U.S. And Colombia Radiological Security Cooperation: A Case of Successful Intergovernmental Collaboration

Angela Abadia Zapata, Ministry of Mines and Energy

Evan Thompson, Office of Radiological Security, National Nuclear Security Administration, U.S. Department of Energy

1. INTRODUCTION

The Ministry of Mines and Energy (MME) serves as Colombia's Regulatory Authority (RA) for the safe use of the country's radioactive and nuclear materials and has a subsidiary body, the Colombian Geological Service (SGC), which runs the largest radioactive facilities and the only nuclear research reactor. Since 2008, both MME and SGC have had a robust relationship with the United States Department of Energy (DOE), collaborating on many aspects of radiological security and improve security for Colombia and the region.

2. STORAGE FACILITY COOPERATION

One of the six most important radioactive facilities under the SGC is the centralized radioactive waste management center (storage facility 2), donated in 2008 through a project with the United States Department of Energy (DOE) for the purpose of providing better safety and security conditions than those at storage facility 1, the facility that had performed the operation until that time.

Storage facility 2 is one of the most modern waste management facilities in Latin America and the Caribbean, with an area of 230 m^2, concrete walls up to 2.5 m thick, and steel doors. This facility is divided into four areas: interim storage, processing, temporary storage, and offices. More specifically, the temporary storage area has 12 underground pits, each one measuring 4 x 3 x 4 m^3 with concrete covers 0.5 m thick.

Storage facility 2 stands out from other waste management facilities in the region, with specific technology for moving heavy loads (up to 5 tons), a robust, redundant security system that uses the two-person rule for ingress into all areas except the offices, and features for maintaining the structural integrity of the facility. Radioactive waste can be separated for processing, depending on the physical and chemical properties of each lot, placing them in known geometries so they can be recovered for future reuse if more advanced technology should become available.

Figure n.° 1: Centralized radioactive waste management facility (storage plant 2)

The donation of storage facility 2 strengthened technical cooperation between the MME and DOE. The facility was designed to store radioactive waste generated in the country based on: *(i)* Colombia's inventory of radioactive and nuclear materials (to date), (*ii)* the possible occurrence of radiological incidents or accidents, and (*iii)* orphan sources or sources out of regulatory control.

The cooperation between MME and DOE was formalized in 2013 through the signing of a Memorandum of Understanding (MoU) between the two organizations.

3. ACTIVITIES DEVELOPED UNDER THE MME-DOE MoU

A The signing of the MoU served as a critical source of support to leverage DOE's technical and operational experience. Colombia benefited from this type of cooperation through upgraded radiation and security programs due to the MoU's various international cooperation mechanisms. The MoU is a three-part instrument whose goals are to (*i)* secure and monitor Colombia's inventory of radioactive sources, (*ii)* support the development and modernization of the regulatory framework, including security, and *(iii)* train RA personnel and users in the safety and security of radioactive and nuclear materials.

3.1. Support for Category 1, 2 and 3 facilities

In 2013, MME and DOE identified 65 IAEA Category 1, 2 and 3 facilities , primarily using Co-60 and Cs-137 sources for teletherapy and blood irradiation practices, 21 facilities using Category 2 sources such as Ir-192 and Am-241 for industrial radiography and well logging, respectively, and 17 facilities using Category 3 Ir-192 sources for brachytherapy.

The criteria for security upgrades under the program included the type and activity of radioactive materials, and risk analysis by experts who then proposed the number of security interlocks, alarms and procedures.

For facilities with Category 1 radioactive materials and nuclear materials, the first task was to reinforce existing barriers, install sensors and high-technology surveillance cameras including biometric readers for ingress to controlled areas, duress buttons, and independent monitoring systems to detect acts of sabotage associated with insider threat.

For facilities with Category 2 and 3 radioactive sources, security barriers were upgraded, sensors and surveillance cameras were installed, and support was offered to improve security procedures.

Note that all the alarms installed were connected to a monitoring station in the city of Bogotá, where a procedure is in place for verifying and responding to security events if needed.

Implementation of all the security devices covered by the program included regular preventive and corrective maintenance for three years after installation.

The program also provided physical protection upgrades to SGC's nuclear research reactor, the gamma irradiation plant, the centralized waste management facility and country's only blood irradiator.

3.2. Modernizing the regulatory framework for security

The DOE has also provided technical assistance since 2014 to develop security regulations for facilities and for the transport of radioactive material.

Starting with regulations that set security guidelines to be followed by radioactive facilities, MME and DOE developed a document that draws on guidance from the International Atomic Energy Agency (IAEA), specifically the recommendations in IAEA Nuclear Security Series No. 14 on nuclear security for radioactive materials and associated facilities. The document was prepared in the following stages:

- **Stage I**: Training workshops were held on security for nuclear and radioactive facilities, attended by both operators and RA personnel.
- **Stage II**: The regulatory document was drawn up under the title "Setting requirements for security in the use of radioactive sources, and amending the 2014 MME Order number 90874;" its purpose is to establish security levels for radioactive sources based on their relative danger rankings, and administrative requirements and procedures to be followed by facilities in order to obtain them and keep them sustainable.
- **Stage III**: Allowance was made for a review of the regulatory document with the support of DOE personnel, and subsequently the dissemination of the document in Colombia.

MME and DOE also collaborated to update the regulatory framework on security in the transport of radioactive and nuclear materials. 2005 Order 181682, "Adopting the Regulations for the Safe Transport of Radioactive Materials," was revised to address all issues of security in land transport based on IAEA recommendations as given in IAEA Nuclear Security Series No. 9, on security in the transport of radioactive materials.

The strategy used to update this document was similar to that of the regulations on radioactive facilities, except that special emphasis was placed on the component of training and dissemination, as seen in Table 1.

Moreover, MME encouraged users of radioactive and nuclear materials to take part in the different training activities for upgrading operators' safety and security skills.

3.3. Donation of a provisional storage container and a truck to carry radioactive and nuclear waste.

3.3.1. Container: With the donation of storage facility 2, the need arose for a robust container to be used in decommissioning storage facility 1, which holds Category 1 to 5 radioactive sources and other sources that for various reasons have fixed contamination. This container would be designed with the space and shielding necessary to hold sources that may not meet acceptable standards for being kept in storage facility 2.

Figure n.° 2: Container for provisional storage of radioactive sources.

The container measures 6.03 m long, 2.35 m wide and 2.54 m high and was installed next to storage facility 2 on a reinforced concrete slab to bear the weight.

The container has the following main features:

- Aluminum sheet flooring
- Moisture-proof coating
- High-performance paint
- White paint inside and out
- Extraction system

The container is located inside a chain-link perimeter fence (see Figure 2) to provide radiation protection and security. The result was a safe alternative for provisional storage of radioactive waste.

The security components include biometric readers, security padlocks, alarm keypad, balanced magnetic switches, sensors with opening-detection capability when the system is armed, duress switches, electronic lock, PIR, cameras, siren and strobe.

3.3.2. Vehicle for transport of radioactive sources: One of the essential activities in waste management is to collect disused and orphaned sources and take them to the centralized radioactive waste management facility.

Accordingly, DOE contributed to Colombia’s efforts by donating a security enhanced 5.1 cargo capacity truck fitted out to carry radioactive and nuclear materials; it has two sections. The first is the cab for the driver, the Radiation Protection Officer (RPO) and the RPO assistant. The second is the trailer or cargo hold, where radioactive material is placed after it has been packaged for transport.

Figure n.° 2: Devices and accessories installed on the temporary storage container.

The trailer is designed with a tie-down system distributed along the chassis of the vehicle (walls and floor). There are two entry routes for loading radioactive material—from the rear or through the roof. The radioactive material should always be placed in the center of the trailer, as far as possible from the cab.

The radiation monitoring system uses the following devices:

- Neutron detector with an area radiation sensor and a neutron probe and moderator;
- Area detector to measure neutron intensity under high radiation emission fields; and
- Radiation monitor (portable) that switches on automatically during transport.

The security system and vehicle access points have various alarms, locks, and sensors to secure the vehicle. The truck is equipped with a remote fuel injection interruption system with a control for the driver as well as the escort. The cargo container is equipped with a hydraulic liftgate with lifting capacity of 3 tons to allow for safe and efficient loading and unloading, while also providing an additional layer of security/delay. As a support system for cargo transfer, a hydraulic stacker with 6000 lb. maximum load capacity was also provided.

Figure n.° 3: Truck donated by DOE for collecting and transporting radioactive waste.

3.3.3. Transport container: After the donation of the secure transport vehicle, MME enhanced the vehicles capabilities with a transport container. The container was designed in Colombia and, if necessary, useful for conducting special arrangement shipments. This container has:

- Locks: three (3) deadbolts with a padlock hasp
- Hinges: three (3) one-inch pin hinges for opening the cargo door at the top
- Couplings: eight (8) couplings located on the sides along the length to secure the cargo
- Jack stands: four (4) jack stands inside the container, specially designed for Theratron 780, Phoenix and Theratron 1000 tractors
- Bracket: U-shaped bracket on the lower part of the profile, with three structural steel bases, 4” X 1 ½” X 6 mm thick; stackable
- Safety rods: two rods marked for a specific position, hitched to the container using studs and plates

- Positioning rods: fixed rods in specific places inside the container, shaped according to the model of the transport tractor

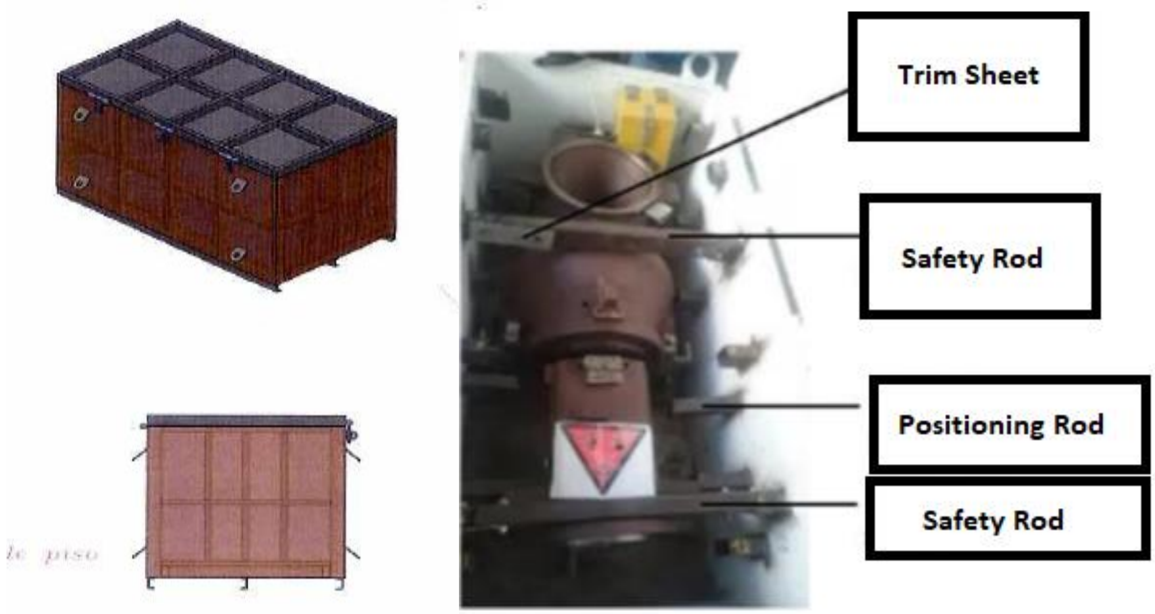

Figure n.° 4: Transport container for carrying radioactive and nuclear wastes.

Structural tubing produced under the ASTM A500-03A grade C standard and ASTM A572 grade 50 steel plate with 2.3% carbon content are used to protect the metal from melting at temperatures above 1000°C. According to manufacturer's specifications, the ductile limit of this steel is 50 kpsi, which means it can stand up to compressive stress on very small areas on the order of 3519.51 kg/cm2 without experiencing permanent deformation.

3.4. Change in technology for the blood irradiator

Under one of the goals of the MoU, and with the intent to support the country in managing high activity radioactive sources, a proposal was made to replace Colombia's only Cs-137 blood irradiator, and installing in its place an X-ray irradiator with the following specifications:

Dimensions
Height: 191 cm
Width: 120 cm
Depth: 86 cm
Electricity requirements
Single phase, 50 Hz to 60 Hz
208 V to 240 V AC
30 A (L1L2/N, GROUND)
Cooling system
Built-in free-standing cooling system
No need to connect to the external water supply.
Irradiation guidelines
USA (FDA): 15 Gy mín.
25 Gy central; 50 Gy max.
Weight
1111 kg
Europe (EDQM) and RU (BCSH)*: 25 Gy mín.; 50 Gy max.*

Figure n.° 5: X-ray technology blood irradiator to arrive in Colombia in late 2021.

This process began in 2018 with negotiating sessions between personnel from the District Institute for Biotechnology Science and Health Innovation (IDCBIS) and the DOE, through the MME.

In 2019, DOE personnel paid technical visits to the IDCBIS facility to check security conditions. It should be noted that this facility was part of the program for security upgrades in 2015. As a result, it will not be necessary to upgrade the system before installing the X-ray irradiator.

The public bidding process was finalized in the second half of 2021 and a company hired to supply the equipment, install it, and perform preventive maintenance over the first two years of operation.

3.5 Training and instruction through regional courses and workshops

One of the key objectives for DOE is to build up technical capabilities, both for personnel in the Colombian RA and for users of the country's radioactive and nuclear materials. For this purpose, plans called for a series of training and instructional events taking place on a regular basis to match current needs and priorities.

The following skills-building courses and workshops have taken place so far:

Table 1: DOE-MME training events

YEAR	COURSE TITLE	OBJECTIVE	TARGET AUDIENCE
2014	Regulations course	Develop security regulations for radioactive facilities	RA personnel (MME and SGC)
2015	Security	Demonstrate the need for appropriate operational security during the transport of radioactive materials, how to define security	RA personnel (MME and SGC) and operators

		levels with suitable security measures, and how to implement programs effectively for operational security in transport	
2018	International Response Training Course Transition	Train RA staff and first responders (National Police of Colombia) to adopt this know-how and adapt it to the country's security needs, and later be able to replicate the instruction	RA personnel (MME and SGC) and National Police of Colombia
2019	International Response Training Course, pilot	Train first responders to serve in security events at radioactive and nuclear facilities	First responders (national police personnel, firefighters, and radiation protection officers from Category 1 facilities)
2019	Security Planning for Transport	Provide personnel with awareness-raising and instruction on security in the transport of radioactive materials based on International Atomic Energy Agency Guide No. 9	Ministry of Transport, Traffic Police, Department of Criminal Investigation and Interpol (DIJIN), Civil Aviation, SGC and MME
2019	Course on Security Inspections for Transport	Raise awareness among personnel responsible for monitoring and surveillance during domestic transport of radioactive material	The course targeted personnel from the MME and SGC
2019	Workshop, "Security in the transport of radioactive materials"	Disseminate drafts of updated regulations for the transport of radioactive materials	Operators and SGC personnel
2021	Regional symposium on security in transport	The purpose is to expand know-how on the specific threats and risks associated with the transport of radioactive and nuclear materials	Members of the public involved in activities that entail management and transport of radioactive and nuclear materials in South America, and the general public
2021	Training course on inspections — security	Provide regulatory personnel and inspectors from government offices with the training they need to understand the requirements for implementation and the authority they hold for security of radioactive sources, and offer an appropriate approach to the inspection of	The course targeted personnel from the MME and SGC

		protection measures consistent with these requirements	

Of note, MME and DOE jointly held the "South America Regional Transport Security Series" (SARTSS) from March-June 2021. The series was held virtually every week for 13 weeks and hosted participants from over 10 countries in the region as well as representatives from international organizations. The series provided a forum to exchange expertise and best practices on the specific threats and risks associated with the transport of radioactive and nuclear materials and how to overcome them.

4. COLOMBIAN INITIATIVES

4.1. Strengthening the RA: DOE has been an essential source of support for Colombia as it developed this initiative through an investment project called "Strengthening the Regulatory Authority for the safe use of radioactive and nuclear materials in the country." It is a five-year process that started in 2018 and is built on four pillars:

i. Updating the regulatory framework
ii. Capacity building for RA personnel
iii. Technological infrastructure assessment for the country's users of radioactive material (including the nuclear sector's contribution to the Gross Domestic Product)
iv. Designing a more suitable structure for Colombia's RA, based on current needs and short-, medium- and long-term projections

From the beginning of the project, MME has hired consulting firms to conduct studies on:

- Assessment of the current functional structure in the institution that holds regulatory authority over the nuclear sector in Colombia, analysis of issues involving the organizational structure of the RA as a function of human resources, and the tools for them to perform their duties.
    - This study also examined the professional profiles represented on the staff of the RA and its delegated agency and concluded that the team consists of 43% in-house staff and 57% contract staff, mostly with annual contract renewals. Of the RA personnel, 62% have graduate studies degrees and 48 to 72 months of professional experience in the nuclear sector.
    - The study also considered the structure and configuration of the information system in the regulatory authority, which from the beginning has used software developed in-house. Following a comparative study, it was decided to begin the process of migrating to IAEA software.

- Quantification and measurement of the contribution that the nuclear sector makes to Colombia's Gross Domestic Product (GDP): this study found that the nuclear sector makes up nearly 0.25% of the GDP, generates approximately 4000 direct jobs, invests an average of COP$ 63 billion in research and development and can claim that women make up approximately 48% of its labor force.

- Assessment of the current state of technology infrastructure in the nuclear sector, with the following results in the framework of the ongoing investment project: an evaluation was performed of the technology infrastructure of users of radioactive material for industrial practices including hydrocarbon exploration and extraction, mineral characterization, industrial radiography, geochemistry and more.
    - This assessment considered current national regulations and compared them with those of other countries in the region and with international guidelines set by the IAEA.

4.2. Gender equity: on another front, data were gathered on the participation of women in the nuclear sector. The information is being used as a basis for developing a network of women in the nuclear field (WiN) in Colombia, with the support of the regional initiative WiN ARCAL – Regional Cooperation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean.

In June 2021, a session was held under Colombia's leadership, with support from the DOE and in the framework of SARTSS-2021, attended by the majority of the countries in the Americas. Speakers included several women representing organizations such as WiN Global, WiN ARCAL and WINS (World Institute for Nuclear Security) that are forging and strengthening ties to foster improved gender equity in the hemisphere.

5. WHAT'S NEXT?

5.1. Security upgrades for mobile sources: One of the initiatives anticipated for 2021 – 2022 is to deploy DOE's Mobile Source Transit Security (MSTS) system in Colombia. MSTS is a system that has been designed to provide added security that includes tracking and alarms for mobile sources. These sources are a high priority because they involve frequent transfers of radioactive material around the country. MME and DOE continue to engage facilities in Colombia on the benefits of this system. The target partners are those companies that practice industrial radiography and have at least four radiography cameras and well logging facilities that have Am-241 radioactive sources with an activity above 555 GBq (15 Ci).

A first meeting has been held with facilities, in which the MME and DOE introduced the project, and users voluntarily agreed to take part and be consolidated as pioneers in this type of initiative to strengthen security of Category1 and 2 radioactive sources that move frequently around Colombia.

4.2. Cybersecurity: Another project that came from the RA assessment in 2018 focused on the need to strengthen information security, including cybersecurity and cyberdefense, at all facilities in the nuclear sector.

A key item in the 2019 assessments was to investigate cybersecurity conditions in these facilities, both physical cybernetic systems and the information systems operating in them.

For 2021, a first draft is being prepared of a baseline program of good cybersecurity practices in the sector's facilities, in the form of a guide for evaluation and assessment based on ISO 27000, in the framework of NIST (cybersecurity), SANS, OWASP and Mitra. Also underway is coordination with CSIRT and CCOCI to identify cyber threats in the sector, a methodology for managing such incidents, and identification of critical infrastructure in the sector, based on the directives of the Ministry of Information and Communications Technology (MinTIC).

6. CONCLUSIONS

- Colombia has improved security conditions in facilities that operate radioactive and nuclear materials, with support from the US Department of Energy, and has now lowered the level of nuclear risk for the country and the region.
- The regulatory system is stronger, with training for personnel from the Regulatory Authority and the development of rules and regulations with an emphasis on security, as well as bringing in all stakeholders, such as response institutions, users and other authorities that have responsibilities in this area.

Thanks to support from DOE:

- Colombia has a wide range of tools that have improved dissemination and communication with operators and users of radioactive material of the work that the MME has been performing to modernize regulations on safety and security in line with international guidelines, especially those developed by the IAEA.
- Personnel in the RA have improved their technical skills through a variety of training activities, attendance at workshops, and donations to overcome areas of weakness that were identified.
- Significantly, these events have focused, not only on skills-building in the RA, but also on bringing together all the Colombian organizations that contribute to regulation and oversight of radioactive and nuclear materials in the country, such as the National Police, firefighters, Ministry of Commerce, Industry and Tourism, Ministry of Transport, Ministry of Health and Social Protection, Foreign Ministry, Civil Aviation, the National Tax and Customs Service, and more.