FIU Applied Research Center

DOE-FIU Cooperative Agreement Annual Research Review – FIU Year 1

September 14, 2021		
9:00 - 9:05 am EDT	Kick-Off	Kurt Gerdes (Director, Technology Development) – DOE EM-3.2
9:05 - 9:10 am EDT	Welcoming Remarks (DOE-EM)	Nicole Nelson-Jean (Assoc. Principal Deputy Asst. Secretary for Field Ops) – DOE EM-3
9:10 - 9:15 am EDT	Welcoming Remarks (DOE-LM)	Carmelo Melendez (Director, Office of Legacy Management) – DOE LM-1
9:15 - 10:30 am EDT	Projects 4 & 5: STEM Workforce Development and Training	FIU, DOE HQ (EM & LM), SRNL, PNNL, WIPP, SRS, ORP, LBNL, WRPS, INL, Grand Junction
10:30 am - 12:00 pm EDT	Project 1: Chemical Process Alternatives for Radioactive Waste	FIU, DOE HQ, PNNL, WRPS, SRNL, SRS
1:30 - 3:00 pm EDT	Project 3: Waste and D&D Engineering & Technology Development	FIU, DOE HQ, SRNL, PNNL, LBNL, INL, ANL
3:00 - 4:30 pm EDT	Project 2: Environmental Remediation Science & Technology	FIU, DOE HQ, SRNL, PNNL, LANL, ORNL
September 15, 2021		
9:30 - 11:00 am EDT	Wrap Up (FIU Projects 1, 2, 3, 4 & 5)	FIU, DOE HQ (EM & LM)

PROJECT 1

Chemical Process Alternatives for Radioactive Waste

FIU Personnel and Collaborators

Project Manager: Dwayne McDaniel

Faculty/Staff: Amer Awwad, Anthony Abrahao, Aparna Aravelli, Jose Rivera, Shervin Tashakori, Mayren Boan, Mackenson Telusma

DOE Fellows/Students: Jeff Natividad, Daniel Martin, Sebastian Story, Joel Adams, Thi Tran, Brendon Cintas, Josue Martinez, Raymond Piloto ,Aubrey Litzinger, Desmond Sinnott

DOE-EM: Genia McKinley, Pramod Mallick, Robert Seifert, Gary Peterson, Kurt Gerdes

DOE-ORP: Erik Nelson

SRNL: Michael Poirier, Connie Herman, Bruce Wiersma, Jean Plummer, Christine Langdon, Tim Alcott, William Wells

PNNL: Kayte Denslow, Carl Enderlin, Matt Fountain, Matthew Ausmussen

WRPS: Jason Gunter, Kayle Boomer, Glenn Soon, Joe Rice, Alex Pappas

SRS: Jane Carter, Saiying Bowers

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Project Tasks and Scope

Task 17: ADVANCED TOPICS FOR HLW MIXING AND PROCESSES	
Subtask 17.2	Evaluation of Pipeline Flushing Requirements for HLW at Hanford and Savannah River Site
TASK 18: TECHNOLOGY DEVELOPMENT AND INSTRUMENTATION EVALUATION	
Subtask 18.2	Development of Inspection Tools for DST Primary Tanks
Subtask 18.3	Development of a Coating Deployment Platform for the H-Canyon Exhaust Tunnel
Subtask 18.4	Long-Term Surveillance of Nuclear Facilities and Repositories using Mobile Systems **(NEW)**
TASK 19: PIPELINE INTEGRITY AND ANALYSIS	
Subtask 19.1	Pipeline Corrosion and Erosion Evaluation
Subtask 19.2	Evaluation of Nonmetallic Components in the Waste Transfer System
TASK 20: CORROSION PROTECTION AND CHARACTERIZATION OF EM INFRASTRUCTURE	
Subtask 20.1	Evaluation of Coatings for the H-Canyon Exhaust Tunnel
Subtask 20.2	Corrosion Evaluation of Steel Canisters for Hanford Integrated Disposal Facility **(NEW)**

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Task 17

Advanced Topics for HLW Mixing and Processes

Subtask 17.1: Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River Site

Site Needs:

- The Defense Nuclear Facilities Safety Board (DNFSB) has indicated a need for vigorous investigation on the technical basis for prescribing flush velocity in pipelines regarding the slurry transport and flushing strategies at Savannah River Site and at Hanford.
- Further tests that investigate optimal conditions assisting the US DOE in waste remediation, preservation of tank storage, prevent additional waste creation, and processing.

Objectives:

- Conduct tests using a 165-foot, 3-inch carbon steel experimental pipe loop to investigate parameters that affect efficiency of flushing operations at various solid concentrations of kaolin and flush modes (fully-flooded, gravity-drained sediment conditions and continuous and pulsation flush velocity).
- The loop can be expanded to lengths ranging from 165-feet to 825-feet to study the effects of pipe length on flush efficiency.

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Subtask 17.1: Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River Site

FIU Year 1 Research Highlights & Accomplishments:

- Testing completed for 165-ft experimental loop
  - Fully-flooded, one day sedimentation, 10, 15 and 20% kaolin
  - Gravity-drained, one day sedimentation, 10, 15 and 20% kaolin
  - 15% gravity-drained, one week and two week sedimentation
  - 15% gravity-drained one day pulsation
- 1.0-1.2 FTLV values obtained for all completed trials

	Fully-flooded	Gravity-drained
10%	1.09	1.17
15%	1.05	1.11
20%	1.09	1.17

Settlement Time	FTLV
One Day	1.11
Pulsation	1.17
1 Week	1.08
2 Weeks	1.10

Subtask 17.1: Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River Site

FIU Year 1 Research Highlights & Accomplishments:

- Extension of experimental loop to 330-ft
  - Land cleared for extension
  - Procurement of materials for 330-ft extension
    - 8x 20’ Sch40 steel pipes (total 168 ft)
    - 8x galvanized malleable unions
    - 18 UniStrut support structures
  - Layout of extended section of loop
  - Procurement of new data acquisition equipment

Subtask 17.1: Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River Site

FIU Year 2 Projected Scope

- Test and commission the loop extended to 330 ft
- Repeat the Test Plan developed for the 165 ft loop
- Analyze the data to determine the effects of pipe length of FTLV ratios
- Develop a CFD model that will be validated with the experimental data and can ultimately be used to evaluate the effects of pipeline geometry on FTLV ratios

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Task 18

Technology Development and Instrumentation Evaluation

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Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

Site Needs:

In 2012, tank waste was found in the annulus of AY-102. In addition, thinning (up to 70%) of the secondary liner in the annulus region has also been observed in other double shell tanks (DSTs). Understanding of the structural integrity of all DSTs at Hanford is of paramount importance - thus, the significant need for development of tools/sensors that can provide information regarding the health of the tanks.

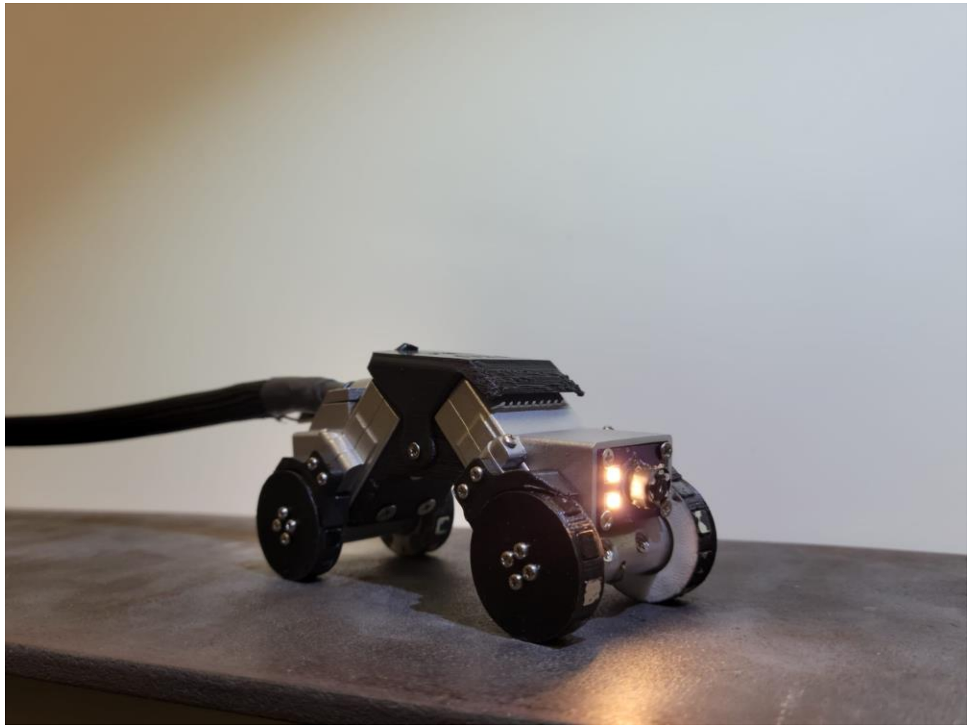
Objectives:

Develop cost effective inspection tools that can travel through the refractory pad air channels underneath the primary liner and the drain line channels underneath the secondary liner and provide information regarding the health of the tanks.

Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

FIU Year 1 Research Highlights & Accomplishments:

Initial testing in the DSTs identified areas for improvement – including a flexible chassis for weld seam traversal and a rust removal systems for rust accumulation on the magnetic wheels.



Mini Rover is capable of traversing the refractory slots of Hanford's DST while providing video feed back to the operator.

The Mini Rover control and accessory box provides the tools needed for operation. On the left is the 200' tether along with joystick and on the right is the control box with the video capture/storage device and control unit.

Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

FIU Year 1 Research Highlights & Accomplishments:

Utilization of scoops on each wheel to redirect the corrosive/magnetic material away from the magnets.

Mini Rover traversing over an oblique angle obstruction.

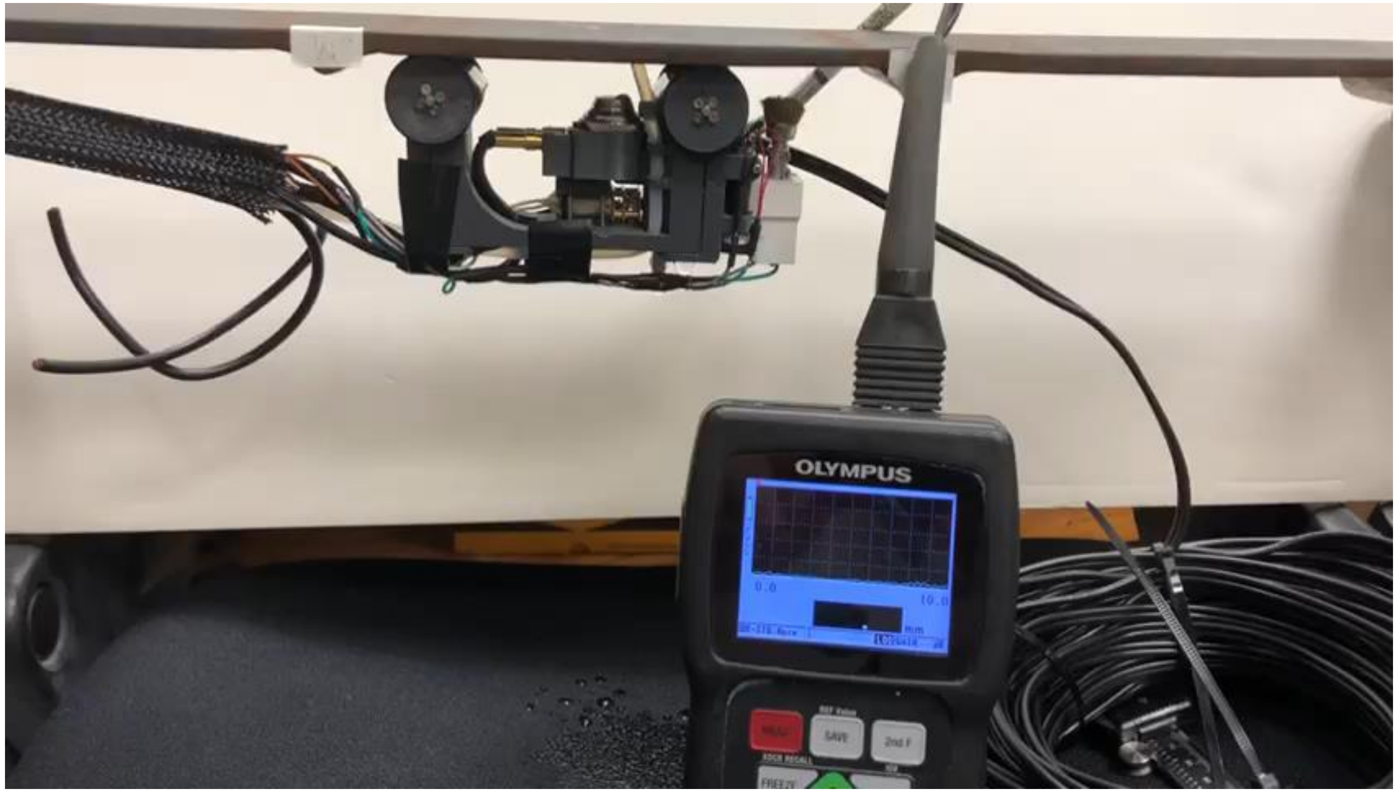
FIU Year 1 Research Highlights & Accomplishments:

UT Rover

- Developed based on the design of the current Mini Rover system

- Includes a UT sensor for point thickness measurements.

- Incorporates a cleaning mechanism to prep the surface and uses water as a couplant for the sensor.



Subtask 18.2: Development of Inspection Tools for DST Secondary Shell

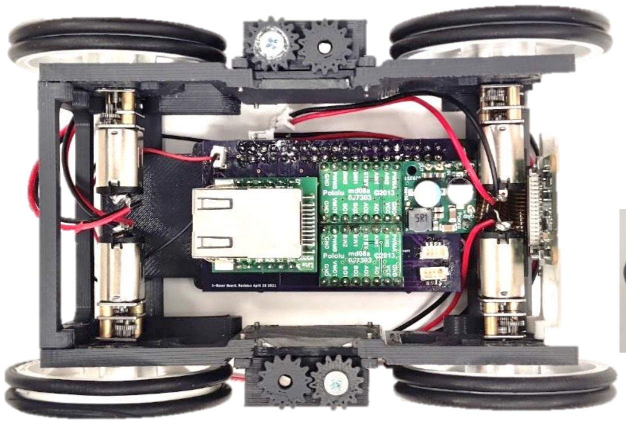
FIU Year 1 Research Highlights & Accomplishments:

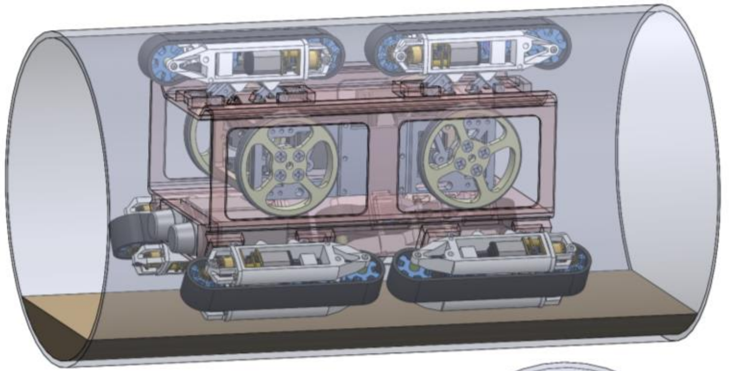
Inspection rover

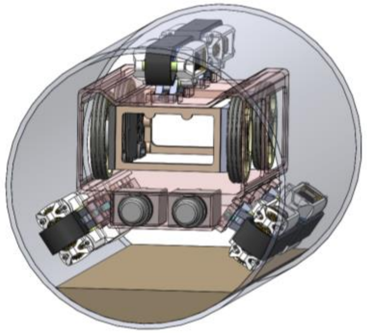
- Functional prototype built
- Embedded electronics integrated

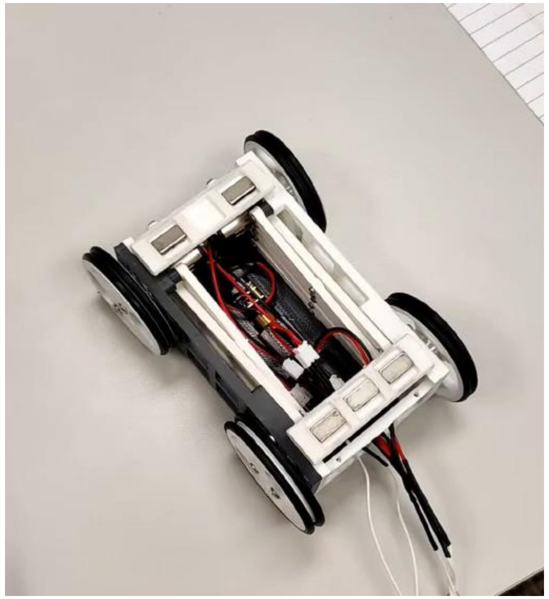
Marsupial Delivery crawler

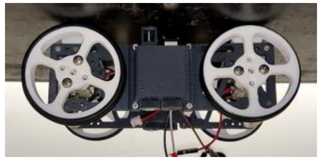
- Electric conceptual redesign finalized
- Deployment ramp designed
- Detachment mechanism built

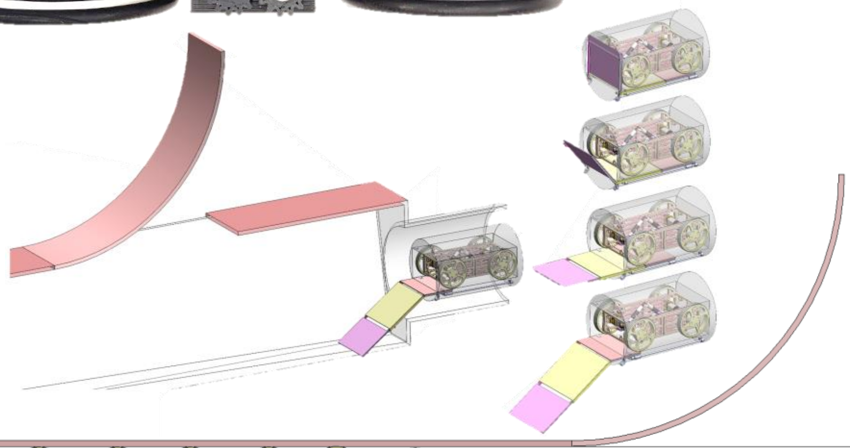


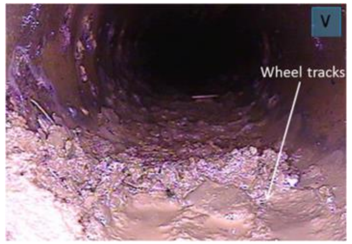


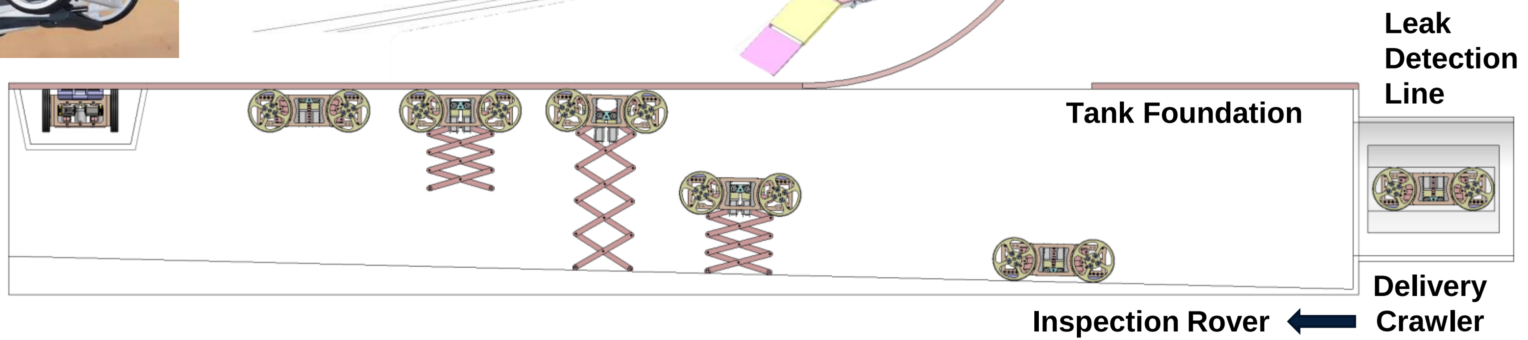












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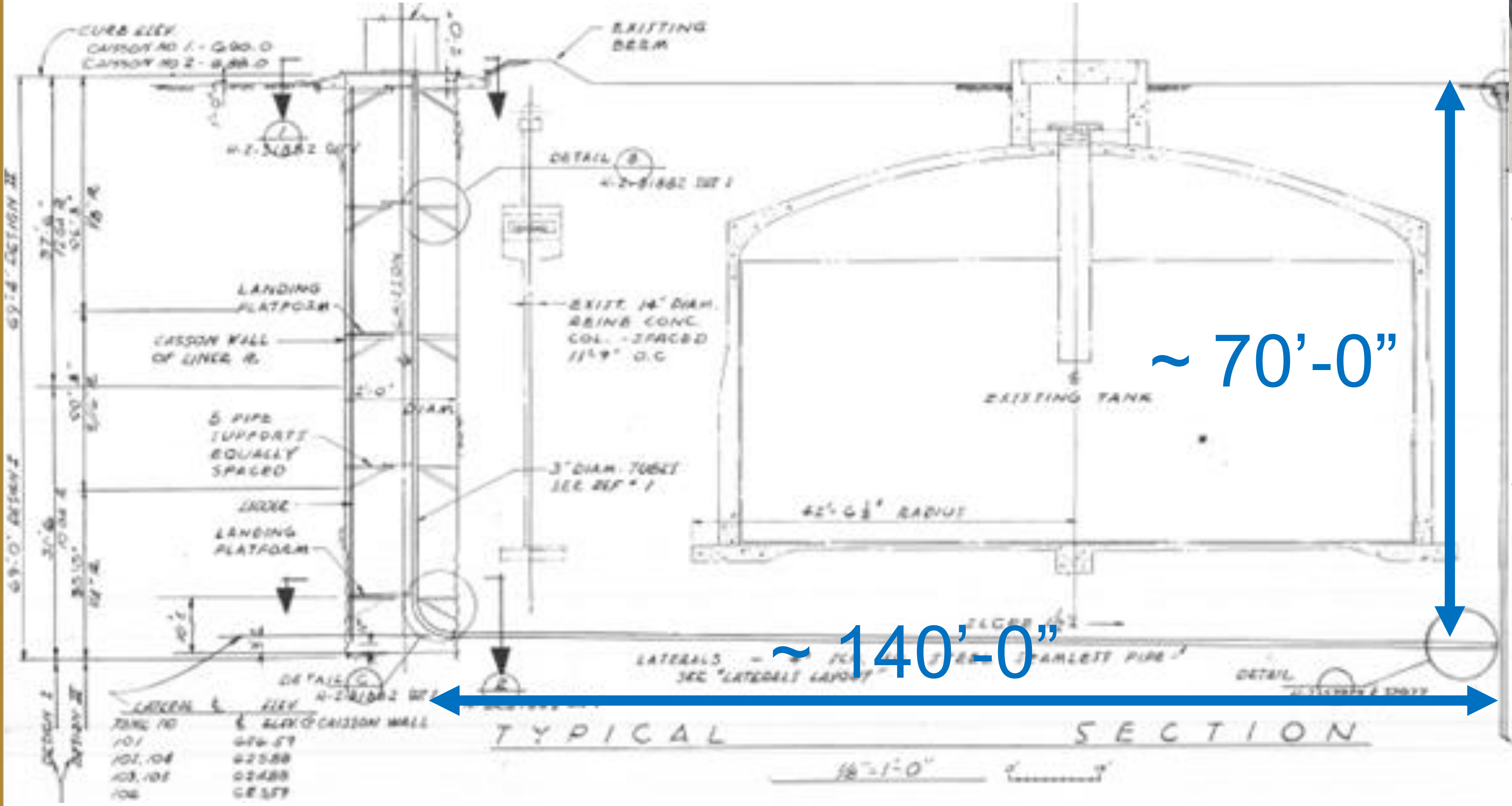
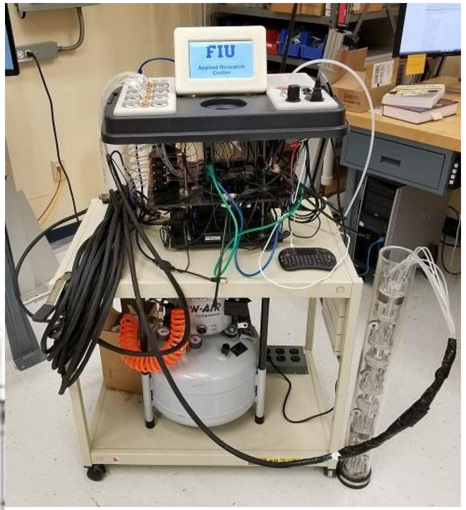
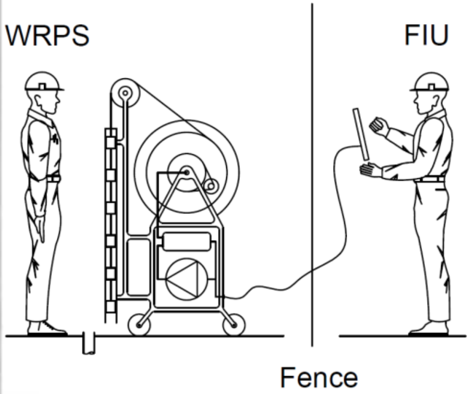
Subtask 18.2: Development of Gamma Scanner for SST Laterals

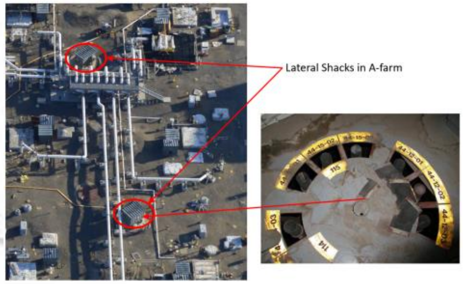
Site Needs:

Gamma survey and visual inspections of Hanford's single shell tanks laterals retrofitting FIU's pneumatic pipe crawler.









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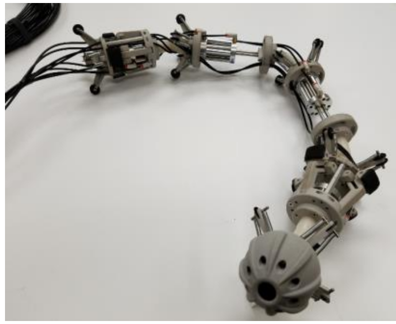
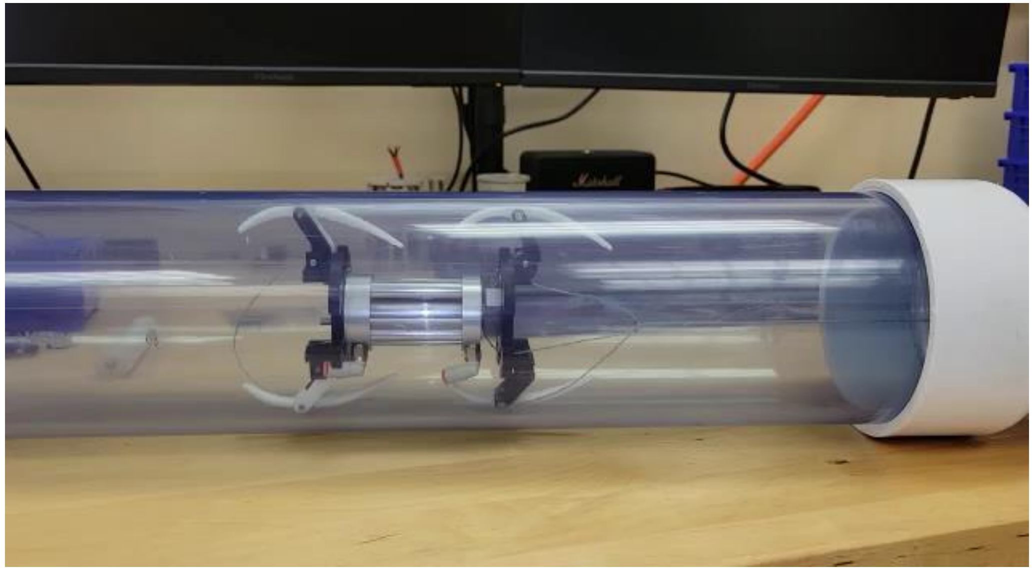
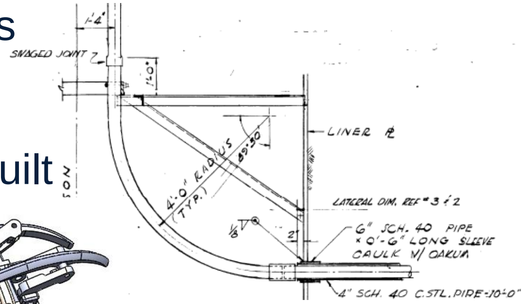
Subtask 18.2: Development of Gamma Scanner for SST Laterals

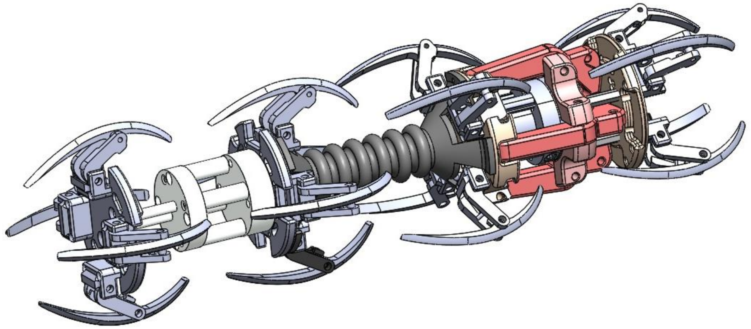
FIU Year 1 Research Highlights & Accomplishments:

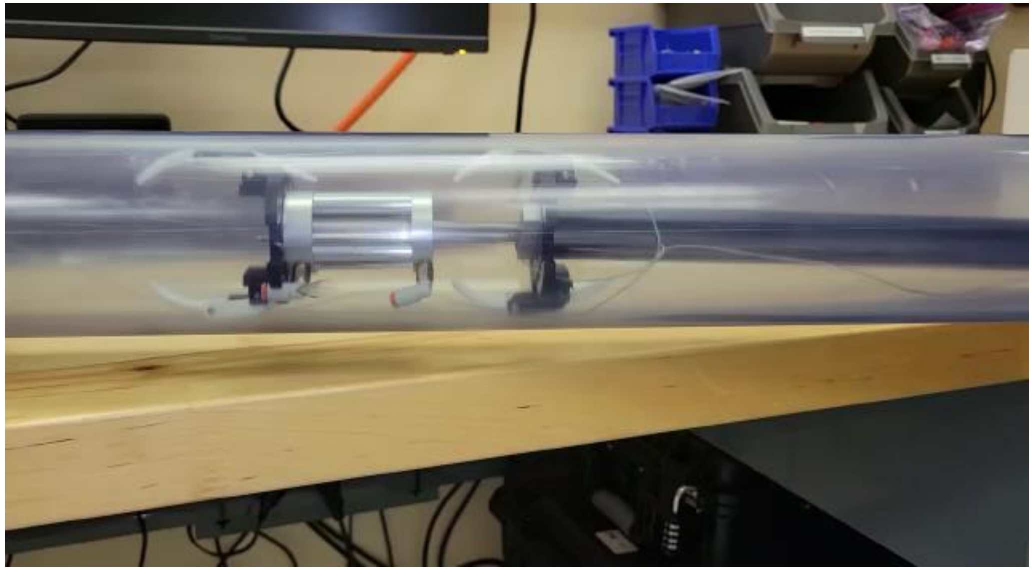
Pipe Crawler
- Design reviewed and improved

Embedded Electronics
- Camera upgraded
- Embedded computer integrated
- IMU integrated to modules

Mockup and Testing
- Full scale designed and built



Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

FIU Year 2 Projected Scope

- Mini Rover
  - Currently being scheduled for re-deployment at Hanford to aid in DST visual inspections early next fiscal year.
- UT Rover
  - Develop a test plan to evaluate the rovers durability, ability to traverse over weld seams and corrosion and remove in case of emergency.
  - Execute test plan in DST mock up at FIU
- SST Pipe Crawler
  - Complete modifications to 3 and 4 inch pipe crawler and test in mock up at FIU
  - Evaluate system at Hanford
  - Incorporate gamma radiation sensor into crawler and develop an automated deployment system
- DST Secondary Liner Inspection Tool
  - Complete modifications to system and test in FIU DST mock up

Subtask 18.3: Development of a Coating Deployment Platform for the H-Canyon Exhaust Tunnel

Site Needs:

Visual inspections of the H-Canyon exhaust (HCAEX) tunnel showed degradation of the concrete walls. Also, a recent tunnel fragility analysis identified safety issues of the affected concrete regarding their strength.

The identification, evaluation and application of protective coatings to prevent further degradation of the concrete walls is needed to mitigate the damage.

Tunnel view

Degraded concrete exposing the steel rebar (red arrows).

Objectives:

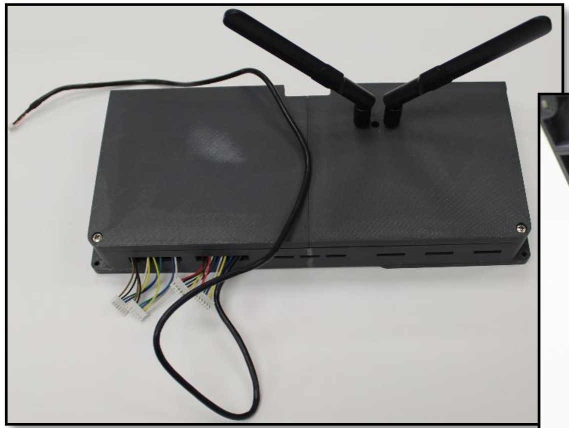
Develop a robotic platform that can navigate on the tunnel walls and apply protective coatings using an integrated coating application system.

Subtask 18.3: Development of a Coating Deployment Platform for the H-Canyon Exhaust Tunnel

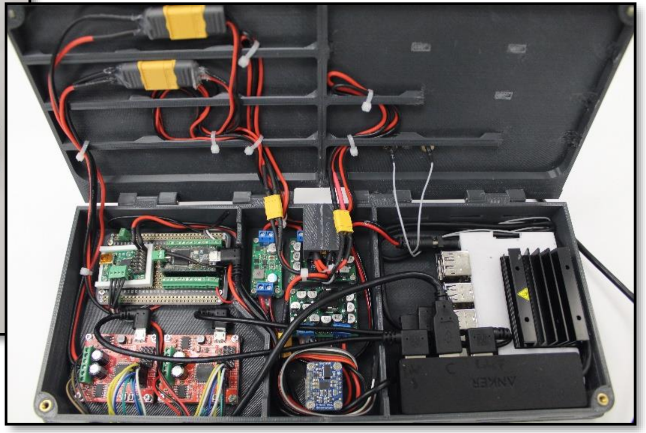
FIU Year 1 Research Highlights & Accomplishments:

Control Unit

- Control box developed which is designed to operate on multiple platform designs
- Wired or wireless communication setup
- Multiple step-down voltage regulators to distribute power to critical components for basic operation
- IMU for orientation measurement



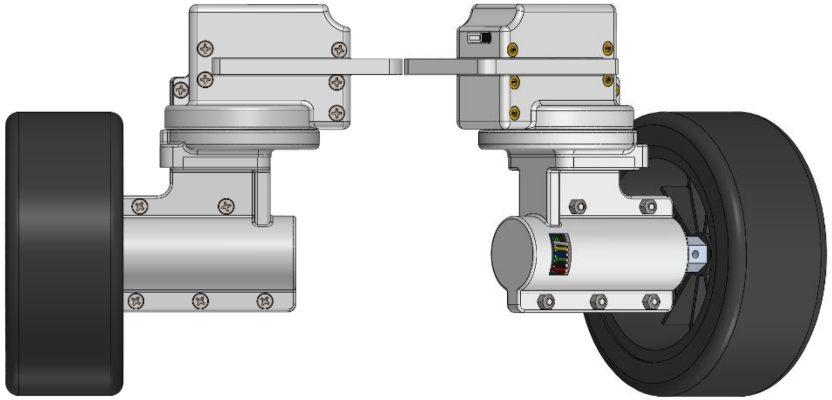
Control box fully assembled and operational



Control box internal view

2 DOF Drive Module

- Drive modules designed to allow omnidirectional movement of platform
- The DC motor enclosure section was shifted outward extending past chassis boundary
- Design reinforces lower section of module against transverse forces acting unit during vertical transition and motion



Updated drive module, lower profile

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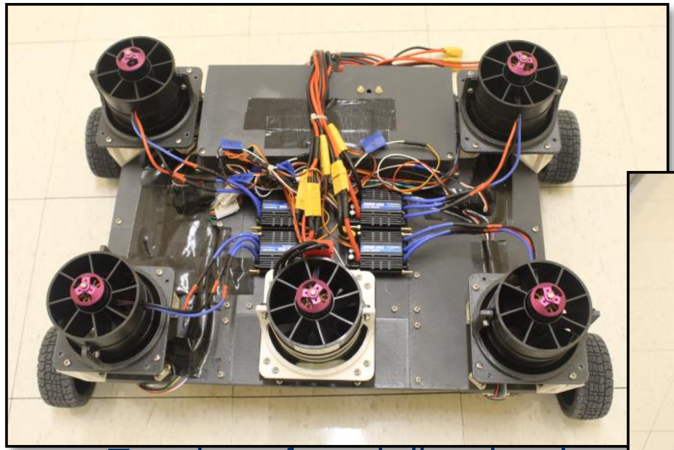
Subtask 18.3: Development of a Coating Deployment Platform for the H-Canyon Exhaust Tunnel

FIU Year 1 Research Highlights & Accomplishments:

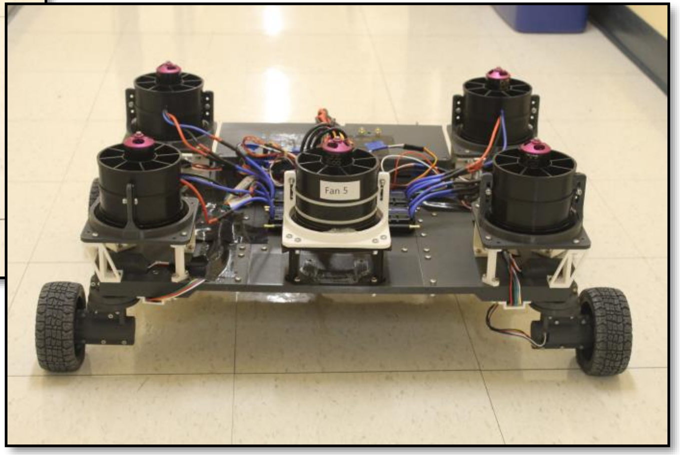
<u>Omnidirectional Wall Crawling Platform</u>

- Wall crawling platform is wheeled based and can generate 22 lbs of thrust via ducted fans surface adhesion
- Platform is capable of front and side transition to vertical plane
- Platform was tested on a concrete wall and was successful in climbing 10-12 feet vertically

Safety harness testing and platform testing



Top view of omni-directional platform



Front view

Successful vertical testing of omni-directional platform

Subtask 18.3: Development of a Coating Deployment Platform for the H-Canyon Exhaust Tunnel

FIU Year 2 Projected Scope

- Develop a carbon fiber chassis to save on weight
- Continue testing and incorporating modifications of current wall crawling platform in order to increase the load capacity
- Integrate sensors for more robust operation and control
- Determine optimal nozzle and configuration after coating selection
- Finalize design and prototyping of coating mechanism – integrate into crawler
- Evaluate coating mechanism with selected coating – validate that the systems meet industry standards

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Subtask 18.4: Long-Term Surveillance of Nuclear Facilities and Repositories using Mobile Systems (NEW)

Site Needs:

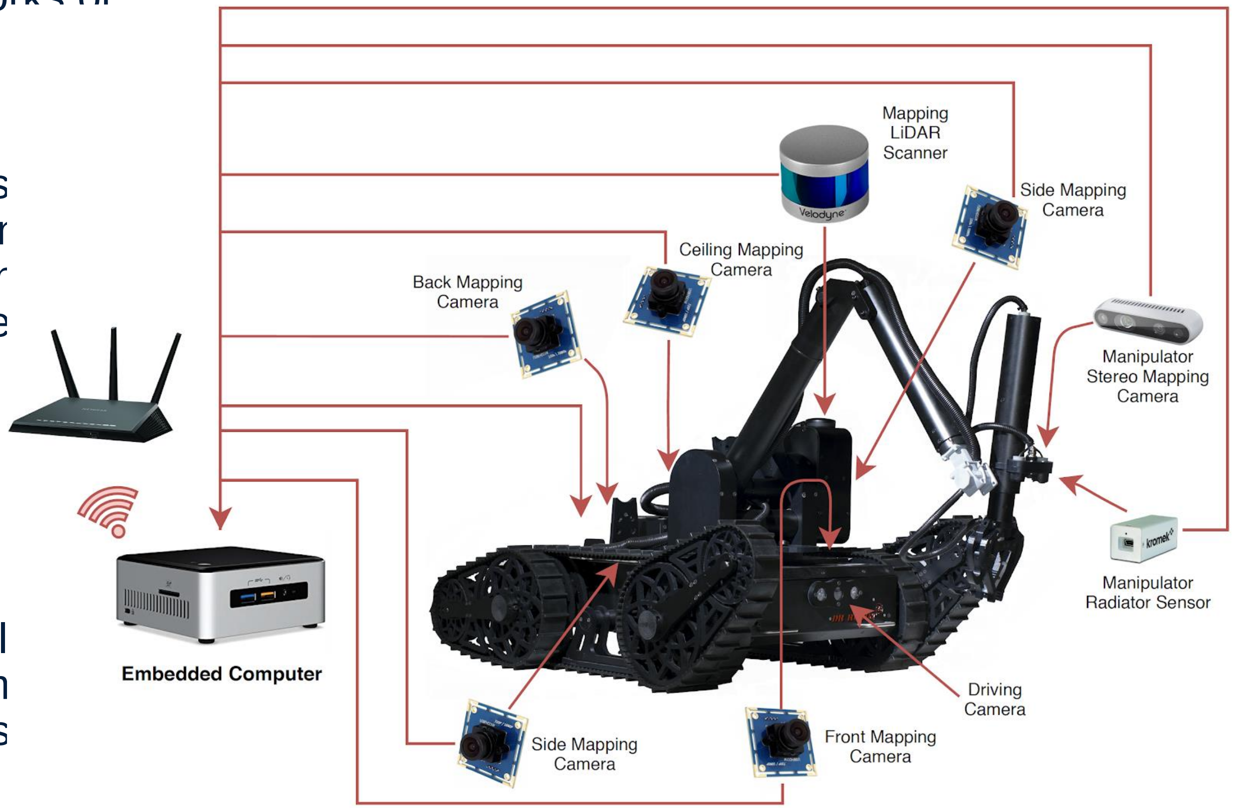
Continuous surveillance of nuclear facilities and repositories is a critical element in successfully controlling and understanding radiological environmental impact, among other hazards, planning cleanup efforts, and meeting quality assurance objectives established by the United States Department of Energy standards and guidelines

Given the large size of many facilities and repositories, coupled with the high cost of radiation sensors and the nature of radiological sources, mobile systems provide a cost-effective solution versus on-site sensor networks or monotonous routine measurements performed by site personnel

Fully autonomous surveillance technologies are us for decision-making because they allow taking mar data and trends into account so that managers car more optimal and safer decisions based on update abundant, and reliable information

Objectives:

Test and customize fully autonomous off-the-shelf multi-use robotics technologies and field deployabl sensory adequate to deploy at Hanford's tank farm automating aboveground routine inspections and s



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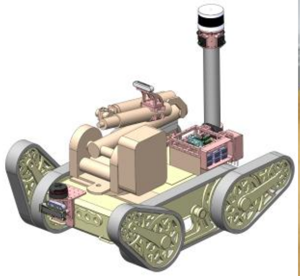
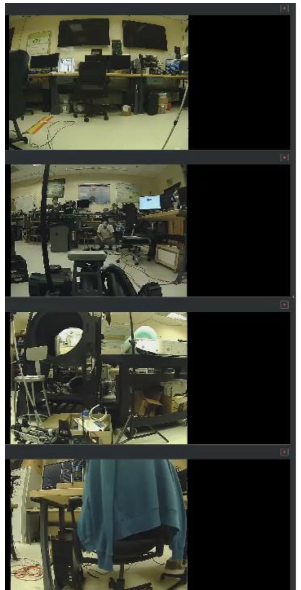
Subtask 18.4: Long-Term Surveillance of Nuclear Facilities and Repositories using Mobile Systems (NEW)

FIU Year 1 Research Highlights & Accomplishments:




- Performed a literature review on relevant topics in autonomous surveillance of nuclear facilities and repositors including
  - radiation mapping, quantification techniques and uncertainty modeling
  - state-of-the-art in sensory and data fusion
  - mapping and localization algorithms
  - open-source risk-awareness and Machine Learning frameworks.



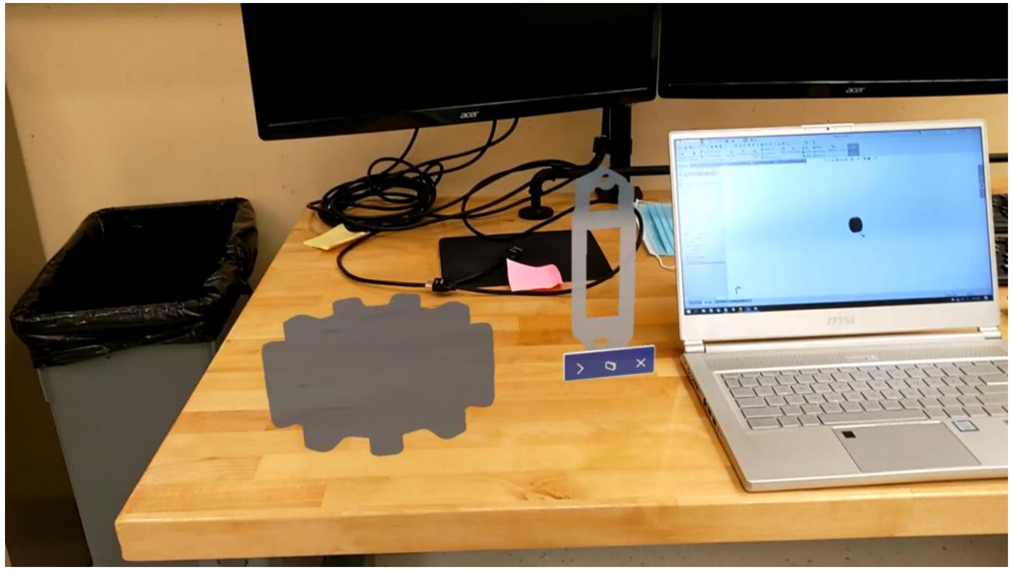
- Implemented a compact synthetic data framework for simulation of radioactive environments for testing autonomous mapping algorithms

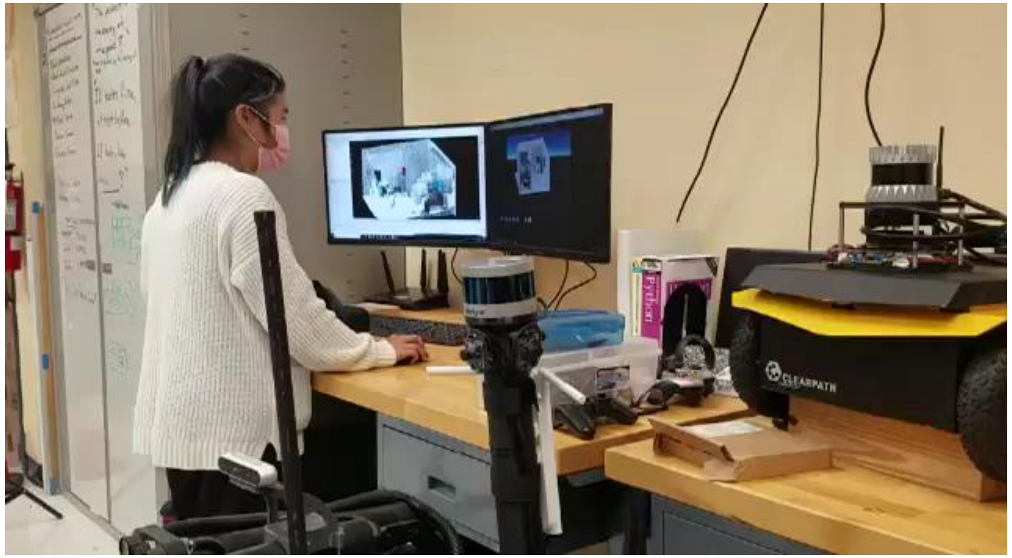
- Customized commercial mobile grounds platforms integrating sensors that create digital twins of facilities fusing data from non-destructive gamma measurements, surrounding imagery, 3D cameras and lidar imagers.

Subtask 18.4: Long-Term Surveillance of Nuclear Facilities and Repositories using Mobile Systems (NEW)

FIU Year 1 Research Highlights & Accomplishments:

- Tested state-of-the-art embedded sensory for mapping, localization and field measurement
- Improved FIU's in-house mapping framework for digital twin capture fusing gamma measurements, surrounding imagery, 3D cameras and lidars.
- Deployed FIU's in-house mapping framework and sensory at Hanford during summer
- Evaluated immersive visualization techniques for digital twin exploration and human-robot interaction including virtual and augmented reality.





Subtask 18.4: Long-Term Surveillance of Nuclear Facilities and Repositories using Mobile Systems (NEW)

FIU Year 2 Projected Scope

- Continue improving FIU's in-house mapping and surveillance framework
- Incorporate higher levels of risk-awareness using object detection and machine learning
- Evaluate and test advanced field sensory for tank farm inspection in coordination with WRPS
- Deploy the improved FIU's mapping framework and sensory package at Hanford during summer
- Extend the FIU's surveillance framework and sensory package to unmanned aerial vehicles and wearables

FIU's aerial lidar system

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Task 19

Pipeline Integrity and Analysis

Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

Site Needs:

- Structural Integrity and life assessment by corrosion and erosion detection in waste tanks and transfer lines.
- Due to uncertainties regarding the structural integrity of pipelines at Hanford, a Fitness-for-Service (FFS) program for the Waste Transfer System has been implemented.
- A direct inspection and assessment of the condition of buried pipelines is required to evaluate the corrosion and erosion wear rates and predict the existing system's remaining useful life.

Objectives:

- Evaluate technologies for real-time thickness measurements, wear rate and leaks in pipes and waste transfer lines.
- Validate flow erosion coupons developed by SRNL for erosion and corrosion detection

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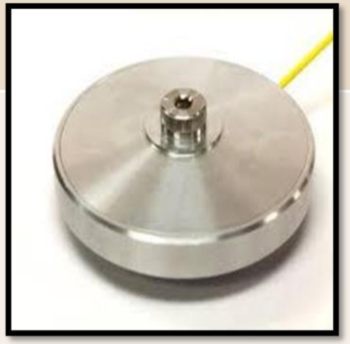
Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

Site	Technology		Benefit
SRNL	**SRNL erosion coupons**		Minute level structural integrity evaluation in pipes and transfer system components (erosion and corrosion)
Hanford	**Fiberoptic Sensors**		Fault and leak detection in waste tanks and transfer systems
Hanford	**Ultrasonic Sensors (Permasense/Emerson Technologies)**		Real-time pipe wall loss detection in waste transfer systems

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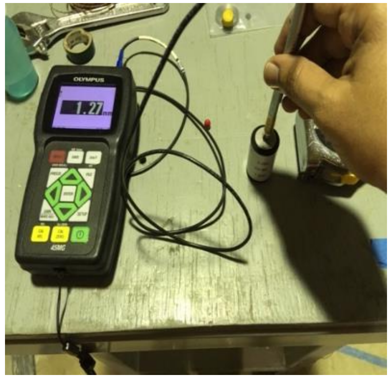
Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

FIU Year 1 Research Highlights & Accomplishments:

<u>Erosion Test Loop (Engineering Scale)</u>

- 5 SRNL coupons, 4 Permasense guided wave sensors, 4 CEL Fiberoptic sensors
- 2 and 3 inch pipe sections (straight sections and elbows)
- Sand/water mixture
- 3 HP centrifugal pump - up to 2.5m/s and 110 gpm
- Sand particle sizes - 400 to 1200 microns
- By-pass system to control flow rates

Pipe Loop



Ultrasonic sensor measurements

FIU Year 1 Research Highlights & Accomplishments:

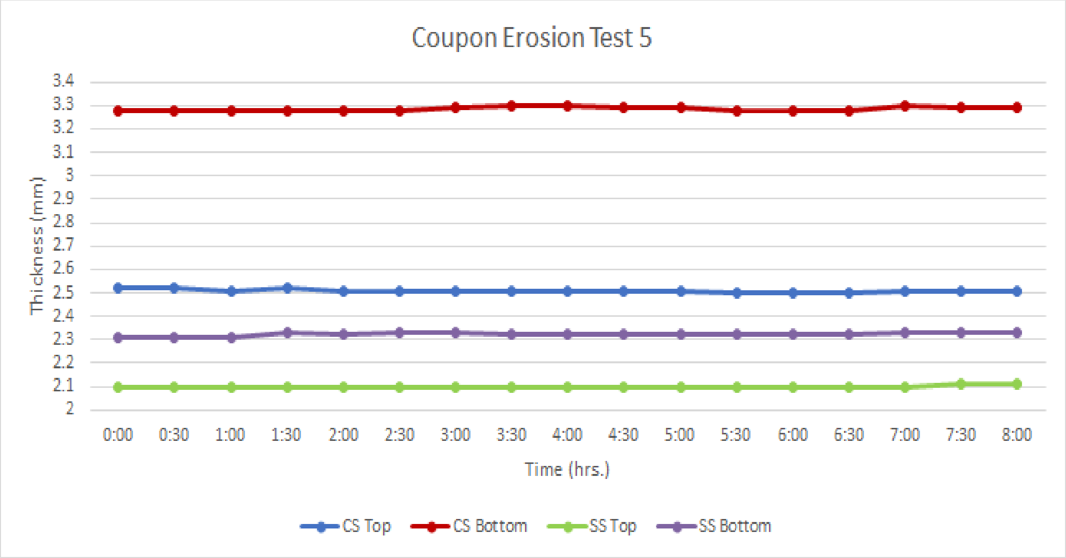
Erosion Test Results

	Pre-test Image	Post-test Image	High Resolution Surface Image (post-test)
Carbon Steel (Bottom)			
Carbon Steel (Top)			

Visual Inspection

Test Matrix (sand-water mixture)

Test	Coupons	Fine Sand (40F) (gallons)	Medium Sand (30/65) (gallons)	Coarse Sand (20/30) (gallons)	Very Coarse Sand (6/20) (gallons)
Test 1	3 SS	1	0	0	3
Test 2	3 SS	2	0	2	2
Test 3	3 SS	0	0	6	2
Test 4	3 SS	4	0	2	2
Test 5	2 SS and 2 CS	0	3.6	2.4	0
Test 6	2 SS and 2 CS	0	2	4	0



UT thickness measurements

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Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

FIU Year 1 Research Highlights & Accomplishments:

Corrosion Test Loop (Bench Scale)

- SRNL coupons and UT sensors
- 2 and 3 inch pipe sections (carbon steel straight sections and stainless-steel elbows).
- Modular test section with reducers
- 1/3 HP centrifugal pump - up to 20 gpm stainless steel impeller and casing suitable for caustic solutions
- Loop footprint - @5 ft X 2 ft
- Chemical simulants for realistic corrosion tests

Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

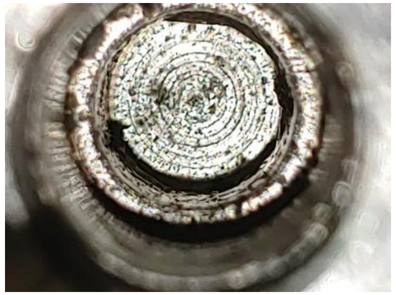
FIU Year 1 Research Highlights & Accomplishments:

Corrosion Test Results (Chemical Simulants)

Chemicals Used

$NaOH$, $Al(NO_3)3*9H_2O$, Na_2SO_4, $Na_2CO_3*H_2O$, $NaNO_3$, $NaNO_2$ and $NaCl$

Static Immersion Test

Stainless Steel #4	Stainless Steel#10	Carbon Steel
		

Static Immersion Test Results (40-day visual inspection)

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Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

FIU Year 2 Projected Scope

- Continue testing the SRNL mass loss coupons using realistic simulants developed by SRNL
- Investigate the effect of simulant flow dynamics in structural integrity assessment using computational fluid dynamic simulations
- Use the experimental sensor data and simulation results to develop machine learning models and predict the remaining useful life of tanks and transfer system components

Subtask 19.2: Evaluation of Nonmetallic Components in the Waste Transfer System

Site Needs:

- Nonmetallic materials are used in the US DOE's Hanford Site Tank Farm waste transfer system. These include inner primary hoses in the HIHTLs, Garlock® gaskets, EPDM O-rings, and other nonmetallic materials.
- Nonmetallic materials are exposed to β and γ irradiation, caustic solutions as well as high temperatures and pressure stressors. How they react to each of these stressors individually has been well established, but simultaneous exposure of these stressors is of great concern.

Objectives:

- Provide the Hanford Site with data obtained from experimental testing of the hose-in-hose transfer lines, Garlock® gaskets, EPDM O-rings, and other nonmetallic components under simultaneous stressor exposures.
- Evaluation includes chemical aging and exposure of hose coupons to elevated temperature over time. Radiation is not included.

Subtask 19.2: Evaluation of Nonmetallic Components in the Waste Transfer System

FIU Year 1 Research Highlights & Accomplishments:

- Previous efforts demonstrated the effects of burst pressure on aged HIHTL coupons with 25% NaOH at 3 separate temperatures for 6 months and 1 year.

Test condition	Burst pressure (MPa)		Change in burst pressure (%) (Compared with EPDM baseline)	
	After 6 months	After 12 months	After 6 months	After 12 months
Baseline	19.49	19.49	0.0	0.0
38°C	18.66	19.23	-4.26	-1.33
54°C	19.20	18.38	-1.49	-5.70
77°C	18.18	14.00	-6.72	-28.17
Water Only 77°C	NA	15.68	NA	-19.55

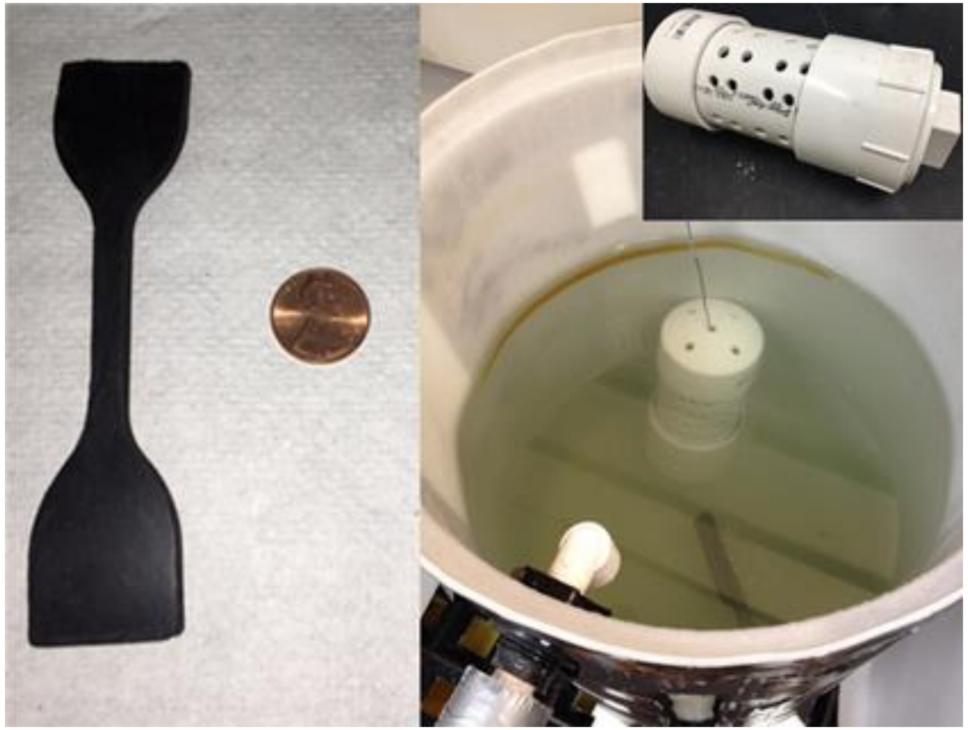
- An additional aging system that included four test loops were fabricated that circulated NaOH solutions of 25%, 12.5%, 6.25%, and 0% respectively at 170°F.
- Each test loop consisted of a pumping loop with three hose sections.

Subtask 19.2: Evaluation of Nonmetallic Components in the Waste Transfer System

FIU Year 1 Research Highlights & Accomplishments:

Material property analysis

- Dog-bone coupon aging consisted of a coupon aging vessel submerged in each test loop’s storage tank.
- Each vessel contained six EPDM dog-bone samples.



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Subtask 19.2: Evaluation of Nonmetallic Components in the Waste Transfer System

FIU Year 2 Projected Scope

- Specimen aging is expected to be completed by the end of September 2021.
- After aging the material properties of each specimen will be measured and compared to the baseline (unaged specimen) values.
- Properties to be measured include:
  - Hose burst pressure
  - Dog-bone coupon tensile strength

- Analysis using scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS) of the HIHTLs and the dog-bone specimens will provide:
  - Level of surface degradation that occurred during aging.
  - How far the NaOH solution penetrated into each specimen during aging.

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Task 20

Corrosion Protection and Characterization of EM Infrastructure

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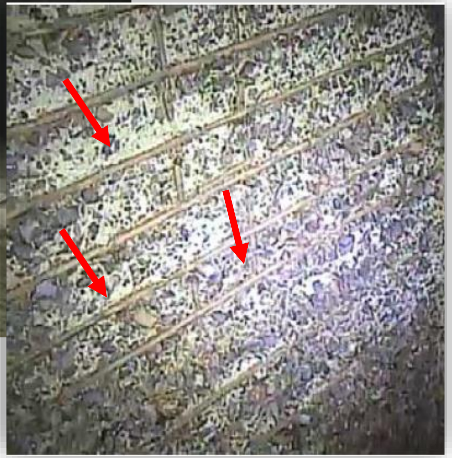
Subtask 20.1: Evaluation of Coatings for the H-Canyon Exhaust Tunnel

Site Needs:

Visual inspections of the H-Canyon exhaust (HCAEX) tunnel has shown degradation of the concrete walls. A recent tunnel fragility analysis identified safety issues of the affected concrete regarding their strength.

The identification and evaluation of protective coatings to prevent further degradation of the concrete walls is necessary.

Tunnel view



Degraded concrete exposing the steel rebar (red arrows).

Objectives:

- Develop and evaluate aged concrete surfaces through accelerated aging tests.
- Evaluate potential coatings for future application in the HCAEX tunnel.
- Develop a robotic deployment platform that can navigate on the tunnel walls and apply protective coatings.

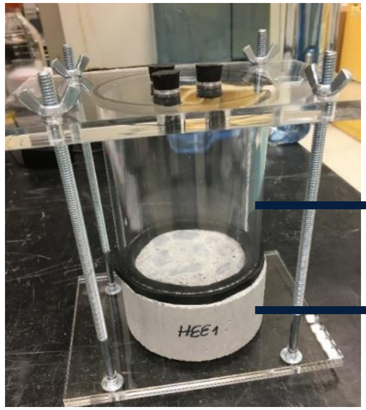
Subtask 20.1: Evaluation of Coatings for the H-Canyon Exhaust Tunnel

FIU Year 1 Research Highlights & Accomplishments:

Materials and Methods

- Concrete specimens prepared
- Accelerated aging procedures: *enhanced and standard*
- Durability and mechanical measures
- Surface characterization

Experimental setup for concrete exposed to nitric acid solutions



Acid solution container

Concrete specimen

Results of accelerated aging Tests

***Visual Inspection*:** Greatest and fastest degradation for specimens exposed to Test 7 & Test 11 aging conditions: enhanced aging + erosion.

Test 7 (no rebar)

Test 11 (rebar)

- Average height of protrusion : > 0.4 inch
- Average length of exposed rebar: ~2.4 inch
- Steel rebar exposed (yellow arrow)

Subtask 20.1: Evaluation of Coatings for the H-Canyon Exhaust Tunnel

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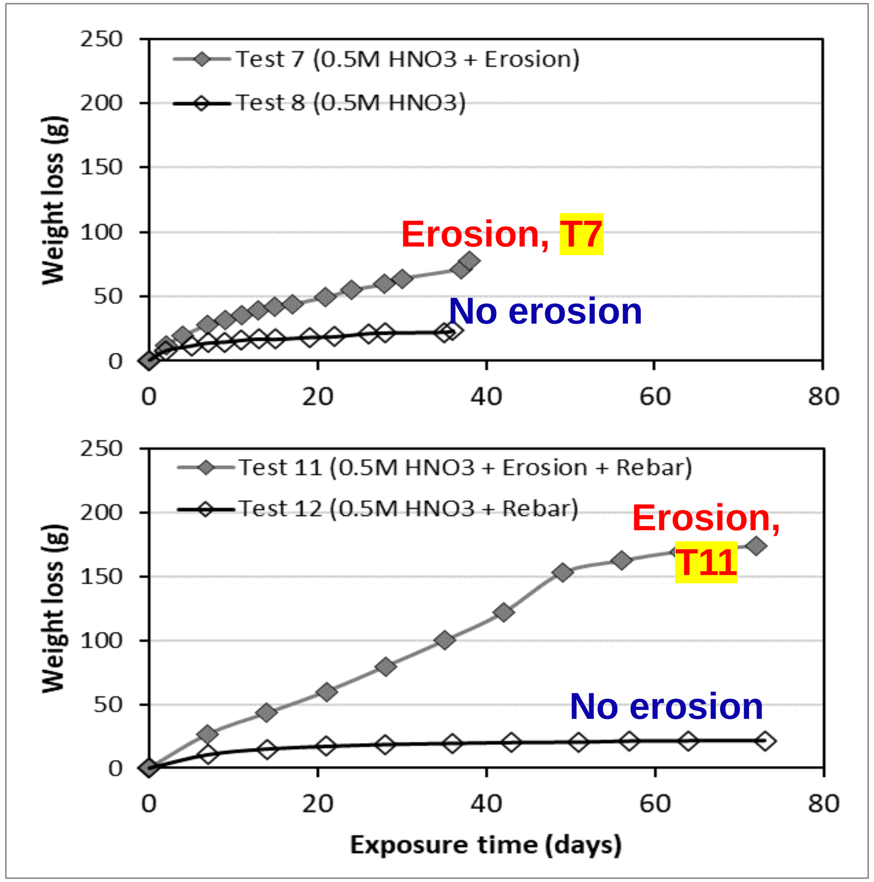
FIU Year 1 Research Highlights & Accomplishments:

Weight loss: Greatest weight loss for specimens exposed to Test 7 & Test 11 aging conditions.



Surface characterization: In agreement with previous findings.

Accomplishments

- Concrete specimens similar to the HCAEX tunnel walls were developed and characterized.
- Aged concrete surfaces with protruded aggregates, exposed rebar and chemical damage were developed, evaluated and will be the substrate to evaluate coatings.
- Accelerated aging procedures for concrete degradation were designed and tested.
- Potential coatings for the tunnel protection have been identified.

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Subtask 20.1: Evaluation of Coatings for the H-Canyon Exhaust Tunnel

FIU Year 2 Projected Scope

- Continue the development of aged and non-aged concrete surfaces for the evaluation of potential coatings through the Test 7 and Test 11 aging conditions.
- Design and execute a comprehensive test plan for the evaluation of potential coatings.
- Complete the selection of coating candidates for further evaluation.
- Initiate the evaluation of selected coatings through accelerated aging conditions.

Subtask 20.2: Corrosion Evaluation of Steel Canisters for Hanford Integrated Disposal Facility (IDF) (NEW)

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Site Needs:

- A technical gap exists regarding the site-specific durability of steel canisters/containers containing waste forms at the Hanford IDF. The canisters are an additional barrier to environmental exposure that are not considered in long-term models.
- Currently, electrochemical corrosion data of steels in site specific conditions of the IDF is limited.

Objectives:

- The primary goal is to evaluate the corrosion behavior of canister/container materials in simulated Hanford IDF groundwaters using electrochemical techniques.
  - Conduct a literature review of steel corrosion related to Hanford
  - Develop a test plan and initiate testing for the steel corrosion study


Containers for the storage of waste. Left: Carbon steel B-25 box for possible placement of cementitious waste forms, Right: Steel canister for LAW glass waste forms.

Subtask 20.2: Corrosion Evaluation of Steel Canisters for Hanford Integrated Disposal Facility (NEW)

FIU Applied Research Center

FIU Year 1 Research Highlights & Accomplishments:

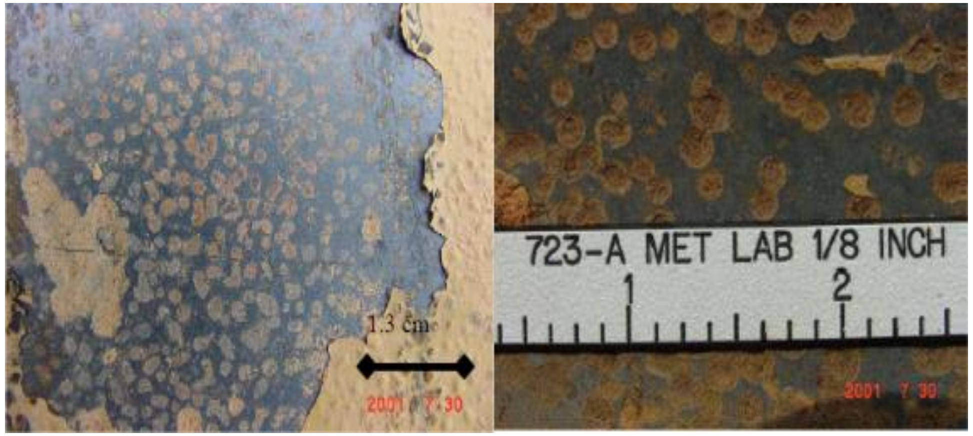
Literature Review Findings

Previous corrosion studies at Hanford

- Previous corrosion studies [1-2], for Hanford burial condition, investigated the corrosion behavior of three different alloys.
- A conservative prediction of the corrosion of the alloys was established through an evaluation of the behavior of the materials in other environments.
- Hence, no real site-specific data was obtained in this study [2].

Corrosion failure of container materials

- The most damaging and prevalent type of corrosive attack is localized corrosion.



Large areas of macroscopic pitting on lid surface of B-25 container [3].

[1] Jenkins, J F. “Naval civil engineering laboratory. Prediction of corrosion performance of submarine reactor compartments after burial at Trench 94, Hanford Washington”. January 1992.
[2] Jenkins J.F. “Corrosion behavior of HY-80 steel, type 304 stainless steel, and Inconel alloy 600 at 218-E-12B burial ground, Hanford, WA”. TR-2001-SHR. December 1993.
[3] Dunn K.A. “B-25 Corrosion evaluation summary report”. WSRC-TR-2001-00587. Jan 2002

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Subtask 20.2: Corrosion Evaluation of Steel Canisters for Hanford Integrated Disposal Facility (NEW)

FIU Year 1 Research Highlights & Accomplishments:

Materials and Methods

- Test plan developed and discussed with Hanford representatives.
- Test plan includes multiple variables such as type of alloy, surface condition and treatments
- Samples of 304 stainless steel prepared
- Faraday cage designed and built for testing.

Experimental setup (left) and sample (right) for electrochemical measurements. Images provided by Mathew Asmussen, Hanford point of contact.

Accomplishments

- Literature review for the steel corrosion study completed
- Test plan for the corrosion study of potential materials for the canister/container was prepared
- A potentiostat for getting corrosion data of canister materials was procured
- Chemicals procured for the preparation of a test solution that will simulate Hanford IDF groundwater
- Initial samples of 304 SS prepared for the beginning of testing

Subtask 20.2: Corrosion Evaluation of Steel Canisters for Hanford Integrated Disposal Facility (NEW)

FIU Applied Research Center

FIU Year 2 Projected Scope

- Initiate the execution of the test plan
  - Evaluation of 304 stainless steel
  - Study the effect of weld regions on the corrosion behavior
  - Study the effect of heat treatment zones on the corrosion behavior
  - Study the effect of various ions on the corrosion process
- Collect and analyze the corrosion data obtained – assessment of steel durability

FIU Year 1 Overall Accomplishments

FIU Applied Research Center

Conference Papers

- 4 Papers presented at WM 2021
- 4 Papers submitted to ANS 2021
- 6 Abstracts submitted to WM 2022

Journal Papers

A. Baharanchi, J. Coverston, M. Poirier, D. McDaniel, “Numerical Simulation of High Level Waste Simulant Flushing in Pipelines”, *Fluids* (Under review 7/21).

A. Awwad, D. McDaniel, L. Lagos, B. Tansel, “Aging characteristics of ethylene propylene diene monomer (EPDM) nonmetallic components used in caustic liquid waste transfer lines: effect of temperature and exposure time", *Engineering Failure Analysis*, (Accepted 7/21).

Awards

Best Poster Presentation and Paper-ASME AWARD. M. Echeverria-Boan, A. Nunez Abreu, L. Lagos, D. McDaniel. “**Aging of Concrete for the Evaluation of Repair Materials to Protect the Walls of the HCAEX Tunnel at Savannah River**”. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.

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Technology Development and Deployment Road Map

Site	Technology	2020	2021	2022	2023	2024
DST Hanford		In-house Deployment	Site Deployment			
DST Hanford		Evaluation	In-house Deployment	Site Deployment		
DST Hanford		Evaluation	In-house Deployment	Site Deployment		
DST Hanford		Evaluation	In-house Deployment	Site Deployment		
H Canyon		Conceptual Design	Sensor Integration	Evaluation	In-house Deployment	Site Deployment
WIPP		Evaluation	In-house Deployment	Site Deployment		
LM Site		Evaluation	In-house Deployment	Site Deployment		

Thank You. Questions?