

Title: Upgrading Physical Security Systems at the Centre Regional d'études Nucléaires de Kinshasa in the Democratic Republic of the Congo for Improved Nuclear Security

Authors: Dana O'Donnell & Jérémie Muswema

Abstract:

The Democratic Republic of the Congo (DRC) has a formidable history in nuclear technology, as it became the first country in Africa to operate a nuclear reactor in 1959 with the purchase of a General Atomics TRIGA MARK I reactor. The reactor was housed at the Regional Center for Nuclear Studies in Kinshasa, DRC and was used for research purposes. In 1970, a second reactor was purchased and installed, and the facility became known as CREN-K, Centre Regional d'études Nucléaires de Kinshasa. The facility operated under agreements to pursue peaceful nuclear research, including production of medical isotopes in Kinshasa, and was submitted to annual inspections under IAEA guidance.

Throughout the 1990s, CREN-K operated under reduced funding from the DRC government and was forced to reduced operating capacity due to an inability to replace some critical spare parts of the reactor facility (a problem of instrumented fuel element, and CREN-K was forced to reduce the operation of TRICO II at 50 kW). Ultimately, in 2004, the reactor was shut down and placed in an extended shut down status. However, recently and since 2010, DRC expressed interest in restarting the reactor to carry out research and experiments in nuclear energy to ultimately contribute to the development of the country.

In addition to the renewed interest in restarting the reactor at CREN-K, DRC was an active participant in the 67th Session of the IAEA General Conference, which demonstrates a commitment to safe and secure nuclear development and advancement through international cooperation. The US Department of Energy Office of International Nuclear Security conducted a site assessment of CREN-K facilities and working in partnership with the Congo Atomic Energy Commission, and site operator, determined recommended physical security upgrades that would improve the security of the reactor and essential materials. These upgrades were installed in 2023 with a plan for continued collaboration between the US and DRC to conduct assurance visits, develop plans for performance evaluations of the new security systems, and to provide on-going training to site staff, local responders and inspectors.

This paper describes the path taken to develop the partnership between INS and DRC and establish the conditions to determine both the feasibility of site upgrades as well as their implementation and sustainment. It exemplifies the positive relationship between INS and a nation developing their capabilities in the field of nuclear energy and their commitment to nuclear security.

Title: Upgrading Physical Security Systems at the Centre Regional d'études Nucléaires de Kinshasa in the Democratic Republic of the Congo for Improved Nuclear Security

Authors: Dana O'Donnell & Jérémie Muswema

History of DRC in Nuclear Energy Enablement

The Democratic Republic of the Congo has a longstanding and significant history with nuclear energy, perhaps stemming from the country's immense quantities of natural uranium, collected from the richest uranium mine in the world. However, this quantity of uranium and the geo-political unrest felt globally during World War II made the former Belgian Congo an area of interest during the race to develop nuclear weapons. Because the United States could not source enough uranium domestically during the Manhattan Project, which produced the first nuclear weapons, the Shinkolobwe mine in the DRC became an attractive site. Due to concerns over the Germans obtaining Congolese uranium, US planners affiliated with the Manhattan Project signed a deal with the Belgian government for exclusive rights to uranium mined from Shinkolobwe, resulting in the shipment of several hundred tons of uranium shipped monthly to the US. Ultimately, two-thirds of the uranium in the bomb used in Hiroshima originated in the Congolese mine.

Following World War II, the demand for Congolese uranium continued, as the global arms race manifested, however the US remained the near exclusive importer of this uranium. A processing plant was developed close to the Shinkolobwe mine and transportation infrastructure was improved to support significant mining operations. In 1960, when the Congo received political independence from Belgian, officially becoming the Democratic Republic of the Congo, controls on the Shinkolobwe mine were tightened and uranium production was secured. However, the years of extensive mining were conducted with minimal understanding of the health impacts of prolonged radiation exposure. Significant numbers of miners, transporters, scientists and other workers suffered negative health effects from their largely unregulated exposure to radiation. Contaminated dust and runoff water from the Shinkolobwe mine potentially affected the lives of thousands through contact with low-level radiation, as it also entered the ground soil and water supplies. While the secondary effects of radiation exposure were not studied as extensively in the DRC as it was in Hiroshima and Nagasaki, there is definite evidence of a population adversely effected by radiation from the uranium mining operations in the Shinkolobwe mine. However, these sacrifices, willingly or unwillingly made by the Congolese, enabled the advancement of nuclear technology globally.

Origins of CREN-K

In 1958, Lovanium University in Kinshasa decided to move forward with aspirations to procure a nuclear reactor and worked collaboratively with the Belgian Congo government to purchase a General Atomics TRIGA MARK-I 50 kW reactor. This was the first nuclear reactor on the African continent. The TRICO Center was built on the campus for the reactor and became operational in 1959. For several years, the reactor operated with students working in science and medical fields.

After receiving independence from Belgium, an Organization of African Unity summit was held in Kinshasa in 1967, at which key leaders decided to broaden the use of the Trico Center into a regional study center. This idea yielded the development of the Centre Regional d'études Nucléaires de Kinshasa (CREN-K), the Kinshasa Regional Center for Nuclear Studies, with funding support from the USA. A new TRICO-II reactor

was also purchased to add to the center. This reactor was a larger 1MW reactor designed for research, training, education and radioisotope production.

Following the expansion to CREN-K and obtaining the new reactor, DRC signed agreements committing to peaceful nuclear research at their facility. These agreements continued to 1987 and included a cooperative understanding that the Institute for Radioactive Elements in Belgium would assist CREN-K in the production of medical isotopes, in exchange for their support to conduct research for Belgian institutions. This allowed for the conduct of broad work at CREN-K and the expansion of nuclear medicine in DRC.

Status of CREN-K Nuclear Security Before Upgrades

The TRICO-II reactor was subject to annual International Atomic Energy Agency (IAEA) inspections and part of an IAEA initiative to receive replacement parts as well as nuclear fuel. However, due to changes in trade restrictions, General Dynamics, initially contracted to supply the parts, could no longer reach the CREN-K facility and service the reactor. The inability to replace spent fuel compromised the operational capability of the reactor coupled by decreases in DRC government funding for the reactor parts challenged the facility staff to keep TRICO-II in good working order. In November 2004, TRICO-II entered a state of extended shutdown due to lack of funding and access to replacement parts.

Throughout the early 2000s, several international groups conducted peer reviews of CREN-K and the reactor in coordination with the “Commissariat Général à l’Energie Atomique” in DRC to assess the reactor’s safety and the Physical Protection of the installations based on IAEA standards.

In 2017, an Expert team of the International Physical Protection Advisory Service (IPPAS) of the IAEA conducted a review of the nuclear security infrastructure relating to physical protection of the CREN-K. The report provided advice on implementing international instruments and IAEA recommendations and guidance on the protection of not only nuclear and other radioactive material, but also their associated facilities.

One year later, in 2018, a five-member Integrated Safety Assessment of Research Reactors (INSARR) review was held and provided recommendations to CREN-K in light of their aspirations to bring the reactor back into an operational status. These recommendations included improvements to regulatory supervision, licensing and inspection programs, changes to organizational structure for reactor operations, the creation of training and qualification program, development of reactor safety documents and programs, and modifications to human resources and financial management systems.

Similarly, the US National Nuclear Security Administration (NNSA) Office of International Nuclear Security (INS), under the US Department of Energy (DOE) began working alongside the CREN-K operator and regulator in DRC to identify nuclear security upgrades that would benefit the reactor site. In this process, teams of physical security experts from INS travelled to CREN-K and conducted site assessments for security enhancements based on performance objectives in IAEA Nuclear Security Series No. 11 Security of Radioactive Sources, and IAEA Nuclear Security Series 13 Nuclear Security Recommendations on Physical Protection of Nuclear Materials and Nuclear Facilities, as well as best practices identified within the NNSA. Collectively, the improvements recommended to CREN-K aid in protecting valuable nuclear material and working to prevent unauthorized access, by terrorists or others, from acquiring material that could be used nefariously.

Scope of Upgrades

The physical security upgrades completed at CREN-K were voluntary enhancements, which included extended maintenance, warranty and monitoring services for a period of 36 months. The upgraded security systems were designed to incorporate into existing measures for site access control, intrusion detection, to include closed-circuit television systems.

The physical security enhancements focused on five distinct locations at CREN-K:

1. Building TRICO I
2. Building TRICO II
3. Primary Monitoring Center/Central Alarm Station (CAS)
4. Onsite Police Station/Secondary Alarm Station (SAS)
5. Calibration and Sterilization Labs
6. Site-wide Enhancements

TRICO I

The upgrades initiated in TRICO I began with the removal of the existing security system. The upgrades were designed to complement each other and provide redundant features in the event of a system failure. A key component of the TRICO I upgrade was a high priority intrusion panel which allows for simultaneous monitoring of all priority elements by using distinct zones and identifying all priority alarms by type and location. The high priority panel is designed to be attack-resistant and equipped with high-security locks and other specialized security equipment. Furthermore, the bolts used on the high priority panel are designed to require only a specialized tool for removal, to prevent unauthorized removal or tampering. All of the sensors, to include radiation, active duress, and source tamper sensors connect to the high priority panel which in turn, feeds to a receiver at the Central Alarm Station (CAS) and offsite monitoring facility, providing a backup level of monitoring. The communication channels used in this system were all configured with a 128-bit encryption algorithm as well to prevent cyber interference. Additionally, the high priority panel included an SMS module, designed to send a text message alert notification to the site or department manager indicating the location, type, and trigger of each alarm. An alarm management system was designed to handle simultaneous storage of 500 events at full resolution, with the ability to



Figure 1: Cabinet Installation with ATS Controller including Extensions with NVR, LUDLUM

play back videos or monitor in real time. This significantly eases the challenge of manual alarm management and enables the CAS operators to better communicate the events triggering alarms based on improved situational awareness. A radiation detector was also added to the high priority panel to detect background radiation in excess to what is present during normal operations. To ensure consistent operation, a 3000-volt uninterruptable power supply equipped with surge protectors was installed as a backup power supply to the high priority panel.

Additionally, TRICO I was outfitted with tamper rated infrared cameras that provided visual coverage of the entire reactor facility. For access control, biometric readers were installed outside TRICO I and enrollment and subsequent enrollment of authorized personnel commenced. This security feature was coupled with a two-person rule, requiring validation from two distinct and authorized employees for access to the reactor. Furthermore, to diversify access control measures, a keypad and card reader were installed.



Figure 2: Deployment of secure magnetic metal doors with cameras and palm reader

Doors in TRICO I were equipped with balanced magnetic switches and wired tamper indicating devices on containers and storage spaces. The actual doors were upgraded to hardened steel with electromechanical locks.



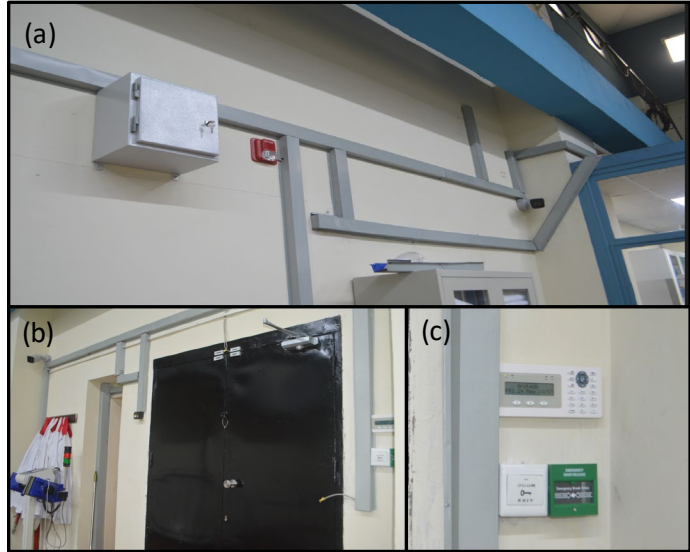
Figure 3: Deployment of secure magnetic metal doors with Cameras and palm reader (a), Motion Sensor and BMS installation (b and c)

TRICO II

Like TRICO I, the process to upgrade physical security systems at TRICO II began with an organized removal of all existing security features. Additionally, this building also received an improved high priority panel, with a uniquely designed security lock. The design of the high priority panel contains similar specialized security features designed to challenge unauthorized access, with particular bolts, sensors, and alarm features. This high priority panel also has a dedicated back up power source. Sensors are connected to the high priority panel which in turn corresponds with alarms synced to the alarm management system at CAS and the offsite monitoring facility. These communication channels between the panel and the CAS

are also encrypted, and also are relayed on SMS text to essential personnel. The alarm management system was upgraded to handle a larger volume of distinct events and facilitate the operator in managing the incoming alarms by highlighting the location and type of alarm. Camera systems and motion sensors were installed to cover the entirety of the TRIGA Mark II facility and are tamper rated.

Figure 4: Interior view of emergency exit device, fire detector, motion sensor (a), metal doors with disarm keypad and exit button (b & c)



Biometric readers were installed outside TRICO II to limit access to authorized personnel, and is coupled with a two-person accountability rule. The facility doors were upgraded to hardened steel with electromechanical locks. To facilitate deliveries to the building, a video intercom was installed outside of a door to coordinate access control with the operator. Radiation detectors were also installed in parallel with the high priority panel and reside inside a tamperproof enclosure. This building is also secured with keypads for entry and duress alarms that can be activated in the event of an emergency.



Figure 5: Deployment of secure magnetic metal doors with palm reader, camera inside the TRICO II hall

Unique to TRICO II, vehicle bollards, rated to stop a medium-weight truck, were installed. These bollards can be operated by an outside controller or integrated in the main alarm management panel. The crane used in the facility also was upgraded to include a tamper indicating switch on the lock out device, and second story doors in the facility have been hardened.

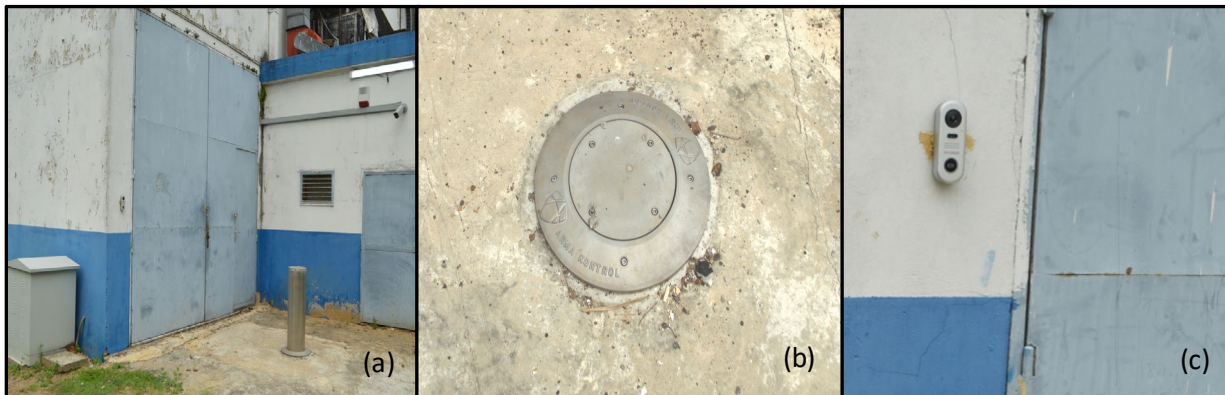


Figure 6: Bollard installation deployed with camera (a), bollard overview (b), access control camera (c)

Primary Monitoring Center (Central Alarm Station/CAS):

Upgrades inside the Primary Monitoring Center include a locked and protected rack unit connected to the intrusion system, with limited access. Operators are not authorized access to the key as a means of preventing insider threat or coercion if the CAS was compromised. The functionality of the operator is limited to screen views and configuration only. Cables are installed with protection from metal conduit or are otherwise inaccessible. The CAS also now features an alarm event screen to list all alarms received in historical order, as well as sensors triggering alarms and camera feeds. This eases management for the operators and allows the ability to easily watch all live site video feeds. Cameras were also added internally in the CAS and to the area immediately outside the building as well as entrances and parking lots. All security equipment has been connected to backup power supplies to ensure continuous operations even if the primary power source was compromised. An air conditioning unit was installed as well to protect the security equipment from overheating.



Figure 7: Central Alarm Station monitoring screens (a), secure cage with magnet to secure rack unit (b), rack unit overview (c)



Figure 8: Metal detector door at pedestrian entrance, with tripod



Figure 9: Guard Force equipped with new uniforms

Several upgrades were also made that focus on the on-site guard force, to include uniforms with boots, rechargeable flash lights, mobile duress buttons, personal radiation detectors, and handheld metal detectors.

Onsite Police Station / Secondary Monitoring Center (Secondary Alarm Station / SAS):

Upgrades in the Secondary Monitoring Center were similar in scope to the CAS, beginning with improvements to the control panel and securing access to it. Also, like in the CAS, operator functionality was limited to screen views and configuration only. Cameras were installed inside the SAS and at entry points, duress alarms were added, and the building door was upgraded to hardened steel. All security equipment was connected to backup power supplies in the event of an outage. A large television screen was added to provide simultaneous video displays of the facility and improve situational awareness for the operators.

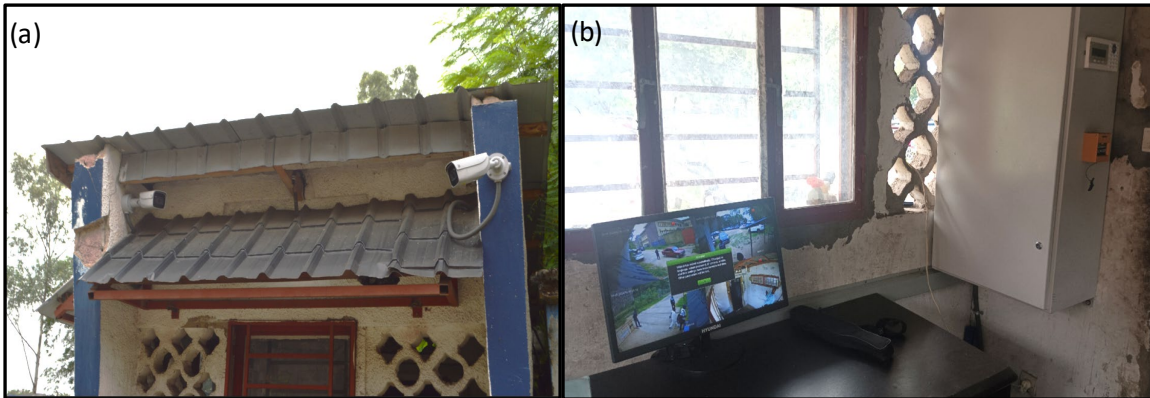


Figure 10: Secondary Alarm Station (a), Monitoring screen with Camera (b)

Calibration and Sterilization Lab:

Improvements to the Calibration Facility include the installation of tamper rated cameras to cover the entirety of the facility, as well as keypad entry points with automatically locking doors. The source housed in the facility was secured with restraints to ensure it remains in place and is tamper resistant. A wired tamper detection balanced magnetic switch was added to the container and its alarm was integrated to the high priority panel. The lab is now equipped with motion sensors to detect unauthorized personnel and dedicated pin reader was installed in coordination with tamper sensors on metal cages surrounding the source. All equipment was connected to the high priority panel in TRICO I and protected with metal conduit.

Figure 11: Calibration and Sterilization Lab (a), emergency exit device equipped with motion detector (b), and a cage with magnet protected by an access code (c), disarm keypad and exit button (d)



Site-wide Enhancements:

Across the complex, several general security improvements were made, in addition to the physical security upgrades. Some of these upgrades improved the ability to manage alarms through the development of central management systems, as well as improvements to target folder procedures and alarm assessment criteria. The facility was equipped with lightning strike surge protection to ensure the integrity of sensors and newly installed technology and all equipment was linked to back up power supplies.

Next Steps for Maintenance and Sustainment:

Following the installation of the new physical security systems at CREN-K, the contracted vendor was required to develop procedures and training on the implementation and operation of the new systems. These written procedures and training ensure ongoing effective function, operation, testing and maintenance of each device, as well as personnel training.

INS and CREN-K also have opportunities for continued partnership and collaboration by conducting assurance visits to ensure the equipment installation is on par with expectations, functionality is maintained, and performance evaluation procedures are developed. Additionally, the INS team has plans to continue to broaden the training conducted with CREN-K, by supporting future needs for response force training.

Future Goals for Nuclear Technology in DRC:

In 2020, the DRC government authorized the restart of the TRICO II reactor at CREN-K pending positive outcome of inspections administered by the IAEA. The physical security improvements to the facility are essential to ensuring secure future operations and sustainability of the reactor, as well as to allow the facility to evolve with the dynamic nuclear technology and research demands in DRC. Access to functional and secure research reactors in DRC is critical and has the potential to provide beneficial solutions to a variety of problem sets. Beyond the traditional uses in medical applications, such as radiotherapy for cancer treatment and radiological imaging, the application of radioisotopes can be used for agricultural improvements, irradiation of food, and water purification – all of which have significant application in DRC and sub-Saharan Africa at large. In addition, a large portion of Sub-Saharan African countries, to include portions of DRC, do not have reliable or consistent access to electricity. This lack of access has countless second and third order effects on people, limiting their access to resources, connectivity to others, and ability to advance.

Research reactors, like the one at CREN-K, are an essential first step to introducing a nuclear power program to a nation. They provide the regulatory framework, as a foundation, to develop larger nuclear energy programs, carry out studies that support nuclear power plant development, and train future operators for such facilities. Additionally, access to a research reactor at the university level encourages the development of students in nuclear engineering and helps to ensure a future of qualified personnel are readily available to promote nuclear power programs and facilities.

The ongoing partnership between DRC and INS in the area of nuclear security has proved to be valuable and necessary. The upgrades recently completed at the CREN-K facility only scratch the surface of potential engagements and exchanges bi-laterally, as well as serving as an example for the region to follow.