Programme for Decommissioning of Multipurpose Nuclear Submarines in the North-West of Russia

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Decommissioning activities are carried out in the North-West of Russia in full compliance with the national Concept of Integral Decommissioning of Nuclear Submarines and Ships with Nuclear Power Installations and the Programme developed for its implementation.

The Concept of Integral Decommissioning of Nuclear Submarines describes essential administrative, scientific, technological and industrial activities meant to provide integral decommissioning of nuclear submarines and ships, from inactivation to disposal of radioactive and other wastes and site remediation.

The Concept was developed relying on domestic and foreign experience in this area. It gives an outline of the problem and discusses principal technical ways of its solution in the current economic and political environment of Russia. The Concept addresses national and international safety concerns, in particular, these of safeguarding and nonproliferation.

The Concept rests upon the following philosophy:

- Nuclear and environmental safety shall be ensured in all stages of integral decommissioning of nuclear submarines, ships with nuclear power facilities and relevant service vessels

- Top priority is given to prompt defuelling of nuclear submarines and ships. Waterborne submarines presenting the greatest hazard, shall be defuelled and dismantled first

- Spent nuclear fuel (SNF) removed from submarines, ships and remediated sites, is to be reprocessed at the RT-1 plant at Mayak (implementation of “closed” cycle of SNF management). Capability should be provided for temporary storage of SNF, if necessary, in dry casks until reprocessing

- Existing infrastructure should be used to facilitate integral decommissioning of nuclear submarines, ships and service vessels

- Dismantling of highly contaminated components of naval nuclear power facilities and subsequent disposal of equipment not subject to dismantling, should be put off for a certain time (approximately 70 years after permanent reactor shutdown). Components will remain in reactor compartments specially prepared for long storage until fit for safe dismantling

- Local population should be fully informed about ongoing and planned activities associated with integral decommissioning of nuclear submarines, ships and nuclear service vessels, about measures taken to ensure nuclear, radiation and environmental safety, conclusions of reviews on decommissioning techniques, and about condition of relevant sites and facilities

- All participating shipyards shall be committed to ensuring nonproliferation and national security.

Principal activities within integral decommissioning of nuclear submarines, ships and service vessels were developed for the following stages: inactivation, lay-off, defuelling, cutting and handling of reactor compartments (units), disposal of other submarine parts, shipment of spent nuclear fuel and radwaste, site remediation.

The Programme developed with a view to Concept implementation, describes main activities to be performed in the stages identified in the Concept.

The whole integral of activities is divided into two major phases tentatively planned for the years 1999 - 2004 (Phase I) and 2005 - 2010 (Phase II).

Baseline activities included in the Phases:

Phase I:

- set up infrastructure and prepare facilities to provide the planned rate of SNF retrieval;
- provide regulatory framework for Programme implementation;
- transfer inactive submarines and ships from the Navy to civil enterprises, to be serviced by civilian crews of these enterprises;
- transfer coastal naval bases to civil operators;
- undertake actual dismantling of nuclear submarines, including fabrication of three-compartment reactor units.

Phase II:

- put in service a pad for long-term buffer storage of reactor compartments, manufacture and deliver vessels and facilities to ship reactor compartments to the pad;
- complete most of dismantling activities and take reactor compartments to the long-term storage pad;
- begin large-scale remediation of coastal bases and disposal of service vessels.

Many activities have already been performed in the framework of Phase I of the Programme, in particular:

- regulatory documents were developed and put in force to establish procedure for handing submarines over from the Navy to shipyards engaged in dismantling. The documents describe regulatory requirements for nuclear, radiation, fire and explosion safety and provision of submarine buoyancy in the time of lay-off. They address nuclear safety enhancement during support activities and defuelling, and other issues;

– maintenance and repair activities were carried out at floating refuelling bases and refuelling equipment (Fig. 1);

Service Vessel of the "Malina" Type

Figure 1

– new casks and SNF packing equipment were manufactured and put in service to be used for shipment and temporary storage of spent fuel (Fig. 2 , 3);

Metal-Concrete Cask TK-108/1

Figure 2

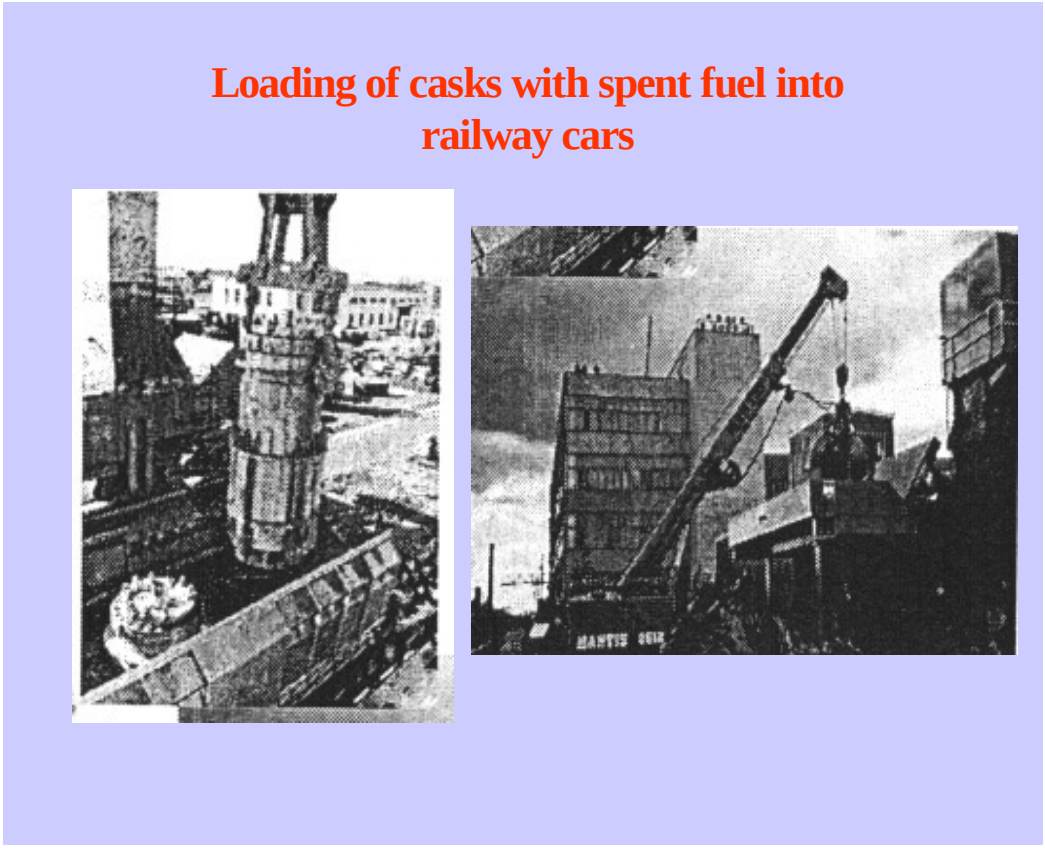

Figure 3

– improvements were made in the infrastructure of shipyards involved in submarine dismantling.

Implementation of these activities, continued attention paid by Minatom management to decommissioning of nuclear submarines, larger fundings from the state budget and extra-budgetary sources, drastically changed the situation existing in the late ‘90s. Fig. 4 show some data on number of submarines retired from the Navy and located in holding areas afloat (including those with SNF on board).

It is clear that starting from 1998-1999 this number is gradually reduces because of increase of the NS defuelling rate, SNF removal for reprocessing, production of three-compartment RC units, and disposal of the NS aft and berth parts.

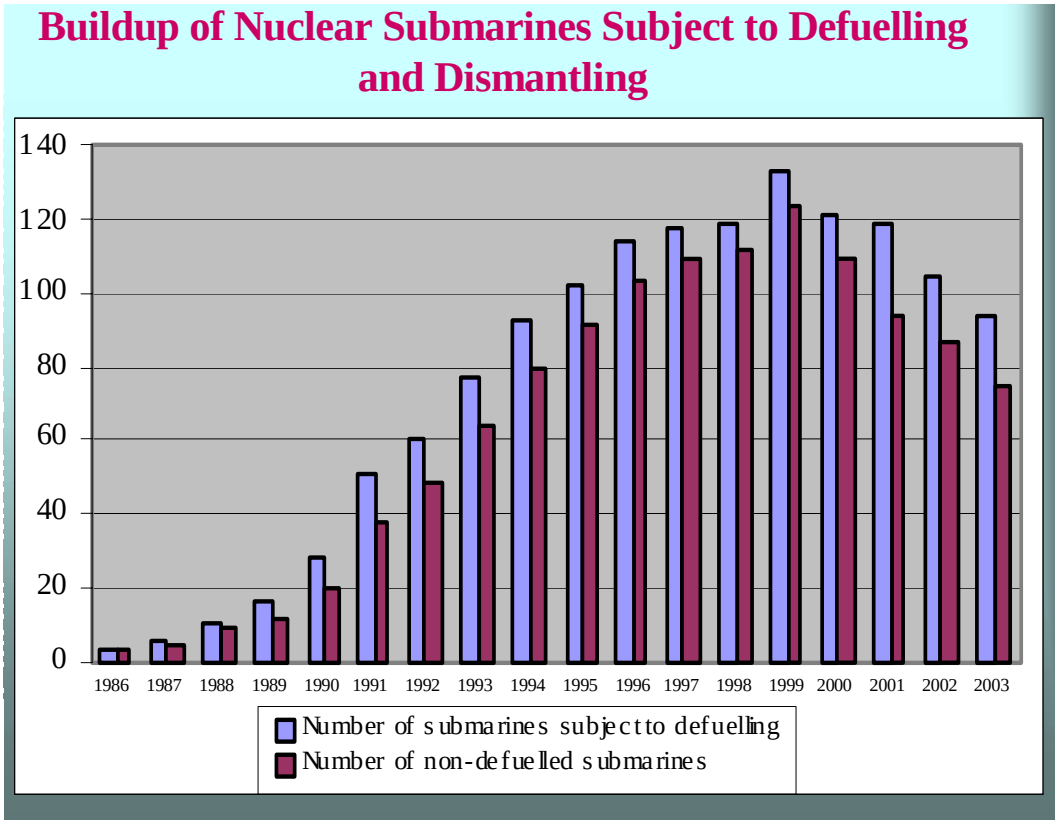

Figure 4

Thus, before 1998, no more than 4 (more often, 3) submarines were defuelled each year. In 1998, SNF was removed from 8 submarines, and by 2001-2002, the rate of submarine defuelling reached 16-18 submarines a year.

Dismantling of nuclear submarines in the North-West of Russia is tackled by several shipyards belonging to the Russian Shipbuilding Agency and the Navy (Fig. 5):

In Arkhangelsk region:

- MP Zvezdochka;
- PO Sevmashpredpriyatiye;

In Murmansk region:

- Nerpa Shipyard;
- Polyarninskiy Shipyard;
- Sevmorput Shipyard.

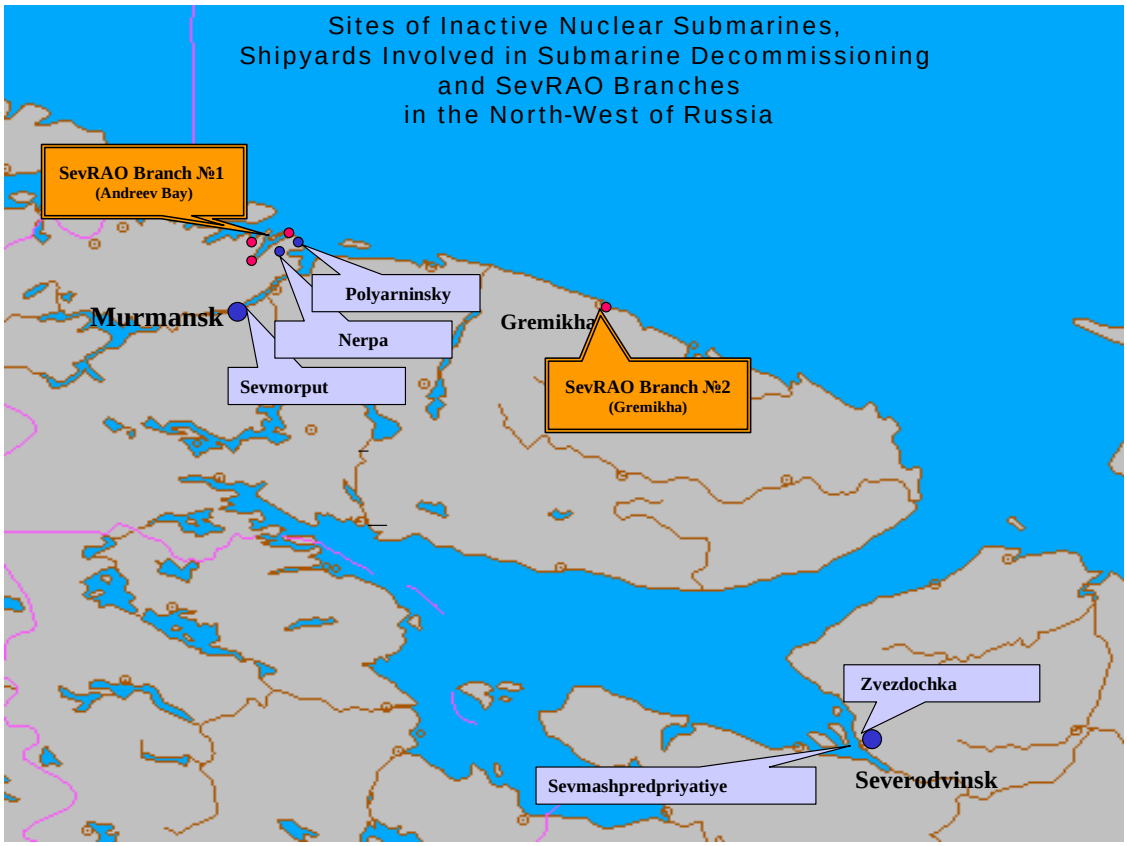

Figure 5

Submarines are given to shipyards for dismantling on a tender basis.

Shipyard capabilities (overall) allow dismantling of up to 10 - 12 submarines a year.

The shipyards involved in the Programme have developed and tried out a three-compartment dismantling technique. Numerous regulatory and technical documents were developed to guide the work of companies involved in nuclear submarine decommissioning. A special procedure was developed for transportation and handling of SNF, radioactive waste, reactor compartments and scrap.

The effort to improve shipyard capabilities and perfect relevant techniques was targeted primarily at dismantling of strategic submarines.

At the same time, each of the above areas still has outstanding issues that have to be resolved in the nearest future.

Thus, one of the issues that has been acquiring increasing importance, is construction of a long-term storage facility for reactor compartments (RC) at the coast of Saida Bay (Fig. 6).

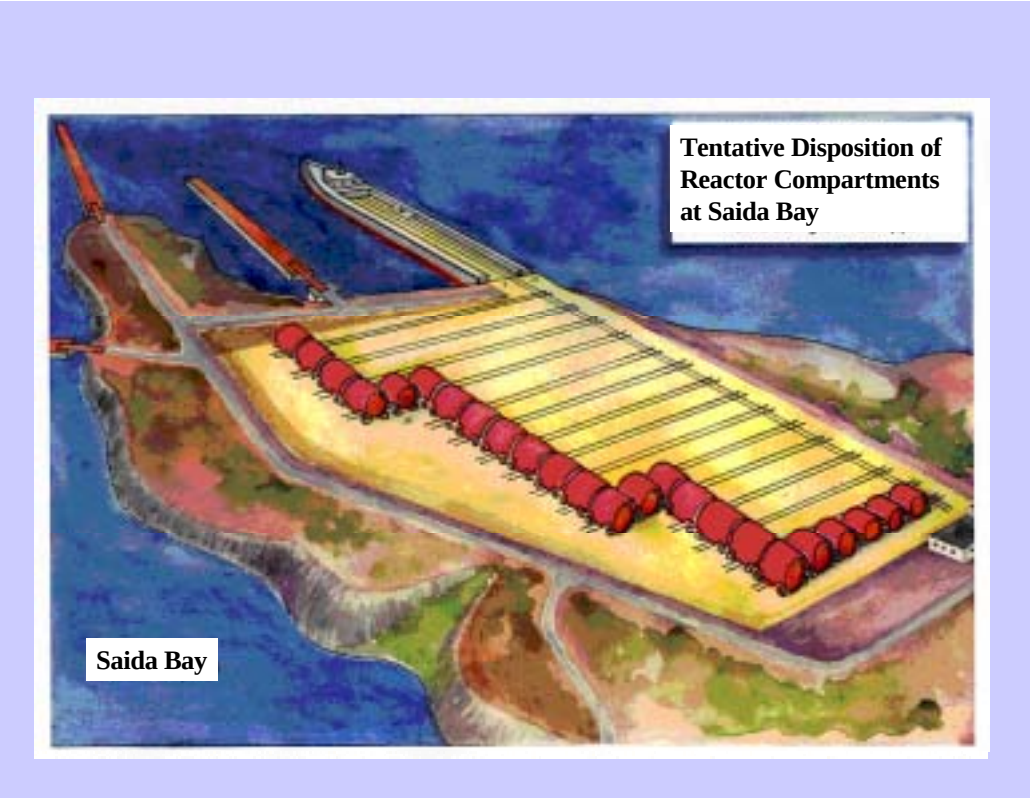

Figure 6

As envisaged in the Concept of integral decommissioning of nuclear submarines and ships, reactor compartments are to be cut from the submarine hulls and placed in long-term storage facility for temporary storage before subsequent RC dismantling is possible (See Fig. 7).

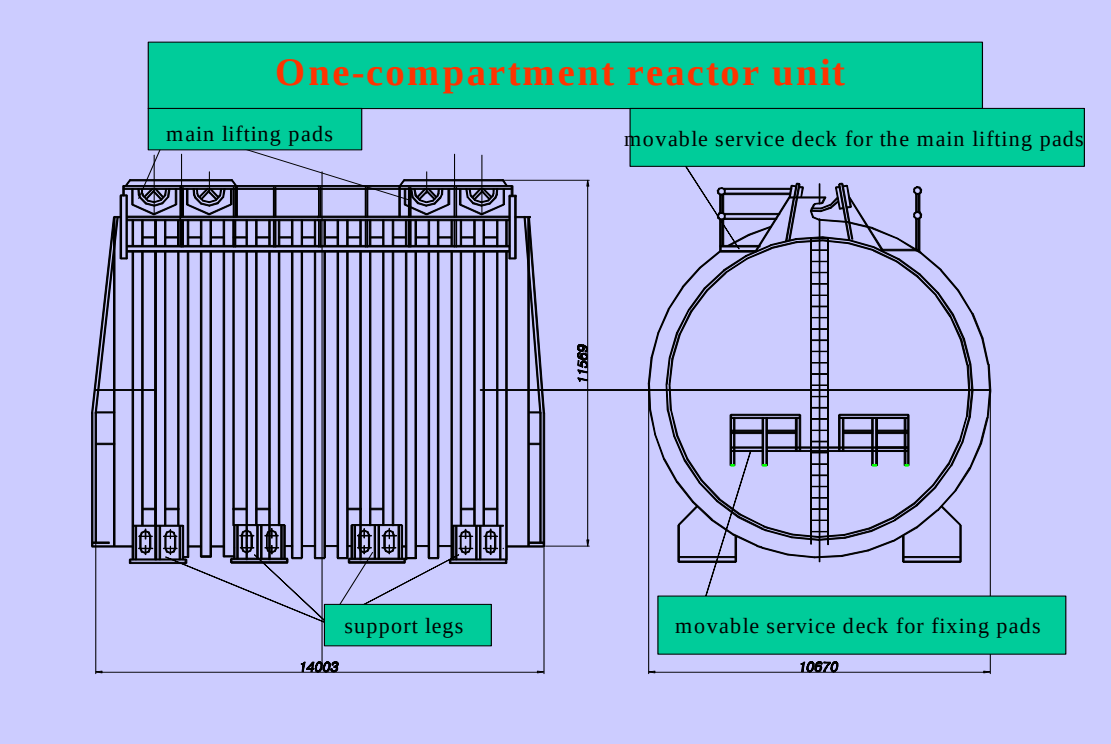

Figure 7

As a temporary measure before the storage facility is available, reactor compartments are formed as three-compartment units, to be temporarily stored waterborne in an interim storage area (see Fig. 8).

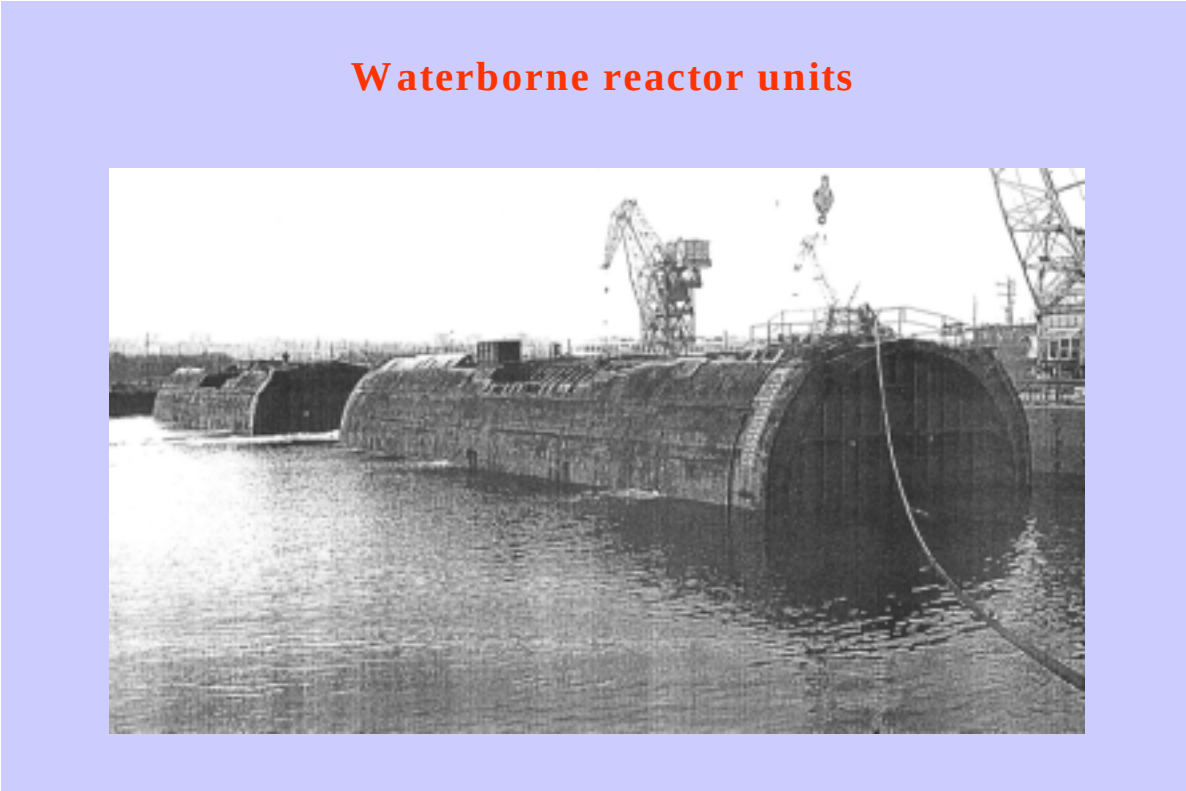

Figure 8

The three-compartment technique allows towing units to interim storage area at a minimum cost, where they can be temporarily safely stored afloat in the absence of the RC storage facility.

Meanwhile, the expediency of moving to one-compartment unit approach is evident. The three-compartment option successfully addresses the issue of nuclear safety because SNF is removed from reactors of inactive submarines. Inconveniently, this also means that the units have to be kept waterborne and serviced, with ensuing unnecessary costs of docking and maintaining buoyancy system to prevent accidental sinking of compartments.

At present, there are more than fifty waterborne reactor compartment units of various configurations in the temporary storage area at Saida Bay, ranging from one-compartment units with buoyant half-sections to multi-compartment units which are more like a proper submarine. It will be difficult and very costly to place more RC units there (see Fig. 9).

Construction of the RC storage facility has not been started yet because of its high cost in general (US$ 200 million.) and considerable annual expenditures in particular (comparable to annual allocations from the state budget for the dismantling Programme on the whole). A serious effort is being made to obtain extra-budgetary funding and secure foreign assistance to help construct the long-term storage facility.

Interim Storage Site at Saida Bay

Figure 9

The project will involve considerable work on construction of a berth pad to accommodate reactor compartments prepared for storage. It will be necessary to provide facilities for taking reactor compartments from sea vessel to traversing crane of the storage pad, as well as facilities for taking reactor compartments to surface vessel at the shipyard producing one-compartment units (Nerpa). A surface vessel itself will have to be built to deliver reactor compartment from shipyard to the RC long-term storage facility. It will be necessary to construct also a berth pad at Nerpa for fabrication and temporary accommodation of one-compartment units before taking them to the long-term storage facility.

Recognizing prime importance of such RC storage, Minatom has developed in the framework of the Global Partnership Programme a project for setting up a long-term storage facility at Saida Bay and passed it to potential participants for review.

Contributing organisations could purchase and deliver equipment, facilities and support systems, and provide financial aid to project activities.

There is no sense in passing to one-compartment technique until the long-term storage pad is available. Otherwise, the shipyards will have to spend more money to provide additional coastal pads for interim storage of reactor compartments (these expenses will be comparable with resources needed for setting up a regional RC storage facility). Moreover, each shipyard will have to be furnished with a special pier and facilities for transferring one-compartment units to the surface vessel. Assessments show that taken together, these extra expenditures will exceed the expected cost of the regional RC storage facility and the whole integral of cutting activities to get single compartment instead of a three-compartment unit. There are plans to set up a pad for handling one-compartment reactor units, but only at Nerpa shipyard (the work has been started) where there is a need for converting three- and multi-compartment

units stored at the interim storage area into one-compartment sections that will be taken to the regional RC storage facility in Saida Bay, which is located near the Nerpa shipyard.

As of today, there are approximately 60 multipurpose nuclear submarines that shall be dismantled in the North-West of Russia. Given existing capabilities of civil and naval shipyards, the bulk of dismantling activities at these submarines could be completed by the year 2007 (see Fig. 10). However, allocations from the state budget are undoubtedly insufficient to keep the work going at the pace it could have with proper funding (defuelling, fabrication of reactor compartment units and submarine dismantling). As estimated, it will cost about US$ 1 billion to provide safe storage of nuclear submarines, ships, three-compartment reactor units, deliver submarines from the location of their current storage to shipyards, defuel the submarines' reactors, transport and reprocess SNF, produce of RC units and dispose of remaining submarine components in the North-West of Russia. The state budget can hardly be expected to provide the funding of such magnitude for these activities.

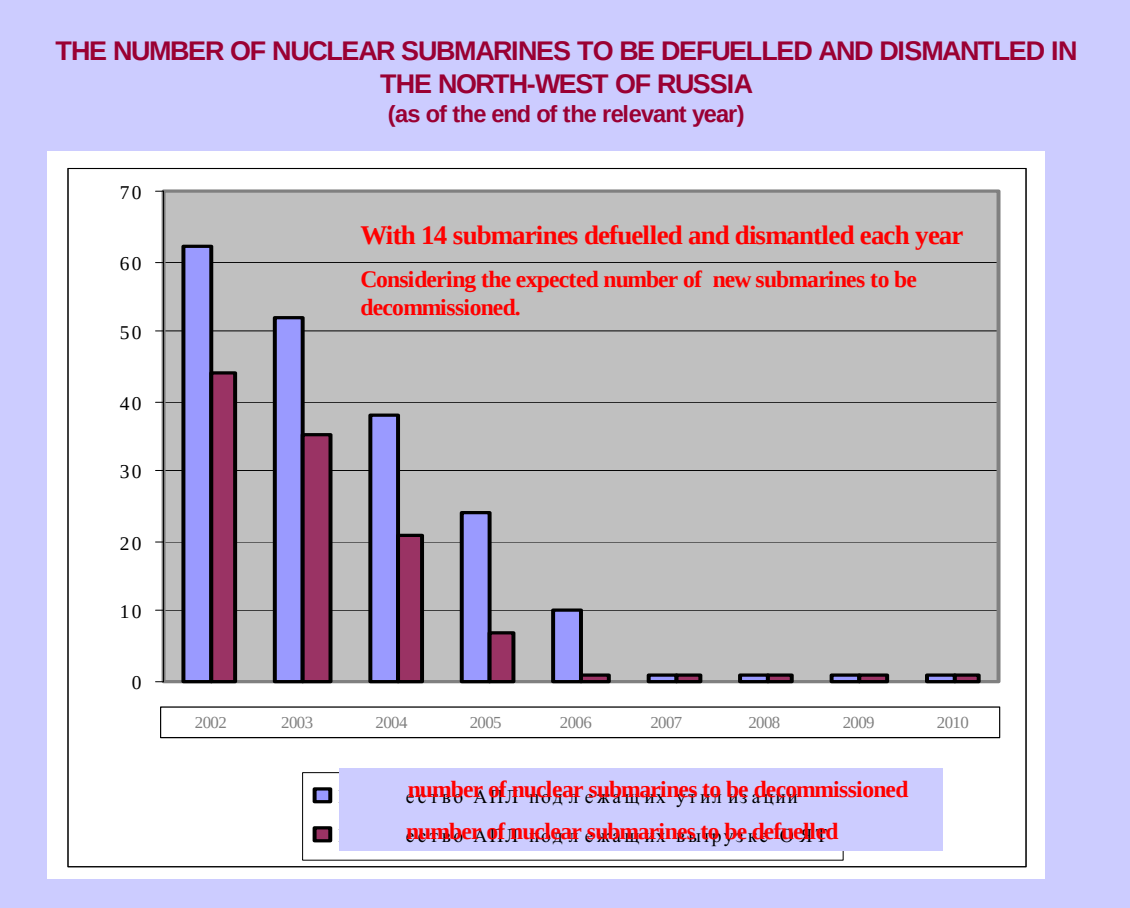

Figure 10

Without financial and technical assistance from the international community, the work will inevitably slow down so that the process will stretch well into the future, hence increasing the risk of incidents associated with storage of facilities presenting a radiation and nuclear hazard (see Fig. 11).

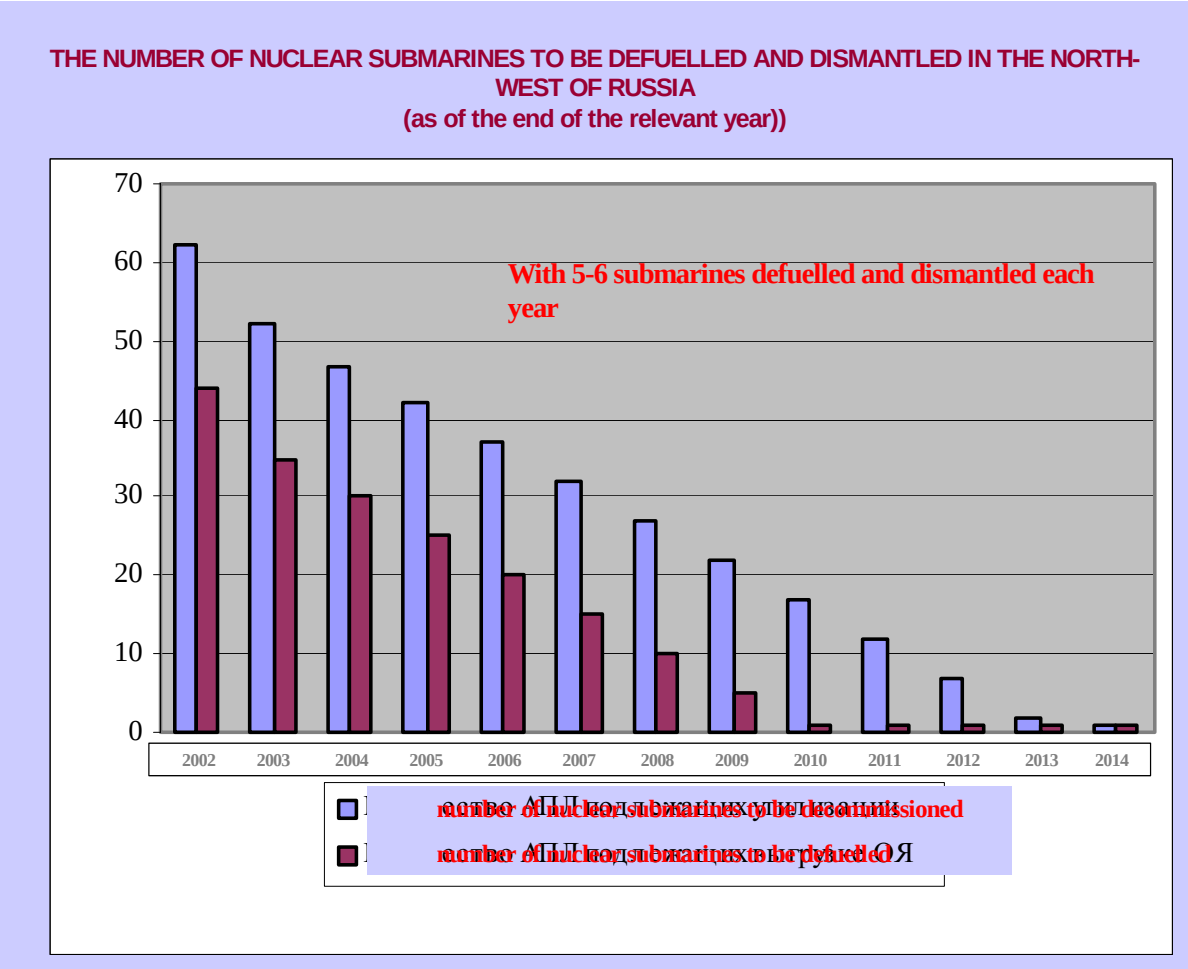

Figure 11

With the good progress in NS defuelling achieved, the total amount of SNF located in retired submarines now is approximately the same as at ex-naval coastal bases transferred to Minatom of Russia (Fig. 12).

Total Amount of Spent Fuel and Radwaste in Nuclear Submarines Subject to Dismantling, Service Vessels, at Coastal Bases and Shipyards

№ №	Facility	Number of Facilities	Number of cores, activity, Ci	Amount of solid radwaste, m^3 activity, Ci	Amount of liquid radwaste, m^3 activity, Ci	Total activity, Ci
1	Defuelled Nuclear Submarines		-	18000 / 3.0×10^6	1200 / 12	3.0×10^6
2	Non-Defuelled Nuclear Submarines		170 / 1.8×10^8	54000 / 1.7×10^7	3600 / 36	2.0×10^8
3	Service Vessels		20 / 2.0×10^7	-	3600 / 30	2.0×10^7
4	Coastal Bases in the North-West Region	2	116 / 5.0×10^7	8100 / 6.0×10^3	3200 / 60	5.0×10^7
5	Coastal Bases in the Pacific Region	2	40 / 2.0×10^7	15500 / 1.6×10^5	2100 / 40	2.0×10^7
6	Shipyards Involved in Nuclear Submarine Decommissioning	8	-	2000 / 3.0×10^2	2500 / 30	3.3×10^2

Figure 12

It should be noted that spent fuel remaining in the laid-off submarines is in normal safe condition and can be safely kept there until unloading and shipment for reprocessing. Technical condition of coastal storage facilities, however, is anything but normal and is getting worse all the time, hence hindering subsequent management of fuel in the framework of the SNF handling procedure.

Condition of storage and support facilities at Andreev Bay and Gremikha sites is such that safe handling of SNF can hardly be ensured without taking special engineering measures and providing extra handling facilities.

Considering that site remediation will take a long time, it is necessary to start doing something practical about site infrastructures right now, to enable safe retrieval of spent nuclear fuel from storage facilities for reprocessing and subsequent remediation of buildings, facilities and site territory.

The total cost of remediation of Andreev Bay and Gremikha sites (storage and other facilities, buildings and territory), including SNF removal and reprocessing, is put at US$ 800 million.

Of no less importance is the issue of managing radioactive waste already in place at the shipyards and generated in the course of nuclear submarine dismantling.

As required by current procedures, the bulk of solid waste (SRW) produced during dismantling is held in reactor compartments and shall remain there until reactor compartment is dismantled.

However, with the large amount of SRW stockpiled at the shipyards and considering the waste stored at Minatom sites at Andreev Bay and Gremikha, it becomes a dire necessity to build regional waste treatment, conditioning and storage facilities in compliance with current safety rules (Fig. 12).

The Programme of Integral Dismantling of Nuclear Submarines and Ships envisages construction of such regional facilities. However, other issues of greater urgency, did not allow launching these activities so far. Now Minatom prepared a relevant project in the framework of the Global Partnership Programme, and passed it to potential contributors for review. The project will allow considerable reduction in the amount of solid radioactive waste subject to storage and subsequent disposal. As estimated, it will cost US$ 30 million to solve this problem in the North-West of Russia.

As regards management of liquid radioactive waste (LRW) already existing and generated in the course of nuclear submarine dismantling, of crucial importance is creation of mobile modular waste treatment facilities. It appears unreasonable to build new plants for treatment of liquid waste because of the high running and treatment costs at such plants.

Other important issues are treatment of LRW with complex composite chemistry and management of high-active sorbents from ion exchange filters.

Recognizing importance of dealing with various wastes produced in the course of nuclear submarine and ship dismantling, Minatom is allocating each year resources for waste

treatment at existing facilities. Expansion of the park of mobile treatment facilities will help reduce the volume of waste put in temporary storage besides the ability to treat newly delivered waste.

Finally, it is worth emphasizing some other issues that should be dealt with in the near term:

- continue defuelling retired submarines to eliminate associated nuclear hazard and downrate the submarines from “nuclear-hazard” to “radiation-hazard” facilities;

- fabricate one- and three-compartment reactor units and dispose of other submarine parts;

- set up a pad for a long-term storage facility for reactor compartments at Saida Bay, to enable transfer to single-compartment dismantling and relieve interim storage areas;

- boost the work on site remediation (coastal bases) and removal of spent nuclear fuel from coastal bases for reprocessing;

- improve physical protection of sites and facilities to ensure their safe operation;

- resolve the issue of management of spent reactor cores of liquid metal cooled reactors.

Apart from financial assistance, other countries could contribute to resolving these issues by providing essential gear for facilities involved in dismantling of nuclear submarines and ships, e.g.:

- provide high-capacity travelling cranes (up to 100 t) for coastal sites belonging to Minatom to enable safe handling of SNF casks;

- participate in setting up physical protection and radiation monitoring systems at sites and shipyards;

- create or restore support systems at coastal sites subject to remediation;

- supply mobile modular facilities for treatment of various wastes, including high-active (ion exchange resins) and liquid waste with complex composite chemistry.