



# Federal Remediation Technologies Roundtable (FRTR) May 21, 2024 - Meeting

## Robotics, Digitalization in Decommissioning, and AI

**Leonel Lagos, PhD, PMP®**

**Director of Research/Associate Professor  
Florida International University**



Applied  
Research  
Center





## Florida International University

A vibrant, 58,000 student-centered public research university located in Miami, Florida.

Among the largest Hispanic-serving institutions in the U.S. and is designated a Minority-Serving Institution.

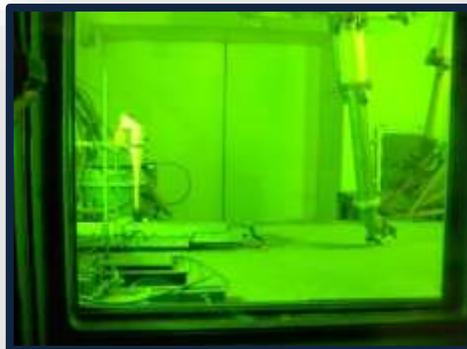
As a top-tier research institution, research is a major component in FIU mission.





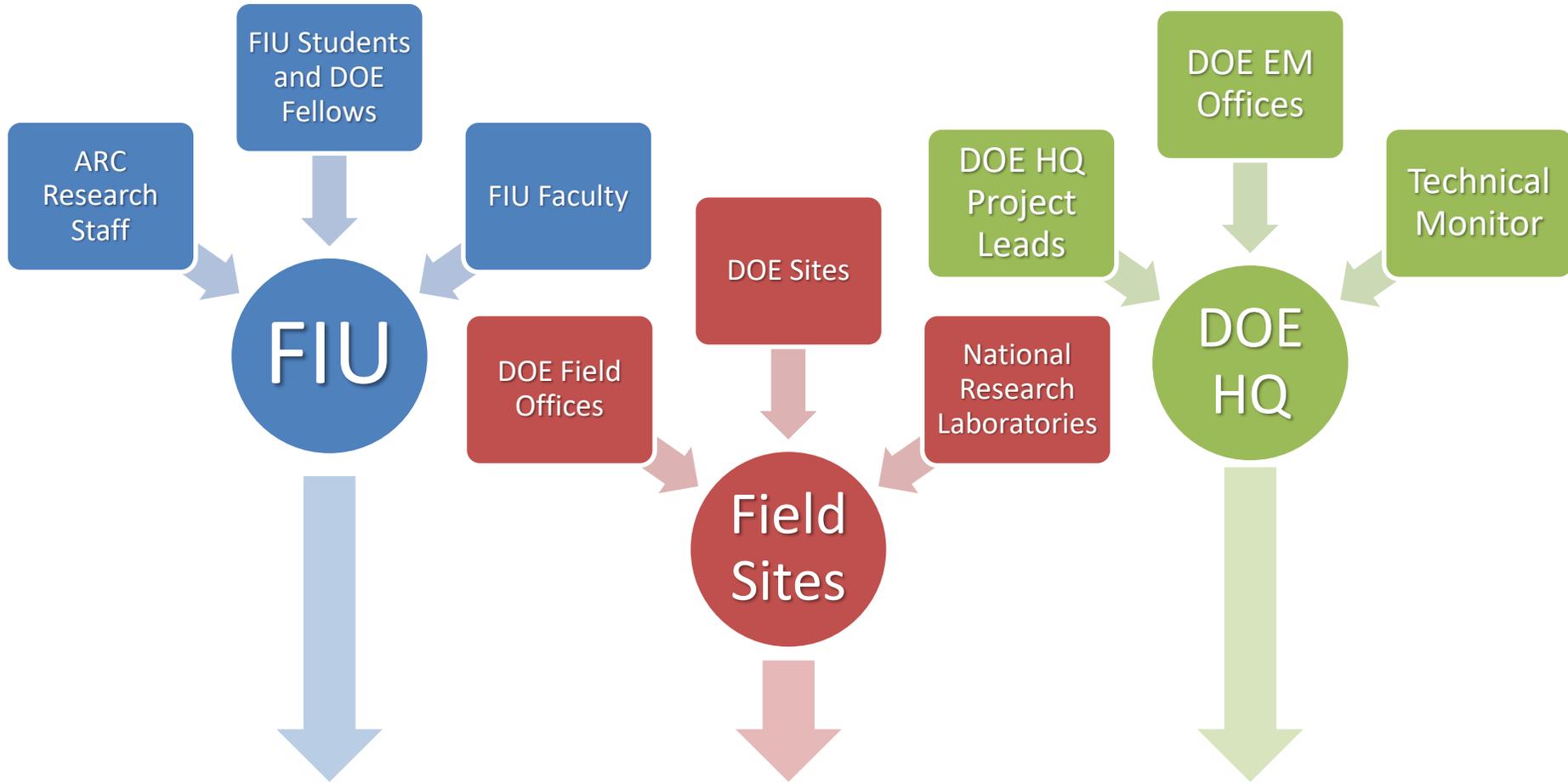
DOE's Environmental Restoration Mission:  
DOE Office of Environmental Management has over 30 years managing and directing the cleanup of contaminated nuclear facilities across the United States due to the legacy of R&D and production of nuclear weapons (i.e. Nuclear Weapons Complex)

DOE Office of Legacy Management is committed to fulfilling DOE's post-closure responsibilities and ensuring the future protection of human health and the environment





# Cooperative Agreement Team



**DOE-FIU Cooperative Agreement**

## Technology Roadmap

2020

2021

2022

2023

2024

Tank Farm  
Hanford



Minirover

In-house Deployment

Site Deployment

Site Deployment

Technology Transferred



UT Rover

Conceptual Design

Evaluation

In-house Deployment

Site Deployment



Lateral Gamma

Integration

Cold Test Facility Deployment

Site Deployment



Off-Riser Sampler

Conceptual Design/Integration

Cold Test Facility Deployment

Site Deployment



Long-Term Surveillance

Conceptual Design

Sensor Integration

Evaluation

In-house Deployment

Site Deployment

H Canyon  
SRNL



Wall Crawler

Conceptual Design

Sensor Integration

Evaluation

In-house Deployment

Site Deployment

WIPP  
MSIPP



Salt Closure Inspection

Evaluation

In-house Deployment

Site Deployment

Rifle Cell  
LM



Aerial Lidar

Evaluation

Site Deployment



Ground Radar

Evaluation

Integration

Site Deployment

Wearable  
SANDIA



Exoskeleton

Conceptual Design

Integration

In-house Deployment

Site Deployment



# Facilitating “Full Deployment” and Technology Transfer to the End User



- Extensive test/evaluation and cold test in-house (FIU) before deployment
- Test/Evaluation of technologies in cold or hot environments at DOE facilities
- Facilitate the introduction and transition of technologies to end users
- Training of operators
- Training of STEM students





# Hanford's Tank Farm



**177** TOTAL  
TANKS

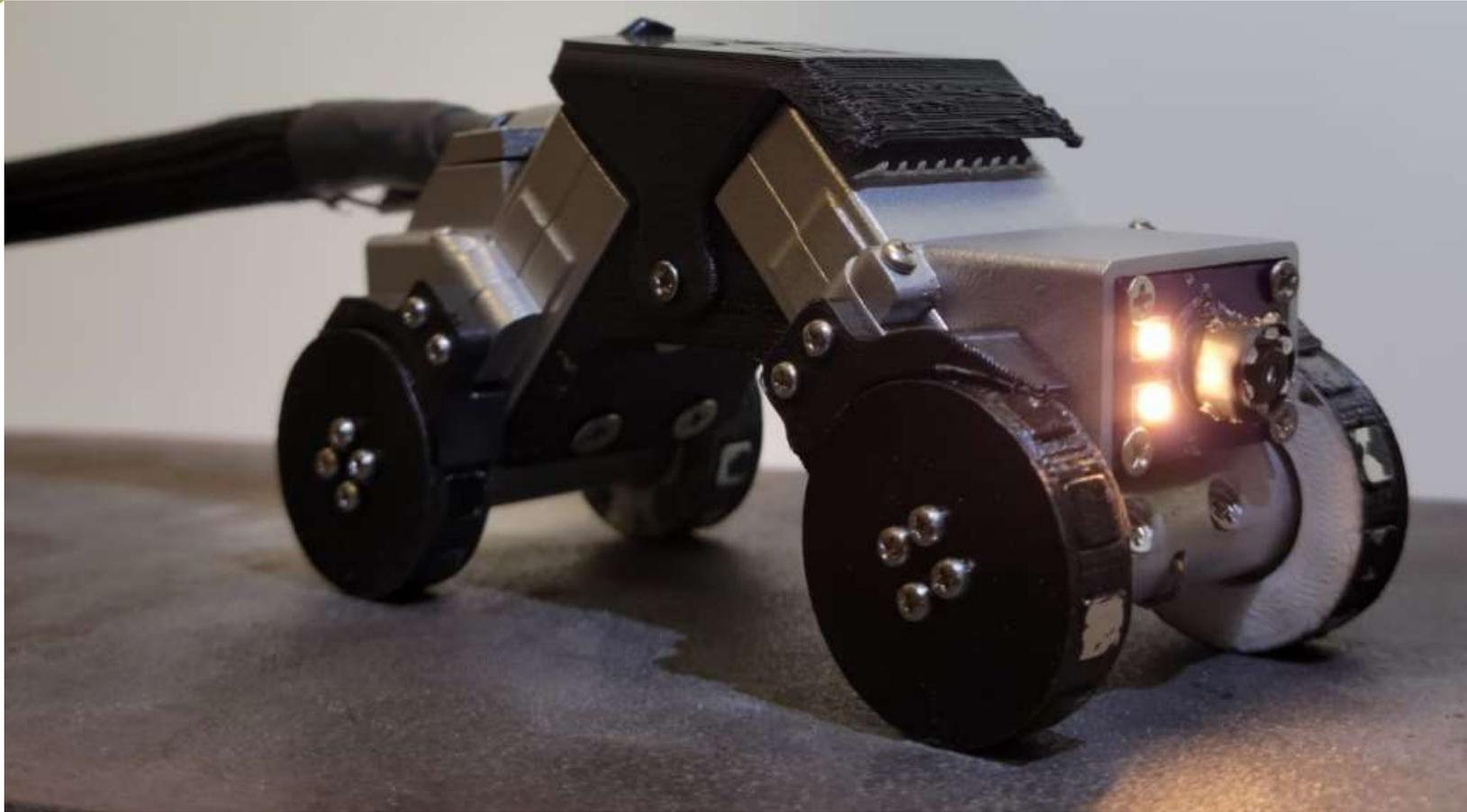
**149** SINGLE-SHELL TANKS  
Constructed 1943-1964

**28** DOUBLE-SHELL TANKS  
Constructed 1968-1986

Hanford site has 56 million gallons of radioactive waste left from the past production of nuclear weapons. The HLW is being stored in underground tanks



# Miniature Rover Inspection Tool for DST Inspections



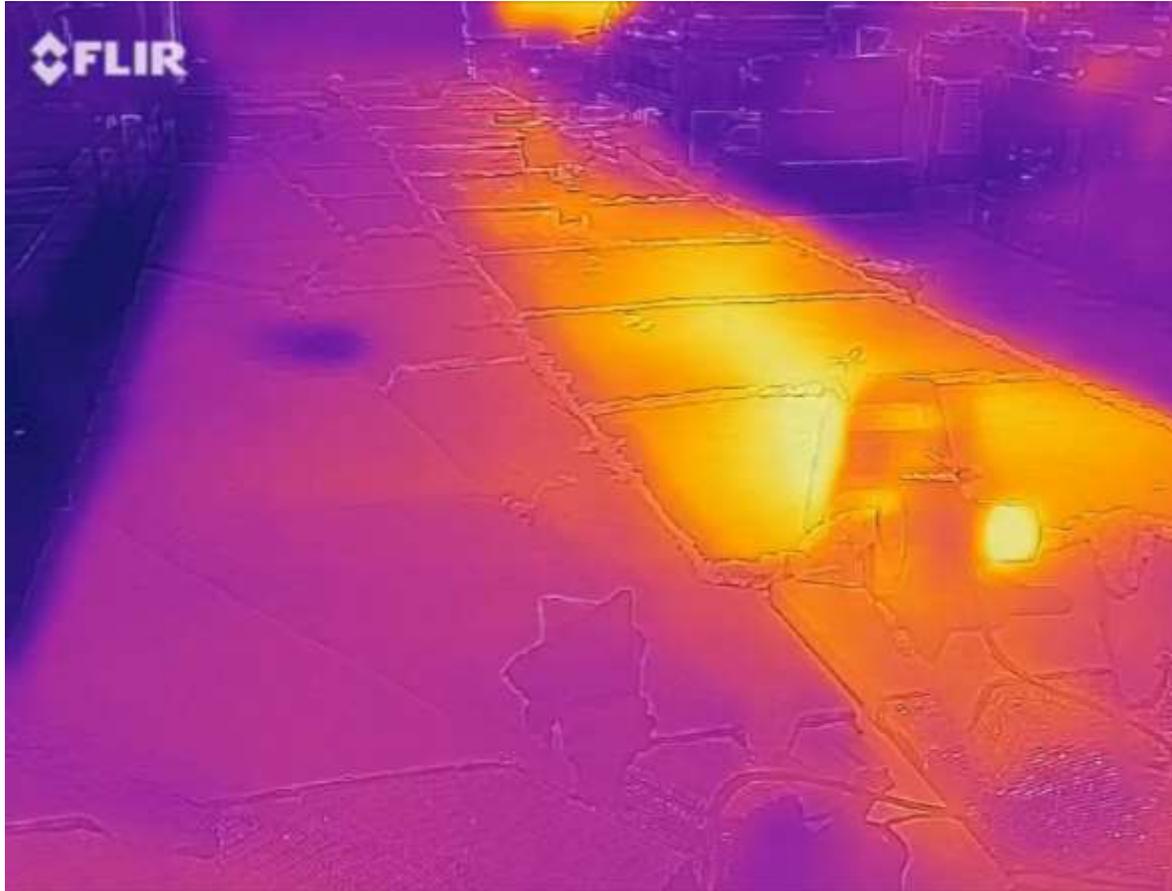
Aluminum 3D Printed Body  
Patented Flexible Chassis

Control Box  
Game Controller





# FIU Test Bed – Hanford Double Shell Tank



Traversing weld seams  
Elevated Temperatures  
Corroded Surfaces

Extensive in-house testing duplicating DOE site conditions



# WRPS's Cold Test Facility Training – March 2022





# AP-105 Double Shell Tank Deployment – March 2022





# Single Shell Tanks Applications WRPS Cold Test Facility Deployment

FIU Applied  
Research  
Center

Applied Research  
Center





# Lateral Gamma Scanner Pipe Crawler Cold Test Deployment – WRPS Cold Test Facility – Summer 2023



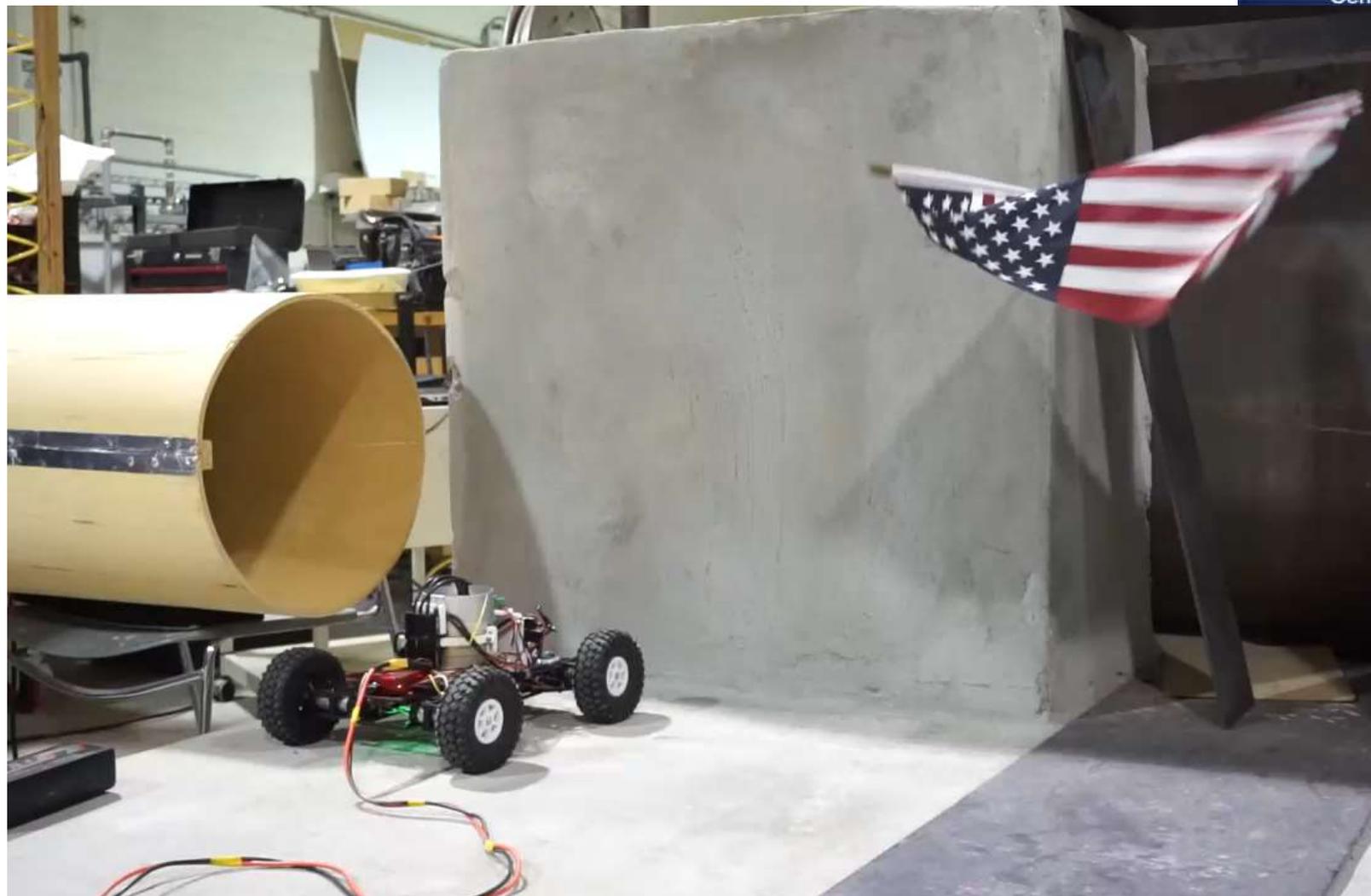
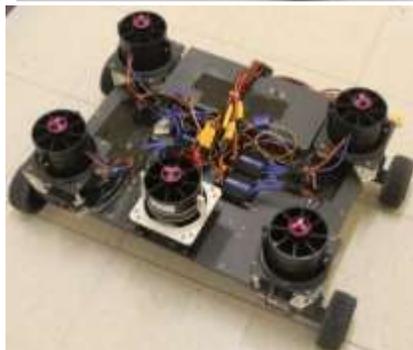
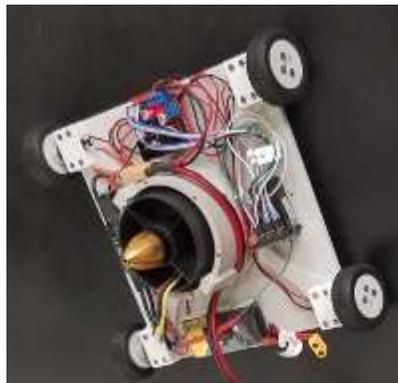


# SRS H-Canyon Concrete Wall Repair





# H-Canyon Concrete Wall Repair Prototype





# Deployment of Robotic Platform Integrated with a Ground Penetrating Radar – LM Mexican Hat Disposal Cell, Utah





# Deployment of Robotic Platform Integrated with a Ground Penetrating Radar – Carlsbad New Mexico





# Digitalization in Decommissioning

- Facilitates virtual walk downs by developing 3D models and digital environments (Digital Twins)
- Supports the development of VR/AR for training
- Supports the various stages of decommissioning (characterization, inventory, decontamination, size reductions, waste management and disposal)
- Trimble X7 3D LiDAR (Light Detection and Ranging) use to develop high quality 3D point cloud scans using laser beams
- The SPOT robot used to navigate indoor/outdoor environments
- Kromek Sigma 25/50 Gamma detector
- Data post-processed by using various software tools (i.e. AutoDesk ReCap, SCENE “video Pro)





# Digitalization of Decommissioning with SPOT/Trimble X7

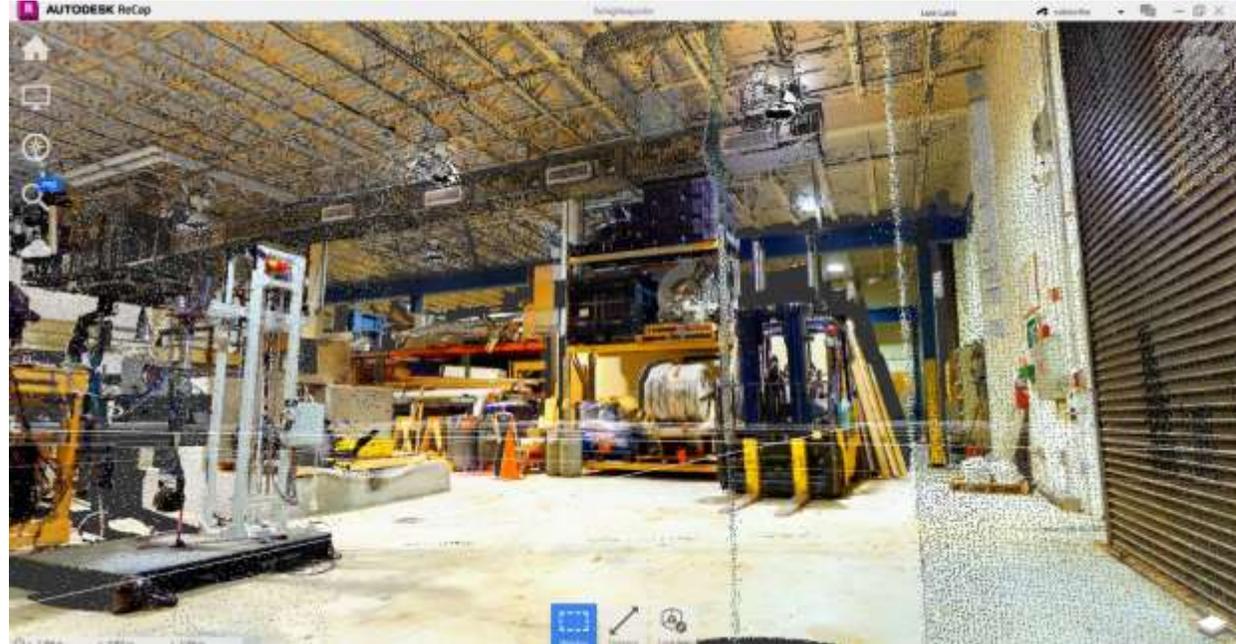


- High-quality detailed scans produced with Trimble X7 (LiDAR fixed in place during scanning)
- SPOT integration allows for autonomous navigation through the facilities
- Focus will be on implementing sequential stops during SPOT deployment for Trimble X7 to activate and scan





# 3D Laser Scanning of ARC's High Bay Facility





# Digital Facility Walk Downs



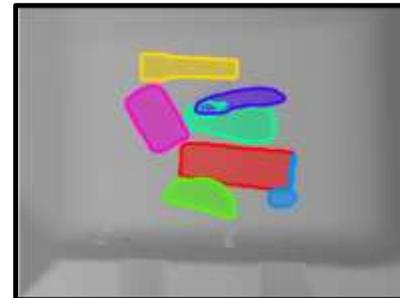
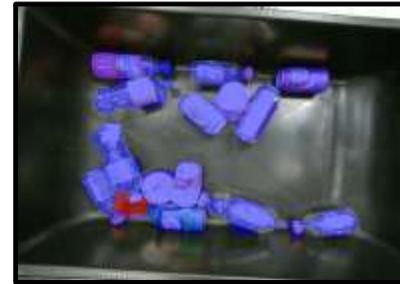
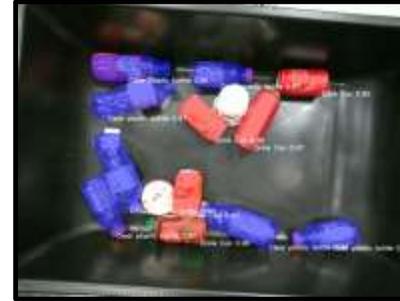
Courtesy of Nucleco (Italy) and IAEA: Laser Scanner "Faro S150 + and SCENE "video Pro"



# Nuclear Waste Identification, Classification and Segregation using Computer Vision and Robotics Arm



- Implemented multiple algorithms for object detection and related tasks such as YOLOv7 (Object Detection & Instance Segmentation), STEGO (Unsupervised Semantic Segmentation)
- The segmentation model developed recognizes and provides polygons of objects seen through images via an array of pixel coordinates
- A depth camera mounted on the end effector of the robot provides a stream of images and the corresponding depth information
- These images are fed into the model and a Point in Polygon (PIP) algorithm is used to grab all pixel coordinates corresponding to the objects and obtain their depth data in order to construct a 3D Point Cloud



Robotic Arm Segregating the Waste

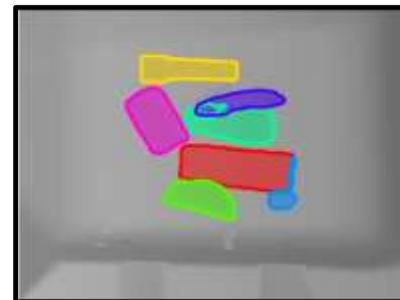
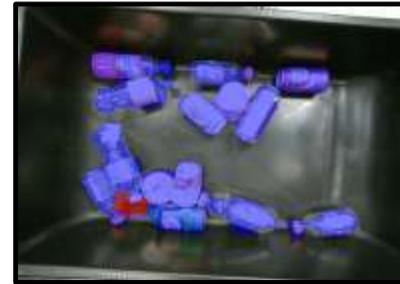
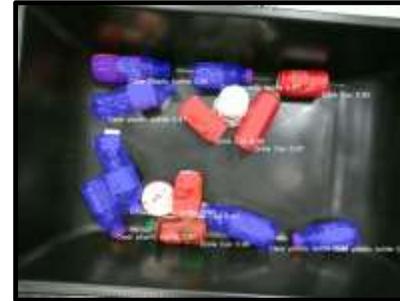


# Nuclear Waste Identification, Classification and Segregation using Computer Vision and Robotics Arm



## Integration to Robotic Arm:

- Robot Operating System 2 (ROS2) is used to publish the arm's joint states and frame of references used to make the cameras point relative to a world frame of reference constructed by the Point Cloud
- Through the use of a behavior tree and inverse kinematics, the arm can move to an identified object, activate gripper or suction (end-of-arm), and place the object in a separate bin based on the object classification
- ROS2 is also used to publish the depth camera information and glue together each component such as the behavior tree and Point Cloud program



Robotic Arm Segregating the Waste



# Robotic Arm Segregating Waste - Demo





# D&D Knowledge Management Information Tool (KMIT) <https://dndkm.org>



The screenshot shows the homepage of the D&D KM-IT website. At the top, it says "D&D KM-IT" in large yellow letters, with "Deactivation & Decommissioning Knowledge Management Information Tool" below it. There is a search bar with the text "Search the D&D KM-IT" and a "Search" button. A mobile link "Mobile: m.dndkm.org" is also present. Navigation tabs include "Home", "Contribute", "About", and "Contact". A "Welcome Guest" message and a "Login" button are on the right. Below this is a large banner with a satellite-style map of the world and the text "Powered by the Global D&D Community". A grid of yellow buttons lists various modules: Hotline, Technology, Web Crawler, Tech Talks, Lessons Learned, Best Practices, Picture Video Library, Document Library, Specialist Directory, Vendors, D&D Research, and Training. Below the grid, there is a registration prompt: "Please register to access all of the features of D&D KM-IT." with buttons for "U.S. Registration" and "International Registration". The bottom section is titled "Additional Features" and contains five feature cards: "D&D RESEARCH" (with a "NEW" tag and "For DOE EM"), "Fixative Module" (with a "See More" link), "ITSR Module" (with a "Summary Report" link), "Search SRS ISSC Reports" (with a "Begin Searching" link and an image of a person in a hazmat suit), and "Prioritization Tool" (with a "Download" link and an image of a computer screen).



# KM-IT Technology Module



Mobile: m.dndkm.org
Search the D&D KM-IT

D&D KM-IT
Deactivation & Decommissioning Knowledge Management Information Tool

Home | Contribute | About | Contact | **More Modules** ▼
Welcome Guest | **Login**

**Technology** | Search | **Advanced Search** | Help

Share page:

Technology > Advanced Search

### Advanced Search Form

Search by: **Technology Category** | Application Category | Vendor

Keyword:       Group:

Demonstrated      Results Per Page:

Category:

Subcategory:

**Advanced Search**

**1 Record found**

### Advance Search Results

**2-D Linear Motion System**

Two-dimensional linear motion systems can be used to semi-robotically operate tools or instruments on surfaces. A two dimensional system, the Pentek, Inc. (Coriapolis, PA) 2-D Wall Walker was demonstr...

[Read More](#)

**Source :** Hanford C-Reactor

**Category :** Characterization > Monitors > Radiation Monitors

**Vendor :** [Pentek, Inc](#)

**Demonstrated**



# KM-IT Technology Module

**D&D KM-IT** Website: m.dnrlm.org

Deactivation & Decommissioning Knowledge Management Information Tool

Home | **Contribute** | About | Contact | **More Modules** ▾

Welcome Guest | **Logout**

**Technology** | Search | Advanced Search | Help

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**Technology Factsheet** | Go to top page |

## 2-D Linear Motion System

Category: Characterization > Monitors > Radiation Monitors  
 Reference #: OST-1475 DOE/EM-0403 Model No.: 2-DLMS

Two-dimensional linear motion systems can be used to semi-robotically operate tools or instruments on surfaces. A two dimensional system, the Pentek, Inc. (Coriapolis, PA) 2-D Wall Walker was demonstrated at the Hanford Demonstration Site C Reactor complex. Such systems are suitable for high flat (or slightly curved) walls. The motor-driven pulleys can be attached to the wall temporarily with magnetic force for steel walls, or with anchors or vacuum force for concrete walls. For locations with no ceiling in the way, the pulleys can be attached to standoffs above the wall, thereby allowing the end effector to reach the full height of the wall. Similarly, if there are no side/call restrictions, the standoffs can be positioned to allow reaching the full wall width. The operator can command the system to traverse any two-dimensional path at constant speeds up to 60 feet per minute. This technology makes it possible to deploy completely automated work modules to large vertical surfaces, while eliminating scaffolding, respiratory protection, and other safety equipment required to protect human workers. Equipment weighs only 55 pounds (20 kg); a single laborer easily handles the operation. Once installed, the initial setup parameters are entered into an IBM-compatible computer via an easy to use touch-screen, and the operator can command the machine to traverse any path at velocities of up to 60 feet per minute (18 M/min). Hands-on operator activities are eliminated, as well as scaffolding, respiratory protection, and other forms of personnel protection and support. Dimensions of Tech Model (L x W x H): Weight of Tech Model (lb.): 350lb Pulley : 50 lb

**Vendor**  
Pentek, Inc.

**Documents**  
 Title: 1475-Linear Motion.pdf  
 (Posted: 09/25/2002)  
 Description: Innovative Technology Summary Report

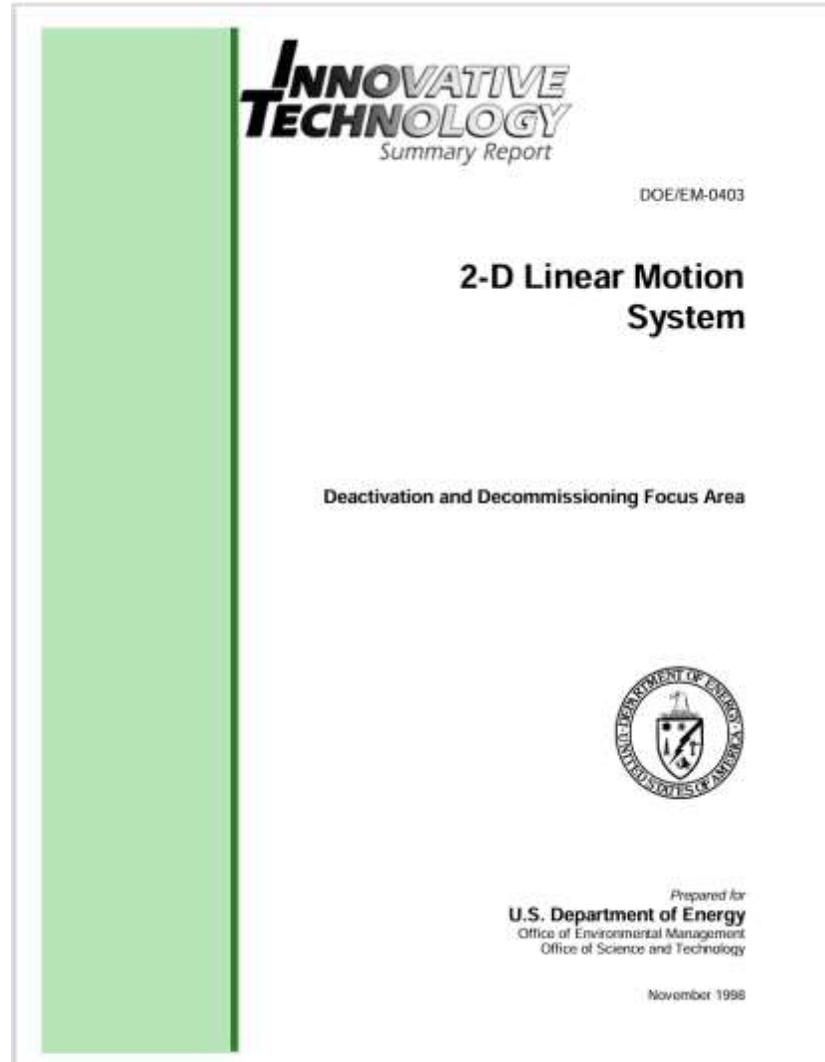
**Demonstrations**  
 Concrete Wall

**Benefits**  
 More accurate and consistent scanning conditions for surveys Improved production rates for large walls Payload capacity at least 300 lb Accurately positions instruments and tools repeatedly Remote operation provides improved ALARA For radiation surveys, the controller software could be adapted to provide maps showing the location of measured radiation levels.

**Limitations**  
 A variety of tool holders need to be developed. Pentek has a few designs completed The technology is not well suited to walls that have many protrusions; rather it works better on flat or slightly curve surfaces Pentek now can apply the technology to floor and ceilings



# Innovative Technology Summary Reports (ITSRs)

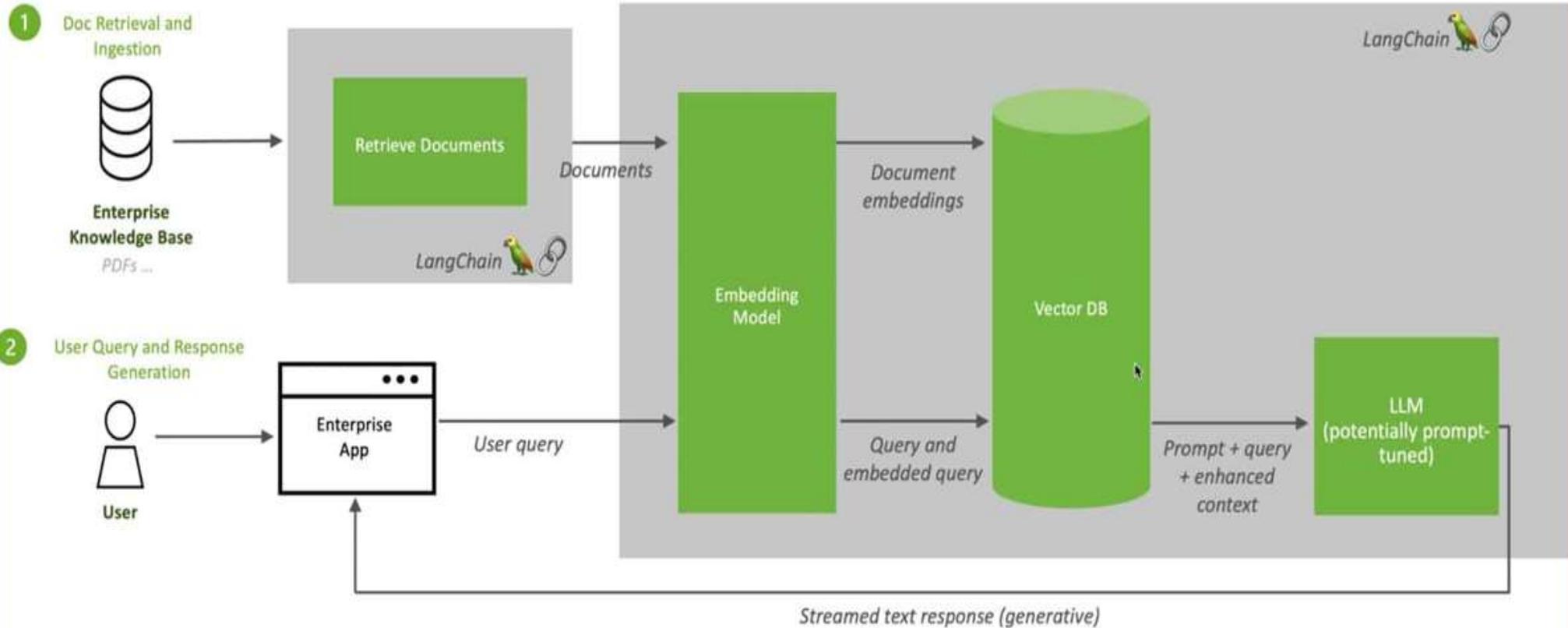




# D&D KMIT Document Summarizer Large Language Model (LLM)



## Retrieval Augmented Generation (RAG) Sequence Diagram





# KM-IT Summarizer Module

## AI OPS

Home

KMIT Summarizer

Chat Bot

KMIT Q&A

Machine Learning

Deep Learning

Generative Ai

Spark Big Data

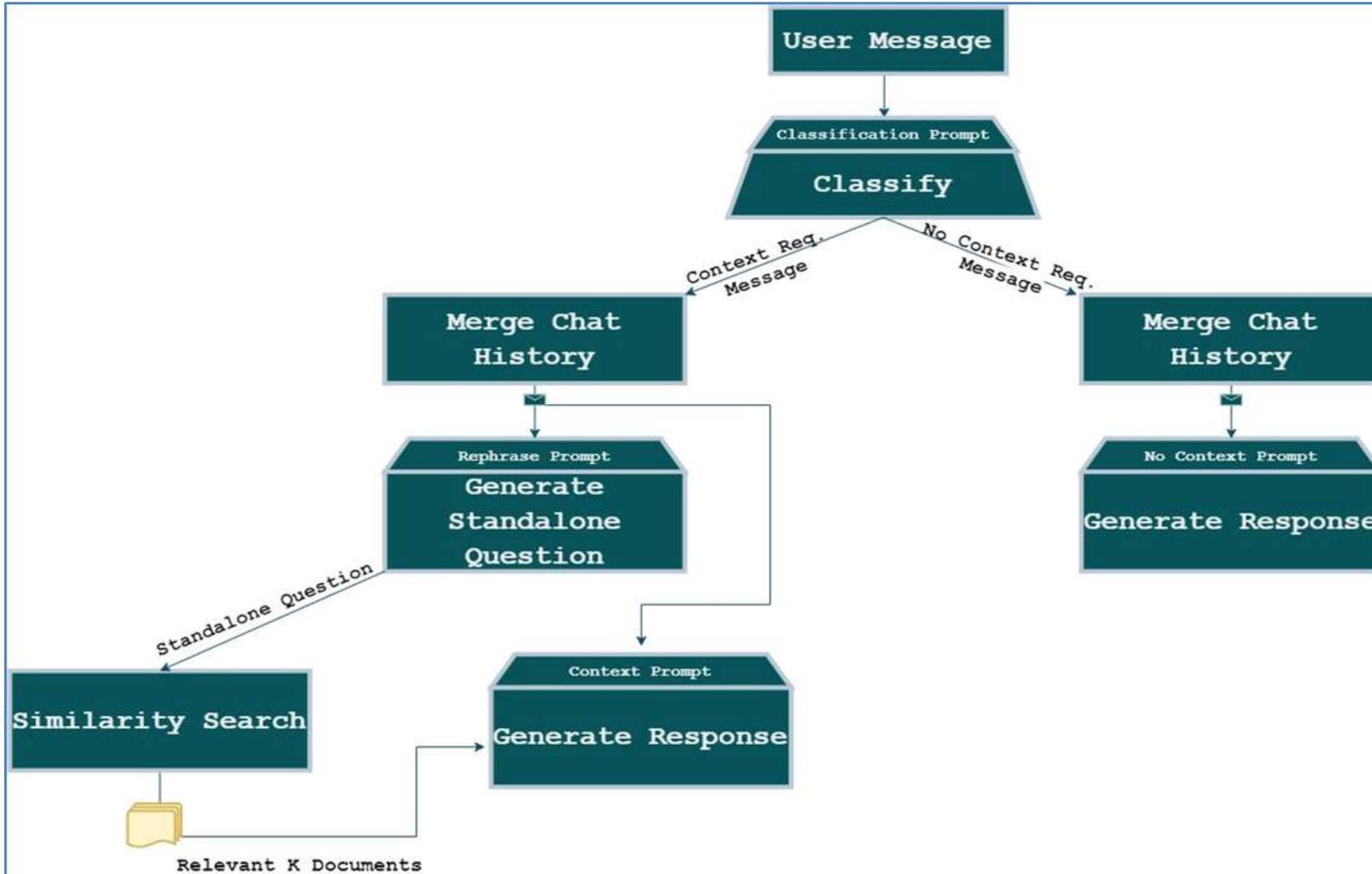
## KMIT Summarizer

Select and Upload File

(<https://aiops.aamls.org/Kmit-Summarizer>)



# KM-IT ChatBot: RAG and LLM Memory





# KM-IT ChatBot Module

## AI OPS

Home

GEN AI OPS

KMIT Summarizer

**KMIT Chat Bot**

KMIT Q&A

DL OPS

Classification

Object Detection

Machine Learning

Spark Big Data

### Chat Bot

Max New Tokens:  Temperature:

Enter your message here...

(<https://aiops.aamls.org/Chat-Bot>)



# Q & A



# Thank You

