SANDIA REPORT
SAND2021-8591 C
Printed July 2021

Sandia National Laboratories

Romania-U.S. Office of Radiological Security (ORS) Cooperation in the Adoption of Alternative Technologies in Support of Radiological Security

Cristian Gentea, Institute for Nuclear Research, Pitesti, Romania
Sorin Repanovici, National Commission for Nuclear Activities Control, Bucharest, Romania
Michael V Strosinski, Sandia National Laboratories, Albuquerque, New Mexico, U.S.

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico
87185 and Livermore,
California 94550

Romania-U.S. Office of Radiological Security (ORS) Cooperation in the Adoption of Alternative Technologies in Support of Radiological Security

Sorin Repanovici
National Commission for Nuclear Activities Control (CNCAN), Bucharest, Romania

Cristian Gentea
Institute for Nuclear Research (RATEN ICN), Pitesti, Romania

Michael Strosinski
Sandia National Labs (SNL), Albuquerque, New Mexico, U.S.

ABSTRACT
This paper describes cooperation between the Government of Romania and the U.S. National Nuclear Security Administration's (NNSA) Office of Radiological Security (ORS) to permanently reduce radiological risk and sustain treatment options for cancer patients in Romania by replacing Cobalt-60 teletherapy machines with linear accelerators (LINACs) and removing the disused Cobalt-60 sources to secure long-term storage.

INTRODUCTION
This paper describes cooperation between the Government of Romania and the U.S. National Nuclear Security Administration's (NNSA) Office of Radiological Security (ORS) to permanently reduce radiological risk and sustain treatment options for cancer Patients in Romania by replacing Cobalt-60 (Co-60) teletherapy machines with linear accelerators (LINACs) and removing the disused Co-60 sources to secure long-term storage.

COOPERATION OVERVIEW
Several stakeholders contributed to the success of this cooperation including: the National Commission for Nuclear Activities Control (CNCAN), the Romanian Ministry of Health, the Institute for Nuclear Research Pitesti (RATEN ICN), the Romanian Gendarmerie, the U.S. NNSA ORS, and Sandia National Laboratories. Table 1 summarizes the primary roles and responsibilities for this cooperation.

Table 1. Primary Roles and Responsibilities

Stakeholder	Role
Romania Ministry of Health	Purchased LINACs devices
CNCAN	Facilitated replacement and removal projects
RATEN ICN	Provided technical expertise and secure long-term storage facilities
Romanian Gendarmerie	Provided transportation security escorts
U.S. NNSA ORS	Provided funding for source removals
Sandia National Laboratories	Coordinated training of RATEN personnel and managed contracts for the source removals

ROMANIA HEALTH SECTOR REFORM PROJECT

To maintain treatment options for cancer patients in Romania, the Romanian Ministry of Health decided to seek avenues to purchase LINACs for use at oncology facilities. Beginning in 2013, The Romanian Ministry of Health initiated negotiations for a loan agreement for the Romania Health Sector Reform Project with the International Bank for Reconstruction and Development (IBRD – World Bank). The purpose was to increase the quality and access to the critical and lifesaving services in Romania. This funding was used for financing civil works and procuring equipment for medical facilities, including the development of regional radiotherapy units.

CNCAN PROJECT COORDINATION

In parallel with the Romanian Ministry of Health efforts to purchase and install linear accelerators, CNCAN began coordinating efforts to find a removal pathway for the old Co-60 teletherapy units. CNCAN contacted ORS and its representative, Sandia National Laboratories, to cooperate on a project for the removal of the old teletherapy heads and the safe long-term storage of the Co-60 sources at the RATEN ICN facility. For its part, CNCAN proposed that the RATEN ICN facility would purchase the transportation vehicle and provide the facilities and personnel expertise for the technical execution of the project. The RATEN ICN facility and its staff were uniquely qualified to handle these tasks.

RATEN ICN

RATEN ICN was selected for the removal and storage of the Co-60 sources. This selection was based on the existing infrastructure at the Post-Irradiation Examination Laboratory (PIEL) at RATEN ICN. PIEL had recovered and stored in its hot cells the used sources of Co-60 from the decommissioning of the ROKUS M-40 installations belonging to the Ministry of Health. The decommissioning activity of Theratron-type of radiological installations was included in the PIEL operating authorization, issued by CNCAN.

U.S. NNSA ORS FUNDING OF SOURCE REMOVALS

The ORS program viewed the efforts of the Romanian government to invest in permanent risk reduction as an opportunity for a cooperative project. For its part of the project, the Romanian's provided new LINACs, facilities, and expertise of the RATEN ICN. This effort included RATEN ICNs ability to remove the sources and place them into long-term secure storage at RATEN ICN. RATEN ICN also purchased a truck to transport the teletherapy head units. The ORS program agreed to fund the removal of eleven cobalt teletherapy units in Romania in part because the Romanians had the capacity and the facilities to do all the activities in country with the staff from RATEN ICN. There was no need to hire any outside contractors to facilitate any of this work, including the transportation, and the long-term secure storage of the sources.

SANDIA NATIONAL LABORATORIES PROJECT FACILITATION

The ORS program funded this work by allocating funding to Sandia National Laboratories to manage this project and to issue the contracts for the removals. The contracting process was similar for all the sites. Sandia National Laboratories contracted with RATEN ICN for all the removal work that ORS funded.

REPLACEMENT PHASE: LINAC PROCUREMENTS AND INSTALLATION/INITIATION

The Romania Health Sector Reform Project was approved by the Romanian Government on December 14, 2014 (Law no. 179) and became effective on January 22, 2015. The current project closing date is December 31, 2024. The Project Development Objective (PDO) is to contribute to improving access to and quality of selected public health services.

One of the PDOs (Indicator 1) established "average number of modern and safe radiotherapy technology available per 1 million (mil) resident population." This was to determine the number of LINACs to procure. The baseline was considered for 2014 as 1.4 linear accelerators/1 mil resident population, and the end targets were established for 2.2 linear accelerators/1 mil resident population. This goal was achieved in September 2020, allowing Romania, which had the lowest value for this indicator among European Union countries, to start closing the gap. The current value of the indicator (April 2021) is 2.69 linear accelerators/1 mil resident population.

The radiotherapy sub-component was developed based on the International Atomic Energy Agency (IAEA) support for the Romanian Ministry of Health. The IAEA conducted five expert missions to support radiotherapy equipment specification, during the period 2015-2018, and 17 radiotherapy centers were evaluated throughout Romania.

A Romanian Technical Working Group established through Ministerial Order beginning in 2015 drafted the technical specifications for all radiotherapy equipment (linear accelerators, computerized tomography [CT] simulators, Treatment Planning Systems, contouring systems, Record & Verify systems, immobilization systems for LINAC and CT simulators, dosimetry equipment). These were incorporated in the bidding documents and submitted for clearance and approval (no-objection).

Beginning at the end of 2016, four procurement procedures were organized for a total of 11 public radiotherapy centers. Fifteen LINACs and related equipment were purchased, including the rehabilitation works for the proper installation of the equipment. Eight public radiotherapy centers received the equipment during 2018-2019 and are operational. The remaining seven centers will receive the equipment by March 2022.

The Romanian Technical Working Group did not decide on the type or manufacturer of the linear accelerators. The technical specifications were opened for both producers (Elekta and Varian) and used in international competitive biddings organized in accordance with the loan provisions. The contracts were awarded to Varian for nine linear accelerators and to Elekta for six linear accelerators.

REMOVAL PHASE: CO-60 REMOVALS

The removal project began in 2014 when ORS funded the first removal of teletherapy units. The removal project was completed in 2020. In total, the ORS program funded the removal of eleven cobalt teletherapy units. Those eleven cobalt teletherapy units that were removed with ORS assistance are noted in Table 2.

Table 2. Romanian teletherapy units removed and LINAC replacements

No.	Beneficiary Unit - RT Center	LINAC Manufacturer	LINAC - Type and Energy	LINAC Treatment Initiation
ORS funded removal of unit				
1	Centrul de Cercetări Sctiintifice Medico Militare (Czech Unit)		No plans for a LINAC at this time given its proximity to other recently installed LINACs	
2	Baia Mare Emergency County Hospital "Dr. Constantin Opriș" (Theratron Unit)	Elekta	**Level 2 - 6/15 MV** Replaced cobalt teletherapy unit with a LINAC	Apr. 2019
3	Emergency County Clinical Hospital Craiova (ROKUS Unit)	Varian	**Level 2 - 6/10 MV** Replaced cobalt teletherapy unit with a LINAC	Nov. 2019
4	Galati Emergency County Clinical Hospital "Apostol Andrei" (ROKUS Unit)	Elekta	**Level 2 - 6/10 MV** Replaced cobalt teletherapy unit with a LINAC	Dec. 2019
5	Oradea Municipal Hospital "Gavril Curteanu" (Theratron Unit)	Elekta	**Level 2 - 6/15 MV** Replaced cobalt teletherapy unit with a LINAC	Jan. 2020
6	Bucharest Oncology Institute “Prof. Dr. Alexandru Trestioreanu” Fundeni (Theratron Unit)	Elekta	**Level 1 – 6 MV** Replaced cobalt teletherapy unit with a LINAC	Aug. 2020
7	Constanta Emergency County Clinical Hospital "Apostol Andrei"(Theratron Unit)	Elekta	**Level 2 - 6/10 MV** Replaced cobalt teletherapy unit with a LINAC	Oct. 2020
8	Galati Emergency County Clinical Hospital "Apostol Andrei" (Theratron Unit)	Varian	**Level 1 – 6 MV** (second unit) Replacing cobalt teletherapy unit with a LINAC	Feb. 2022
9	Timisoara Municipal Emergency Clinical Hospital (Rokus Unit)	Varian	**Level 1 - 6/10 MV**, new bunker Replacing cobalt teletherapy unit with a LINAC	Feb. 2022
10	Iasi Regional Oncology Institute (ROKUS Unit)	Varian	**Level 1 - 6/10 MV**, new bunker Replacing cobalt teletherapy unit with a LINAC	Feb. 2022
11	County Emergency Hospital Brasov (Theratron Unit)	TBD	The old Cobalt teletherapy unit was removed, there are plans to place a LINAC at this location in future	

No.	Beneficiary Unit - RT Center	LINAC Manufacturer	LINAC - Type and Energy	LINAC Treatment Initiation
Hospital financed removal of units and new installations				
12	Elias University Emergency Hospital (Theratron Unit)	Elekta	**Level 2 - 6/15 MV** Replaced cobalt teletherapy unit with a LINAC	Nov. 2020
13	Cluj Napoca Oncological Institute "Prof. Dr. Ion Chiricuță"	Varian	**Level 2 - 6/10 MV** Replaced cobalt teletherapy unit with a LINAC	Jun. 2020
14	Bucharest Oncology Institute "Prof. Dr. Alexandru Trestioreanu"	Varian	**Level 1 - 6/15 MV** (second unit)	Feb. 2022
15	Cluj Napoca Oncological Institute "Prof. Dr. Ion Chiricuță"	Varian	**Level 1 – 6 MV** (second unit)	Feb. 2022
16	Mures County Clinical Hospital	Varian	**Level 1 - 6/15 MV**, new bunker	Feb. 2022

Note: All Cobalt teletherapy machines in Romania were decommissioned by the end of 2020.

Facility Characteristics

The PIEL, on the RATEN ICN facility, is a complex nuclear facility, intended for the safe performance of operations for the handling and examination of irradiated nuclear fuel and irradiated structural materials used in energy reactors. PIEL has unique facilities at the national level, which allow testing, handling and examination of nuclear fuel and structural materials in nuclear power plants. Due to its infrastructure (hot cells with biological steel/lead protection, dry storage pits of radioactive waste inside the hot cells) PIEL is the only strategic facility in Romania authorized to decommission the cobalt teletherapy installations and to store the Co-60 used sources. These facilities allow the insertion of the irradiation head into the hot cell for the recovery of radioactive sources and its storage in the storage pit. The personnel involved in the operation of the hot cells for the safe performance of operations for the handling and examination of irradiated nuclear fuel, as well as to produce closed sources of Iridium-192, are authorized by CNCAN and the State inspection body for control of boilers, pressure vessels and hoisting equipment (ISCIR). At the same time, PIEL is qualified to perform post-irradiation examinations according to the work procedures developed in the laboratory.

Personnel Training

While the engineers at PIEL had experience in working with removal of ROKUS units, they did not have experience working with Theratron units. It was mutually agreed that ORS would support three engineers from RATEN ICN along with the Sandia National Laboratories project lead engineer to travel to the Southwest Research Institute in San Antonio, Texas, to complete a course of hands-on instruction on Theratron units. This training focused on the dismantling of Theratron teletherapy heads, the removal of the source drawers and the removal of the cobalt sources. All four engineers successfully completed the training in August 2016.

The criteria underlying the selection of the PIEL engineers who participated in the training in the U.S. were the following: experience in hot cell operation, level II permit issued by CNCAN for the performance of nuclear activities, and ISCIR permit for handling authorized lifting installations.

Authorization for Theratron Work

Within RATEN ICN Pitesti, there were procedures performed for the activities of transport of radioactive materials and for the decommissioning of Theratron-type telecobalt therapy installations. Authorizations for the decommissioning of Theratron-type telecobalt therapy installations were issued by CNCAN for the PIEL infrastructure, and the certificates of competence and the working procedures were developed.

Onsite Teletherapy Head Removals and Transport

The personnel involved in carrying out the decommissioning operations went to the beneficiary's premises to assess the location of the radiological installation. Site inspection was required

- to establish the optimal transfer route of the irradiation head from the location to the truck,
- for the evaluation of the electricity supply in the location,
- for establishing the devices and equipment necessary for dismantling the irradiation head, and
- for performing dosimetry measurements.

These site visits were necessary because some radiological facilities planning to be dismantled were in bunkers located in the basement of the building, such as the Galati Emergency County Clinical Hospital "Apostol Andrei" and the Constanta Emergency County Clinical Hospital "Apostol Andrei."

The transport of the irradiation heads from the hospitals to RATEN ICN Pitesti was carried out in accordance with the provisions of the Transfer Authorization and the Shipment Certificate for Radioactive Materials, issued by CNCAN. The transport was carried out with a truck purchased by RATEN ICN, equipped with a crane, in full-safe conditions, on the route established by CNCAN. The truck and the dosimetric surveillance car were led and followed by escort vehicles of the Romanian Gendarmerie.

PIEL Teletherapy Head Source Removal

As soon as the convoy arrived on the RATEN ICN platform, the irradiation head was unloaded from the transport crate of the truck and transferred to the PIEL. After performing the dose rate measurements, the irradiation head was prepared for insertion into the hot cell.

Before inserting the irradiation head into the hot cell, the cartridge locking device was removed. A temporary locking piece of the cartridge, designed and executed by PIEL, was also fitted to prevent it from coming out during the maneuvers to lower the irradiation head into the hot cell.

The knowledge and skills demonstrated by this team were successfully applied to each task completed within the decommissioning project of Theratron cobalt therapy facilities. The satisfaction of the team members was exemplified in the fact that, through their work of

decommissioning the old installations and replacing them with state-of-the-art ones, they saw happy people who will benefit from a new efficient treatment regime, which gives them hope of a speedy recovery.

Contracting Requirements

In the contracts between RATEN ICN and Sandia National Laboratories, the work was broken into three separate taskings. It began with preparatory work that included requesting the RATEN ICN team to go to the site to determine the level of effort that would be necessary to remove the teletherapy head from the machine base and move the head from the bunker room to the RATEN ICN truck (in some cases, doors and or windows had to be removed, ramps had to be built, cranes were rented, and in one location part, a roof covering was removed). Permits or licenses would be necessary for the transport of the unit, as well as the transfer of the source from the Ministry of Health inventory to the RATEN ICN facility. The site visits also included the RATEN ICN team taking radiological smears to verify that there was no contamination on the head or any part of the machine mechanism or the walls of the bunker and to provide radiological surveys necessary to obtain permission to transport the heads back to RATEN ICN.

It should be noted that the RATEN ICN work only included the removal of the teletherapy head from the site. It was the responsibility of the medical facility to remove and dispose of the associated equipment such as the machine base, counterweight arm, and any associated controls and wiring.

Once the RATEN ICN team sent the report on their site visit and their proposed project plan and proposed materials costing for the removal and transport of teletherapy head, it was reviewed by the Sandia National Laboratories project engineer. The project engineer sometimes questioned items in the project plan and materials lists and, once questions were answered, the proposal was approved. It should be noted that CNCAN worked with the facilities and RATEN ICN to ensure the paperwork was processed in a timely manner.

Once the RATEN ICN team had all the requisite paperwork, they worked with the individual sites to set up the dates for the removal. Once the teletherapy head was removed and safely transported to the RATEN ICN facility, a separate dismantlement and packaging report on the removal and transport was sent to Sandia National Laboratories.

Finally, once the teletherapy head was in the hot cell and the source was removed and sealed for long-term storage at the RATEN ICN facility, a separate source removal, packaging, preparation, and storage report was sent to Sandia National Laboratories. This report contained photos of the source including the source identification number. This identification number was checked against the information from the IAEA and other databases.

During visits to Romania to check on other ORS projects, the Sandia National Laboratories project engineer would travel to RATEN ICN where the sources were removed from storage so that the serial numbers and safe secure storage could be physically verified. This was a contractual requirement for final verification of the teletherapy and source removal.

CONCLUSION

The success of this project was due to the cooperative efforts of the Romanian government and the NNSA ORS program. Contributing factors to the project success include:

- The Romanian government had the facilities and the personnel to accomplish the removal and long-term secure storage work in country.
- Utilization of outside contractors and removal of sources from Romania were not necessary.
- CNCAN coordinated all interfaces between the medical facilities, RATEN ICN, and the Gendarmerie, allowing the timely acquisition of all necessary permits for the work and transport of the sources.
- The Gendarmerie provided security while the sources were in transit.
- The NNSA ORS program saw this as a unique opportunity for permanent risk reduction and agreed to fund the removal of eleven teletherapy units.
- Sandia National Laboratories, acting on behalf of the ORS program, facilitated the training of some of the RATEN ICN facility personnel and contracted for the eleven source removals.