RTG Master Plan Development Results and Priority Action Plan Elaboration for its Implementation

Alexander S. Grigoriev, Mark A. Sazhnev, Alexei M. Khudykin,
Russian Research Center "Kurchatov Institute"
Natalia T. Sherbina, Rosatom, Russia

List of Acronyms

APS	Alternative Power Source
BF	Baltic Fleet
VNIITFA	Federal State Unitary Enterprise All-Russia Research Institute for Applied Physics and Automation
HE	Hydrographic enterprise
HS	Hydrographic Service
HD	Head Department
ZAO TSPK	Closed Joint-Stock Company Pacific Construction & Manufacturing Company
EDM	EDM Limited Liability Enterprise
KI	Russian Research Center "Kurchatov Institute"
LSK Radon	Federal State Unitary Enterprise Leningrad Special Combine "Radon"
RTG ICG	RTG Interagency Coordination Group
PA Mayak	Federal State Unitary Enterprise Production Association "Mayak"
SMF	Strategic Missile Forces
RHS	Radionuclide Heat Source
RTG	Radioisotope Thermoelectric Generator
Roshydromet	Federal Service for Hydrometeorology and Environment Monitoring
Rosmorrechflot	Federal Agency for Sea and River Transport of Russian Ministry of Transport
NF	Northern Fleet
PF	Pacific Fleet
FASRT	Federal Agency for Sea and River Transport
FSUE DalRAO	Federal State Unitary Enterprise Far East Enterprise for Handling Radioactive Waste

1. Preamble

Russian Research Center "Kurchatov Institute" in cooperation with concerned and competent organizations of the Russian Federation developed the Master Plan to decommission, replace with alternative power sources and dispose of radioisotope thermoelectric generators of the Russian Federation (hereinafter referred to as "Master Plan").

Department for Decommissioning Nuclear and Radiation Facilities of the Federal Agency of Atomic Energy (hereinafter referred to as "Rosatom") and RTG ICGexercised general control over the development of the Master Plan

The Canadian side provided financial support for development of the Master Plan within the framework of the Agreement Concerning Cooperation on the Destruction of Chemical Weapons, the Dismantlement of Decommissioned Nuclear Submarines, and the Physical Protection, Control and Accountancy of Nuclear and Radioactive Material signed on June 9, 2004 by the Government of Canada and the Government of the Russian Federation.

Development of the Master Plan consisting of 16 sections (1008 pages in total) was completed in March 2007.

The Master Plan was handed over to representatives of the countries – members of the IAEA CEG interested in it at the IAEA CEG Meeting in Vladivostok in May 2007.

To implement the Master Plan in the fastest and most effective manner it seems expedient to develop a Priority Action Plan for decommissioning and disposal of RTGs, which will define in particular critical activity directions for 2007-2008, requiring concentration of efforts and funds.

2. Current Situation

By the beginning of 2007 there were 582 RTGs at the Russian sites. Earlier 2 RTGs were lost (sank) near Sakhalin Island during transportation. All these RTGs are mainly operated in an unattended autonomous mode and intended, as a rule, to power light beacons.

RTGs are mainly installed in the following regions of Russia:

- North-West, the Barents and White Sea coastal areas. Operating organization is Hydrographic Service of Northern Russian Navy (51 pcs).
- Northern Sea Route (from Novaya Zemlya archipelago to Chukotka). Operating organization is Hydrographic Enterprise of Rosmorrechflot of Transport Ministry (218 pcs).
- Far East of Russia, from Vladivostok in the south to Anadyr in the north including Sakhalin and Kuril Islands. Operating organization is Hydrographic Service of Pacific Russian Navy (91 pcs).
- Chukotka.
    - Operating organization is Hydrographic Enterprise of Rosmorrechflot (85 pcs.).
- Baltic Sea.
    - Operating organization is Hydrographic Service of Baltic Russian Navy (90 pcs).
- Group of 46 RTGs located in the mainland of Russia is under other operating organizations of Russian Ministry of Defense.

More detailed information on activity and quantitative distribution of RTGs of various types as of early 2007 is given below in Table 1.

Table 1

	Operating RTGs. Total of RTGs	APSs required to eplace RTGs	RTG type	Activity, Bq
Total of RTGs:	**582**	**525**		**1,07E+18**
Including RTGs under:				
Russian Ministry of Defense:	***276***	***222***		***6,46E+17***
Baltic Sea coast (operating organization is BF HS)	90	72	81 - Beta-M, 2 - Efir-M, 3 - IEU-1, 1 - IEU-1M, 2 - IEU-2, 1 - IEU-2M	1,20E+17
North Europe coast (NF HS)	51	51	31 - Beta-M, 4 - IEU-1, 2 - Garant-2, 8 - IEU-2, 6 - IEU-2M	1,34E+17
Far East (PF HS)	89 (including a wrecked RTG at the Navarin Cape)	88	46 - Beta-M, 3 - Gong, 7 - IEU-1, 3 - IEU-1M, 22 - IEU-2, 8 - IEU-2M, 2- REU-3	2,80E+17
SMF	12	11	12 - Beta-M	1,13E+16
12 HD of Ministry of Defense	34	0	24 - Beta-M, 10 - Gorn	9,99E+16
Rosmorrechflot of the Russian Ministry of Transport (Northern Sea Route)	303	303	211 - Beta-M, 29 - Gong, 35 - Gorn, 28 - Efir-M	4,22E+17
Roshydromet	3 (in Antarctica)	0	3-Beta-M	28,25E+14

3. Transportation and Handling Procedures used to remove RTGs

According to the Master Plan, the total radioactivity of the RTGs operating in unattended mode equals to 1068*E+15 Bq. It is proposed to remove these RTGs using procedures described below.

Fig. 1. General points and directions for transportation of decommissioned RTG

The RTG removal procedure consists of the seven conventional main stages (see Fig. 2):

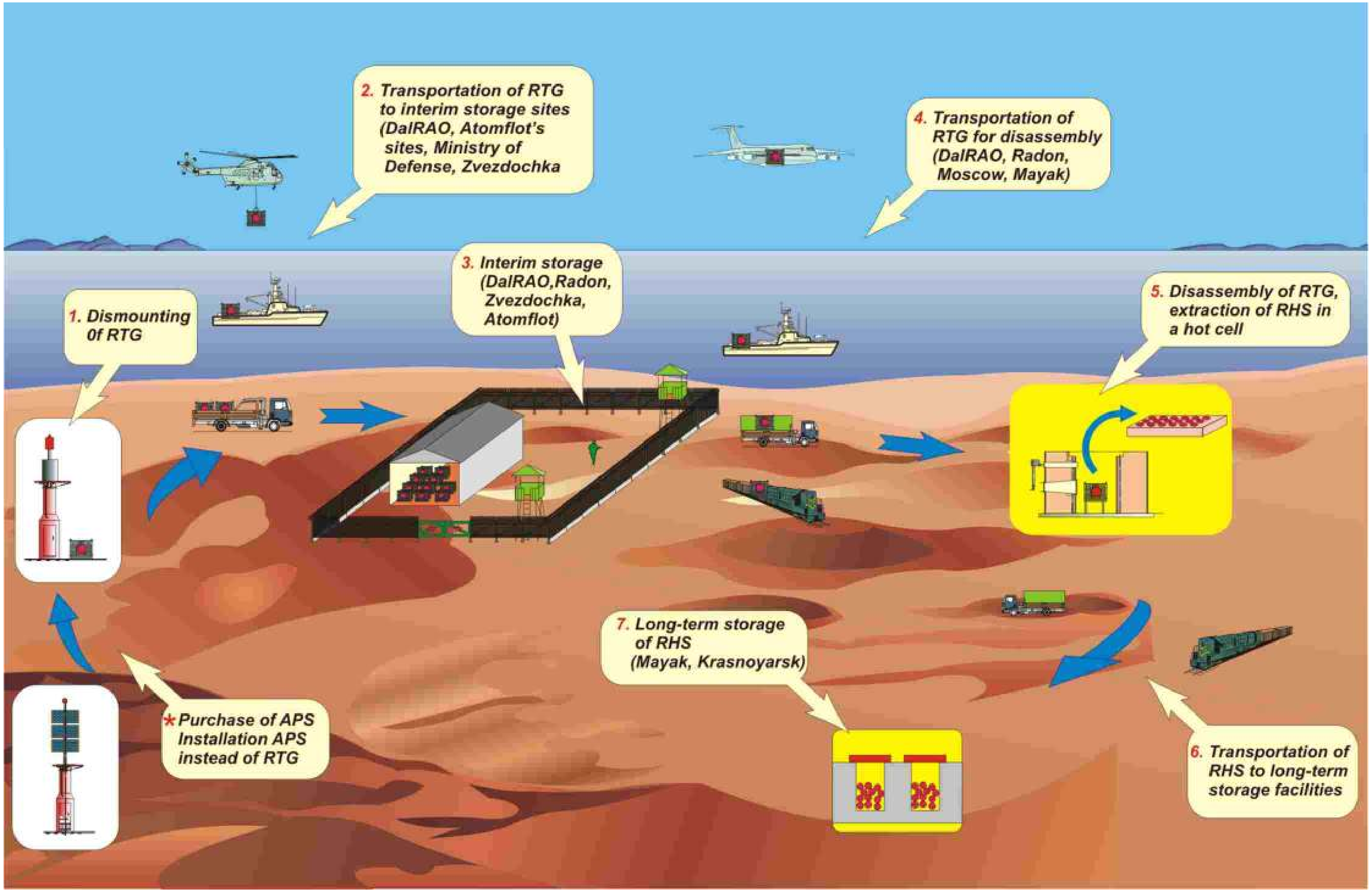

Fig. 2. RTG Removal Procedure

Stage 1. Dismounting of RTGs

At this initial stage the RTG is examined directly at its operational location in order to evaluate its technical status and its transport package. If the RTG is recognized as damaged, a protocol is completed and a complex of evacuation procedures is developed specifically for this case. In case the transportation package is damaged, it is repaired at the site, if possible, or replaced with an intact one. In case the RTG is considered to be operable (non-emergency) and its transportation package is intact or put in an intact state, RTG is disconnected from aids to navigation prepared for transportation from the facility. If the dismounted RTG is to be replaced with an alternative power source, such a source should be purchased, delivered to the site, assembled and connected to the aids to navigation instead of the evacuated RTG (in Fig. 2 these works are marked with *).

Stage 2. Delivery of RTGs to the Temporary Storage Sites

At this stage the dismounted RTG is delivered from its operation location to a secured site or temporary storage facility. Depending on geographic position of the facility and its access conditions, it is possible to use motor, water or air (helicopter) transport or combination of these transport types for this purpose.

Stage 3. Interim Storage

At this stage the RTG is placed for storage at a secured storage site and stored until the time when it is sent for disassembly, RHS extraction and further disposition. The temporary storage period is defined by the site capacity and possible disposition capacities and can last several years. So far there is no limitation imposed on the storage period of good-order RTGs.

Stage 4. Delivery of RTGs for Disassembly

At this stage the RTG is delivered from its temporary storage facility to the place of its disassembly and RHS extraction. Depending on geographical location of the RTG interim storage site and place of its disassembly it is possible to use railway, motor, water or air (transport plane) transport or combination of these transport types.

Stage 5. RTG Disassembly and RHS Extraction in the Hot Cell.

At this stage the RTG delivered from its temporary storage facility is disassembled in the hot cell and its RHS is extracted. The RHS is placed in a special shielding container to be delivered to the place of its long-term storage (isolation). The remaining parts of the disassembled RTG are not radiation hazardous and are to be disposed of in a routine order.

Stage 6. Delivery of RHSs to Long-Term Storage Facility

На этом этапе помещенный в специальный защитный транспортный контейнер РИТ доставляется в пункт договременного хранения (изоляции). Для этих целей в настоящее время используется железнодорожный и автомобильный транспорт. At this stage the RHS placed in a special shielding container is delivered to a long-term storage facility (for isolation). Railway and motor transport is used now for this purpose.

Stage 7. Long-Term Storage of RHSs

At this final stage the RHS is installed in a special well-protected place for a long-term storage (isolation). The RHS safe storage period can reach hundreds of years until its activity is reduced to a secure level.

Radiological risk related to RTG and RHS operation and handling reduces gradually from stage to stage (see Fig. 2). The RTG is exposed to the maximal risk when it operates in an unattended mode at the beacon site. When it is placed for a long term storage at Mayak PA, the risk is minimal.

Table 2 represents possible ways of implementation of the above stages of the transportation and handling scheme for each of the regions where RTG are located (names of organizations already involved in these activities are also specified).

Table 2

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Region	Dismounting and replacement with APS	RTG transportation to the mainland	RTG interim storage	RTG delivery for disassembly	RTG disassembly	RHS delivery	RHS storage
Baltic Sea	Navy/KI	Radon, Sosnovy Bor	Radon, Sosnovy Bor	By road, V/O Isotop vehicles	VNIITFA	By railway, Atomspetstrans	Mayak PA
Barents and White Sea	Department for Economic Development, Murmansk Region Authority	EDM	Atomflot, Rosliakovo	By railway Atomspetstrans? Or by road V/O Isotop vehicles	VNIITFA	By railway, Atomspetstrans	Mayak PA
Northern Sea Route	Hydrographic Enterprise of Rosmorrechflot	Hydrographic Enterprise of Rosmorrechflot	Atomflot	By railway, Atomspetstrans	VNIITFA	By railway, Atomspetstrans	Mayak PA
Arctic coast of Chukotka	?	?	?	?	?	?	Mayak PA
Pacific Ocean including Pacific coast of Chukotka	Navy/KI TSPK Rosmorrechflot	TSPK	DalRAO	By railway, Atomspetstrans	Mayak PA	-----------	Mayak PA
12 HD of MOD	12 HD/KI TSPK	TSPK	DalRAO	By railway, Atomspetstrans	Mayak PA	-----------	Mayak PA
SMF	SMF/KI TSPK	TSPK	DalRAO	By railway, Atomspetstrans	Mayak PA	-----------	Mayak PA

4. Main Problems Emerging in the Course of the Master Plan Implementation. Proposed Ways for Handling the Problems.

Main problems hindering the Master Plan Implementation:

- Considerable number of RTGs operating at lighthouses and beacons (582 RTGs according to the Master Plan);
- Underfinancing. According to the Master Plan, solving the RTG problem requires 130 million dollars;
- There is only one transportation and handling procedure under which RTG disassembly and RHS extraction is performed in the only available hot cell at VNIITFA, whereas only Mayak can provide long term storage of RHSs.

The hot cell at VNIITFA can support disassembling of about 80 RTGs per year (depending on the RTG type and status). If the RTG is damaged, its disassembly becomes a more complicated and long procedure. Due to availability of only one hot cell designed for disassembly of one RTG at a time, disassembly of the other RTGs is postponed.

Mayak PA can accept for long-term storage about 80 RHSs per year.

Availability of only one hot cell at VNIITFA imposes some restrictions on transportation routes for RTGs sent for disposal and binds them to Moscow, that is all RTGs with their radioactive filling are to be sent to VNIITFA.

Rosatom concluded that the most acceptable RTG transportation and handling procedures should provide for RTG disassembly and RHS long-term storage at Mayak PA. In this case all radiation hazardous operations with high-level sources will be performed far away from Moscow.

RTG disassembly facility at Mayak PA should consist of a storage designed to accommodate up to 160 RTGs at a time and a hot cell intended for RTG disassembly and RHS extraction.

Output of this facility – disassembly of 120 RTGs per year.

Construction of the facility includes the following two functional components:

- Construction of a site to unload delivered RTGs and a hangar to accumulate RTGs waiting for disassembly;
- Reconstruction (improvement) of the available hot cell to make it fit for RTG disassembly and RHS extraction.

Work on both functional components can be performed simultaneously.

Reconstruction of the available hot cell, including required construction and assembly works, will take 2 years.

Talks with the Nuclear Agency of France in respect of designing of such a facility are under way.

Estimated feasibility study cost – up to 293 thousand euro. Now the contract for the feasibility study development is in the process of preparation. If funding starts in 2008, the facility could be put into operation in 2010.

Commissioning of the above facility for RTG disassembly and RHS long-term storage at Mayak PA will make it possible to redirect flows of RTG sent for disassembly to VNIITFA, Moscow.

After commissioning of the facility the Far East RTGs, which are now accumulated at DalRAO in Primorie region, will be transported to Mayak PA by Trans-Siberian Rail Road.

It will be possible to use a shorter route to deliver the RTGs removed from the Northern Sea Route (303 as of today) to Mayak PA via port/railway station Yambourg in the Gulf of Ob (sea Fig. 1).

5. Forecasted RTG Removal Developments

By early 2008 there will be 525 RTGs operating at the sites in Russia (see Table 3).

Table 3

	Operating RTGs. Total of RTGs	**APSs required to replace RTGs**	**RTG type**	**Activity, Bq**
Total of RTGs:	**525**	**472**		**9,72E+17**
Including RTGs under:				
Russian Ministry of Defense:	***229***	***179***		***5,74E+17***
Baltic Sea coast (operating organization is BF HS)	80	65	71 - Beta-M, 2 - Efir-M, 3 - IEU-1, 1 - IEU-1M, 2 - IEU-2, 1 - IEU-2M	1,12E+17
North Europe coast (NF HS)	28	28	12 - Beta-M, 4 - IEU-1, 7 - IEU-2, 5 – IEU-2M	1,11E+17
Far East (PF HS)	75	75	38 – Beta-M, 3 - Gong, 5 - IEU-1, 3 - IEU-1M, 17 - IEU-2, 7 – IEU-2M, 2- REU-3	2,40E+17
SMF	12	11	12 – Beta-M	1,13E+16
12 HD of Ministry of Defense	34	0	24 – Beta-M, 10 - Gorn	9,99E+16
Rosmorrechflot of the Russian Ministry of Transport (Northern Sea Route)	293	293	206 - Beta-M, 29 - Gong, 31 - Gorn, 27 - Efir-M	3,98E+17
Roshydromet	3 (in Antarctica)	0	3 - Beta-M	28,25E+14

By now a contract has been concluded with the USA to deliver 35 RTGs belonging to the Navy from Sakhalin and Kurila islands to the interim storage facility at DalRAO-1, the RTGs are to be replaced with APSs.

One more contract with the USA to remove and place for temporary storage 42 RTGs belonging to the 12 Head Department of the Ministry of Defense (10 RTGs from Peledui, 24 RTGs from Bilibino, 10 RTGs from Severomorsk) is at the final stage before conclusion.

A contract with France to remove 4 RTGs of IEU-1 type from Nerva and Rodsher islands in the Baltic Sea, deliver them to Radon in Sosnovy Bor, disassemble the RTGs at VNIITFA and dispose of at Mayak PA.

It is planned to develop a feasibility study of a hot cell at Mayak PA, France might fund its reconstruction.

55 RTGs will be removed from the North-West Region under an agreement with Norway.

Within the framework of the Federal Program Nuclear and Radiation Security in Russian it is planned to allocate 25 million rubles per year to Rosmorrechflot, which will enable it to remove about 10 RTGs per year.

If the forecast for 2008 work well, there will be 387 RTGs not covered by contracts and fund allocations (see Table 4).

Table 4

	Operating RTGs. Total of RTGs	**APSs required to replace RTGs**	**RTG type**	**Activity, Bq**
Total of RTGs:	**387**	**370**		**5,27E+17**
Including RTGs under:				
Russian Ministry of Defense:	***128***	***114***		***1,95E+17***
Baltic Sea coast (operating organization is BF HS)	76	63	71 - Beta-M, 2 - Efir-M, 2 - IEU-2, 1 - IEU-2M	6,97E+16
North Europe coast (NF HS)	0	0		
Far East (PF HS)	40	40	20 - Beta-M, 1 - Gong, 3 - IEU-1, 2 - IUE-1M, 7 - IEU-2, 5 - IEU-2M, 2- REU-3	1,14E+17
SMF	12	11	12 – Beta-M	1,13E+16
12 HD of Ministry of Defense	0	0		
Rosmorrechflot of the Russian Ministry of Transport (Northern Sea Route)	256	256	185 - Beta-M, 24 - Gong, 24 - Gorn, 23 - Efir-M	3,33E+17
Roshydromet	3 (in Antarctica)	0	3 - Beta-M	28,25E+14

6. Conclusion

The information on dynamics of RTG removal per region and radiological capacity reduction resulting from these works allows making optimistic forecast: if the works are funded the same way as now, all beacons of **North-West** and **Pacific Ocean** will be free of RTGs by 2010.

If works in the Baltic region resume in 2008, all RTGs in this region may be also removed by the same time since they are mainly located in the Gulf of Finland. The RF Navy dismounted 10 RTGs in the Kaliningrad region in 2007.

The situation is rather complicated when it comes to the central and eastern parts of the Northern Sea Route and especially to Chukotka with its 85 RTGs installed on the coast. An option is considered to remove these RTGs through the interim storage site at DalRAO in Primorie and then transport these RTGs with the Far East RTGs to Mayak PA.

Dismounting and replacement with alternative power sources of the RTGs (i.e. from Stage 1 to Stage 3), which are not covered by contracts, will initially require at least about 40-50 million US dollars. After that it is necessary to start to remove RTGs accumulated in the temporary storage facilities to Mayak PA for disassembly and isolation.