- Existing emergency preparedness systems in case of accidents along the Nordic coastline with the involvement of nuclear icebreakers, radioactive wastes and spent nuclear fuel;
- Possible scenarios and capabilities in each country (resources, mobile services, decision support systems, models, etc.);
- Notification procedures;
- Interactions between countries.

Figure 2. Workshop in progress: Day 1. *Photos: Anna Nalbandyan and Øyvind Aas-Hansen, NRPA.*

The Workshop consisted of four Sessions (see details under 2. Workshop abstracts, 3. Overview of discussions and 4. Identification of target areas for further cooperation) where general issues related to the workshop topic area were discussed. Each country gave an overview on existing emergency response systems, resources and capabilities as well as identified points for improvement and target areas for further cooperation between Nordic countries and Russia.

Figure 3. Workshop in progress: Day 2. *Photos: Anna Nalbandyan and Øyvind Aas-Hansen, NRPA.*

At the end of the Workshop, project partners had a joint meeting where they evaluated workshop results, discussed challenges and based on the identified topics for future collaboration, elaborated a draft proposal for a new project to be submitted to the NKS.

Altogether, 22 participants attended the NORCOP-COAST Workshop (incl. participation of one IAEA representative via electronic meeting). Presentations from the Workshop are available on the NKS website with a link: http://www.nks.org/en/seminars/presentations/nks-b-norcop-coast-workshop-13-14-october-2015.htm.

Abstracts of 17 presentations prepared by participants are included in the part 2 ‘Workshop abstracts’ of the current report under respective Session.

2. NORCOP-COAST Workshop Abstracts

2. 1 Abstracts – Session I: Introductions to the topic: overview of the status. Legal framework and possible scenarios

Status of the present transport, routes and activity along the Nordic coastline

Alf-Tore Kristoffersen
The Norwegian Coastal Administration (NCA)
Norwegian Oceanic Region, Vessel Traffic Service (NOR VTS)

Vardo VTS Norwegian Coastal Administration - NOR VTS

Traffic Service for Increased safety at sea: the main objectives for this service are to improve sea safety and protect the marine environment from acute pollution. NOR VTS has a scope of operations in the Norwegian economic zone from the Swedish border in the South to the border between the Norwegian and Russian economic zones in the North, in addition to Svalbard and Jan Mayen.

Within the area the VTS monitors tankers and other risk-presenting traffic using a vast network of monitoring sensors. On behalf of the Norwegian authorities, the traffic control centre provides Vessel Traffic Services based on domestic and international laws, and regulations.

Another important task is the management and control of the state emergency tow response service in Norway. In the case of incidents at sea, NOR VTS and the emergency tow response service will be included as a part of the NCA's total resources in cooperation with the NCA's emergency department. If required, NOR VTS and the emergency tow response service will also assist the Rescue Coordination Centers in the North and South Norway.

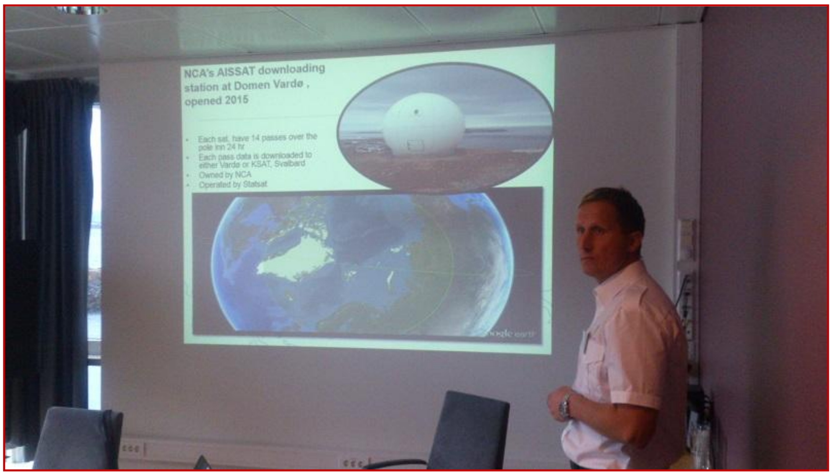

Figure 4. Overview of NCA's AISSAT station. *Photo: Øyvind Aas-Hansen, NRPA.*

Hammerfest VTS area

Gas and tanker vessels must obtain permission from NOR VTS to use the waters and follow the regulations that apply to the waters. For safety reasons, the waters surrounding Melkøya at a distance of 1.5 nautical miles are closed to all ship traffic on arrival and departure from the Melkøya terminal.

NOR VTS is cooperating with NRPA and other governmental agencies. There is a written agreement between Norwegian Radiation Protection Authority (NRPA) and NOR VTS. If NOR VTS discover a nuclear-powered vessel or a vessel caring radioactive materials, this should be reported to NRPA and opposite - if NRPA have information regarding scheduled transports, this should be reported to NOR VTS. NRPA is also providing lists with vessels of interest. NOR VTS is monitoring and contacting this vessel to find out if they carry any radioactive materials.

Barents SRS (Ship reporting system)

All ships carrying out hazardous cargoes, all tankers and vessels more than 5000 gt are required to report before entering BSRS area. This reports provide the following information:

- Name of the ship, call sign, IMO identification number and MMSI;
- Date and time;
- Position expressed in latitude and longitude;
- True course;
- Speed in knots;
- Date, time (UTC) and point of entry into Barents SRS area;
- Destination and ETA;
- Maximum present draught;
- Hazardous cargo, class and quantity;
- Brief details of defects or restrictions in maneuverability;
- Contact information (ship owner and representative);
- Total number of persons on board;
- Characteristics and total quantity of bunkers in metric tons.

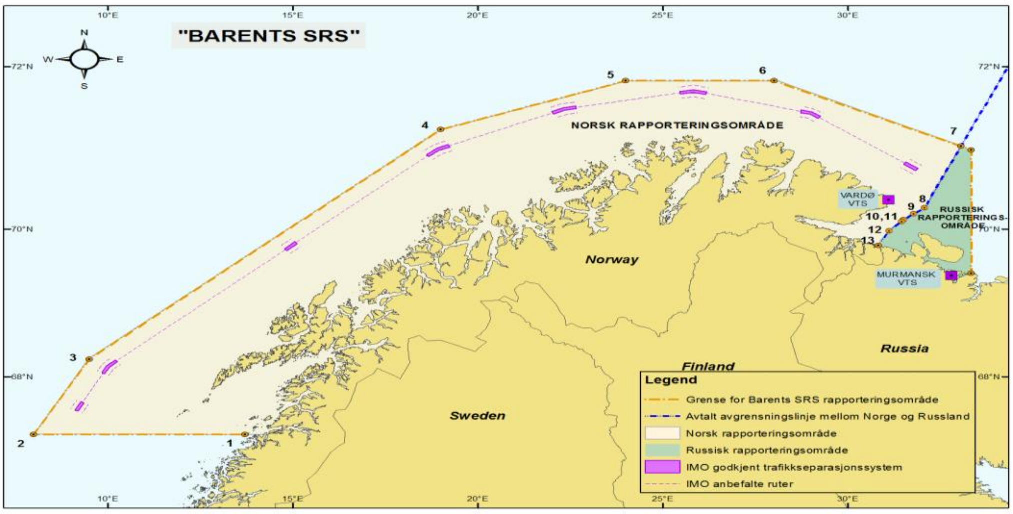

Figure 5. A map of the Barents ship reporting system.

Traffic separation schemes (TSS) are first implemented in July 2007 and included Røst-Vardø areas. In June 2011, South and West parts were also included.

Possible sources, scenarios and consequences: real and hypothetical accidents

Hanne Breivik and Steinar Høibråten
The Norwegian Defense Research Establishment (FFI)

Russia is the only state currently operating civilian vessels with nuclear propulsion, namely six icebreakers and one container ship. These vessels usually have one or two reactors. The characteristics of these reactors are to some extent known, and because it is assumed that Russian submarine reactors are based on similar designs, icebreaker reactors are generally taken as a first order approximation when defining source terms for Russian submarines. Currently Russia is operating approximately 45 strategic and tactical submarines, of which around half is in the Northern fleet.
Other states to possess nuclear-powered vessels are USA (75 submarines, 11 carriers), France (10 submarines, 1 carrier), UK (12 submarines), China (12 submarines), India (1 leased submarine, 13 to be constructed), Brazil (1 planned submarine). All numbers given are based on open sources.
Propulsion reactors are usually pressurized water reactors, with a tertiary circuit open to cooling by the ocean. The fuel can be as low as about 20 % enriched HEU and up to weapons grade, giving a core size of 150-300 kg HEU and physical dimensions in the order of 1 m^3. The power output is up to around 200 MW. Submarines are often equipped with a substantial number of nuclear warheads in the form of torpedoes or missiles.
States are not very open about mishaps involving nuclear vessels, but of the confirmed events Russia have had three times as many incidents (>30) as the West collectively (<10). Because of the small reactor size, the consequences will be moderate.
The accidents of Komsomolets (K-278), Echo II (K-131), Kursk (K-141), and K-are examples of different types of accidents. Of the four, Echo II was the only one without any acute deaths, but also the only one with confirmed radiation doses to crew and rescue workers.

General legal framework for sea transport and maritime accidents

Rune Bergstrøm
The Norwegian Coastal Administration (NCA)

NCA is the Norwegian authority under the Ministry for Transport and Communications. The main responsibilities includes coastal management and infrastructure planning, maritime traffic safety and monitoring, and preparedness and response against acute pollution (sea and inland). The geographical area of responsibilities includes acute pollution on land, in Norwegian territorial waters to 12 nm, and Norwegian EEZ (to 200 nm or to neighboring states EEZ), as well as intervention at high seas based on the intervention convention.

Legislations in Norway are based on our national laws with regard for acute pollution at sea, the laws applies out until 12 nm from the coastal baseline (national waters). The most important acts for the NCA pollution preparedness and response is the Pollution Control Act and the Svalbard Environmental Protection Act. An important regulation is the Regulations concerning notification of acute pollution or danger of acute pollution.

Outside national waters, in the 200 nautical Economic Zone, the Pollution Control act applies to all off shore oil and gas exploration installations and to all Norwegian ships. For international traffic in the Norwegian Economic Zone and in international waters, our possibilities for intervention are based on international law and regulations. The most important once being; The IMO Convention relating to Intervention on the High Sea in cases of Oil Pollution, and radioactive substances. It is aimed at preventing, mitigating end eliminating danger of pollution. It is more complicated to intervene in an situation outside our national waters. Contact has to be established with owners, flag state, etc. before action is taken. There are also other Marpol- regulations concerning the prevention of pollution from ships.

Another system of notification that is important for Norway is the Safe Sea net. Early notification to the traffic Control makes it possible to follow HAZMAT transports closely ant to take precautionary action. This system of notification applies only to ships coming to or going from an EU- harbor.

With all sorts of accidents in Norway, the following priority applies:

1. Life, health, safety
2. Environmental
3. Economical interest

The Norwegian Coastal administration has their own special oil recovery ships and emergency tug boats, airplane, oil spill equipment stored at 16 locations along the coast and trained personnel. The Pollution Control Act gives NCA the right to use necessary public and private resources if an severe accident should occur. NCA has signed several international agreements, both regional and bilateral, that will secure international support if necessary. NCA’s equipment and training is mainly aimed at taking care of oil pollution.

IAEA Response to Maritime Accidents

Florian Baciu and Pat Kenny
IAEA Incident and Emergency Centre

An overview of the IAEA Incident and Emergency Centre as a world’s centre for coordination of international emergency preparedness and response assistance was given; roles and responsibilities of the IAEA in notification, assessment of potential emergency, provision of public information, provision of assistance upon request and coordination of inter-agency response were presented; different aspects of Early Notification Convention, including notification of a maritime accident, were discussed as well as the scope of RANET – Response and Assistance Network.

An overview of the specific task group under Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE) - Working Group on Air and Maritime Transportation was presented. Different IAEA documents related to the legislation, operational activities and organisation of emergency preparedness and response relevant to the workshop topic were outlined.

The presentation was provided via video-conference between IAEA in Vienna and the Fram Centre in Tromsø.

Presentation of some relevant scenarios

Øyvind Gjølme Selnæs
Norwegian Radiation Protection Authority (NRPA)

The Norwegian government decided in May 2010 on six scenarios that should found the basis of future work with nuclear and radiological preparedness in Norway (NRPA, 2012). Three of these scenarios are in particular related to severe events with nuclear-powered vessels and transportation of spent nuclear fuel and other radioactive materials along the Norwegian coast. The three scenarios are:

- *Airborne release from a domestic facility* – i.e. events during transport of spent nuclear fuel or other radioactive material to a Norwegian harbour in connection with the operation of the two Norwegian research reactors, and visits from allied nuclear-powered military vessels to the Norwegian naval base of Haakonsvern outside Bergen.
- *Local event from mobile source* – i.e. events during any traffic of nuclear-powered vessels or transport anywhere outside the Norwegian coast.
- *Marine release, and/or fear of contamination* – i.e. any event, real or perceived, near Norwegian waters or further away, that will have impact on public perception or otherwise have consequences for Norwegian export industries or other societal issues.

The fact that this kind of scenarios may have a very short time-frame and may happen anywhere, even in the most remote of areas, gives some additional challenges in the handling of the situation:

- Saving lives, rescuing crew members and possible assistance in fire-fighting on short notice by trained or untrained personnel
- Detection of radioactivity and discovering that there is an on-going release with very limited availability to necessary resources
- Mapping of contamination with very limited availability to necessary resources
- Difficulties with poor infrastructure in remote areas
- Vulnerable local population and societies
- Vulnerable nature, ecosystems and natural resources – especially in the Arctic region
- Extensive and demanding clean-up and handling of the vessel.

Simulation of pollutant dispersion along the oceanic food chain with CODE/eco_CODE

Kai Logemann and Gudrun Marteinsdottir

University of Icleand

The dispersion of radionuclides caused by a hypothetical nuclear submarine accident at the position of 66.5°N, 25°W and northwest of Iceland within Denmark Strait is simulated with the ocean model CODE including its ecosystem module eco_CODE.

During the period from 1st of January to 31st of March a radionuclide source term is applied to the entire water column (around 170 m). From here the North Icelandic Irminger Current carries most of the pollutant eastwards onto the north Icelandic shelf whereas the East Greenland Current leads to a smaller counter directed transport towards East Greenland.

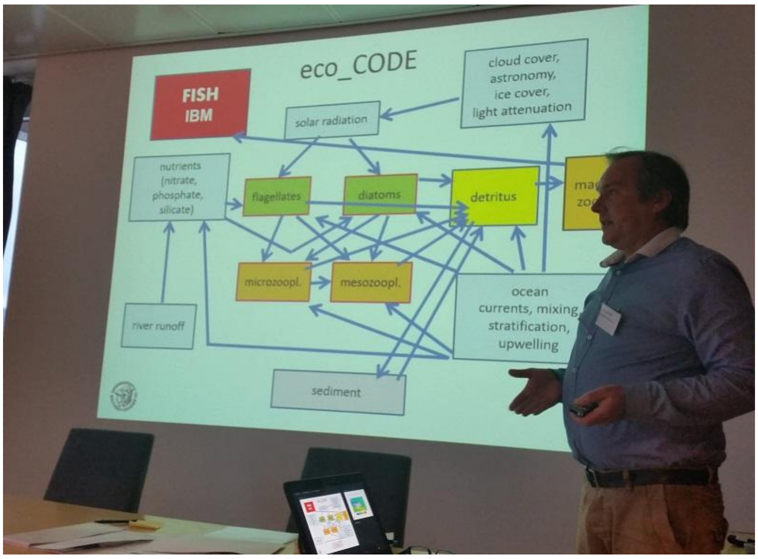

Figure 6. Presentation of the ocean model CODE. *Photo: Anna Nalbandyan, NRPA.*

In the beginning of April the spring bloom of phytoplankton to the north of Iceland causes an uptake of radionuclides into the food chain. At the end of April the amount of radionuclides absorbed by the phytoplankton reaches its maximum. At that time the radionuclide transfer into the zooplankton starts. The zooplankton contamination reaches its peak value in the beginning of May and declines rapidly afterwards. In mid-May the transfer of radionuclides to fish starts and reaches a maximum level by the end of May. Migration of the individual fishes leads to a significantly increased dispersion of the pollutants.

Modelling of the nuclear-powered icebreaker accident at Eastern Gulf of Finland and assessment of possible consequences

Sergei Vasilev
Emergency Response Center of the ROSATOM (St. Petersburg)

Experience of winter navigation from winter 2010-2011 till last year in the Russian harbors at the eastern part of the Gulf of Finland showed that in hard winter conditions (if thickness of ice is more 1,5 meter) it is necessary to deploy nuclear-powered icebreakers (NPIB) of FSUE "Atomflot". This icebreakers have a better performance compared to traditional diesel-electric powered icebreakers. During the winter of 2010-2011 the NPIB "Vaygatch" was used, then – "50 Years of Victory" and during the last winter the navigation was supported by NPIB "Rossia".

This situation required from experts of emergency response center of the Rosatom assessment of possible potential consequences in case of serious accident with NPIB in framework of emergency cooperation plans between ERC and harbors "Bolshoi port Saint-Petersburg", "Vysozk", "Primorsk" and "Usty-Luga".

ERC experts fulfilled modeling of accident and assessment of consequences of nuclear-powered icebreaker. By modeling of potential accident with radiological consequences were taken into account following parameters from the worst case considerations:

- possible accident place;
- technological scenario;
- source term assessments;
- possible meteorological parameters;
- selection of an atmospheric dispersion model.

Overview of results of assessments allows drawing following conclusions:

- For worst-case meteorological conditions and serious nuclear accident on board of NPIB accompanied by release products of fission nuclear fuel in atmosphere, for nearest settlements (distance 6,5 km) aren't necessary any intervention actions.
- Soil contamination coastline for dose forming radionuclide's does not exceed the permissible levels [PL-98] in consideration with direct ground shine dose and food chains.
- Result of work was designed event model, based on open information, which can develop and use in case of a real or training emergency.

Rescue service operations in hazardous environment: cooperation between rescue service, authorities and other actors

Bent-Ove Jamtli
The Norwegian Joint Rescue Coordination Centre (North-Norway)

The Norwegian SAR services - The SAR service is coordinated by two Joint Rescue Coordination Centres (JRCC). It is "The organised activity in connection with immediate effort, to save human lives from death or injuries caused by sudden accidents or danger. The Norwegian Search and Rescue (SAR) service is a fully integrated set of services directed by a single coordinating organization responsible for all types of rescue operations (sea, land, air). These services are performed through a cooperative effort involving governmental agencies, voluntary organizations and private enterprises.

Figure 7. Presentation of the Joint Rescue Coordination Centres in Norway. *Photo: Anna Nalbandyan, NRPA.*

Cooperation between the Crisis Committee for Nuclear Preparedness (CCNP) and the JRCC

- The JRCC will always be responsible for the coordination of the immediate effort to save lives (rescue) and can utilize the expertise of the NRPA/CCNP to assess the hazards involved, and to get advice on the proper procedures to be implemented to ensure the most safe and effective rescue under such circumstances.
- When rescue incidents also causes radiation or nuclear hazard against the population in an area, all actions directed to protect the population is the responsibility of the Crisis Committee for Nuclear Preparedness (CCNP)
- CCNP will cooperate with the JRCC to gain proper situational awareness and map all possible consequences of an incident.
- The JRCC is responsible for alerting the NRPA whenever there is a radiation or nuclear hazard. The NRPA will notify the CCNP via SOP.
- The JRCC will notify as necessary within its own chain of command.
- If a hazardous incident occurs, the head of the CCNP in close cooperation with the NRPA will decide the level of preparedness.

Two organizations involved:

- The immediate Rescue operation will be led and coordinated by the JRCC.
- The Nuclear incident is to be handled by the CCNP at the national level and the county Governor at the regional level.
- Close cooperation and good communications between the two is paramount.
- Information on the scale of the incident, weather and radioactive measurements are of uttermost importance to assess what actions need to be taken to reduce any consequences.
- The main aim is to ensure an effective rescue of lives with lowest possible hazard to the rescuers.
- All information to the media and public must be coordinated between the JRCC and the CCNP.
- JRCC will only give information about the actual rescue operation.
- The CCNP and the County Governor is responsible for all information concerning the nuclear incident.

2.2. Abstracts – Session II: Status presentations from Nordic countries and Russia

Emergency preparedness system in case of maritime accidents involving radioactive substances, Sweden

Catarina Danestig Sjögren
Swedish Radiation Safety Authority (SSM)

The Swedish emergency preparedness system is organized in levels and is based on interaction between all the organizations operating in each level. Each organization is responsible to carry out its tasks within their level, and to cooperate with other organizations at all levels. In the first instance, a crisis is managed by the municipality or the municipalities where the crisis occurred together with the licensee responsible for the activity. If necessary, the Regional County Administrative Boards support the counties in aligning and coordinating the resources in their region – the regional level. Both the counties and the Regional County Administrative Boards can take support from the central authorities to be able to handle the crisis in the best way. At the national level the government can support both the county and regional level by appointing one of the authorities to be responsible for the coordination of resources.

Because the system is built on collaboration, it is important to achieve an effective way of working that leads to a coordination of resources and an agreement on direction of handling. That requires a good ability to communicate between the organizations to be able to interact on relevant issues at the right time and to provide consistent information to media and to the public.

When it comes to an accident in a NPP the Regional County Administrative Board of the county the NPP is located takes the operational management, with support from both the counties in the region and different central authorities. They take decisions on protective measures after recommendations from the Radiation Safety Authority.

When it comes to maritime accidents there are two organizations that have operational responsibility. The Swedish Coast Guard takes the operational crises management at sea. If there is any radioactive release spreading in over land, the counties take the lead of the crises management within their own county. In case the release is spread out over a whole region the County Administrative Board support the counties with coordination of resources within their region. In case of terror attacks the Police take the lead of the crises management at sea with assistance from the Swedish Cost Guard. Regarding the release over land, it´s the same handling as if it is an accident.

There are a lot of authorities involved in a radiological emergency, therefor the Swedish Contingencies Agency, MSB, has an important role to encourage the authorities to see the big picture and based on this, coordinate resources and prioritize actions for the good of the public.

The Swedish Radiation Safety Authority (SSM) is responsible for providing advices and recommendations concerning protective measures regarding radiation protection, radiation measurements, clean-up and decontamination following a release of radioactive substances. To manage this SSM try to develop effective procedures and routines together with administrative tools and systems that are user friendly.

The emergency organization of SSM manages the crisis from a control center. When an alarm goes the crises management start with cooperation between the radiation protection officer on duty, the reactor safety officer on duty and the press officer on duty. All, with availability 24 hours a day. If an accident is considered to be of the nature Crisis the Emergency response group is called in to handle the crisis as the first shift. A plan, depending on type of crises, for how to staff the crisis organization is made before more people are called in. The organization as a whole includes experts in nuclear safety and security, radiation safety and communicators.

Overview of Finnish emergency preparedness system and actions in radiological maritime accidents

Tuomas Peltonen
STUK - Radiation and Nuclear Safety Authority in Finland

In the case of a nuclear or radiological accident, there can be many Finnish authorities involved in decision-making and protective actions. Each authority decides upon measures concerning their own administration responsibilities. The Nuclear and Radiation Safety Authority STUK issues information concerning the accident, radiation situation and the impact of the situation on public health and safety.

In the case of maritime accidents, the most important Finnish authorities include Finnish Transport Agency (under the Ministry of Transport and Communications), Border Guard, and Defence Forces. The Finnish Transport Agency as a VTS authority (Vessel Traffic Service) can close the sea area, the sea route fully or partially in Finnish territorial waters. It is also able to warn about radiological incidents ships outside Finnish territorial waters. The Border Guard is leading maritime rescue authority, which is responsible for search and rescue organization of operations. Maritime Forces has some ships suitable for assisting in radiation accidents.

The major challenge in the management of maritime radiological accident is communication between different authorities. Thus, it is important regularly to exercise also this kind of situations in addition to nuclear power plant exercises.

Figure 8. Presentations from Sweden, SSM and Finland, STUK. *Photos: Anna Nalbandyan and Øyvind Aas-Hansen, NRPA.*

Emergency preparedness system in case of maritime accidents in Icelandic waters

Kjartan Guðnason
Icelandic Radiation Safety Authority (IRSA)

General description of the emergency preparedness system in Iceland. The Icelandic Coast Guard plays a key role in the coordination and execution of SAR at sea while the Civil Protection Department of the National Commissioner of the Police is responsible for general coordination in emergency situations, e.g. when the Natioal Rescue Centre is activated. Natural disasters are not uncommon in Iceland and general and specific emergency plans are relatively mature and frequently implemented in exercises and actual situations. The Icelandic Search and Rescue Region is fairly large (1,8 million km^2) and challenging due to rough seas, darkness in winter, ice and long distances. This limits rescue capabilities in the region. The sensitive ecosystem of the area and the importance of the fishing industry for the economy of the country are among main concerns regarding increased maritime traffic. The Icelandic Radiation Safety Authority (IRSA), as a National Competent Authority, builds upon streamlining with existing emergency preparedness infrastructure, with special emphasis on establishing and maintaining communication with first responders, law enforcement, academia, research institutions and related parties domestically and abroad through training, exercises, communication tests and scientific cooperation. Real-time monitoring of aerosols and total gamma dose rates, together with monitoring of radionuclides in yearly samples of seawater and biota from Icelandic waters provide a background for measurements that could be made in emergency situations.

The Danish Nuclear emergency preparedness plan

Jeppe Vöge Jensen
Danish Emergency Management Agency, Nuclear Division (DEMA NUC)

The Danish Emergency Management Agency (DEMA) is a Danish governmental agency under the Ministry of Defense. The agency was formed under the Danish Emergency Management Act, which came into force on January 1, 1993. DEMA's mission is to cushion the effects of accidents and disasters on society and to prevent harm to people, property and the environment.
Consequently, DEMA has a series of operational, supervisory and regulatory functions concerning emergency management and preparedness.

In Danish preparedness planning five general principles are used:

- Sector responsibility i.e. that the department or agency which has the daily responsibility for a given sector retains responsibility for that sector during crisis;
- Similarity stating the importance of maintaining the largest similarity possible between the daily setup and the crisis management setup in order to minimize the extent of organizational re-arrangements when activating the crisis management organisation;
- Subsidiarity which means that emergency management and crisis management activities should be handled at the lowest organizational level possible;

- Cooperation: Authorities are responsible for cooperating and coordinating with each other in terms of both preparedness planning and crisis management.;
- Precaution in a situation with unclear or incomplete information, it is always preferable to establish a higher, rather than a lower, level of preparedness.

The Danish Emergency Management Agency's (DEMA) Nuclear Division (NUC) is responsible for maintaining the general nuclear emergency preparedness plan for Denmark and is National Competent Authority (NCA) in accordance with IAEA conventions. The nuclear Division maintains expert knowledge regarding measurements and consequence assessment and is responsible for the physical protection of transport of nuclear materials in Denmark. In addition to this the Danish Nuclear Division has an inspectorate function for the remaining parts of the old RISØ research reactors.

The Nuclear Division at DEMA has created Standard Operation Procedures in case of passage nuclear propelled vessels. When DEMA NUC becomes aware of a passage other authorities and countries are informed and steps are taken to: follow the ship and estimate its course and time-of-passages and make dispersions calculations.

Norwegian Nuclear Emergency Organisation

Inger Margrethe Eikelmann
Norwegian Radiation Protection Authority, Section High North (NRPA)

The Norwegian nuclear preparedness is organized around the Crisis Committee for Nuclear Preparedness. The Crisis Committee consists of representatives from key government offices, who have a special responsibility for a sector in the management of a nuclear or radiological event. The emergency preparedness organisation comprises the Crisis Committee for Nuclear Preparedness, the Crisis Committee's advisors, the Crisis Committee's secretariat, and the county governors as the Crisis Committee's regional links. The Crisis Committee has the authority to, and is responsible for, implementing protective measures (NRPA, 2013).

The Nuclear Emergency Preparedness Organisation was established to make expertise available to handle nuclear incidents and to ensure the rapid implementation of measures to protect life, health, the environment and other important public interests.
Nuclear incidents include both accidents and incidents resulting from intentional actions during peacetime and during political security crises/war. If a nuclear incident has occurred or when a nuclear incident cannot be ruled out, and this may affect Norway or affect Norwegian interests, the Crisis Committee for Nuclear Preparedness shall ensure the coordination of efforts and information. During the acute phase of a nuclear incident the Crisis Committee has the authority to issue orders concerning measures it specifies. The Crisis Committee also performs tasks in the continuous work on preparedness and is intended to function as an advisor to the authorities during later phases of a nuclear incident.

The Crisis Committee's mandate also covers incidents that take place outside Norway and which do not have direct consequences on Norwegian territory, if the incident affects Norwegian citizens or Norwegian interests (NRPA, 2013).

The Crisis Committee for Nuclear Preparedness

The following governmental agencies appoint a representative and deputy representative to the Crisis Committee for Nuclear Preparedness:

- The Norwegian Radiation Protection Authority
- The Directorate for Civil Protection and Emergency Planning
- The Ministry of Defence
- The National Police Directorate
- The Norwegian Directorate of Health and Social Services
- The Norwegian Food Safety Authority
- The Norwegian Coastal Authority
- The Ministry of Foreign Affairs

The Crisis Committee for Nuclear Preparedness is chaired by the Director General of the Norwegian Radiation Protection Authority.

The Crisis Committee's advisors

The Crisis Committee's advisors perform tasks in both the continuous work on preparedness and in connection with the management of a nuclear incident. The advisors are:

- The Norwegian Institute og Bioeconomy Research (NIBIO)
- The Norwegian Environmental Agency
- The Norwegian Directorate of Fisheries
- The Norwegian Defence Research Establishment
- The Institute of Marine Research
- The Institute for Energy Technology
- The Norwegian Meteorological Institute
- The Norwegian Institute of Public Health
- The Geological Survey of Norway
- The Norwegian Polar Institute
- The Norwegian Center for NBC Medicine
- The Norwegian University of Life Sciences
- The National Veterinary Institute

Working methods of the Crisis Committee and the advisors
The Crisis Committee shall with the support of its advisors issue coordinated orders pursuant aimed at protecting life, health, the environment and other important public interests.

During the acute phase:

- ➢ Obtain and process information and measurement data, if necessary by issuing orders to private and public enterprises, in order to prepare as best an overview as possible of the situation, as well as prognoses concerning how the situation will develop.
- ➢ Ensure the coordination of the information provided to the authorities, the general public and the media.

Authorities responsible for following up the decisions that have been taken shall report on their implementation to the Crisis Committee. Affected authorities, which possess relevant information about the situation in their respective areas, shall communicate this to the Crisis Committee without unnecessary delay.

During later phases, the Crisis Committee, with the support of its advisors, shall provide expert, coordinated advice concerning more long-term measures, e.g. further planned readings, production restrictions and the sale of foodstuffs. During this phase, it may be appropriate to gather the relevant authorities at a conference at which the measures can be coordinated.

During the continuous work on preparedness:
The Crisis Committee and the advisors shall:

- Take the initiative with respect to developing, maintaining and coordinating the emergency preparedness organisation, materials and services with the aim of ensuring the most effective efforts possible in the event of a nuclear incident.
- Maintain contact with the responsible authorities at all levels, assist with information and advice in connection with preparedness questions.
- Serve as a forum for continuous mutual information sharing between member agencies and institutions.
- Maintain a continuous overview of the relevant threat picture.
- Hold drills, possibly in cooperation with other bodies.

County governors
County governors shall establish the necessary regional forum for coordination in which affected government agencies shall participate and establish plans for their nuclear preparedness function. County governors shall ensure that the regional and local government agencies that fall under a county governor's synchronisation and coordination responsibilities have established satisfactory plans for nuclear incidents as part of the coordinated plans.

Future of the Northern Fleet – an overview of nearest plans of FSUE Atomflot for the future

Sergei Vasilev
Emergency Response Center (ERC) of the ROSATOM (St. Petersburg)

FSUE Atomflot is one of more than 30 facilities for which ERC is ready to provide emergency response 24/7.

FSUE Atomflot was established to provide technological service and maintenance of nuclear-powered icebreakers and special fleet. In 2008 FSUE Atomflot joined ROSATOM. There are 6 working NPIB: Vaygatch, Soviet Union, Jamal, 50 y Victory, Taymyr and Rossia. The three others (Lenin, Arktic and Siberia) are anchored.

Main services of FSUE Atomflot are:

- Ice pilotage of vessels on the Northern Sea Route (NSR) and to the freezing ports of Russia;
- Container shipping by atomic lighter Sevmorput;

- Support of expeditionary, scientific and research works aimed at studying hydro-meteorological conditions of seas and mineral and ore resources of the Arctic shelf adjacent to the northern coast of Russia
- Emergency and rescue ice operations on the Northern Sea Route and freezing seas;
- Tourist voyages to the North Pole, islands and archipelagoes of the Central Arctic;
- Common and special technical maintenance and repair works of the atomic fleet;
- Handling of nuclear materials and radioactive wastes.

The nearest plans of FSUE Atomflot for the future:

- In 2017 (or earlier) FSUE Atomflot together with ERC of ROSATOM will establish one more branch, located in Murmansk to be closer and effective for response on northern objects accidents;
- In 2019-2020 FSUE Atomflot will have 2 newest nuclear-powered icebreakers KL-60 project, produced by Baltic Shipyard, Ltd.

2.3. Abstracts – Session III: Cross-border handling of accidents: main challenges, assistance, emergency plans and exercises

Nuclear icebreaker near Svalbard and other exercises and assessments from Norway

Øyvind Gjølme Selnæs
Norwegian Radiation Protection Authority (NRPA)

Norwegian authorities have done several assessments the last few years on consequences from severe events related to nuclear-powered vessels and transportation of spent nuclear fuel and other radioactive materials along the Norwegian coast. Two examples are the NRPA Report *"Radioecological consequences of a potential accident during transport of radioactive materials along the Norwegian coastline"* from 2007 (NRPA Report 2007:3) and the NRPA Report *"Atomtrusler"* from 2008 (NRPA Report 2008:11, in Norwegian). The NRPA has also participated in several NKS activities on this matter.

The presentation given at the NORCOP-COAST workshop, however, will focus on two major exercises we have had in Norway on this topic.

In 2008, the annual exercise in the health sector was based on a release of radioactive material from a reactor accident onboard a nuclear icebreaker just outside the Svalbard archipelago. In the scenario, a nuclear-powered icebreaker sought emergency sheltering on the east side of Spitsbergen during a developing reactor accident. The accident caused a release of radioactive material to the sea and the atmosphere, affecting the whole archipelago and with the possibility of also reaching the Norwegian mainland after a few days (Finnmark county).

The exercise was a table-top exercise on a ministerial level, with participants from the Ministry of Health and Care services, the Ministry of Justice, the Ministry of Foreign Affairs, the Ministry of Defence, the Ministry on the Environment, the Ministry of Agriculture and

Food, and the Ministry of Fisheries and Coastal Affairs. Topics for discussion were on a ministerial level, and included implemented mitigating measures, international assistance, monitoring strategies, management of radioactive waste, handling of the damaged vessel, travel restrictions, distribution of iodine tablets, funding issues, contamination of goods and communication issues.

On the 24th of June 2015, the Norwegian Radiation Protection Authority (NRPA) and the Norwegian Coastal Administration had a joint table-top exercise on the top management level. The exercise was based on a scenario with a foreign transport of spent nuclear fuel outside the Norwegian coast. In the scenario, the transporting vessel lost propulsion during a fire on-board and was adrift 17 nautical miles west of Stavanger. Topics for discussion during the exercise were handling of the vessel, possible rescue of crew members from the vessel, media management, and the possibility of emergency sheltering of the vessel.

Norwegian authorities have a high focus on the risk from the traffic of nuclear-powered vessels and transportation of spent nuclear fuel and other radioactive materials along the Norwegian coast, and several exercises to come during the rest of 2015 will be based on this topic.

Safety and Security in the marine transport of radioactive materials: Swedish experience and exercises in 2015

Helmuth Zika and Tommy Nielsen
Swedish Radiation Safety Authority (SSM)

Part I (Safety)
The Swedish legal requirements for transport of radioactive materials (RAM).
Swedish Authorities involved in the supervision of RAM transports.
The Swedish Radiation Safety Authority (SSM). Joint authority inspections of RAM transports under Swedish jurisdiction. Swedish nuclear fuel cycle facilities, modes of transports, type of RAM transported. Packages for RAM and requirements for those.
Swedish experience from 30 years of RAM transports summarized.

Part II (Security)
The in Sweden conducted transport security exercise at open sea (PILOT-2015) was
prepared and planned during 1, 5 years and had a tabletop exercise some months before the field exercise. Cooperation was done with IAEA who invited international experts/observers on both tabletop exercise and field exercise.
Objectives were both to support the IAEA in the work on the transport security exercise guide and the development of the Swedish system for countering malicious acts against transports of nuclear material

Experiences from the tabletop and field exercise together with the challenges were presented.

STUK's threat analysis of a nuclear submarine accident

Tuomas Peltonen
STUK - Radiation and Nuclear Safety Authority in Finland

In 1993 STUK carried out a threat study including deterministic analyses on the consequences of severe accidents at near-by NPPs and on a nuclear submarine. It was assumed that half of the total release takes place (immediately after the reactor shutdown) during the first hour and the latter half in 5, 11 or 23 hours depending on nuclide group. The release height was near sea level.

Weather situation was defined by the Finnish Meteorological Institute with wind speed 2.5 m/s and Pasquill stability class between E and F. The weather situation was chosen to maximize radiological consequences. The submarine was assumed to be in the middle of the Gulf of Finland, at a distance of 40 km from Helsinki. Calculations were performed with the late code OIVA which contained a Gaussian plume model.

Consequence assessment of scenario nuclear submarine accident near Helsinki was carried out with following conclusions: Due to short distance (40 km) there's is not much time to implement protective actions. During first 10-20 hours the inhalation dose is dominant. Iodine isotopes cause most of the effective dose and the significance of transuranium isotopes is smaller than in the case of nuclear power plants.

3. Summary of Workshop Sessions and discussions

3.1 Session I: Introductions to the topic: overview of the status. Legal framework and possible scenarios

At Session I, a general overview was given on the current situation with the maritime transport of radioactive materials along the Nordic coastline, traffic of nuclear-powered vessels, general legal framework and monitoring of all activities and routes by the Nordic countries. Some possible accident scenarios and consequences were discussed (incl. real and hypothetical cases), as well as possible sources for such accidents. Workshop participants shared experience in modeling and radiological assessments. An important part of discussions were notification procedures between Nordic countries.

The Norwegian Coastal Administration gave an overview on their capabilities, the scope of operations in the Norwegian Economic Zone (NEZ), including legislation within and outside NEZ and regulations concerning notification of acute pollution. Presented was a network of monitoring sensors to follow tankers and other risk-presenting traffic. Cooperation with NRPA and other governmental authorities was emphasized. The Barents Ship reporting system (Barents SRS) was introduced that deals with registration of all ships carrying out hazardous cargos. Such ships provide reports containing information on the name, position, course, destination, hazardous cargo and total quantity, etc.

The Norwegian Defense Research Establishment shared information on types of nuclear-powered vessels, the current status and the history involving accidents with different consequences.

The IAEA's Incident and Emergency Centre contributed to the Workshop via video-presentation between Vienna and Tromsø to share information on the coordination of international emergency preparedness and response assistance, international regulations (incl. notification of maritime accidents), the scope of the RANET network and a specific task group on Air and Maritime Transportation. An overview of relevant documents and manuals from IAEA was given.

The NRPA presented some scenarios related to the severe events with nuclear-powered vessels and transportation of spent nuclear fuel and other radioactive materials along the Norwegian coastline. Scenarios included: an airborne release from a domestic facility; a local event from mobile sources and a marine release and/or fear of contamination. The possible consequences and challenges while handling such accidents were discussed.

An experience on modelling of a pollutant dispersion within ecosystem after a hypothetical nuclear submarine accident with a location Northwest of Iceland within the Denmark Strait was shared by the University of Iceland. The difference between seasonal changes in the ecosystem (i.e. season when the hypothetical accident occurred) and the degree of uptake of radionuclides by the phytoplankton and zooplankton was presented.

Another modelling experience related to a hypothetical nuclear-powered icebreaker accident was shared by the Emergency Response Center (ERC) of the ROSATOM in St. Petersburg, Russia. Discussed were different parameters used in modelling of potential radiological consequences of such an accident, and results of the assessment of the worst-case scenario.

With regard for rescue operations in a hazardous environment, cooperation between different actors, authorities, rescue services and related challenges was presented by the Norwegian Joint Rescue Coordination Centre (JRCC). The scope of the Norwegian Search and Rescue (SAR) service was given, and the current cooperation between JRCC, NRPA and the Norwegian Crisis Committee for Nuclear Preparedness was outlined.

3.2 Session II: Status presentations from Nordic countries and Russia

Session II consisted of status presentations from each of the Nordic countries providing an overview of their emergency preparedness system and experience in case of maritime incidents or accidents involving radioactive substances. Specially emphasised were the main challenges within each country. The session also included a presentation from the ERC of ROSATOM in St. Petersburg, Russia with an overview and future plans of the Northern Fleet / FSUE Atomflot. The Nordic status presentations and the presentation on Atomflot were followed by plenum discussions.

The *Swedish system* presented by SSM is based on interaction and coordination between organizations in three levels - national (governmental/central authorities), regional (regional county administrative boards), and county (local) level. There was some emphasis on the organizational structure with distinctions between and within these levels.

In the *Finnish system*, each authority decides on their response and interaction level. The presentation focused on STUK's tasks and organization during emergencies. An overview of relevant exercises was also given.

In the *Icelandic system*, the situation differs from Finland and Sweden in that there is no nuclear industry and a less complex organisational structure with short and effective communication channels between few responsible actors. Given the large size of the Icelandic SAR area, financing and human resources are limited. Experiences from natural disasters such as earthquakes and volcanic eruptions have established well-tested and efficient cooperation between IRSA and relevant response parties. In a crisis situation, the National Rescue Centre will be activated to coordinate and handle the crisis.

The organization of DEMA and the *Danish system* is based on five general principles: sector responsibility, similarity, subsidiarity, cooperation and precaution. It was discussed that request for reporting and subsequent notifications can be a useful initiative with regard to Russian nuclear-powered icebreakers.

In the *Norwegian system*, NRPA has responsibilities comparable to its sister organizations in the other Nordic countries, but in addition, the NRPA is heading and providing secretariat for the Norwegian Crisis Committee for Nuclear Preparedness. In addition to the different national authorities represented in the Crisis Committee, another important actor in case of an accident is the Joint Rescue Coordination Centre, which is responsible for coordinating all national search and rescue operations.

In the *overview and future plans for FSUE Atomflot*, it was informed that FSUE Atomflot and ERC of ROSATOM will open a new branch in Murmansk in order to improve effective response in case of accidents involving objects in the north. It was also informed that two new nuclear-powered icebreakers of the LK-60 class will be built in the period up until 2020.

The discussions emphasized that:

- Both Sweden and Finland have many organizations operating in the area at different levels, and that counties bear great responsibilities;
- In case of a maritime accident in Nordic waters, cross-country assistance may be of high relevance. Routines for cross-country Nordic assistance should complement the IAEA’s RANET and should fit in with the already existing systems with regard to communication channels, agreements and protocols;
- An important aspect is complexity in handling an accident involving military vessels;
- There is a need for joint training, including receiving assistance in case of an accident;
- The psychological factor related to the impact from maritime accidents involving radioactive substances should not be underestimated;
- There is a need for better education of first responders and communication to the public.

3.3 Session III: Cross-border handling of accidents: main challenges, assistance, emergency plans and exercises

Session III was dedicated to the discussion of main challenges, assistance, emergency plans and exercises while handling maritime incidents or accidents across the border. Workshop participants presented different experience from Nordic countries.

In recent years, Norway has been very active to arrange and participate in exercises involving nuclear-powered vessels. As an example, a scenario with a nuclear-powered icebreaker accident near Svalbard with a release to the sea and to the atmosphere was presented, and experience from this exercise summarized. Another accident scenario presented involved outbreak of fire in a ship transporting spent nuclear fuel (SNF) outside the Norwegian coastline. In 2015, NRPA together with the Norwegian Coastal Administration (Kystverket) and the Norwegian Ministry of Foreign Affairs observed an IAEA exercise with a scenario on the transport of SNF outside a third party's coastline. It was discussed that the development of a new joint project as a follow-up of the current activity could improve the situation.

Unlike other Nordic countries, Sweden deals with quite a lot of marine transport of nuclear material. The material in general is very well shielded and these transports are widely accepted in Sweden. However, this type of activity requires consideration of all the safety and security issues. Workshop participants discussed handling of such accident scenarios and a possibility for a joint exercise. A challenge in such a scenario is a difficulty to assess the possible source term. As an example of exercises, the Swedish exercise PILOT 2015 was presented which had international participants and consisted of a table-top part with experts and observers and a field exercise part. At this time, the focus was on physical protection and not on environmental impact. The other important aspect is the specificity of transported radioactive material: as an example, UF6 was discussed that has a very high risk and will react easy with water in case of a discharge.

Finland presented a threat analysis of a nuclear submarine accident carried out in STUK in 1993. The analysis related to the worst-case scenario with deterministic consequence analysis, using the Gaussian dispersion model. If performing this kind of analysis using modern tools, then it should also include effects on the marine environment and a statistical approach to assess consequences with a more sophisticated dispersion model and real weather data. Results from the Finnish study were also discussed in relation to the comparable Russian study, presented in Session I.

4. Identification of target areas for further cooperation and improvements

As a result of the 2-days discussions on response to maritime emergencies at the NORCOP-COAST Workshop, the following areas and needs for further improvement and cooperation were identified and specified:

A) Notification

- A need to improve and test the pre-notification and notification procedures and their implementation between Nordic countries and Russia in case of maritime emergency situations.

B) Assistance

- A need for joint training on providing and receiving assistance between Nordic countries in case of an accident.

C) Sources, risk assessment and modelling

- A need to define potential sources, source term and related risks;

- A need to define possible scenarios and jointly assess potential consequences;
- A need to provide knowledge on the probability of accidents under different scenarios;
- A need to improve and test modelling tools both for atmospheric and marine dispersion of radioactive substances.

D) Exercises and cross-border cooperation

- A need for a real-time exercise on notification of a radioactive cargo transport or a nuclear icebreaker;
- A need to jointly practice rescue activities for different scenarios in each country and across the border;
- Regional cooperation: a need to establish better cooperation with regional branches of authorities, coastal administration and rescue service in all Nordic countries and Russia and involve them in exercises.

E) Education and communication

- A need for better education of first responders – produce manuals and information sheets, organise educational seminars on basic risk and non-risk representing areas with regard for radiation.
- A need for better public communication: produce different thematic fact sheets or short videos in advance (example: info on floating NPPs, safety of containers transporting radioactive materials, etc.), organise public seminars; provide information on recent status and preparedness.
- A need for better communication and provision of information to politicians and stakeholders.
- A need for knowledge on potential consequences of decisions related to the handling of different accidents on everyday life of public and stakeholders.

F) Post-accident preparedness

- Follow-up and decision-making after the accident: national approach and interaction between countries.

5. Conclusions

The NORCOP-COAST activity allowed to get an overview of the existing emergency preparedness systems in each of the Nordic countries and in Russia; ways of handling the maritime accidents resulting in spread of radioactive substances; overview of responsible organisations and procedures and plans for interaction with neighboring countries (including notification and assistance). Relevant contacts were exchanged and networks established within the workshop topic between involved authorities, organisations and participants. Challenges and target areas for future cooperation under maritime emergency and response were identified and further ways for improvement discussed that underlines steps for future success in handling of potential maritime accidents.

As a first stage for follow-up, a new joint project related to the development of scenarios and a table-top concept was drafted and submitted to NKS for cooperation in 2016, with a purpose to organize a Nordic execise in 2017-2018.

6. References

NRPA, 2012. Norwegian Radiation Protection Authority. Roles, responsibilities, crisis management and challenges in Norwegian nuclear and radiological preparedness. StrålevernRapport 2012:5. Østerås: Norwegian Radiation Protection Authority, 2012. Language: Norwegian.

NRPA, 2013. Norwegian Nuclear Emergency Response Organisation. Central and regional organisation. Kgl.res. of 23. August 2013. StrålevernHefte 31. Østerås: Norwegian Radiation Protection Authority, 2013. Language: Norwegian.

7. Recommended literature to the topic

While the NORCOP-COAST project focused on response systems and cooperation in handling of accidents related to maritime traffic of nuclear-powered vessels and transport of radioactive materials by sea, several other aspects have been subject to previous assessments. Below, it is suggested a list of recommended literature/reports related to the topic of maritime emergency preparedness and response:

Amundsen I, Iosjpe M, Reistad O, Lind B, Gussgaard K, Strand P, Borghuis S. Sickel M, Dowdall M, 2002. «The accidental sinking of the nuclear submarine, the Kursk: monitoring of radioactivity and preliminary assessment of the potential impact of radioactive releases». *Marine Pollution Bulletin* 44, pp 459 – 468.

Dowdall M, Standring W.J.F., 2008. “Floating nuclear power plants and associated technologies in the northern areas”. *StrålevernRapport* 2008:15. Norwegian Radiation Protection Authority, Østerås, Norway.

Gaffney, P., 2011. “The transport of nuclear materials by sea in northern Europe”. *KIMO Secretariat*, Shetland, p. 53.

Halldórssón Ó., Iosjpe M., Isaksson M., Joensen H.P., Jonsson G., Logemann K., Roos P., Suolanen V., Thomas R., Vartti V.-P., 2015. “Effects of dynamic behaviour of Nordic marine environment to radioecological assessments”. *Nordic Nuclear Safety Research report* NKS-326 (EFMARE 2014-2016, interim report for 2014). NKS Secretariat, Roskilde, Denmark.

Hermansen K, Selnæs Ø, Eikelmann IM, Holo E, Liland A, Sickel M, Amundsen I, Reistad O., 2006. “K-159. The loss of the Russian nuclear submarine K-159 at sea and the Norwegian nuclear emergency organisation’s handling of the accident“. *StrålevernRapport* 2006:8. Norwegian Radiation Protection Authority, Østerås, Norway. (in Norwegian).

Hosseini A, Amundsen I, Brown J, Dowdall M, Standring W. "Inventory and source term evaluation of the dumped nuclear submarine K-27". *StrålevernRapport* 2015:6. Norwegian Radiation Protection Authority, Østerås, Norway.

Høibråten S, Haugan A, Thoresen P, 2003. «The environmental impact of the sunken submarine Komsomolets». *FFI report* 2003/02523, The Norwegian Defense Research Establishment, Kjeller, Norway.

Iosjpe M., Reistad O., Amundsen I., 2007. «Radioecological consequences of a potential accident during transport of radioactive materials along the Norwegian coastline". *StrålevernRapport* 2007:3. Norwegian Radiation Protection Authority, Østerås, Norway.

Iosjpe M., Reistad O., Liland A., 2011. «Radioecological consequences after a hypothetical accident with release into the marine environment involving a Russian nuclear submarine in the Barents Sea". *StrålevernRapport* 2011:3, the Norwegian Radiation Protection Authority, Østerås, Norway.

Iosjpe M, Isaksson M, Joensen HP, Lahtinen J, Logemann K, Pálsson SE, Roos P, Suolanen V, 2013. «Consequences of severe radioactive releases to Nordic Marine environment". *Nordic Nuclear Safety Research report* NKS-276. NKS Secretariat, Roskilde, Denmark. NKS-B, Radioecological assessments. (COSEMA 2013).

Iosjpe M, Isaksson M, Joensen HP, Lahtinen J, Logemann K, Pálsson SE, Roos P, Suolanen V, Vartti V-P, 2014. «Consequences of severe radioactive releases to Nordic Marine environment». *Nordic Nuclear Safety Research report* NKS-276 (COSEMA 2013). NKS Secretariat, Roskilde, Denmark.

Kauker F, Kaminski T, Karcher M, Dowdall M, Brown J, Hosseini A, Strand P, 2016. "Model analysis of worst place scenarios for nuclear accidents in the Northern Marine Environment». *Environmental Modelling and Software*, Vol. 77, pp 13-18.

Kystverket 2015. «Sjøsikkerhetsanalysen 2014 - Miljøfarlig, radioaktiv og eksplosjonsfarlig last og drivstoff». *Kystverket / DNV GL Report* 2015-0367, Rev. B. (in Norwegian).

Reistad O, Ølgaard PL, 2006a. «Russian nuclear power plants for marine applications". *Nordic Nuclear Safety Research report* NKS-138. NKS Secretariat, Roskilde, Denmark.

Reistad O, Ølgaard PL, 2006b. Inventory and source term evaluation of Russian nuclear power plants for marine applications. *Nordic Nuclear Safety Research report* NKS-139. NKS Secretariat, Roskilde, Denmark.

Reistad O, Hustveit S, Pálsson SE, Hoe S, Lahtinen J, 2012. «A Nordic approach to impact assessment of accidents with nuclear-propelled vessels". *Nordic Nuclear Safety Research report* NKS-268 (MARENUC). NKS Secretariat, Roskilde, Denmark.

Sawhill SG, Ragner CL, 2002. "Shipping nuclear cargo via the Northern Sea Route", Polar Record, Vol 38 (204), pp 39-52.

Ølgaard PL, 2001. "The potential risks from Russian nuclear ships". *Nordic Nuclear Safety Research report* NKS-57. NKS Secretariat, Roskilde, Denmark.

Appendix I – Workshop program

NKS-B NORCOP-COAST

Workshop on nuclear icebreaker traffic and transport of radioactive materials along the Nordic coastline: response systems and cooperation to handle accidents

13-14 October 2015, Tromsø, Norway

PROGRAM

Venue: FRAM-High North Research Centre on Climate and the Environment, Hjalmar Johansens gate 14, 9296 Tromsø, Norway (www.framsenteret.no), 2nd floor, room Ny Ålesund

13 October – Workshop Day 1, 09.00 – 18.00

Chair: Anna Nalbandyan, NRPA, Norway

I. Introductions to the topic: overview of the status, legal framework and possible scenarios

1. **Status of the present transport, routes and activity along the Nordic coastline** Alf-Tore Kristoffersen, the Norwegian Coastal Administration, NOR VTS (Kystverket).

2. **General legal framework for sea transport and maritime accidents.** Rune Bergstrøm, The Norwegian Coastal Administration, Norway (Kystverket).

3. **Maritime accidents with a focus on nuclear accidents or incidents involving spread of radioactive substances - international cooperation in this area**.

   IAEA Response to Maritime Accidents. Florian Baciu and Pat Kenny, IAEA Incident and Emergency Centre (video-presentation).

4. **Possible sources, scenarios and consequences: real and hypothetical accidents.** Hanne Breivik and Steinar Høibråten, The Norwegian Defense Research Establishment (FFI).

   Presentation of some relevant scenarios. Øyvind G. Selnæs, NRPA, Norway.

   Simulation of pollutant dispersion along the oceanic food chain with CODE/eco_CODE. Kai Logemann, University of Iceland.

   Modelling of the nuclear-powered icebreaker accident at the Eastern Gulf of Finland and assessment of possible consequences. Sergei Vasilev, Emergency Response Center of ROSATOM, St. Petersburg, Russia.

5. **Rescue Service operations in hazardous environment: cooperation between rescue service, authorities and other actors.** Bent-Ove Jamtli, The Norwegian Joint Rescue Coordination Centre, North Norway (Hovedredningssentralen).

   Presentations followed by a discussion between workshop participants.

12:30 – 13:30 Lunch

Chair: Jonas Lindgren, SSM, Sweden

II. Status presentations from Nordic countries:

6. **Overview of emergency preparedness system and experience in case of maritime accidents involving radioactive substances; main challenges.**

   - Presentation from Sweden: Emergency preparedness system in case of maritime accidents involving radioactive substances. Catarina Danestig Sjögren, SSM
   - Presentation from Finland: Overview of emergency preparedness system and actions in radiological maritime accidents. Tuomas Peltonen, STUK
   - Presentation from Denmark: The Danish emergency preparedness plan. Anna Nalbandyan on behalf of Jeppe Vöge Jensen, DEMA NUC
   - Presentation from Iceland: Emergency preparedness system in case of maritime accidents in Icelandic waters. Kjartan Guðnason, IRSA, Iceland
   - Presentation from Norway: Norwegian Nuclear Emergency Organisation. Inger Margrethe H. Eikelmann, NRPA

7. **Future of the Northern Fleet – an overview of nearest plans of FSUE Atomflot for the future**. Sergei Vasilev, Emergency Response Center of ROSATOM, St. Petersburg, Russia.

19:00 - Joint dinner hosted by NRPA at the Arctandria Seafood Restaurant, Strandtorget 1, Tromsø city centre.

<u>14 October</u> – Workshop Day 2, 09.00 – 12.30

Chair: Inger Margrethe H. Eikelmann, NRPA, Norway

III. Cross-border handling of incidents and accidents: main challenges, assistance, emergency plans and exercises. Experiences from Nordic countries.

8. **Nuclear icebreaker near Svalbard and other exercises and assessments from Norway.** Øyvind G. Selnæs, NRPA.

9. **Safety and Security in the marine transport of radioactive materials: Swedish experience and exercises in 2015.** Helmuth Zika and Tommy Nielsen, SSM.

10. **Finnish experience overview: STUK's threat analysis of a nuclear submarine accident.** Tuomas Peltonen, STUK.

IV. Identification of target areas for further cooperation and improvements - Discussions
Each country presents ideas for future cooperation and improvements.

V. Conclusions, plans for further follow-up

12:30 – 13:30 Lunch

13:30 -15:00 Project group meeting

Discussion and drafting of a new joint proposal/s; planning of the Final report to the NKS.

Appendix II – NKS-B NORCOP-COAST Workshop participants

Country and representative	Organisation short	Organisation
NORWAY		
Inger Margrethe Eikelmann	NRPA	Norwegian Radiation Protection Authority
Anna Nalbandyan	NRPA	Norwegian Radiation Protection Authority
Øyvind Aas-Hansen	NRPA	Norwegian Radiation Protection Authority
Øyvind Gjølme Selnæs	NRPA	Norwegian Radiation Protection Authority
Hilde Elise Heldal	IMR	Institute of Marine Research, Bergen
Andrey Volynkin	IMR	Institute of Marine Research, Bergen
Alf-Tore Kristoffersen	NCA	The Norwegian Coastal Administration
Lars Erik Svanekil	NCA	The Norwegian Coastal Administration
Elisabeth Sørnes	NCA	The Norwegian Coastal Administration
Tina Warelius	NCA	The Norwegian Coastal Administration
Rune Bergstrøm	NCA	The Norwegian Coastal Administration
Bent-Ove Jamtli	JRCC	The Norwegian Joint Rescue Coordination Centre
Hanne Breivik	FFI	Norwegian Defence Research Establishment
Steinar Høibråten	FFI	Norwegian Defence Research Establishment
Anne Katrine Normann	NORUT	Northern Research Institute
SWEDEN		
Jonas Lindgren	SSM	Swedish Radiation Safety Authority
Catarina Danestig Sjögren	SSM	Swedish Radiation Safety Authority
Helmuth Zika	SSM	Swedish Radiation Safety Authority
Tommy Nielsen	SSM	Swedish Radiation Safety Authority
FINLAND		
Tuomas Peltonen	STUK	Radiation and Nuclear Safety Authority in Finland
DENMARK		
Jeppe Vöge Jensen*	DEMA NUC	Danish Emergency Management Agency
ICELAND		
Kjartan Guðnason	IRSA	Icelandic Radiation Safety Authority
Kai Logemann	UoI	University of Iceland
RUSSIA		
Sergei Vasilev	ERC ROSATOM	Emergency Response Center of the ROSATOM
IAEA Florian Baciu** Pat Kenny**	IAEA	International Atomic Energy Agency, Incident and Emergency Centre

*was not able to come to Tromsø, but participated on meetings and provided contribution to the workshop and report.
**was not able to come to Tromsø, but contributed to the workshop via video-presentation.

Bibliographic Data Sheet NKS-362

Title	Nuclear icebreaker traffic and transport of radioactive materials along the Nordic coastline: response systems and cooperation to handle accidents (NORCOP-COAST): Final report
Author(s)	Anna Nalbandyan[1], Øyvind Aas-Hansen[1], Inger Margrethe H. Eikelmann[1], Jonas Lindgren[2], Kjartan Guðnason[3], Tuomas Peltonen[4], Jeppe Vöge Jensen[5]
Affiliation(s)	[1]Norwegian Radiation Protection Authority, Section High North, PO Box 6606 Langnes, 9296 Tromsø, Norway [2]Swedish Radiation Safety Authority, S-171 16, Stockholm, Sweden [3]Icelandic Radiation Safety Authority, Raudararstigur 10, 150 Reykjavik, Iceland [4] STUK-Radiation and Nuclear Safety Authority in Finland, PO Box 14, 00881 Helsinki, Finland [5]Danish Emergency Management Agency, Datavej 16, 3460, Birkerød, Denmark
ISBN	978-87-7893-447-5
Date	March 2016
Project	NKS-B / NORCOP-COAST
No. of pages	32
No. of tables	0
No. of illustrations	8
No. of references	2
Abstract max. 2000 characters	The maritime traffic in the Arctic region is already considerable and expected to increase in the future years.This includes traffic of nuclear icebreakers and transport of radioactive materials along the Nordic coastline. An increase in such traffic will increase potential risks for accidents resulting in spread of radioactive materials into the terrestrial and marine environments. All this put an additional pressure on monitoring and responding authorities, coastguards and rescue services. In the frames of the NORCOP-COAST project a 2-days workshop was organized in Tromsø, Norway on 13-14 October 2015 where authorities from Norway, Finland, Denmark, Sweden and Iceland as well as Emergency Response Center of ROSATOM from Russia and Incident and Emergency Centre of the IAEA contributed. The joint discussions covered existing emergency preparedness and response systems in each country; possible scenarios and ways of handling the maritime accidents

resulting in spread of radioactive substances; national and international laws; notification procedures; interaction between Nordic countries and Russia. This report summarizes results of joint discussions and provides a description of identified challenges and target areas for future cooperation in order to further improve cross-border assistance and handling of maritime accidents both between Nordic countries and between Nordic countries and Russia.

Key words Nordic coastline, maritime accidents, response systems, notification, radioactive cargo, nuclear icebreaker, nuclear-powered vessels, cross-border preparedness.

Available on request from the NKS Secretariat, P.O.Box 49, DK-4000 Roskilde, Denmark.
Phone (+45) 4677 4041, e-mail nks@nks.org, www.nks.org