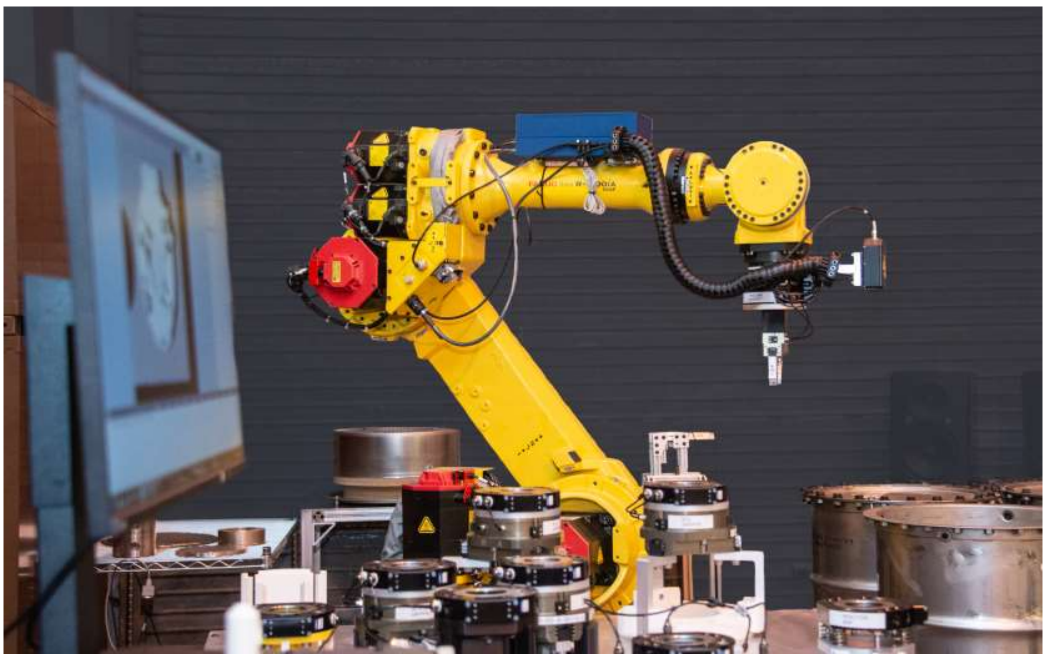
Proceedings of the INMM & ESARDA Joint Virtual Annual Meeting,
August 23-26 & August 30-September 1, 2021

K-Area Six-Year Automation Implementation Plan



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Abstract

The Savannah River Site (SRS) has recently initiated several large-scale projects associated with nuclear material disposition. Two of these projects will be completed and operated in the K Facility within the next eight years. If collaborative robots were incorporated into the nuclear material operation strategy to assist with common, repetitive tasks, operators would be made available to perform higher value work elsewhere in the facility, ultimately reducing dose to the general work base. Implementation of robotic systems can execute tasks that are precise, procedural, and can be integrated with control systems to verify, record, and maintain data for historical archiving. By incorporating camera and data scanning applications in the robotic system, remote observation (or remote control) can be integrated into verification applications by Operations, Quality Assurance, and other work groups. Based on the success of two demonstrations involving automated drum handling equipment, the Nuclear Non-proliferation Program group has collaborated with K-Area Operations to assess a six-year Automation and Robotic infusion capability for the current (and projected) K-Area operation flow map. This assessment proposes four unique automation opportunities in nuclear material handling operations and evaluates the benefits associated with each individual opportunity, including dose savings, throughput efficiency and human capital re-allocation.

Introduction

Ramping up SRS operations to disposition surplus nuclear material will entail a vast number of material and container moves. It is important to design future operations which reduce worker radiation exposure and increase production capacity, while improving both safety and efficiency. Since many of the steps associated with these activities require hands-on work, NNSA and SRNS are interested in evaluating options that increase use of automation and/or robotic systems.

In February 2019, a jointly sponsored meeting by NA-233 and NA-532 was held at SRS. Proposals were discussed and revised to provide a quick-term (< 1-year) demonstration that would provide proof of concept for reducing the time of nuclear material handling for a current or planned process. If the demonstration was successful, it would then lead to a multi-phased approach to deploying automation and robotic technologies in SRS operating facilities.

Following the successful joint sponsored Automated Handling Demonstration (Ref.1), further interest had generated for integration of automation in future nuclear material projects. NA-233 held a robotics workshop at SRS in December 2019 (Ref. 2). During the workshop, K-Area facility management discussed critical areas needing to be addressed to support future projects (i.e., human resource management, dose reduction, and commodity life-cycle management).

Resultant from the Automated Handling Demonstration and Robotics Workshop results, NA-233 requested the SRNS Nuclear Nonproliferation Program group, with SRNL input, to work with K-Area Operations and assess a six-year Automation and Robotic infusion capability that supports the K-Area operation flow map. The *K-Area Six-Year Automation Implementation Assessment* SRNS-RP-2020-00266 (Ref. 3), referred to hereafter as *The Plan*, was produced to capture the long-term strategy for infusing automation into future K-Area operations.

The Six-Year Plan

The Plan outlines the FY 2021 – 2026 objectives, benefits, and schedule towards implementation of four unique Automation Opportunities.

OPPORTUNITY 1: CCO RECEIPT AND INSPECTION SUPPORT

Originally developed in FY 2020, the Scope of Work for Receipt and Pre-Use Inspection & Staging of Criticality Control Overpack (CCO) (Ref. 4), provides a proof of concept toward executing automated pre-use inspection and security checks of CCOs prior to entering 105-K for use.

Automation Objectives

Opportunity 1 consists of three proposed work efforts to automate the receipt of newly manufactured CCOs into 105-K:

1) Streamline the receipt process for receiving the CCO directly into K Area
2) Use a robot arm to perform required key steps defined for Receipt Inspection (Ref. 6) and K-Operations Pre-Use Inspection and Security Checks (Ref's. 7 and 8), including application of a Tamper-Indicating Device (TID) seal on the CCO to ensure the integrity of the inspection is maintained. Validate and historically maintain all key criteria using an electronic database and video capture.
3) Incorporate manufacturing design changes into the Specification for Fabrication of the Criticality Control Overpack (Ref. 9) to improve compatibility of the drum design with robotic arm tooling for automation task execution.

Benefit

By utilizing mechanical robots to assist with common, repetitive tasks, operators are available to perform higher-value work. Over the next 30 years, CCO receipts are projected to surpass 125,000 units. This ultimately correlates to over 2,000,000 individual CCO container-handling operations throughout the facility's life cycle, and over 500,000 moves associated with the receipt and inspection process alone.

By streamlining and centralizing the receipt process, the site will be able to take advantage of consolidated resources. Performing the inspection using the integrated scanners and cameras will allow remote observation of the activities and ensure all identified key data will be retained electronically for historical purposes.

Incorporation of an autonomous CCO receipt and inspection process is an opportunity to reallocate the following resources (based on receipt and acceptance of 100 containers per week):

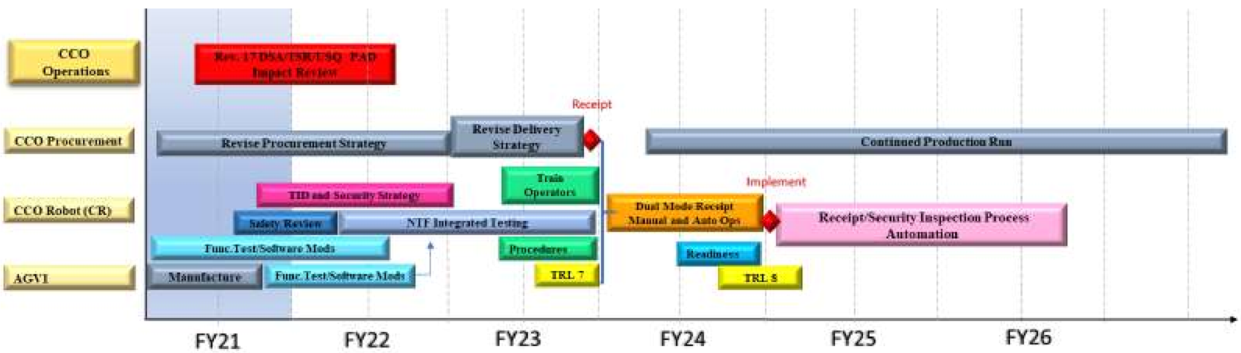
Table 1: Opportunity 1 FTE Comparison

Activity	FTE without Automation	FTE with Automation	Delta
Container Design Support	0.15	0.15	0
K-Area Operations Container Handling	4.5	0.5	-4.0
Mechanical Maintenance	0	0.5	0.5
QA Receipt Program	1.0	0.5	-0.5
N-Area Receipt Staff	2.0	0	-2.0
		Total Delta:	**-6.0**

Opportunity 1 will allow organizations to reallocate up to 6.0 FTEs per year over the period of the operation. This, in conjunction with the other opportunities that follow, will greatly benefit optimization of human resources needed over the course of the program.

Schedule

Schedule 1: CCO Receipt and Inspection Schedule



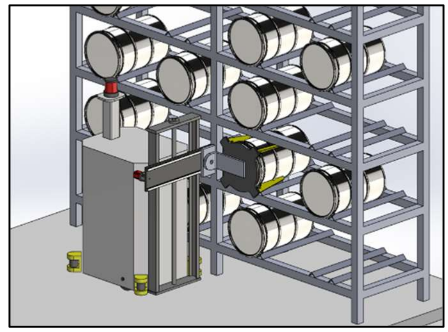
Opportunity 2: CCO Pad Operations

Automation Objective

An AGV is envisioned as the primary mechanism to transport shipping containers between various work locations. AGVs are used in manufacturing and warehouse operations to move material from place to place. As the name implies, AGVs operate without drivers and rely on a control guidance system. Initial activities will involve working with K-Area Operations personnel to determine the preferred guidance technology, performance requirements, and handling specifics for the equipment. Additionally, coordination with Safeguards and Security personnel is required to integrate potential control programs with a Material Tracking System (MTS) for material identification, location, and delivery operations. MTS is being developed and implemented in phases, and activities are being tracked through project and facility schedules. Automation is planned for integration with MTS in one of the later phases.

As originally conceived in 2019, Opportunity 2's primary scope is to develop an automated drum delivery system for use on the CCO pad. This system will have the ability to retrieve, stack, stage and deliver CCOs to predetermined work locations to support CCO drum operations.

In 2020, the vision for opportunity 2 was expanded to include procurement of an AGV (known as AGV2) with a specialized tool designed to pick containers and place them horizontally, while satisfying the original scope of storage and delivery of containers required for CCO Pad operations. The addition of the specialized tool employed to place drums in a horizontal position will be tested to determine if horizontal storage racks could potentially be used on the CCO pad.



Incorporation of a horizontal rack system with an AGV has the potential to improve the efficiency of drum storage on the CCO pad versus using a vertical pallet stacking system. The system would also allow a Just-In-Time pick system to be utilized during drum mining operations, instead of a First In/Last Out strategy which is inherent to pallet operations.

If automated drum movement and horizontal storage operations are implemented, the CCO pad may be able to greatly increase its storage capacity because horizontal storage allows for a more dense-pack arrangement than conventional vertical stacking.

Benefit

Over the next 30 years, pad operations will entail over 800,000 individual CCO moves. Allowing an AGV to execute the common, repetitive task of pad CCO movement eliminates the potential for workplace injuries associated with manual drum movements. Future ergonomic consequences will also be significantly reduced by eliminating repetitive activities from daily pad operations. Automatically recording data associated with the numerous moves and staging will also eliminate transcription errors and the potential for procedural non-compliance. Use of an AGV for pad CCO movement also allows reallocation of human capital (based on receipt and acceptance of 100 containers per week).

Table 2: Opportunity 2 FTE Comparison

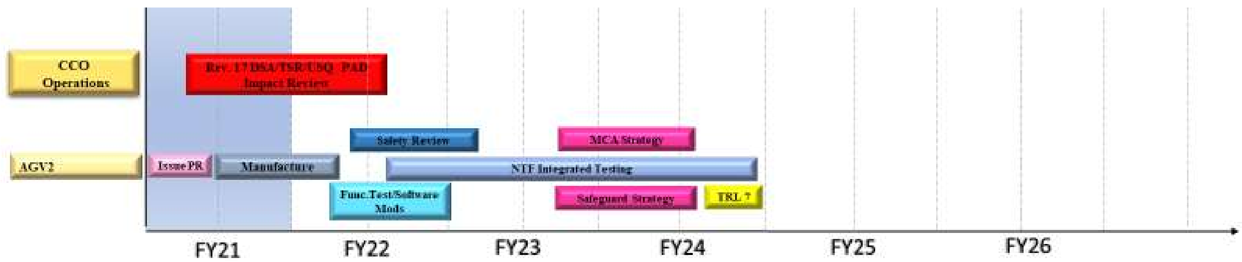
Activity	FTE without Automation	FTE for Automation w/ Vertical Stacking	Delta	FTE for Automation w/ Horizontal Storage	Delta
K-Area Operations Container Handling	6.0	4.0	-2.0	2.0	-4.0
Mechanical Maintenance	0	0.5	0.5	0.5	0.5
Radiological Control support	1.0	1.0	0.0	0.5	-0.5
Safeguards and Security support	1.5	0.5	-1.0	0.5	-1.0
		Total Delta:	**-2.5**		**-5.0**

Opportunity 2 if pursued and implemented, would allow reallocation of 2.5 to 5 FTEs per year over the period of the operation (see Table 2) based on the pursued drum handling concept.

Opportunity 2 will provide improved commodity throughput and dose reduction to operations personnel, while reducing time and motion during drum operations

Schedule

Schedule 2: CCO Pad Operations Schedule



3.1 Opportunity 3: KAMS AGV Mining

Automation Objective

An AGV is envisioned as the primary method to mine and deliver 9975 shipping packages from the K-Area Material Storage (KAMS) Material Access Area (MAA) to the work cell. Incorporation of AGVs in a nuclear material storage area would remove the operator from potential hazards of industrial accidents and radiological dose accumulation. KAMS currently stores over 5,000 nuclear material containers that will require mining and delivery to a designated work location for unpackaging.

Benefit

Unlike Opportunities 1 and 2, the primary objective of Opportunities 3 and 4 is to reduce the facility operators' cumulative dose during routine operations. Implementing automation into the mining operation will allow the operator to be utilized in more productive, skilled tasks in other areas of the plant.

Table 5 shows that by incorporating Automated Mining Operation into future K-Area operations (based on handling 5,000 containers), the Operations workforce will avoid 340 REM that would otherwise be accumulated over 30 years of operation.

Table 3: Dose Evaluation for Mining Containers

Manpower Activity	Operator	RCO	ENG	time/act	Total Time	Dose mR/hr	Combined
Mining	3	1		30	120	22	44
Pallet Breakdown	3	1		20	80	8	10.66666667
Drum Delivery	3	1		20	80	10	13.33333333
							0
	Activity time per drum (hours)			1.166667			
	Manpower per drum (hours)				4.6666667		
	Total Dose received per drum (mR)						68
	Total Dose (R) for facility per 5000 containers						340

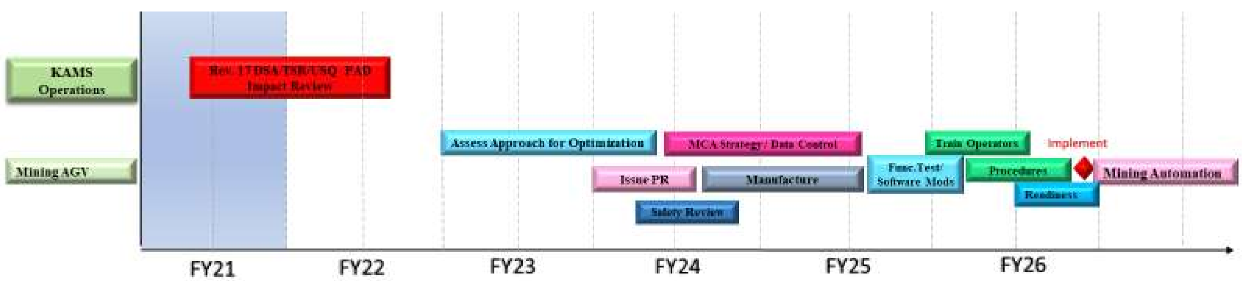
Opportunity 3 allows organizations to reallocate up to 3.5 FTEs per year over the period of the operation, as shown in Table 4. Again, this paper does not delve into an analysis of implementation cost versus savings. More formal analysis will be performed as each opportunity is authorized and funded.

Table 4: Opportunity 3 FTE Comparison

Activity	FTE without Automation	FTE with Automation	Delta
Engineering/MC&A support	1.5	0.5	-1.0
K-Area Operations Container Handling/Mining	3.0	0.5	-2.5
Radiological Controls	1.0	0.5	-0.5
Mechanical Maintenance	0	0.5	0.5
		Total Delta:	**-3.5**

Schedule

Schedule 3: KAMS AGV Mining Schedule



3.2 OPPORTUNITY 4: AUTOMATED 9975 UNPACKAGING (FUTURE PROJECT SUPPORT)

Automation Objective

The use of industrial robotic technology for removing radioactive items from Type B radioactive material packages will reduce worker dose and eliminate material-handling hazards. The current operation is labor-intensive and results in radiological dose to the operators involved. The technology to incorporate robotics into the material-handling cycle is currently available. The process can be broken down into the following activities:

- Verification and selection of a single package for presentation to the mechanical robot arm
- Retrieval of the product from the package
- Verification of components, including weight, bar code scans, ID confirmation
- Radiological surveys of process and components

Benefit

Table 5 shows that by incorporating Automated 9975 Unpackaging for future K-Area operations (based on handling 5,000 containers), the Operations workforce will avoid 350 REM that would otherwise be accumulated over 30 years of operation.

Table 5: Dose Evaluation for Unpackaging 9975s

Manpower Activity	Operator	RCO	ENG	time/act	Total Time	Dose mR/hr	Combined
Initial breakdown	3	2	1	25	150	5	12.5
Open SCV	3	2	1	15	90	7	10.5
Open PCV	3	2	1	25	150	10	25
Rerack pallet	2	1	0	20	60	22	22
	Activity time per drum (hours)			1.416667			
	Manpower per drum (hours)				7.5		
	Total Dose received per drum (mR)						70
	Total Dose (R) for facility per 5000 containers						350

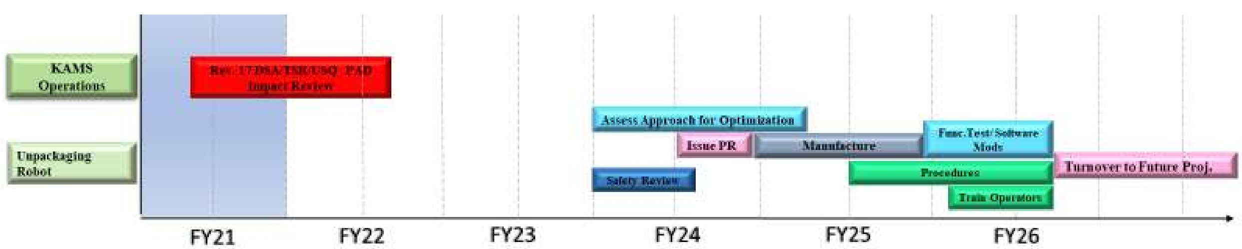
Opportunity 4 allows organizations to reallocate up to 4.5 FTEs per year over the period of the operation (see Table 6). More formal analysis will be performed as each opportunity is authorized and funded.

Table 6: Opportunity 4 FTE Comparison

Activity	FTE without Automation	FTE with Automation	Delta
Engineering/MC&A support	2.5	0.5	-2.0
K-Area Operations Container Handling/Mining	3.0	0.5	-2.5
Radiological Controls	1.0	0.5	-0.5
Mechanical Maintenance	0	0.5	0.5
		Total Delta:	**-4.5**

Schedule

Schedule 4: Automated 9975 Unpackaging Schedule



TECHNOLOGY DEVELOPMENT APPROACH

A systematic approach must be utilized to execute this plan. Though *The Plan* outlines a method to achieve success for the four basic opportunities, additional technologies must be analyzed and developed to augment an overall Technology Implementation Plan for facilities. Commercial technologies and platforms must additionally be reviewed, benchmarked and tested to ensure compliance and integration capability with existing DOE Complex security requirements.

The ability of support organizations to adopt technology will be a key contributor to the overall acceptance and success of this plan. Integration of technology will require collaboration of Safety, Security, Industrial Hygiene, Nuclear Criticality Safety Engineering, and other groups during the testing and design phases of the projects.

TESTING APPROACH

As progress continues toward the ability to develop automation for use in SRS facilities, a robust testing plan will be developed. To execute a test plan, a facility with adequate footprint must be located and modified to support placement of the required control station and support equipment to execute a robust test plan. SRNL currently does not have adequate, available space to execute the various test programs needed for this long-term automation effort.

K-Area Operations has identified building 741-2N as the location to support future automation testing of Opportunity 1 and 2 equipment. K-Area Engineering has initiated *Preparation of Building 741-2N for Testing Activities,* MT-KL-2020-00008 (Ref. 12), for proposed upgrades to the building to provide both operator habitability and power supply for automation testing.

Conclusion

Demand for safer, faster, and more efficient service continues to rise throughout the operational structure in production organizations. More operational organizations are turning to autonomous robots to augment their workforce. With the advancement of technology and decrease in costs, industry has moved to small, agile robots to perform repetitive tasks in safe, precise manners.

Various Department of Energy sites have determined that robotics can and should be implemented to address improvements toward operational production efficiency, worker ergonomics, radiological dose reduction, and facility safety. The robot must be designed, implemented and synchronized with a facility's safety basis, classification, and security constraints to improve the current operation. The proposed system should utilize proven state-of-the-art technologies. The desired robotic implementation should provide a path to potential long-term savings, reduce/eliminate hazardous conditions and radiological exposure, or improve quality and reliability of an operation.

NNSA is extremely interested in developing automated and robotic handling systems for processes where operators must handle radioactive materials. Automation should be implemented into these repetitive processes to enhance worker safety and ergonomics, increase throughput, reduce personnel radiation exposure, and maximize organizational human resource capital. Successful implementation depends on the site's primary contractor and NNSA working together with the same goals.

Implementation must be introduced and executed in a systematic and controlled manner to allow all support organizations and facility operations to gain confidence while understanding the capabilities and limits of the technology. This document is merely a plan for operating and technology organizations to generate support and sponsorship from NNSA to invest in the evaluated automation concepts.

References

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