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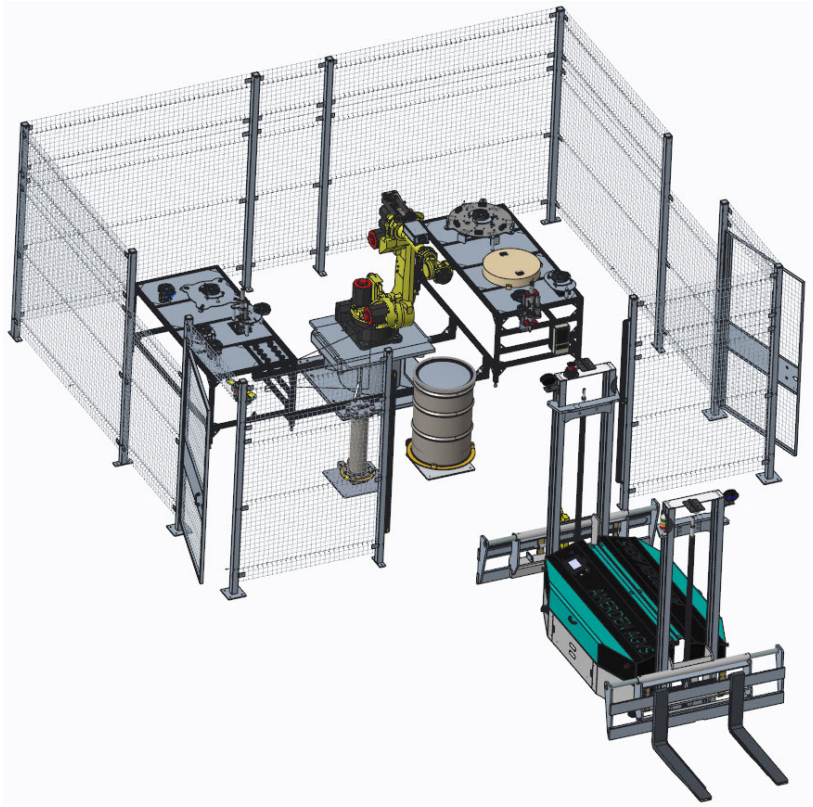
Deploying Automation Technology supporting Packaging and Transportation Operations



SRNS-TR-2023-00250

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Abstract

Various United States Department of Energy (DOE) sites are investigating the deployment of robotics to provide safer, effective, and more efficient operations. By implementing robotics in packaging and transportation operations, improvements toward production efficiency, worker ergonomics, radiological dose reduction, and security assurance can be realized. Robotic Systems must be designed and implemented in concert with a facility's safety basis, classification, and security constraints, while improving overall operational effectiveness. The desired robotic implementation should provide a path to potential long-term cost savings, reduce/eliminate hazardous conditions and radiological exposure, while improving quality and reliability of an operation process.

The Savannah River Site (SRS), a DOE Site located in Aiken South Carolina, has initiated several large-scale projects supporting future nuclear material disposition activities. Incorporation of automation and robotic equipment in system designs will support effective and efficient material handling operations, including container movements and packaging activities. Robotic systems will execute tasks that are precise, procedural and integrated with control systems to verify and record data for material inventory and historical archiving. An overview of the current robotic system development to perform receipt inspection, packaging, storage and shipment preparation activities of designated Type A and B shipping packages will be presented.

Introduction

Ramping up SRS operations to disposition surplus nuclear material will entail a vast number of nuclear 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 during packaging operations, DOE and the Operating Facilities are interested in evaluating options that increase use of automation and/or robotic systems.

In May of 2020, following a successful robotic arm demonstration that provided proof of concept for reducing the time of nuclear material handling when unpackaging a Type B container, DOE requested the SRS Nuclear Nonproliferation Program Group to work with K-Area Operations and assess a six-year Automation and Robotic infusion capability to support the K-Area operation nuclear material operational flow map process (Figure 1)

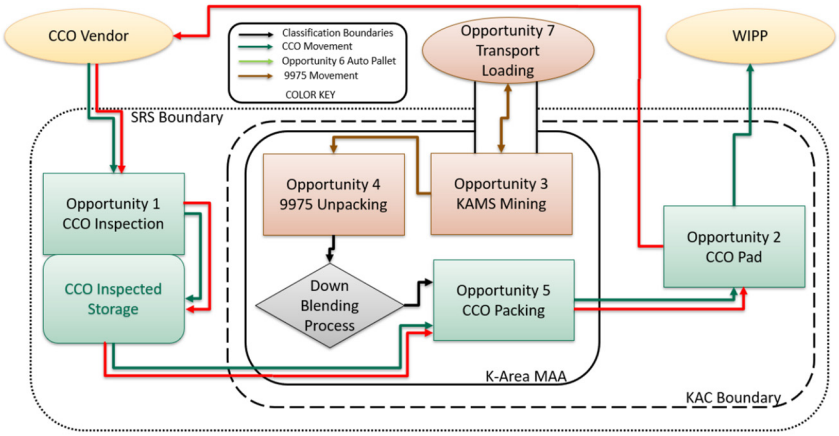


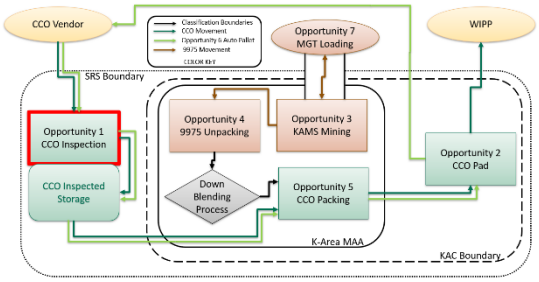
Figure 1 Material Operational Flow Map Process

In May of 2021, *K-Area Six-Year Automation Implementation Assessment* SRNS-RP-2020-00266 (Ref. 1), was produced to capture the long-term strategy for infusing automation into future K-Area operations. This plan details future automation opportunities which will provide increased through-put, operational efficiency, and dose reduction (for Opportunity 2) for the facility operation crews.

This paper will specifically review two of those programs.

OPPORTUNITY 1: TYPE A CONTAINER RECEIPT AND INSPECTION SUPPORT

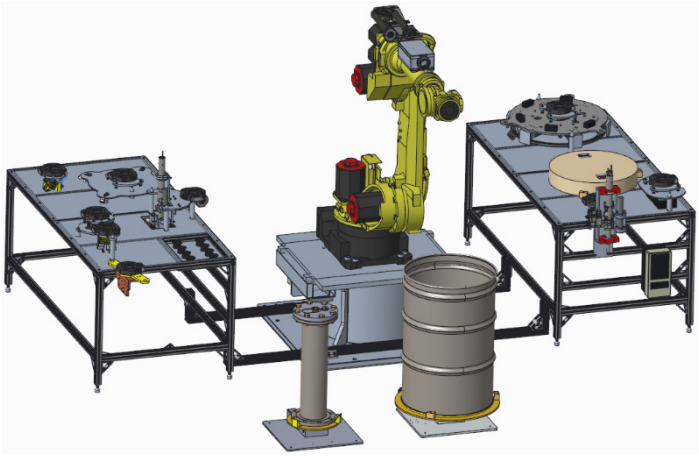
Originally developed in FY 2020, the Scope of Work for Receipt and Pre-Use Inspection & Staging of a Type A container, specifically the Criticality Control Overpack (CCO) (Ref. 2), provides a proof of concept toward executing automated pre-use inspection and security checks of CCOs prior to entering 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 and K-Operations Pre-Use Inspection and Security Checks, including application of a Tamper-Indicating Device (TID) seal on the CCO to ensure the integrity of the inspection is maintained.
3) Validate and historically maintain all key criteria using an electronic database and video capture.



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 facility 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):

Opportunity 1 FTE Comparison for per year Operations

Activity	FTE without Automation	FTE with Automation	Delta
Container Design Support	0.15	0.15	0
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 will benefit optimization of human resources needed over the course of the program.

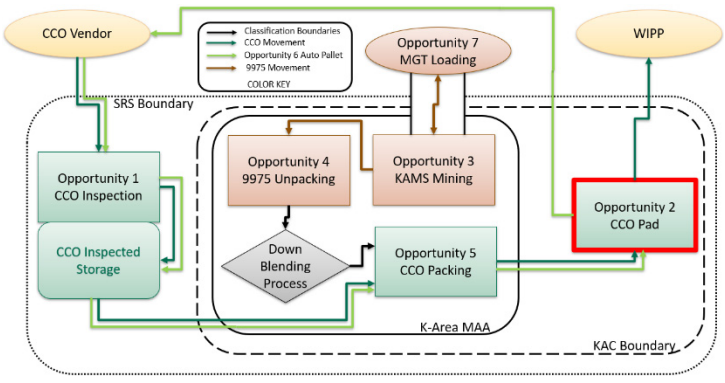
Schedule

Opportunity 1 project is well underway as we are currently in the testing phase of the system. This October (2023) the facility will begin full system integration testing for 6 months. Once the testing program has successfully met the performance objectives for throughput and reliability, the system will enter an Operational Integration period for facility training and familiarity.

It is expected to have the system fully operational and in production mode by FY2026

OPPORTUNITY 2: CCO PAD OPERATIONS

Automation Objective

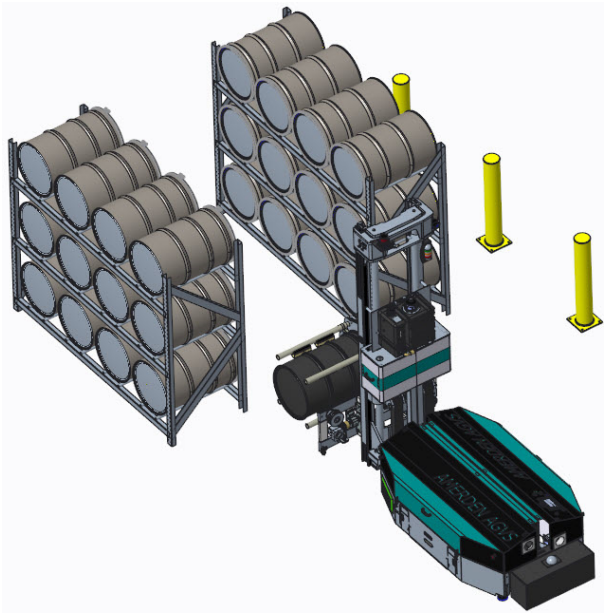


An Autonomous Guided Vehicle (AGV) is to be used as the primary mechanism to transport shipping containers between various work locations. AGVs are used in manufacturing and warehouse operations to move material from place to place. As the name implies, AGVs operate without drivers and rely on a control 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 control programs with a Material Tracking System (MTS) for material identification, location, and delivery operations.

As originally conceived, Opportunity 2's primary function is to operate as an automated drum handling system for use on the K Facility CCO pad. This system will have the ability to retrieve, stack, stage and deliver loaded CCOs to measurement equipment

In 2020, the vision for opportunity 2 (Ref.3) was expanded to include procurement of an AGV 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.

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 will allow a Just-In-Time pick system to be utilized during drum handling operations, instead of a First In/Last Out strategy which is inherent to pallet operations.



When automated drum movement and horizontal storage operations are implemented, the CCO pad will be able to greatly increase its storage capacity (>50%) 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).

Opportunity 2 FTE Comparison

Activity	FTE without Automation	FTE for Automation w/ Vertical Stacking	Delta	FTE for Automation w/ Horizontal Storage	Delta
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, when implemented with Automation and Horizontal Racks, will allow reallocation of 5 FTEs per year over the period of the operation.

Opportunity 2 will provide overall dose reduction to operations workforce by removing the operator from drum handling. A CCO PAD Dose Model report was issued in May 2023 (Ref. 4) which calculates the dose savings to the Operation Crews when comparing palletizing containers to automation with rack storage. Substantial dose reduction (~60%) will be realized by operational workers on the CCO Pad when automation has been deployed.

Schedule

The AGV has been manufactured and will be shipped to Savannah River site in the summer of 2023. Site testing will commence in 2024 with the anticipation for facility operation to begin in Fiscal Year 2026.

TECHNOLOGY DEVELOPMENT APPROACH

A systematic approach must be utilized to execute the Six Year Plan. Additional technologies must be analyzed and developed to augment an overall Technology Implementation Plan for facilities. Commercial technologies and platforms must continuously 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.

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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3. White Paper, *"Strategic Plan to Improve CCO Pad Storage Capacity through Horizontal Rack Storage by 6/30/23" rev 1.*, R. Koenig, October 6, 2020.

4. SRNS-E1620-2023-00010, Rev.0, *SMG KAC CCO PAD Dose Model – Scenario 1 & 2*, Jared Corbett, May 2, 2023.