DET NORSKE VERITAS

Report

Evaluation of the Norwegian funded project on decommissioning of Russian nuclear submarines

Norwegian Radiation Protection Authority

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Evaluation of the Norwegian funded project on decommissioning of Russian nuclear submarines	DET NORSKE VERITAS AS P.O.Box 300 1322 Høvik, Norway Tel: +47 67 57 99 00 Fax: +47 67 57 99 11 http://www.dnv.com Org. No: NO 945 748 931 MVA
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Summary:

In September 2011 Det Norske Veritas (DNV) was contracted to (i) evaluate the success of projects under the dismantling programme in achieving improvements in the nuclear safety and environmental benefits and to (ii) evaluate the project management and financial aspects of submarine 609. In DNV's opinion Norwegian funding has been instrumental in ensuring that the four non-strategic nuclear submarines were dismantled and the spent nuclear fuel and radioactive wastes were removed and destined for disposal. The dismantling took place without any reported serious events with release of radioactivity to the environment or uncontrolled exposure to people. Compared to the alternative of non-intervention, DNV is of the impression that improvements in nuclear safety and environmental protection have been achieved at the relevant locations for the decommissioned sub-marines. However, due to lack of long-term impact data as well as limited information on the further handling and final disposal of spent nuclear fuel at Mayak, it is difficult to assess improvements in nuclear safety and environmental protection beyond the relevant locations and in a long term perspective.

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EXECUTIVE SUMMARY

Nuclear safety in the north is an important part of the collaboration between Norway and Russia. In 1995 the Norwegian Government established a Nuclear Action Plan which is considered to be the most important management tool of the Norwegian authorities in their nuclear safety work with Russia. One of the programmes in the Action Plan has been the dismantling of Russian nuclear-powered non-strategic submarines. Between 2003 and 2007 Norway financed dismantling of three submarines at the Nerpa shipyard north of Murmansk and one at the Zvezdochka shipyard in Severodvinsk.

In September 2011 Det Norske Veritas (DNV) was contracted to (i) evaluate the success of projects under the dismantling programme in achieving improvements in the nuclear safety and environmental benefits and to (ii) evaluate the project management and financial aspects of submarine 609. The evaluation was undertaken as a desk top study supported by interviews with selected key stakeholders during the assignment period between September and November 2011.

For the purpose of the evaluation DNV has analyzed achievements of the dismantlement programme along three major success areas: long-term impact, outcome and deliverables. Each success area is scored[1] along the dimensions goal accomplishment and performance. Accordingly, good performance is acknowledged as an important input to the overall benefits even though goal achievement may not be provable.

In DNV's opinion Norwegian funding has been instrumental in ensuring that the four non-strategic nuclear submarines were dismantled and the spent nuclear fuel and radioactive wastes were removed and destined for disposal. The dismantling took place without any reported serious events with subsequent release of radioactivity to the environment or uncontrolled exposure to people. Compared to the alternative of non-intervention, DNV is of the impression that improvements in nuclear safety and environmental protection have been achieved at the decommissioning locations. However, due to lack of long-term impact data as well as limited information on the further handling and final disposal of spent nuclear fuel at Mayak, it is difficult to assess improvements in nuclear safety and environmental protection beyond the decommissioning locations and in a long term perspective.

In our view, the dismantling performance i.e. risk identification and handling as well as ensuring safe management, transport and storage of spent nuclear fuel and radioactive waste, in general has been carried out satisfactorily. Security risks, as well as the most severe safety risk seem to have been considered during the respective defueling steps. Additionally, for associated routine operations, mitigating actions and restrictions basically appeared to be in place. As regards the main aspects of safe management, transport and storage of spent nuclear fuel and radioactive waste, DNV supports the main impression that this has been handled satisfactorily and according to applicable Russian regulations.

From a risk handling perspective, two areas could have been improved i.e. issues with respect to contaminated water inside the vessel tanks after removal of the spent fuel and non-radioactive

[1]The scoring is only undertaken for part one of the scope.

wastes. Risks related to contaminated water may not have been handled satisfactorily, as evidenced by alleged leakages inside the hall where dismantlement was carried out. Furthermore, non-radioactive waste may seem to have been given disproportionately limited attention during the decommissioning process, at least as compared to the low-level radioactive waste. Although concerns with regard to management and disposal of other non-radioactive hazardous substances, such as PCB, were highlighted by the Norwegian side, the documents reviewed by DNV do not demonstrate that this was undertaken in a safe matter.

With respect to cooperation and knowledge sharing, DNV's view is that this success area has been achieved only partially. It appears that knowledge, communication and trust between Norwegian and Russian stakeholders steadily developed throughout the dismantlement activities, and that previous unknown information was made available by the Russians. However, in general, the involvement of Russian authorities seems to have been related directly at Russian stakeholders – in particular in conjunction with approvals and licensing of the shipyards, and not towards the Norwegian authorities. Additionally, DNV has not seen documentation showing that Norwegian requests for changes or additional information resulted in actual changes in Russian work practices.

Looking at fulfilment of requirements, independent review of risks assessments and EIA was undertaken for all four submarines. Although the Russian EIA process is much in line with Norwegian and European principles, an important deviation is that Russian EIA is mainly a tool for the implementation process while the Norwegian/European EIAs is a tool for the planning and decision making. This was also the case for the submarines in question. Looking at the timing aspect of the risk assessment and EIA process, an independent review of the EIA documentation for submarine 625 and 627 was undertaken *after* the decision made for Norwegian funding. This was regarded as a non-compliance with respect to the Norwegian requirements. For the other two submarines (297 and 609), timing of the independent review of EIA was not an issue. It is, however, noted that no separate EIA was undertaken for submarine 609. Rather, EIA documentation for the previous dismantling of submarine 297 was used as a basis. Despite this fact, DNV considers it reasonable to conclude that the Norwegian side had satisfactory knowledge of risk assessments and EIA issues and to start up with the dismantling of submarine 609.

All documentation reviewed points in the direction that the dismantling was performed according to plan and budget and without any serious incidents involving uncontrolled releases of radioactivity to the environment or exposure to people. Consequently, it is our view that the expected deliveries of the dismantling programme have been achieved completely.

With respect to project management of submarine 609 the project organisation appeared to function well. Obviously, having the same project manager on board as in the three previous dismantling projects strengthened the execution of the project. The major role of the PM was to carry out regular inspections at the shipyards and recommend payment from MFA to the shipyards upon fulfilment of milestones. This arrangement appeared to function well and no deviations were found. Although the dismantling was undertaken according to agreed budget, documents reviewed showed unsatisfactory documentation of man-hours used and overhead costs at Nerpa. Together with lack of reference to fraudulent and corrupt practices and competitive bidding processes in the contractual documents, the area of internal control appeared weak. This aspect was also pointed out by the PM himself as well as in other reports[2]. The principle of lessons learned is important for future involvement in similar projects. Although lessons learned have been incorporated throughout the years with Norwegian funding, no documents reviewed for submarine 609 addresses this aspect in particular. In our view, this is necessary in order to institutionalize experiences gained.

[2] Following the 2010 report by the Office of the Auditor General of Norway, MFA has now included anti-corruption risk assessments as part of their funding requirements.

ABBREVATIONS

EIA	Environmental Impact assessment
LRW	Liquid radioactive waste
PM	Project Manager
SRW	Solid radioactive waste
MFA	Ministry of Foreign Affairs
MPC&A	Material Protection, Control and Accounting
NRPA	Norwegian radiation Protection Authority
OVO	Russian requirements to develop impact assessment (Russian EIA equivalent)
PCB	Polychlorinated Biphenyls
SNF	Spent nuclear fuel

GLOSSARY

Environmental impact assessment. A legal requirement under EU Directive 85/337/EEC (as amended) for certain types of project, including various categories of radioactive waste management project. It requires information on the environmental impacts of a project proposal to be submitted by the developer and evaluated by the relevant competent authority (the planning authority, HSE or other regulators concerned).

Environmental protection. Protection from contamination from nuclear fuel and radioactive waste coming from the submarines.

Environmental risk. Actual or potential threat of adverse effects on living organisms and environment by effluents, emissions, wastes, resource depletion, etc., arising out of an organization's activities.

Nuclear installation safety. The role of safety in the design, construction and operation of nuclear installation facilities.

Nuclear safety. IAEA's definitions to nuclear safety and security is used. Nuclear Safety concerns the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks. Safety concerns both risks under normal circumstances and risks as a consequence of incidents, as well as other possible direct consequences of a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation. Nuclear safety covers the actions taken to prevent nuclear and radiation accidents and to limit their consequences. Safety matters, in contrast to security matters, are intrinsic to activities, and transparent and probabilistic safety analysis is used.

Nuclear security. The prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities. Security matters concern malicious actions and are confidential, and threat based judgment is used.

Radioactive waste. By-products from nuclear power generation and other applications of nuclear fission or nuclear technology that contain radioactive material hazardous to the environment and to human health.

Spent nuclear fuel. Nuclear fuel that has been irradiated in a nuclear reactor (usually at a nuclear power plant). It is no longer useful in sustaining a nuclear reaction in an ordinary thermal reactor.

1 INTRODUCTION

1.1 Background

The former Soviet Union constructed about 250 nuclear submarines. Numerical superiority was imperative during the Cold War and consequently few submarines were retired as more capable platforms were constructed. This all changed when the Iron Curtain fell and close to 200 submarines were subsequently decommissioned[3]. The existing infrastructure to dismantle the submarines and process the spent fuel and radioactive waste was already inadequate. The retired submarines were kept afloat, slowly decaying. Non-intervention, as seen in Figure 1, is likely to increase the risk accordingly. Whereas intervention introduces a net risk increase for a limited time, mitigation is required. After some 20 to 30 years of service, the submarines have to be dismantled and their spent fuel and reactor plants disposed of.

Figure 1 – Conceptual model of risk development over time, intervention versus non-intervention, with an added risk during the intervention periode.

Between 2005 and 2009, more than 1,4 bill. NOK was allocated by the Norwegian Parliament towards nuclear safety in Northwest Russia. In 1995 the Norwegian Government established a Nuclear Action Plan (hereinafter referred to as the Action Plan) which was later revised in 1997, 2005 and 2008. The Action Plan contains concrete programmes aimed at reducing the risk of accidents and pollution from nuclear activities and nuclear installations in Northwest Russia.

One of the programmes in the Action Plan has been the dismantling of Russian nuclear-powered non-strategic submarines. Between 2003 and 2007, Norway and Russia cooperated to ensure the dismantling four Victor class submarines. Three were dismantled at the Nerpa shipyard north of Murmansk and one at the Zvezdochka shipyard in Severodvinsk. In addition, Norway and the

[3] Decommissioning and dismantlement is further driven by disarmament agreements, as well as past submarine accidents and costs; Greatly reduced Russian defence budgets precludes maintenance and upgrading of the large Cold War force of nuclear submarines established by the Soviet Union.

United Kingdom jointly financed the dismantling of a fifth submarine in 2008 at the Nerpa shipyard.

The Norwegian Ministry of Foreign Affairs (MFA) is the responsible ministry overseeing the Action Plan, while the Norwegian Radiation Protection Agency (NRPA) acts as the competent authority in the fields of radiation protection and nuclear safety and security and as directorate for MFA regarding the Action Plan. Within the context of the submarine dismantling program, NRPA has reviewed risk assessment documentation and maintained dialogue with the Russian authorities and the Norwegian Project Manager[4].

Following the conclusion of the Norwegian contribution to the dismantling programme, the Office of the Auditor General in Norway, in cooperation with its Russian counterparts, conducted a review in 2010 of the Norwegian and Russian support towards improving nuclear safety in Northwest Russia. One of the findings from this review was the lack of independent evaluations undertaken upon completion of projects financed under the Action Plan. MFA acknowledged the need for independent evaluations in their comments to the report prepared by the Office of the Auditor General.

In response, in the 2011 grant letter from the Ministry of Health and Care Services to NRPA, NRPA is asked to initiate an evaluation of a project under the Action Plan. Consequently, following a tender competition NRPA appointed Det Norske Veritas (DNV) to undertake such an evaluation in September 2011. This report constitutes the findings from the evaluation.

1.2 Scope and limitations

The evaluation shall cover:

Task 1	Evaluation of success of projects in achieving improvements in nuclear safety and environmental protection.
Task 2	Evaluation of project management and financial aspects for submarine 609.

With respect to Task 1, environmental protection refers to improvements in risk reduction of contamination from nuclear fuel and radioactive waste from the submarines. Assessment of the handling of non-radioactive waste will thus be limited. The scope for Task 1 covers four submarines, no 625, 627, 297 and 609 and the results of the evaluation are presented at an aggregated level. With respect to Task 2, the assessment focuses on to what extent critical elements of project management were covered and how the project management was carried out. As agreed with NRPA, the assessment does not include a cost-benefit analysis.

[4] Norwegian Project Manager is the project manager engaged by MFA for all dismantling projects funded by Norway.

2 OVERALL APPROACH AND METHODOLOGY

The evaluation has followed an approach as outlined in the figure below.

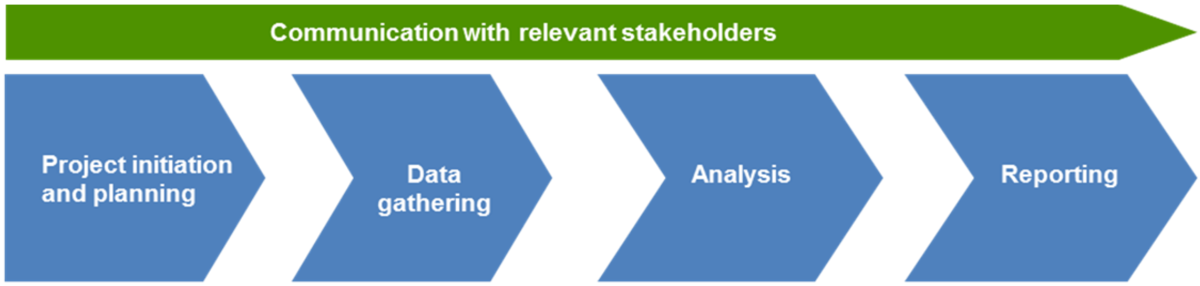

Figure 2 – Overall approach

The evaluation has been undertaken as a desk top study supported by interviews with selected key stakeholders. Data collection has been undertaken at the MFA and NRPA. No data collection has been undertaken from Russian stakeholders. Interviews were undertaken during the assignment period between September and November 2011. A list of persons met is included in Appendix 2. The open contribution from all interviewees has been a valuable input to the report.

3 SUMMARY OF PROGRAMME ACHIEVEMENTS AND BENEFITS

3.1 Introduction

Table 1 summarises the achievements of the dismantlement programme with respect to long-term impact, outcome and deliverable - areas that all contribute to the overall long-term objective of securing safety and protecting the environment in Northwest Russia.

Long-term impact refers to the objectives for which the dismantling programme is designed to contribute to, i.e. improve nuclear safety and environmental protection in Northwest Russia. *Outcome* refers to the level of performance of the dismantling programme, knowledge sharing and fulfilment of requirements. Furthermore, *deliveries* refer to the outputs or tangible products i.e. the actual dismantling of four submarines.

The scoring in Table 1 is qualitative and based on DNV's best judgement from assessing programme documents and reports. The assessment criteria used is provided in Figure 3 .Chapter 5 provides a more detailed explanation of the summary table as well as an analysis of the different success areas.

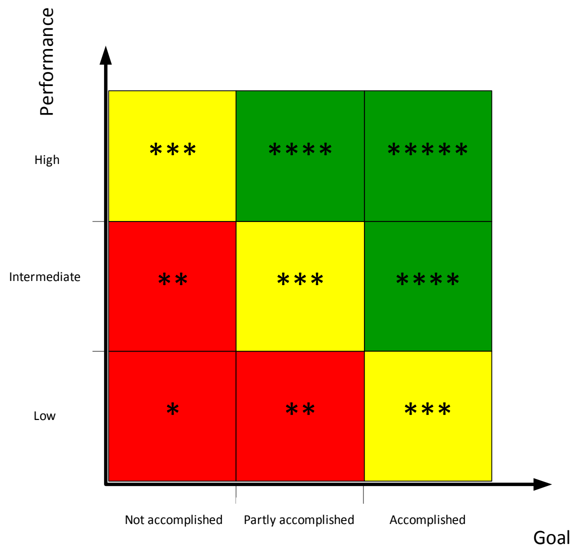

Figure 3- Assessment criteria

Each success area is analysed and a score is given along the two dimensions: goal accomplishment and performance level. Given the clearly stated goals of the dismantlement projects, goal accomplishment is given more emphasis than the actual performance. However, given the need and interest in continued cooperation and dialogue between Russian and Norwegian counterparts, good performance is acknowledged as an important input to the overall benefits.

Colour	***Explanation***
Red	Describes a situation where goals are not/partly accomplished combined with low or intermediate performance.
Yellow	Describes a situation where goals are accomplished, partly accomplished or not accomplished combined with three levels of performance (low, medium and high).
Green	Describes a situation where goals are accomplished or partly accomplished combined with medium or high performance level.

Success Area		Description of goals, outcomes and deliverables	Reference to overall agreements and plans	Summary of basis for scoring	Score
Long-term impact		Improved nuclear safety and environmental protection in Northwest Russia.	St. meld. nr. 34 (1993-1994), St. meld. 11 (2009-2010), Nuclear Action Plan.	Essentially achieved in terms of removal of the submarines and assosiated spent fuel and radioactive waste, without any known serious events of leakage or exposure of radioactive matter. However limited information of conditions and actual handling at point of end-disposal (Mayak) has been avaiable.	****
Outcome	Dismantling performance	Main risks identified and acted upon during each phase of the decomissioning process.	Nuclear Action Plan.	On a aggregate level, all significant risks seem to have been addressed properly - largely through the level of expertise and knowledge gained by the Russians after a decade of internationally assisted nuclear submarine dismantlement.	****
		Reduced risks of nuclear proliferation and radiactive sources coming astray.	G8 Global Partnership on Protecting Against the Spread of Nucelar , Biologial and Chemical Weapons (2003), St. meld. 11, Nuclear Action Plan.	The largely safety-driven incentives of the submarine dismantlement has inherent nuclear and radiological security benefits, as material are controlled and managed. However, no efforts have focused on nuclear material protection, accountability and control per se.	****
		Ensured safe management, transport, and storage of spent nuclear fuel and radioactive waste related to dismantling of nuclear submarines .	Nuclear Action Plan.	Essentially ensured by the established Russian systems and procedures together with issues adressed through Norwegian involvement.	****
	Cooperation and knowledge sharing	Improved knowledge of the risks involved related to nuclear sources in Northwest Russia.	Nuclear Action Plan.	The information aquired is likely to be known to Norwegian stakeholders already or possibly available through open souces.	***
		Improved cooperation between Norwegian and Russian authorities.	Nuclear Action Plan.	Russian-Norwegian coorporation has largely been on the practical arena - and hence between contractors.	***
		Strengthened Russian administrative and supervisory authorities in the areas of nuclear safety, radiation protection, preparedness and environmental monitoring.	Nuclear Action Plan.	Nuclear submarine disposal involves several actors and Russian entities. Moreso, it may involve transfer of juristiction from the military domain to the civilian. Several inherent challenges exist.	**
	Fulfillment of requirements	Environmental impact assessments prepared according to Russian requirements and international best practices.	Agreements between MFA, Nerpa and Zvezdochka shipyards, Regjeringens handlingsplan for atomvirksomhet og miljø i Nordområdene (2008).	EIA documentation was available throughout the programme period and essentially followed important principles with regard to content of EIAs, however with some deviations from international practices.	****
		Independent review of risks assesment and EIA undertaken before start-up of dismantling.	Office of the General Auditor in Norway (Report 2009-2010).	For two of the submarines independent EIA review was undertaken after project start-up.	***
		Dismantling undertaken according to Russian laws and regulations and best international practice.	Agreements between MFA, Nerpa and Zvezdochka shipyards.	Essentially achieved, however, some descrepencies with regards to handling of Polychlorinated Biphenyls (PCB) has been indicated by the Norwegian side.	****
Deliverable (Output)		Dismantlling of non-strategic nuclear submarines completed on time and within budget.	Nuclear Action Plan, Agreements between MFA, Nerpa and Zvezdochka shipyards.	Dismantling was undertaken according to plan and budget for all four submarines reviewed.	*****

Table 1 - Summary of achievements

4 OVERALL ORGANISATION OF THE DISMANTLING PROGRAMME

4.1 Roles and responsibilities

The main stakeholders in the dismantling program with corresponding roles and responsibilities are outlined in Table 2.

Stakeholder	Role and responsibility
Norwegian Ministry of Foreign Affairs (MFA)	• Overall responsibility for overseeing and implementing the Action Plan. • Providing funding for the all projects and programmes under the Action Plan. • Administers MFA's advisory board on nuclear projects and programmes under the Action Plan.
Norwegian Radiation Protection Agency (NRPA)	• Professional advisor to the MFA in the fields of radiation protection and nuclear safety and security. • Responsible for reviewing the risk assessment documentation related to the dismantling programme. • Responsible for maintaining dialogue with the Russian radiation authorities and the Norwegian Project Manager.
Storvik & Co (later Rambøll Storvik[5])	• Provided the Project Manager for inspection and follow-up of the dismantling of submarines 625, 627, 297 and 609.
Nerpa and Zvezdochka shipyards	• Responsible for dismantling of submarines in Russia. • Nerpa shipyard dismantled three of the four submarines funded by Norway (submarines 625, 297 and 609).
Russian contractors	• Sub-agreements with Nerpa and Zvezdochka shipyards for various dismantling work.
Enviros Consulting Limited	• Responsible for independent review of the environmental impact assessments undertaken by the Nerpa and Zvezdochka shipyards for submarine 625 and 627. • Contracted by NRPA.
Institutt for Energiteknikk (IFE)	• Contracted by Storvik & Co to provide comments in the fields of radiation protection and nuclear safety and security.
Russian authorities	• Responsible for ensuring that Russian rules and regulations are followed.

Table 2 – Stakeholders and responsibilities

[5] There has been name changes with respect to Storvik & Co following restructuring of the company. For the purpose of this report, the name of Storvik & Co is being used.

Although the responsibilities of the main stakeholders remained the same throughout the dismantling of the four submarines, the contractual arrangement changed during the period. This was mainly due to lessons learned from the first two dismantling projects which in effect served as "pilot" projects. A project organisation chart for submarines 625 and 627 as well as for submarines 297 and 609 is presented in 2.2.

4.2 Project organisations

In the following chapter two organisation charts are presented - one for submarines 625 and 627 and one for submarines 297 and 609. The first two submarines had a somewhat different organisational set-up compared to the latter two. The main difference was related to the contractual arrangements with the shipyards. For submarines 625 and 627 the MFA signed contracts directly with the shipyards which was not the case for submarines 297 and 609.

Project organisation for submarines 625 and 627

Following negotiations between Norwegian and Russian authorities in May 2003 the MFA signed an agreement in June 2003 with the Nerpa shipyard in Murmansk and the Zvezdochka shipyard in Severodvinsk for dismantling of submarines 625 and 627, respectively.

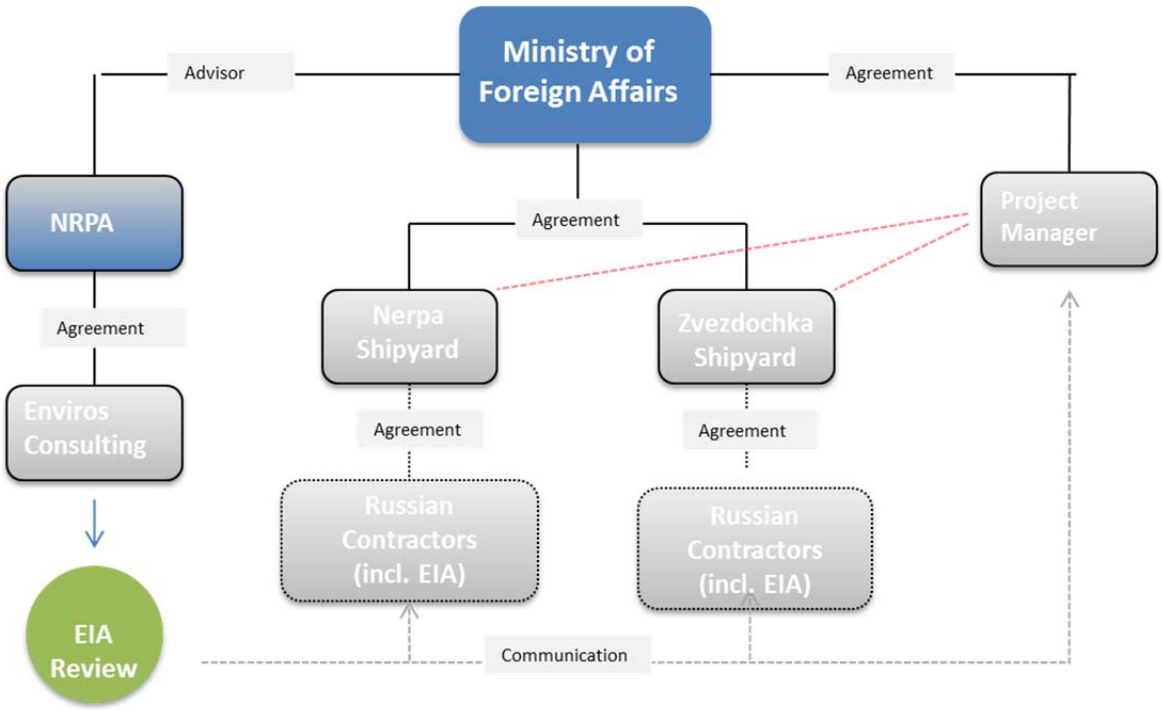

Figure 4 – Project organisation of 625 and 627

Project organisation for submarines 297 and 609

In the spring of 2005 Norwegian authorities approved financing for the dismantlement of submarine 297. One year later the fourth submarine, 609, was approved for financing. Both dismantling contracts were signed between Nerpa shipyard and Storvik & Co.

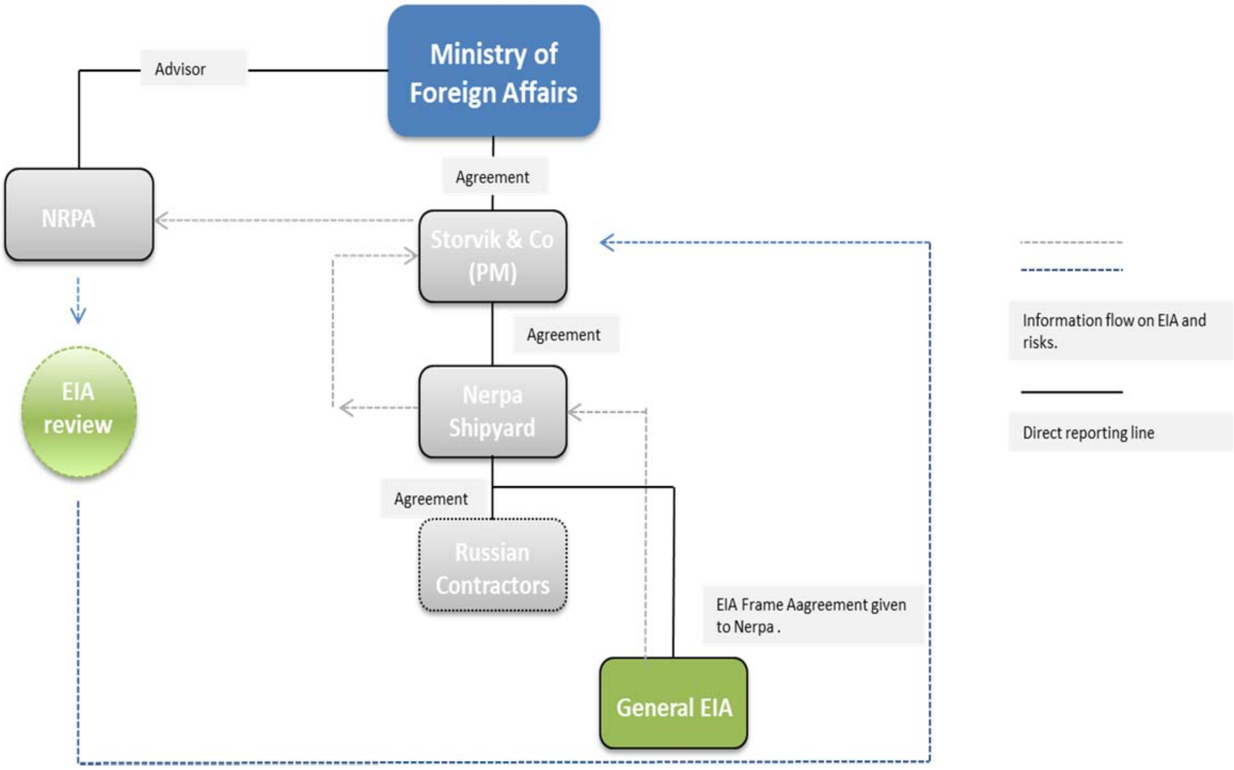

Figure 5 – Project organisation of 297 and 609

4.3 Timeline of the dismantling programme

Figure 6 presents the timeline of the dismantling programme from the first signed contract between the Norwegian authorities and the Russian shipyards in 2003 until the completion of the dismantling of submarine 609 in October 2007.

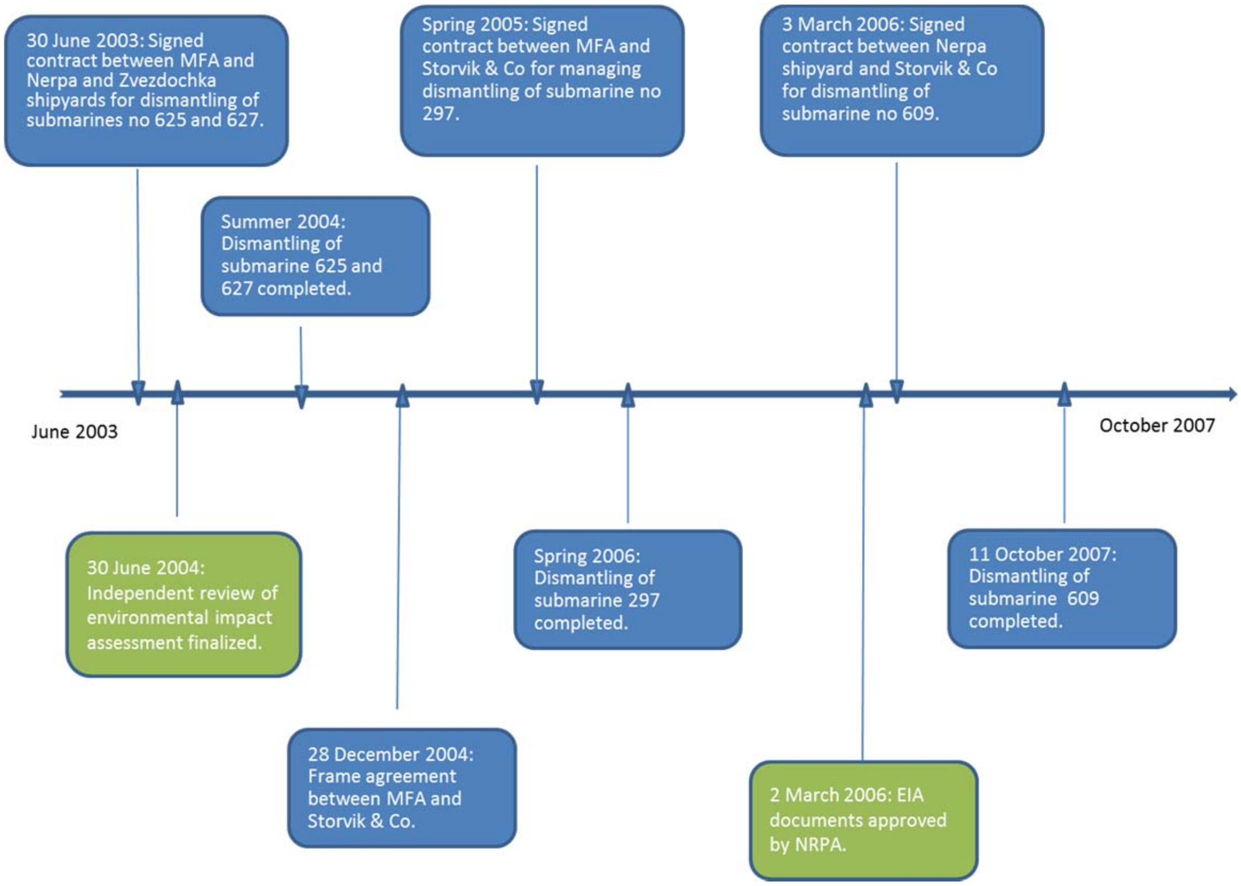

Figure 6 – Timeline

5 ASSESSMENT OF PROGRAMME ACHIEVEMENTS AND BENEFITS

5.1 Long term impact

Long-term impact	Improved nuclear safety and environmental protection in Northwest Russia.

5.2 Nuclear safety and environmental protection in Northwest Russia

Norwegian funding was instrumental for ensuring that the four retired non-strategic nuclear submarines were dismantled and the spent nuclear fuel and radioactive wastes were removed and destined for disposal. The dismantling was performed under a professional and well established setting in Russia. Among the States undertaking nuclear submarine dismantling, Russia is in the forefront with regards to numbers, experience and expertise. As such, the “Russian way” will flavour international best practice in the field.

Indeed, the dismantling took place without any reported serious incidents with release of radioactivity to the environment or uncontrolled exposure to people. Compared to the alternative of non-intervention, DNV is of the opinion that improvements in nuclear safety and environmental protection have been achieved at the decommissioning locations (see Figure 7). A similar evaluation of the development in risk in case of non-intervention was drawn by Enviros' in their independent EIA considerations.

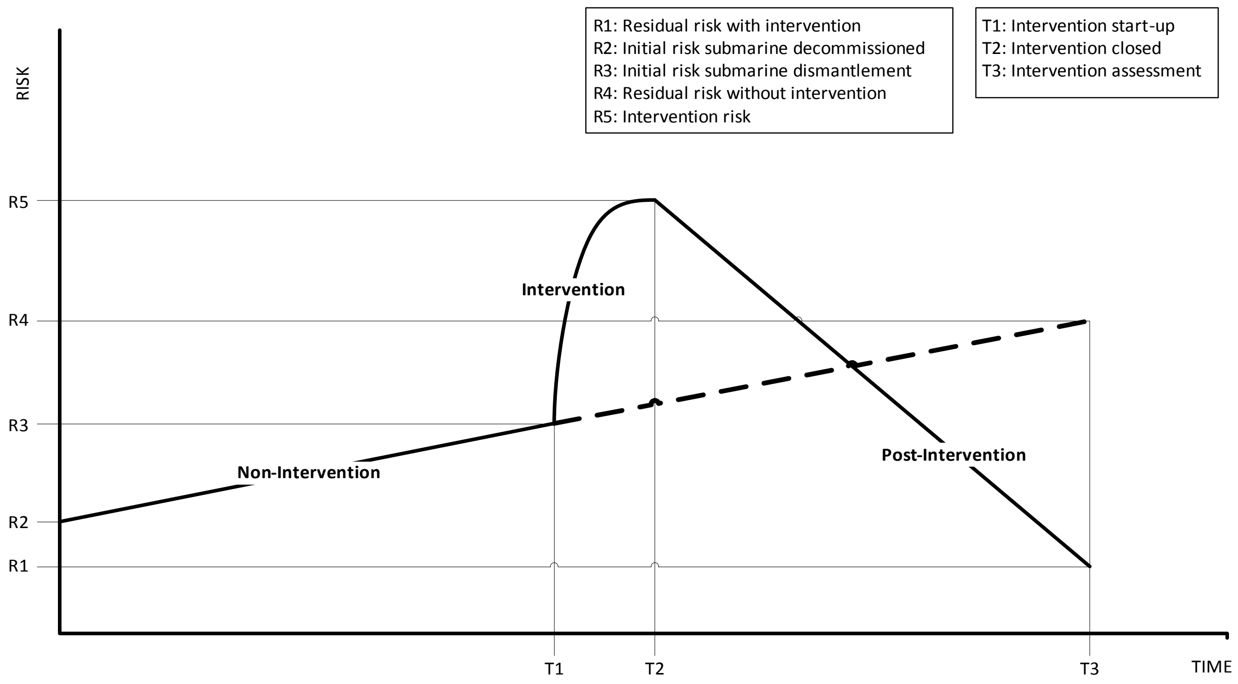

Figure 7 – Non risk intervention, intervention, and post-intervention

None of the documents reviewed by DNV clearly addressed the aspect of monitoring and follow-up in order to assess potential long term impact on humans and the environment resulting from the dismantling. This aspect, together with limited information on the further handling and final disposal of spent nuclear fuel at Mayak, makes it difficult to assess improvements in nuclear safety and environmental protection in a long term perspective. [6]

On the Norwegian side, it has been concluded that monitoring and measuring results from the shipyards and their close surroundings did not indicate any releases during the course of the dismantling projects that exceeded the limit values. In any case, DNV is of the opinion that further studies on the long-term impact on humans and the environment are needed in order to conclude decisively with regards to long-term impacts.

The aspect of perception of contamination of the greater dismantling area (even if proved to not be relevant) should not be underestimated. These is of particular relevance for seafood export or influx/outflux of people to the area. DNV has no evidence stating any such indirect effects. On the other hand, it is reasonable to believe that the less "end-of-life" nuclear submarines stranded

[6] The further handling of the spent fuel at Mayak was not part of the scope of this assessment.

in this area, and the more submarines decommissioned in an acceptable manner with wastes adequately taken care of, the more acceptable this should be to the public, both inside and outside Russia.

Submarine dismantling is accompanied by potential releases of other harmful chemical substances (non-radioactive) and by generation of large quantities of chemical waste posing a possible threat to human health and environment.[7] An issue which appears to have been handled inappropriately is the disposal of materials potentially containing Polychlorinated Biphenyls (PCB). The submarines were built in 1960s and were likely to contain a variety of equipment and materials containing PCB. PCBs are persistent organic pollutants that accumulate in organisms and may cause damage to nature and human health over a long time perspective. Although little attention was given to PCB issues in the early phase of the dismantling programme – the revised Nuclear Action Plan of 2008, clearly states that this aspect needs to be covered in the future.

5.3 Outcomes

5.3.1 Dismantling performance

Dismantling performance	Main risks identified and acted upon during each phase of the decommissioning process.
	Reduced risks of nuclear proliferation and radioactive sources going astray.
	Ensured safe management, transport, and storage of spent nuclear fuel and radioactive waste related to dismantling of nuclear submarines.

Identification and mitigation of risks during each phase of the decommissioning process

Russian naval nuclear fuel and reactors pose both proliferation and environmental threats, ranging from the possible theft of highly enriched uranium fuel to the radioactive contamination of the environment and human exposure, whether due to accident, neglect, or sabotage. An overview of the different steps of the dismantling process is given in Table 3. In the following, focus is given to nuclear and radiological risks.

[7] Again, this is beyond the scope of this assessment.

1	**Defueling**
1a	Submarine placed next to onshore defueling facility or defueling ship
1b	Containment barrier mounted on submarine
1c	Hull cut
1d	Top shield of reactor removed
1e	Reactor drained and fuel assemblies exposed
1f	Fuel assemblies transferred in special transfer container
1g	Special transfer container into TUK-18 transport containers
2	**Spent Fuel Management and Transportation**
2a	Temporary storage of fuel in TUK-18 containers
2b	Transportation of fuel in TUK-18 containers
3	**Radioactive Waste Management**
3a	Liquid and solid radioactive wastes contained
3b	Handling liquid and solid radioactive wastes
4	**Dismantling the submarine**
4a	The submarine is moved into a dry dock
4b	The submarine is cut into three sections
5	**Disposal of reactor compartment**
5a	The reactor section and adjacent parts sealed off
5b	Modified reactor section moved to Saida Bay for long-term storage
6	**Non-radioactive waste management and recycling**
6a	Salvageable metals, materials and internal fittings of value removed
6b	Electrical cable processed into copper, steel and rubber pellets
6c	Precious metals and electrical components sorted separately

Table 3 – Stages and associated steps in the submarine dismantlement process

Risk identification[8]

As a point of departure for the assessment, a set of nuclear safety/security and environmental protection risks associated with the decommissioning process are identified. The probability and the consequences of the scenarios outlined will differ. Associated risks will vary accordingly.

The presence of a source in the vicinity of a person (target) could potentially, in the absence of measures for safety and protection, give rise to exposure. Possible pathways to radiation exposure are presented in Figure 8. Direct exposure stems predominately from gamma-radiation. Such exposure may occur when there is some level of proximity between the exposing material and the exposed. Indirect exposure results from inhalation or intake or uptake of radioactive particles and materials, as they are transported throughout the ecosystem, with air, sea or soil as carriers.

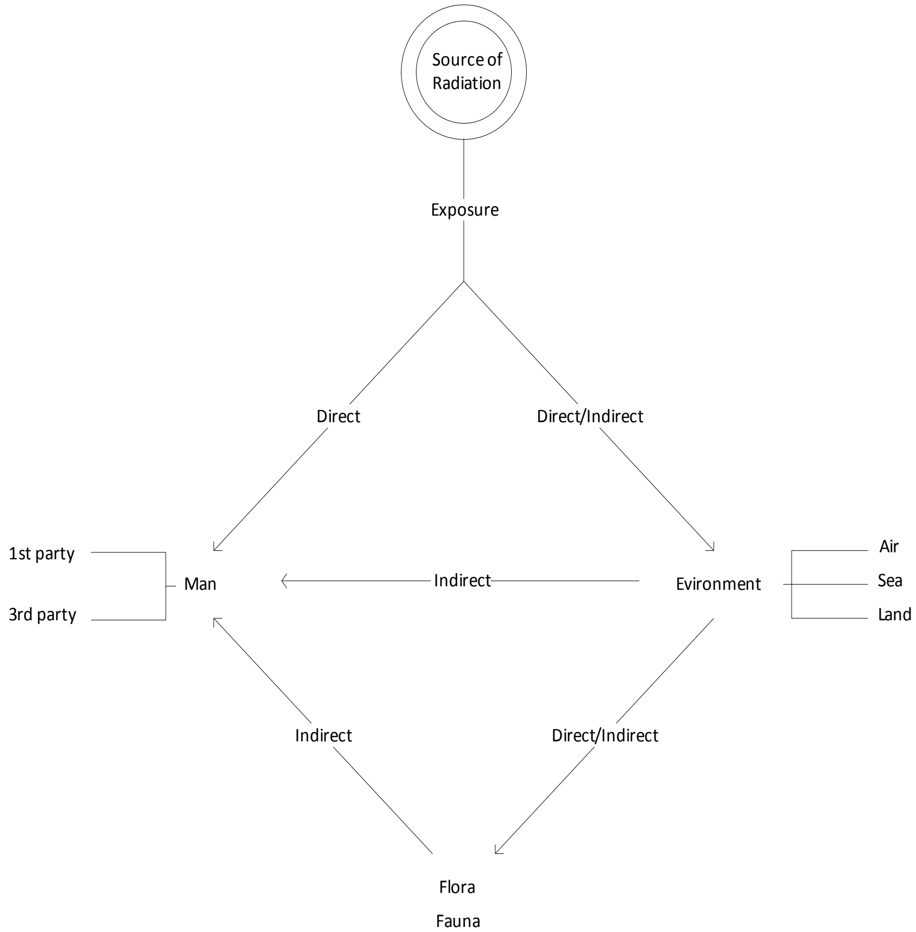

Figure 8 - Schematic representation of direct and indirect exposure pathways. 1st party represents on-site workers, while 3rd party refers to the public possibly to be affected.

[8] Risk identification is understood as the process to find, list and characterize elements of risk. This would typically include identification of the property or situation that could lead to harm.

Safety matters are intrinsic to all nuclear activities. Specifically, in conjunction with nuclear submarine dismantlement, there are a range of different situations possibly creating safety risks to possible 1st party (workers) and 3rd party (public) for instance the safety of nuclear installations, radiation safety, the safety of radioactive waste management and safety in the transport of radioactive material.

Security risk may be divided into i) nuclear material diversion and the subsequent development of nuclear explosives, ii) radioactive material diversion and the possible production of Radiological Dispersal Devises, and finally, direct attacks against nuclear activities, causing radioactive releases and exposures. As seen in Table 4, security scenarios may come into play to different degrees and with varying impacts throughout the dismantlement process.

Environmental risk relates to possible releases to air, land or sea – causing harm to flora and fauna, and possibly, indirect harm to humans. As such, environmental nuclear risks may be seen as an integral part of safety risks and possible 1st Party and 3rd party exposures. In the following, focus is given to nuclear and radiological risks.

Risks during the respective dismantling stages

	SAFETY				**SECURITY**		
	RELEASE		***EXPOSURE***		***EXPLOSIVE***		***ATTACK***
STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD**	*NUCLEAR*	*HIT*
DEFUELLING	X	X	X	X	X	(X)	X
SPENT FUEL MANAGEMENT AND TRANSPORTATION	X	X	X	X	X	X	X
RADIOACTIVE WASTE MANAGEMENT	X	X	X	X	X	NA	NA
DISMANTLING OF SUBMARINE	X	(X)	(X)	NA	NA	NA	NA
DISPOSAL OF REACTOR COMPARTMENTS	X	X	X	NA	X	NA	(X)
NON-RADIOACTIVE WASTE MANAGEMENT AND RECYCLING	NA	NA	NA	NA	NA	NA	NA

Table 4: Overall nuclear and radiological risks throughout the nuclear submarine decommissioning stages. (RDD = Radiological Dispersal Device. i.e. a "Dirty Bomb", NA = "Not Applicable"). Parenthesis indicates less relevance.

Risks identified may be managed by the introduction of mitigation measures.[9] The respective risks of the dismantling stages as presented in Table 4 are discussed in the following, with a view to assessing the extent to which the risks have been identified and acted upon.

Defueling

STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD*	*NUCLEAR*	*HIT*
DEFUELING	X	X	X	X	X	X	X

As the nuclear submarines are being decommissioned, the greatest radioactivity is concentrated in the spent nuclear fuel of its reactors.[10] Both safety and security risk scenarios may occur during this phase. Depending on power, length of lifetime and operating conditions, as much as 95% of the total submarine radioactivity may remain in the core, therefore, the main radiation hazards are associated with the defueling operation.[11] In effect, using well-established defueling procedures, all fissile material and the great majority of radioactive material is removed before dismantling starts.

Whereas a direct hit or attack against the defueling activities may release radiation, any production of nuclear explosives from the fuel extracted from the reactors seems unlikely. The immense radiation from the fission products embedded in the fuel would render any such efforts challenging, at best. Depending on cooling-time, the fuel extracted is self-protective for many years to come.

More so, while a direct attack during defueling operations may not be excluded, the probability seems limited. Potential perpetrators looking for ways to hit the dismantlement site and activities face at least two sets of uncertainties: Firstly, the success-probability of the attack itself as the defueling takes place in restricted areas. And secondly, the likelihood of initiating the type and magnitude of radioactive releases sought. If nuclear terrorism or sabotage is desired paths, other and less hardened targets are available in the region.

Accordingly, during defueling the most prominent risks are safety related. The gravest consequences are associated with a self-sustained chain reaction (SCR) which may be initiated by erroneous actions of personnel and violations of the operating procedure. After a serious accident in Chazhma Bay in 1985, killing several workers, measures were taken to rule out the very possibility of such an accident, including the requirement to drain off the coolant prior to

[9] Risk mitigation covers efforts taken to reduce either the probability or consequences of a threat. These may range from physical measures to procedural measures.
[10] Although nuclear powered attack submarines are not equipped to launch ballistic missiles, they can be used to fire cruise missiles which have been modified to carry a nuclear payload. Theft of intact nuclear explosives is not an issue, however, as any missiles are removed as the vessel is decommissioned.
11 http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws032003_vasiliev-e.pdf

breaking loose of the reactor.[12] Hence, the risk of re-criticality is acted upon, given that operational defueling procedures are followed.

In conclusion, the security risks, as well as the most severe safety risk (re-criticality), is likely to have been considered during the respective defueling steps associated with this stage of the submarine dismantlement process. That mitigating actions and key restrictions basically seem to be in place, may also be expected, after the number of nuclear submarines being dismantled, and the significant Russian expertise acquired.

Spent Fuel Management and Transportation

STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD*	*NUCLEAR*	*HIT*
SPENT FUEL MANAGEMENT/ TRANSPORTATION	X	X	X	X	X	X	X

According to the Russian decommissioning concept, all spent nuclear fuel discharged from submarines is to be reprocessed. Spent fuel transfer to casks is conducted at transhipment bases, where the casks are loaded onto railcars and then transported to Mayak for reprocessing.

Over the last years, significant upgrades have ensured a streamlining of the transport and intermediate storage (i.e. dedicated casks and pads for safe storage). New special railway wagons for spent fuel transportation have contributed to a safer and swifter transfer and delivery of spent fuel to Mayak[13]. The associated risk reduction benefits may stem from a reduced probability of accidents, as more modern equipment has been introduced. More so, updated and strengthened transportation casks will likely reduce consequences – i.e. leaks and contamination – if accidents are to occur. Improved casks may, moreover, contribute to stronger barriers against deliberate attacks against the transports. Any consequences may be harder to predict for potential perpetrators.

Risks associated with the transportation and management of fuel locally at sea may become less prominent as compared to potential releases to air/and or land during incidents associated with railway transportation.

Reprocessing at Mayak may, however, contribute to nuclear proliferation, both directly and indirectly, as the separated plutonium resulting from the reprocessing may find its way into nuclear explosives. Earlier assessments show that traces of radioactive fission products from the reprocessing at Mayak are, moreover, to be found in the Barents Sea, after being transported by rivers.

In conclusion, risks associated with standard work operations pertaining to spent fuel management and transportation seems to have been handled well by the Russian organization. However, the lack of impact assessments with regards to the transportation of spent nuclear fuel

[12] http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws032003_vasiliev-e.pdf
[13] http://www-pub.iaea.org/MTCD/publications/PDF/rwmst3/IAEA-WMDB-ST-3-Part-6.pdf

(and radioactive waste) has been pointed out by the Norwegian side throughout the project. On this issue in particular, the information received is still seen as insufficient. This could be indicative as of to which extent such risks have been acted upon in planned and properly manners.

Radioactive Waste Management

STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD*	*NUCLEAR*	*HIT*
RADIOACTIVE WASTE MANAGEMENT	X	X	X	X	X	NA	NA

In the course of the maintenance process of nuclear submarines, SRW is generated during fuel assembly replacement, repairs in the reactor section, and replacement of cooling water filters or further reactor equipment. In addition, filters from the destruction plant for liquid radioactive waste and from the incineration plant for solid radioactive waste have to be stored.In the course of the maintenance process of nuclear submarines, SRW is generated during fuel assembly replacement, repairs in the reactor section, and replacement of cooling water filters or further reactor equipment. In addition, filters from the destruction plant for liquid radioactive waste and from the incineration plant for solid radioactive waste have to be stored.

Much efforts have been put into developing technologies and facilities built for LRW treatment, SRW compacting and storage, SNF unloading, shipment and interim storage. As such, the handling and management of radioactive waste has improved.

Yet, there are remaining issues. The practice of filling the reactor compartments with solid radioactive waste may seem a beneficial and practical waste handling solution. Waste containers are simply filled during the dismantlement process and then stacked upon each other inside the reactor compartments before these are sealed off. However, proper inventories are near impossible to establish, along with predictions of cooling-time and residual radiation levels and protective needs, due to the lack of accounting and classification of the solid waste.

Dismantling of Submarine

STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD*	*NUCLEAR*	*HIT*
DISMANTLING OF SUBMARINE	X	(X)	(X)	NA	NA	NA	NA

As the spent fuel, the reactor and the reactor compartment have been removed, the only residual risks of exposure to radiation stem from any remaining radioactive material, liquid or solid, inside the vessel structures and components. The primary concern, if any, should then probably relate to contaminated water inside tanks, possibly exposing workers on-site as the waste streams are released to surrounding soil or sea. Such risks may not have been handled satisfactory, as evidenced by alleged leakages inside the hall where dismantlement is carried out[14]

Disposal of Reactor Compartment

STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD*	*NUCLEAR*	*HIT*
DISPOSAL OF REACTOR COMPARTMENTS	X	X	X	NA	X	NA	(x)

Once a nuclear submarine is decommissioned, the most heavily contaminated waste generally stems from the reactor system excluding the spent nuclear fuel. Because of the high levels of radioactivity in the reactor section, the reactor section cannot be dismantled until the radiation has decayed to safe levels (70-100 years). In order to move and store the reactor to the German built Saida Bay storage site a three-compartment unit is formed consisting of the reactor section and a proportion of the adjacent compartments cleared of all heavy equipment. As seen above, nearly the entire radioactivity is removed as the reactor and reactor core is removed.

However, the nuclear submarine reactor still contains a significant quantity of radionuclides in two forms: (1) induced radionuclides, created by neutron bombardment during the reactor's operation and embedded in the metal of the reactor's pressure vessel, piping and adjacent bulkhead walls) and (2) radioactive corrosion products (mainly cobalt-60), deposited as film on the internal surfaces of the reactor pressure vessel and piping.

These sources of radiation may have, as seen above, an additional (unknown) component due to the introduction of the solid radioactive waste in to the reactor compartment, before it is sealed off. Such long term risks are hence difficult to predict.

In general, operational risks seem accounted for with regards to the creation and management of the reactor compartment for storage. However, the UK proposed technical option is to remove the Reactor Pressure Vessel (and other radioactive materials) from the Reactor Compartment rather than separating the entire Reactor Compartment from the submarine[15]. While separation remains the lines of action of both French and US nuclear submarine dismantlement, an overall risk assessment of the preferred UK approach could have been beneficial.

[14] Information acquired by DNV during interviews with key project stakeholders.
[15] http://www.mod.uk/NR/rdonlyres/FC661994-9950-43E3-B4A9-EADCFD5CD872/0/SDP_FS9_InternationalPerspectivesWEB.pdf

Non-Radioactive Waste Management and Recycling

STAGE	*SEA/LAND*	*AIR*	*1. PARTY*	*3. PARTY*	*RDD*	*NUCLEAR*	*HIT*
NON-RADIOACTIVE WASTE MANAGEMENT AND RECYCLING	NA	NA	NA	NA	NA	NA	NA

Decommissioning of all types of nuclear submarines results in considerable quantities of non-radioactive waste which poses threats to the health of personnel and local people as well as to the environment.[16] The greatest hazards to personnel are the harmful chemical substances which arise as gases and aerosols (in amounts of up to 2 tons per submarine) [17]. Human health is also affected by high loads of airborne industrial dust and aerosols produced by condensation during welding.

In conclusion, non-radioactive waste may seem to have been given disproportionally limited attention during the decommissioning processes, at least as compared to the low-level radioactive waste.

Risks of nuclear proliferation and diversion of radioactive sources

Risks related to nuclear proliferation calls for strict control and accounting of nuclear material, in particular those of weapons origin or quality. As such Material Protection, Control, and Accounting-systems (MPC&A) are intended to protect material against theft or diversion, and to detect such events if they occur. Physical protection systems should allow for the detection of any unauthorized penetration of barriers and portals, thereby triggering an immediate response. The system should delay intruders long enough to allow for an effective response. Material control and containment systems should prevent unauthorized movement of material and allow for the prompt detection of the theft and diversion of material. Material accounting systems should ensure all material is accounted for, enable the measurement of losses, and provide information for follow-up investigations to detect any irregularities.

Whereas the project itself did not focus on establishing dedicated MPC&A-systems for the spent nuclear fuel, the fact that highly radioactive fuel has been handled in accordance with ruling domestic practices and schemes, must have contributed to reduced risks of nuclear proliferation and possible diversion of radioactive sources. Relevant safety and security synergies' concern, for example: the regulatory infrastructure; engineering provisions in the design and construction of nuclear installations and other facilities; controls on access to nuclear installations and other

[16] An assessment of such challenges is outside the scope of this study. The risk to personnel and population from other types of waste is much lower, although their quantities are significantly larger. Decommissioning of nuclear submarines leaves in its wake ~ 60-80 t of liquid toxic waste (combustible and lubricating materials, spent electrolyte, etc.) and ~ 600 t of solid waste. Some of these materials are burned, others are utilised, but the bulk of the waste is stored at factory sites or is removed to industrial dumping grounds.

[17] http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws032003_vasiliev-e.pdf

facilities; the categorization of radioactive sources; the security of the management of radioactive sources and radioactive material; emergency response plans; and radioactive waste management.

Management, transport, and storage of spent nuclear fuel and radioactive waste

In general, previous assessments of the dismantling programme reviewed by DNV clearly indicate that the respective shipyards, within the framework of Russian regulations, have demonstrated systems, procedures, work practices and infrastructure that ensure the essential aspects of safe management and storage of spent nuclear fuel and radioactive waste related to the dismantling of nuclear sub-marines. Such conclusion was drawn in the initial independent EIA and as part of later reviews of Russian EIAs, on-site inspections and evaluation of additional Russian documentation during the life span of the project.

Furthermore, the documentation reviewed by DNV clearly demonstrates that Norwegian stakeholders, both by means of its own inspections and by the provided documentation, has had credible reasons for regarding that the dismantling followed procedures and applicable Russian legislation.

Moreover, it appears to be a unified view that the spent nuclear fuel and radioactive waste in the end was removed and destined for disposal in a way that by existing knowledge did not result in any serious events with release of radioactivity to the environment or exposure to people. DNV considers this a reasonable view.

However, more specifically, several areas of improvement have been identified by the Norwegian side, both initially and during the entire life span of the project. Such issues have been raised in various correspondence documents and reports. Areas of concern included, among others, need for better and/or more complete documentation of procedures, work practices, monitoring equipment and levels for measurement. Additionally, there were also examples of requests for changed practices. In sum and over time, it is DNV's opinion that the questions from the Norwegian side targeted information that was essential for the consideration of whether safe management, transport and storage of spent nuclear fuel and radioactive waste could be achieved, even if the Russian side had good systems in place from the beginning.

As per documented, the requested additional information seems to have been provided by the Russian side, resolving many of the issues. Alternatively the Norwegian PM gave adequate explanations, based on his on-site observations and communication with the Russian side. It is however difficult to find documentation on situations where Norwegian requests led to changes in actual work practices.

Although several issues were solved some were not, despite repeatedly communicated to the Russian side. Such areas included:

- Questions about the variation in reported radiation doses exposed to workers during removal of spent nuclear fuel for sub-marine 297 and 609.
- Certain problems with gaining information about limit values for α-radiation within and outside the reactor sections during unloading of spent nuclear fuel.

- Questions regarding level of control of the containers and its content (solid radioactive waste and other waste) returned to the reactor compartments for storage.
- Questions about the procedures and infrastructure for handling of potentially contaminated drainage water inside the covered berth for sub-marine dismantling.
- Questions about the implementation level of safety precautions due to the situation where the cutting of submarine 609 started while there was still combustible material (polystyrene) adjacent in the cutting areas.
- Questions about environmental monitoring programs, methods and equipment. Even though information has been given demonstrating aspects of environmental monitoring, there has been a need for a more systemized and structured description of this aspect.
- Problems getting documentation on impact assessments in connection with transport of spent fuel to Mayak and solid radioactive waste to Saida Bay.
- As far as DNV can see, there is no documentation demonstrating programs for monitoring of long term effects in terms of radioactive contamination in the surrounding environment and population. While this (vital) information is not included in the project documentation portfolio, it is available elsewhere. [18]

Although the scope of this evaluation is the nuclear waste aspects, issues with regard to other hazardous waste categories have been raised. Some important issues still remain insufficiently documented, including:

- Harmful chemical substances originate primarily from the dismantling operations, including cutting, welding, grinding, scraping. Gas, plasma-arc and mechanical cutting methods are in use. The main source of harmful releases to the atmosphere and, hence, the main source of danger to human health is the gas cutting. This method is employed at all stages of submarine dismantling where cutting is required[19].
- Concerns about the control on ambient air quality for workers in the cutting areas.
- Documentation of environmental monitoring and surveillance with regard to emissions and discharges to air and sea of other pollutants has been limited.
- Concerns have been raised with regard to management and disposal of other hazardous substances. In this respect, the safe handling and disposal of PCB has been highlighted in particular. The safe handling and disposal of PCB has not been demonstrated by any means. Even though no inventory of PCB on board has been available, it is likely that PCB have been applied in a range of equipment and materials on board, due to the submarine building period (1960'ies).
- Preparedness and mitigation measures (for instance oil booms, etc) in case of spills/leakages to sea of oil and other pollutants during those phases of the dismantling

18 For an overview of waste treatment at Nerpa, see for instance http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws052005_19E.pdf. For radioactive waste treatment at "Zvyozdochka", see http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws052011/1_English_Folder_CEG_Workshop/2.6%20Nayman%20Engl.pdf

19 http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws032003_vasiliev-e.pdf

process where the sub-marines where still afloat, have not been demonstrated as far as DNV can see. This issue has to DNV's knowledge not been raised by the Norwegian side.

The above issues should not be regarded as insignificant. However as regards the main aspects of safe management, transport and storage of spent nuclear fuel and radioactive waste, DNV is supporting the main impression that this has been handled satisfactory and according to applicable Russian regulations.

5.3.2 Cooperation and knowledge sharing

Cooperation and knowledge sharing	Improved knowledge of the risks involved related to nuclear sources in Northwest Russia.
	Improved cooperation between Norwegian and Russian authorities.
	Strengthened Russian administrative and supervisory authorities in the areas of nuclear safety, radiation protection, preparedness and environmental monitoring.

Improved knowledge of the risks involved related to nuclear sources in Northwest Russia

It is beyond doubt that the dismantling programme has contributed to increased knowledge of the risks related to decommissioning of nuclear submarines and handling of spent nuclear fuel and radioactive waste. The documentation reviewed by DNV reveals that a variety of information have been made available, previously not seen by the Norwegian side. In addition, the Norwegian side gained valuable insight by being able to observe the on-site conditions through inspections and visits, in areas previously restricted for access.

There are several examples of information that were not made available in the early phases of the project, but which were made available at a later stage as the project and co-operation with the Russian side progressed. For instance, in connection with submarine 297 at Nerpa, significantly more extensive documentation than in earlier phases was provided with regard to impact assessments for removal of spent nuclear fuel, where different accident scenarios and resulting consequences were described. Also, general information with regard to towing of the submarine, dismantling at Nerpa and waste management including transport of spent fuel and waste were more extensive than in earlier phases. In addition, in connection with submarine 297, the Norwegian side got access to the actual location for removal of spent nuclear fuel and better descriptions of the actual work process.

Moreover, knowledge, communication and trust steadily developed throughout the dismantlement activities. This was probably instrumental in, if not solving, at least dealing with the information void the Norwegian parts experienced at the early cooperative stages.

The Norwegian side gained knowledge about Russian procedures and governing approaches inter alia with regard to EIAs. In addition, the Norwegian side steadily improved practical knowledge on nuclear submarine dismantling, including the handling of the fuel. However, specifics related to fuel composition remains classified and hence outside the current dialog. Such information may be fundamental in the safe and secure clean-up activities facing stakeholders in the region, beyond the cluster of problems associated with decommissioned submarines. Insufficient knowledge regarding fuel compositions and inventories could hamper ongoing and planned nuclear clean-up activities in Northwest Russia, for instance in the Andreeva bay.[20]

Improved cooperation between Norwegian and Russian authorities

It is likely that the process of continuous reviews of documentation and practices, inspections and the repeated requests for additional and/or improved information by the Norwegian side has led to a stronger focus from the respective shipyards on implementation of stated procedures and work practices in general, as well as from the controlling bodies in Russia in their undertaking of their work. In fact, practical cooperation has seemed the prevailing way to improve cooperation between Norwegian and Russian authorities within the nuclear safety and security domain, as well as elsewhere.

The documents provided, however, do not allow for any firm conclusions. In general, the involvement of Russian authorities seems to have been related directly at Russian stakeholders – in particular in conjunction with approvals and licensing of the shipyards.

Strengthen Russian administrative and supervisory authorities in the areas of nuclear safety, radiation protection, preparedness and environmental monitoring

Given the international focus and the interest generated, as well as the substantial revenues generated for local entities during the submarine dismantlement, a general strengthening of the relevant Russian administrative and supervisory authorities may be anticipated. However, DNV did not find any direct indications of a general strengthening of Russian authorities.

More important is probably the effect of the dismantling process on the Russian civilian-military relations. Firstly, the transfers of material and hence jurisdiction from the military to the public spheres pose obvious challenges for civilian authorization and supervision. Secondly, Russian supervisory practices may not be sufficiently embedded in the key principle of independence. The line of division between licensing authorities and licensee may become particularly weak in submarine dismantlement settings where there probably are particularly close relationship after years of cooperation and on-site inspections.

[20] Ole Reistad, Morten Bremer Mærli, and Nils Bøhmer, "Russian Naval Nuclear Fuel and Reactors: Dangerous Unknowns," *Nonproliferation Review*, Vol. 12, No. 1 (March 2005), pp. 163-197

5.3.3 Fulfilment of requirements

Fulfilment of requirements	Environmental impact assessments prepared according to Russian requirements and international best practices.
	Independent review of risks assessment and EIA undertaken before start-up of dismantling.
	Dismantling undertaken according to Russian laws and regulations and best international practice.

Environmental impact assessments (EIA) according to best practice and international standards

According to the documentation reviewed by DNV, it is clear that EIAs have been prepared for both the Zvezdochka and Nerpa shipyards from the Russian side. Such EIAs are subject to approval by Russian authorities.

The following EIAs were available and reviewed by Norwegian authorities:

- EIA for Victor type II submarines (625 at Nerpa & 627 at Zvezdochka) – reviewed by Enviros (D4.1)
  - For Nerpa shipyard, only a summary of EIA documents was made available for review.
  - For Zvezdochka, original EIA documents were made available for review.
- EIA for Victor type III submarine (297 at Nerpa) – reviewed by NRPA[21] (D4.14 and D4.15)
  - Original EIA documents were made available for review.

No separate EIA was made available for submarine 609 (Victor type I) at Nerpa. However the EIA for Victor type III (297) was considered acceptable as basis for considerations also for submarine 609 due to the similarities between the two submarines.

DNV has not reviewed any of the Russian EIAs, only the independent assessment of the EIAs by Enviros and NRPA. Enviros' assessment concludes that the Russian EIA process is much in line with Norwegian and European principles and approaches to EIA. This applies both in general terms and in terms of addressing radiation risks and mitigation measures. An important deviation is, however, that the aim of the Russian EIA is to facilitate the mitigation and avoidance of already planned activities, i.e. mainly a tool for the implementation process. The Norwegian/European EIAs is more developed as a tool for the planning and decision making

[21] With support from Enviros.

process, by gaining knowledge of the environmental impacts of different alternative solutions prior to consent for an activity.

It is outside the scope of this evaluation to study in detail whether the Russian EIA approach and the actual prepared EIAs are in accordance with best practice and international standards. The EIA reviews by Enviros and NRPA both identified areas that were insufficiently covered, and suggested areas for follow-up and improvement. Still, the Norwegian side concluded that received material was essentially satisfactory as EIA documentation for the purpose of the programme as such and for signing dismantling contracts (for submarine 297).

It should be noted that for submarine 625 and 627, on relevant subjects that were not covered by the Russian EIAs, Enviros performed independent EIA considerations, however of limited magnitude. Similar independent assessments were not undertaken for 297 and 609.

Independent review of risks assessment and EIA by NRPA before start-up of dismantling

For submarines 625 and 627, no independent review of risk assessments and EIAs was undertaken upon contractual agreement or start-up of the dismantling. This was regarded as non-compliancy with respect to Norwegian requirements for funding. Enviros was then engaged to undertake the necessary independent review and assessment of environmental impacts including review of the Russian EIAs. Although the results of the Enviros review came at a time when the decommissioning processes were well underway, still, the conclusions drawn from the EIA review provided the Norwegian authorities with a fair basis for continuation of the project. As stated by Enviros (D4.1); *"Subject to the points raised below, it is concluded that decommissioning of the two submarines has been undertaken in compliance with the applicable regulations. In addition, the safety requirements and methods for demonstrating compliance are broadly consistent with international recommendations and other national practice."*

In contrast to the situation with the first two submarines, independent review of risk assessments and EIA was undertaken prior to contractual agreement and start-up of dismantling of submarine 297. The review was undertaken by NRPA, with support from personnel from Enviros, targeting the EIA documentation for a Victor type II submarine. This review is documented in D4.14 and D4.15 (undated documents), and consists basically of a collection of detailed comments and questions linked to specified sections in the Victor III EIA documents. A few general comments are given, however no independent evaluation of risks and impacts have been undertaken for areas not covered by the EIA documents.

The Norwegian side concluded that received material was essentially satisfactory as EIA documentation, despite numerous comments, questions and a few areas where further studies were suggested to determine the sufficiency of the information. It is somewhat unclear for DNV of what importance it was to resolve those issues prior to contractual agreement and commencement of work.

No separate EIA was made available for submarine 609 at Nerpa, which was of Victor type I. However the EIA for Victor type III (297) was considered acceptable as basis for considerations also for submarine 609 due to the similarities between the two submarines. However, an important difference was the change in practice from previous operations that involved temporary floating storage, to direct land-storage of the reactor compartment from submarine 609. Even though regarded an improvement with regard to safety and environment, it was stated that the issue required additional documentation because it included some other activities and practices, compared to previous submarines.

All in all, DNV considers it as plausible to conclude that the Norwegian side had a satisfactory knowledge base within the area of "risk assessments and EIA" to agree and start up with the dismantling of submarine 297 and 609. This evaluation is also based on the fact that in addition to the specific information provided with regard to these two submarines, one had gained a lot of valuable and relevant knowledge and experience from previous risk assessments and EIA considerations (ref submarines 625 and 627), from on-site presence and inspections, and from various additional documentation provided throughout the project up to then.

Dismantling according to Russian laws and regulations and best international practice

As per the previous evaluations of the aspect of compliance with Russian laws and regulations, including audits and independent assessment of this aspect in particular, DNV has not seen any evidence indicating that Russian laws and regulations have not been followed.

It has not been within the scope of this assesment to go deeper into verifying the actual state of handling and potential discrepancies on-site. Moreover, it is in principle not possible for DNV to conclude categorically to what degree the stated safe and environmentally sound dismantling process was achieved through good planning and strict follow-up of regulations and procedures or if it was achieved through individual professionalism despite the non-existence of plans and procedures. However, based on the general impression of the demonstrated organisation of Russian nuclear sub-marine dismantling, the latter is not likely to be a predominant factor in the project.

5.4 Deliveries

Deliveries	Dismantling of non-strategic nuclear submarines completed on time and within budget.

Between 2003 and 2007 Norway funded dismantling of four non-strategic nuclear submarines[1]. The submarines were dismantled and the spent nuclear fuel and radioactive waste was removed and destined for disposal. Furthermore, the documentation provided points in the direction that the dismantling was performed, based on existing knowledge and procedures, such that the activities did not result in any serious incidents with uncontrolled releases of radioactivity to the environment or exposure to people.

[1] Dismantling of a fifth submarine, 291, was co-financed between Norway and the UK but is out of scope of the DNV evaluation.

DNV has no indication as to the opposite. Consequently, in terms of accomplishing dismantling of four non-strategic nuclear submarines – this delivery or success area has been achieved. To Norway, the infrastructure in place and the flow established provided an opportunity for meeting obvious dismantlement needs in the vicinity of Norwegian borders and fisheries. It allowed moreover, for a door-opener into G8 and associated fora.

5.5 Conclusion

Long-term impact

- Compared to the alternative of non-intervention, DNV is of the impression that improvements in nuclear safety and environmental protection have been achieved at the decommissioning locations.
- However, due to limited information addressing monitoring and follow-up of potential long term impact on humans and the environment resulting from the dismantling as well as limited information on the further handling and final disposal of spent nuclear fuel at Mayak – it is difficult to assess improvements in nuclear safety and environmental protection beyond the decommissioning locations and in a long term perspective.

Outcome

- Security risks, as well as the most severe safety risk (re-criticality), all seem to have been considered during the respective defueling steps. For associated routine operations, mitigating actions and restrictions basically appeared to be in place.
- Operational risks seem accounted for with regards to the creation and management of the reactor compartment for storage.
- Non-radioactive waste may seem to have been given disproportionately limited attention during the decommissioning processes, at least as compared to the low-level radioactive waste.
- As regards the main aspects of safe management, transport and storage of spent nuclear fuel and radioactive waste, DNV supports the main impression that this has been handled satisfactory and according to applicable Russian regulations.
- Despite improvements in management, transport and storage of SNF and radioactive waste, areas of Norwegian concern have included the need for better and/or more complete documentation of procedures, work practices, monitoring equipment and measurement levels.
- DNV has not seen documentation showing that Norwegian requests for changes or additional information resulted in actual changes in Russian work practices.
- Although concerns with regard to management and disposal of other non-radioactive hazardous substances, such as PCB, were highlighted by the Norwegian side, the documents reviewed by DNV do not demonstrate that this was undertaken in a safe manner.

- DNV is of the opinion that the dismantling programme has contributed to increased knowledge of the risks related to Russian decommissioning processes – and that previous unknown information has been made available by the Russians.
- It is DNV's view that knowledge, communication and trust between Norwegian and Russian stakeholders steadily developed throughout the dismantlement activities. However, specifics related to fuel composition remained classified and hence outside the dialog.
- The documents reviewed do not provide for any firm conclusions with respect to improvements in the cooperation between Norwegian and Russian authorities. In general, the involvement of Russian authorities seems to have been related directly at Russian stakeholders – in particular in conjunction with approvals and licensing of the shipyards.
- EIAs have been prepared for both the Zvezdochka and Nerpa shipyards. Although the Russian EIA process is much in line with Norwegian and European principles, an important difference is that the aim of the Russian EIA is mainly a tool for the implementation process while the Norwegian/European EIAs is a tool for the planning and decision making.
- Independent review of risks assessments and EIA was undertaken for all four submarines.
- Independent review of EIA for submarines 625 and 627 was not undertaken before start-up of the dismantling – which was regarded as a non-compliance with respect to the criteria for Norwegian funding.
- DNV considers it plausible to conclude that the Norwegian side had satisfactory knowledge of risk assessments and EIA issues to start up with the dismantling of submarine 297 and 609, despite the fact that no separate EIA was undertaken for submarine 609.
- Through the review DNV has not seen any evidence indicating that Russian laws and regulations have not been followed.

Deliveries

- All documentation reviewed points in the direction that the dismantling was performed according to plan and budget and without any serious incidents involving uncontrolled releases of radioactivity to the environment or exposure to people.

6 ASSESSMENT OF PROJECT MANAGEMENT OF SUBMARINE 609

6.1 Introduction

Dismantling of submarine 609 was the fourth in line funded by Norway, and the third Norwegian financed submarine to be dismantled at Nerpa. For the dismantling of this submarine, Norway and Russia agreed on storage of the reactor on land. This was the first foreign-financed dismantling with storage of this type. The dismantling started in the Spring of 2006 and was officially completed in September 2007. Bjørn Borgaas from Storvik & Co was the Norwegian Project Manager – a role he also had in the three previous dismantling projects.

6.2 Scope and methodology

	Project start up	Project implementation		Project completion
Strategies and appraisal documents	Needs	Actual spend vs budget		Handover
	Objectives	Procurement		Approval
	Expected impact	Contractual arrangements	Changes in scope and the effect on plan/budget/quality	
	Requirements			Documentation
	Project organisation	Project organisation and control		
	Plan	Communication		Transfer of responsibility
	Budget	Use of subcontractors		Transfer of knowledge
	Change management	Quality assurance		Lessons learned

Figure 9 - Project Management Framework

Figure 9 shows a generic project management framework covering phases from start-up to completion. For the purpose of the assessment key elements from the framework are grouped into performance areas and then analysed focusing on the corresponding key indicators. The requirements and expectations to project management as presented in the contracts and agreements between key stakeholders form the baseline for the assessment.

Performance Area	Performance indicators
Project organisation	Contractual arragements incl. roles and responsibilities Lines of communication Monitoring, control and quality assurance
Progress and implementation	Expected vs actual implementation period Follow-up and adjustments
Budget and costs	Actual spend vs budget System for transfer of funds Use of subcontractors
Change management	System for change handling Change in scope
Handover	Approval Documentation Transfer of knowledge Lessons learned

6.3 Assessment of project management performance

6.3.1 Project organisation

Roles and responsibilities

Table 2 presents the roles and responsibilities for the key stakeholders in the dismantling programme. All stakeholders are relevant for submarine 609 except Enviros Consulting Ltd. For submarine 609 no external consultant was contracted when NRPA provided comments on the EIA documentation[22].

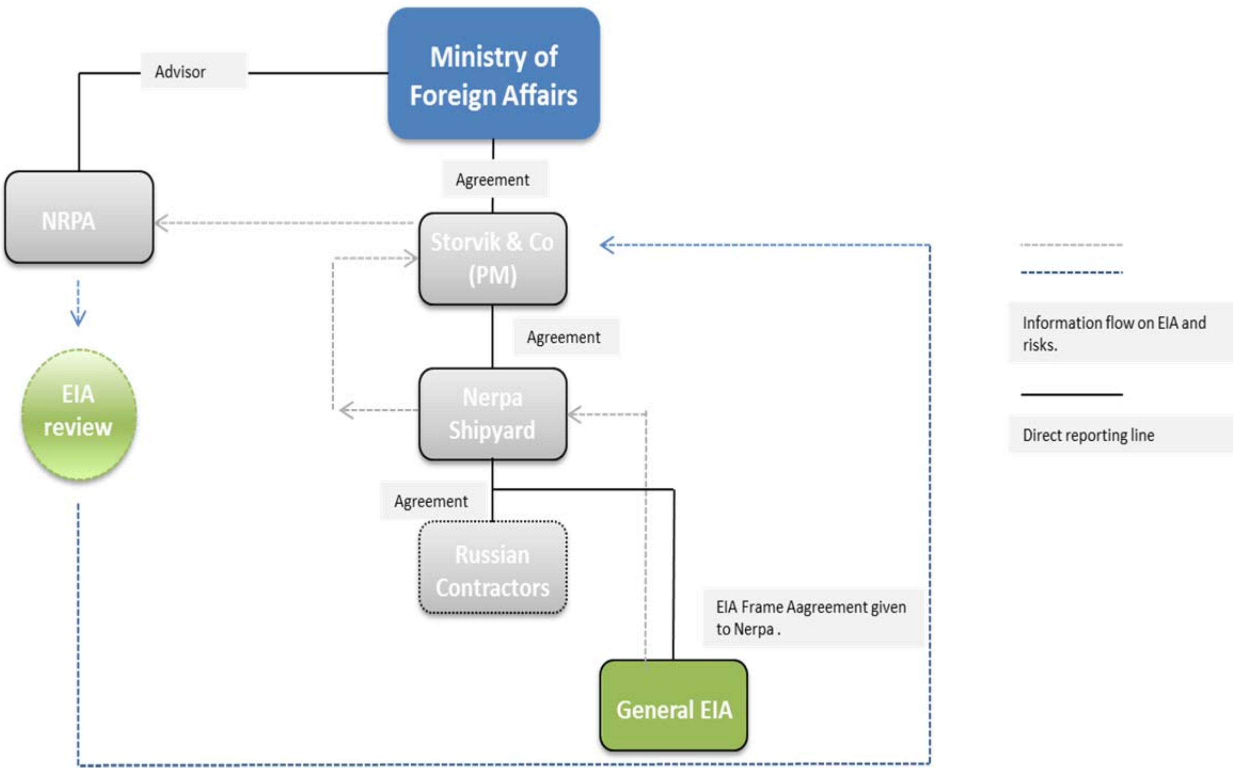

Figure 10 - Project organisation of submarine 609

Figure 10 shows the organisation chart for submarine 609. The PM reports to the MFA while Nerpa reports directly to the PM. The PM is responsible for supervising the work at the shipyard on behalf of the Norwegian authorities as well as endorsing payment of invoices issued by Nerpa. With respect to risk and EIA issues Nerpa submitted required documentation to the PM, who then submitted the documentation to NRPA for review and approval.

[22] For submarine 609 no separate EIA was prepared. Instead EIA documentation for the previous submarine 297 was used as a basis.

As previously stated submarine 609 was the fourth in line to be dismantled. Furthermore, the organisational set up for submarine 609 was similar to that of submarine 297, the latter being completed immediately before signing of agreements for submarine 609 (see time line in 4.3). The documents reviewed do not signal any conflict among stakeholders in terms of understanding the various roles or responsibilities. Keeping the same organisational set-up and roles for submarines 297 and 609 and having the same Norwegian PM on board most likely had a positive effect on the organisation as such. According to the completion report provided by the PM, the negotiations with the shipyard with respect to the general obligations and scope of work went smoothly and the only part that was up for discussion was the price.

Contractual arrangements

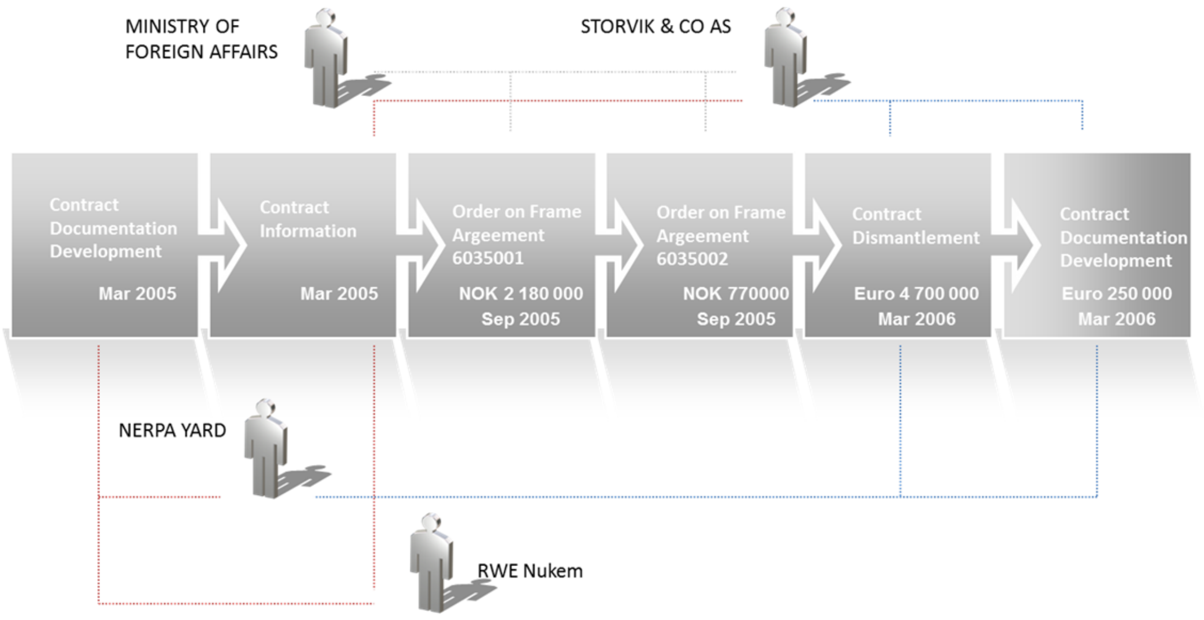

Figure 11 - Contractual arrangements for dismantling of submarine 609

For submarine 609 there were four main contracts:

- Project Management Contract (between MFA and Storvik & Co)
- Negotiations and Documentation Contract (between MFA and Storvik & Co)
- Dismantlement Contract (between Nerpa shipyard and Storvik & Co)
- Preparation of Design and Documentations Contract (between Nerpa shipyard and Storvik & Co)

A detailed overview of the above contracts is provided in Appendix 1.

The contractual set-up for submarine 609 differed at one major point compared to the first two dismantling projects. For 609 the actual dismantling contract was between Nerpa and Storvik & Co, and not between Nerpa and MFA. In this way the operative management and follow-up of the dismantling process for submarine 609 was contracted out of the MFA. DNV considers this arrangement as an improvement compared to what was practised on the first two dismantling projects.

The contract strategy of the MFA was to have a frame agreement with call-offs[23] with Storvik & Co. The two major contracts between MFA and Storvik & Co, i.e. the negotiations and documentations contract and the project management contract, are call-offs. DNV is of the opinion that the agreements between MFA and Storvik & Co are in general according to good practice.

The major contract for submarine 609 is the Dismantlement Contract between Nerpa shipyard and Storvik & Co. The contract clearly states the obligations of the contractor (Nerpa) and the customer (Storvik & Co) and is in general according to good practice.

There are, however, certain elements that appear to be lacking or areas that could be improved in future contractual arrangements. One such element is reference (or rather lack of) to fraudulent and corrupt practices. No agreements or call-offs reviewed have any specific reference on how to combat fraudulent and corrupt practices. This was also pointed out by the Office of the Auditor General of Norway in their assessment in 2010. It is worth mentioning that following abovementioned report, the MFA has now included anti-corruption risk assessments as part of their funding requirements.

Another element is procurement and competitive bidding processes among Russian suppliers. The agreement between Nerpa and Storvik & Co does not include a requirement for purchases to be undertaken according to a competitive bidding process. However, in Annex 1 in the agreement between Nerpa and Storvik & Co it is pointed out that: “According to this Scope of Work, the Contractor is to enter into certain sub-contract agreements with organizations of the Russian Federation. The Contractor is to engage subcontractors to fulfil definite functions, and is to make sure that they respect the requirements of Russian Federation laws, and that they provide all relevant regulatory documents required. According to the PM no initiatives were taken from his side in terms of following up Nerpa’s sub-contractors – the reason being that this was considered ouside his scope.

Lines of communication

As outlined in Figure 9 the main line of communication was between the PM and Nerpa. Issues of concern among Norwegian authorities are forwarded to the PM who is then responsible for follow-up towards Nerpa. It is difficult to assess to what extent the lines of communication were good or not only from reviewing documents. However, interviews with the MFA, NRPA as well

[23] A call off is based on an already signed frame-agreement.

as the PM indicate that lack of communication was not an issue during the implementation. Rather, the PM has been acknowledged for his project management skills and for communicating well with the Russian side.

Monitoring, control and quality assurance

An important element of monitoring and control was the use of milestones and physical inspection by the PM before payment. This is clearly set out in Annex 3 of the agreement between Nerpa and Storvik & Co: "The payment will be made by a recommendation by the Contractor to the Donor. The recommendation will have Works Completion Report as a basis Payment Request and the results of the conducted Monitoring Visits". The Office of the General Auditor in their report of 2010 also acknowledges this arrangement.

Due to limited documentation, DNV has only reviewed a few inspection reports. Despite this, our impression is that, overall, the inspections were undertaken according to plan and expectations, except for one milestone (MS 12 in table 5). Some of the major findings from inspections are provided below.
Inspections were undertaken for both contracts between Nerpa and Storvik & Co. With respect to the "Negotiations and Documentation" contract inspections were undertaken in order to certify that documentation was produced according to time schedule. The review shows that, overall, the documentation contract was fulfilled without any substantial deviations. It is worth mentioning is that the PM inspection team early on had difficulties assuring to what extent the documentation was in place before the start-up of work. One reason for this was that much work was ahead of schedule. However, this issue was solved by coordination of the schedules for inspections for the two contracts. The inspection team compared the documentation produced for submarine 297 and 609 and observed great similarity between the two projects. There were, however no sign of copying of documentation.

Polystyrene was removed from the ballast tanks after the submarine was placed in the hall and not while in the floating dock, as agreed in the contract. The documentation for the process (MS 5) was approved on 28 July 2006 which is on schedule. Inspections, however, showed that the work on MS 5 started already 19 April 2006, which meant that the work started before corresponding documentation was approved. Nerpa thereby broke the contract on this point. It was also detected that the shipyard had not established procedures for monitoring the employees' possible exposure to radiation. This question was addressed by the Norwegian side, but not answered by Nerpa. According to the PM, it was difficult to get information from the shipyard on this issue.

Inspections showed that hot work (welding etc) was not performed according to the contract. "Hot work" was done in parallel with removal of styrofoam and flammable liquids may have been removed from the hull during "hot work", albeit not recognized by Nerpa. In addition, the documentation for these procedures was not in place at the time the work started. Storvik & Co acknowledged their dissatisfaction with Nerpa on this point in their completion report, however, the issue does not appear to have been discussed directly with Nerpa.

Submarine 609 was declared completed in October 2007, 11 months behind schedule. The reason for the delay was related to fulfilment of MS 12, which is further described in paragraph 6.3.2.

6.3.2 Progress and implementation

Milestone (MS)	Date of Completion as Scheduled in the Contract	Statement of Work Completion	Contract Value	Invoice (€)
MS 1	15 Feb. 2006	3. Mar 2006	235 000	235 000
MS 2	15. Mar. 2006	26. Apr. 2006	470 000	470 000
MS 3	15. Apr. 2006	27 Apr. 2006	470 000	470 000
MS 4	10. May 2006	27 Apr. 2006	235 000	235 000
MS 5	5. Jun. 2006	28. Jun. 2006	235 000	235 000
MS 6	5. Jul. 2006	28. Jun. 2006	470 000	470 000
MS 7	25. Aug. 2006	28. Jun. 2006	235 000	235 000
MS 8	25. Sep. 2006	14 Jun. 2006*	470 000	470 000
MS 9	25. Oct. 2006	16 Aug. 2006	470 000	470 000
MS 10	25. Oct. 2006		235 000	235 000
MS 11	25. Oct. 2006	16 Aug. 2006	470 000	470 000
MS 12	Oct. 2006	28. Sep. 2007	235 000	235 000
MS 13	First half 2006	27 Apr. 2006	235 000	235 000
MS 14	First half 2006	28. Jun. 2006	235 000	235 000

*date of Date of fund's receiving

Table 5 - Planned vs actual completion/cost

Table 5 gives an overview of the milestones as stated in the Dismantling Contract between Nerpa and Storvik & Co and the corresponding actual completion date. The actual milestone completion date is also the date for which payment to the shipyard was approved. The table shows that there were no significant time variances except for MS 12.

Dismantling of submarine 609 was ahead of schedule when it was placed in the decommission hall. Then, in the summer of 2006 the landing dock in Saida Bay was damaged during placing of the first reactor sections. As a result of this accident MS 12 was postponed several times with final inspection carried out on 19 September 2007. MS 12 was still not approved on this day as the section was not placed in its final storage site at Saida with responsibility transferred to SevRAO[24].

The PM and Nerpa agreed that no additional inspection was needed. However, Nerpa had to submit the final documentation to Storvik & Co in order for the work to be completed. By 11 October 2007 Rambøll Stovik had received the following documentation:1) formal delivery document stating SevRAO as responsible for the section, 2) announcement from SevRAO that the section is stored at the site and 3) photos that document transport and final placement. MS 12 was then considered fulfilled and the project as such completed about 11 months behind original plan.

Except for the accident with the landing dock which affected project completion, dismantling of submarine 609 followed the agreed schedule. This is also reflected in the Independent Auditor's report (2007) which stated that "the dismantling works were performed basically in accordance with the project and timetable, unaccountable variances have not been detected excepting only

[24] D5.1 05 14873-27 - 3065001 Rapport fra siste inspeksjon - Opphugging av Viktor 1 ubåt nr 609 ved Nerpa

stage No 12 - Shift of one-compartment unit to the floating dock and transfer to the long-term storage area in Saida".

6.3.3 Budget and costs

The value of the dismantling contract was 4 700 000 €. The Russian accounting firm Audit Servis commented on the financial aspects of the project during their audit in 2007: “In our opinion, by 01.10.2007 Federal State Unitary Enterprise "Center of ship repairing "Zvezdochka" (branch-office Plant "Nerpa") was in all material respects concerning financial and accounting requirements in compliance with the terms of Contract No NOR-04/609 for dismantlement of one non-strategic NPS project "VICTOR I" construction number 609 excepting facts described in the attached auditor's report.”

According to the PM and the completion report of submarine 609 the explanation for “excepting facts described in the attached auditor's report” was lack of documentation with respect to time used and allocation of overhead costs. For example, actual wage costs exceeded budgeted wage costs with 261 000 €. Book-kept wage costs was 138,7% of budgeted costs.

Audit Servis acknowledged that appropriate documentation was missing for several transactions, and therefore the actual costs for those transactions could not be verified. The financial report was, however, accepted, partly due to the fact that it was comparable to the financial report for submarine 297, which was well documented.

The review of documents show that submarine 609 were dismantled according to agreed budget. Another question is to what extent 4 700 000 € was the “right price”. From the initial negotiations it appears that as long as the cost of dismantling did not differ substantially from the previous submarine, i.e. submarine 297, the price would be accepted. The challenges with the cost estimates provided by the Russian counterparts during the contract negotiations are also mentioned, although in general terms, in the 2010 report by the Office of the Auditor General of Norway. According to the report there is a risk that the price is higher than it normally would be without external funding.

6.3.4 Change management

DNV has come across only one change in contract for submarine 609, i.e. for the project management contract between MFA and Storvik & Co. In a letter to MFA from the PM dated 10 November 2006, a delay of about 6 months for completion of the dismantling of submarine 609 was estimated. As a consequence the contract (order 3065001) between MFA and Storvik & Co was extended.

6.3.5 Handover

As pointed out previously the last inspection of submarine 609 was undertaken in September 2007. Then, in October 2006 the remaining documentation of MS 12 was submitted by Nerpa and the project was eventually closed. A completion report was prepared in December 2007 by the PM. It is not clear to what extent a similar completion report was prepared by Nerpa.

No specific lessons learned chapter is provided in the PM completion report. Although several issues and potentially improvement areas are discussed, there is no reference to how issues could be handled differently in the future. This is not to say that transfer of knowledge did not occur, only that the documentation of it appear to be missing.

6.4 Conclusion

- The major contract for submarine 609 clearly states the obligations of the contractor (Nerpa) and the customer (Storvik & Co) and is in general according to good practice.
- However, elements such as reference to fradulent and corrupt practices as well as requirements for competitive bidding processes were lacking in the contract between Nerpa and Storvik & Co.
- Interviews with stakeholders confirm that lack of communication was not an issue during the implementation of 609. Rather, the PM was acknowledged for his project management skills and for communicating well with the Russian side.
- Payment from MFA to Nerpa shipyard was linked to physical inspection of milestones by the PM. This arrangement appeared to function well and no deviations were found.
- Payment from MFA to Nerpa was undertaken despite lack of sufficient documentation of time used and overhead costs at Nerpa. The need for improved internal control measures in future projects has also pointed out in the latest review undertaken by the Office of the General Auditor in Norway.
- Dismantling of 609 was undertaken according to agreed budget. DNV has not analysed to what extent the negotiated price in the first place was the "right" price. It appears that the basis for the price negotiations between MFA and Nerpa shipyard was the costs of the previous dismantling of submarine 297, rather than an independent costs analysis of 609.
- The accident with the landing dock during placing of the first reactor sections resulted in a delay in project completion with 11 months. Except for this delay, dismantling of submarine 609 followed agreed schedule.
- DNV has not come across any documents summarising lessons learned from the dismantling programme. Although it is obvious that experiences have been gathered and acted upon during the years, institutionalizing lessons learned is recommended.
- A project completion report was prepared by the Norwegian PM. DNV has not come across a similar report written by Nerpa. DNV is of the opinion that such a report could give added value.

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