YEAR-END TECHNICAL REPORT

September 29, 2023 to September 28, 2024

DOE-FIU Science & Technology Workforce Development Initiative

http://fellows.fiu.edu/

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FIU | Applied Research Center
FLORIDA INTERNATIONAL UNIVERSITY

Addendum:

This document represents one (1) of five (5) reports that comprise the Year End Reports for the period of September 29, 2023 to September 28, 2024 prepared by the Applied Research Center at Florida International University for the U.S. Department of Energy Office of Environmental Management (DOE-EM) under Cooperative Agreement No. DE-EM0005213.

The complete set of FIU's Year End Reports for this reporting period includes the following documents:

Project 1: Chemical Process Alternatives for Radioactive Waste
Document number: FIU-ARC-2023-800012997-04b-009

Project 2: Environmental Remediation Science and Technology
Document number: FIU-ARC-2023-800013918-04b-006

Project 3: Waste and D&D Engineering and Technology Development
Document number: FIU-ARC-2023-800013919-04b-006

Project 4: DOE-FIU Science & Technology Workforce Development Initiative
Document number: FIU-ARC-2023-800013920-04b-015

Project 5: Long-Term Stewardship of Environmental Remedies: Contaminated Soils and Water and STEM Workforce Development
Document number: FIU-ARC-2023-800013922-04b-005

Each document will be submitted to OSTI separately under the respective project title and document number as shown above. In addition, the documents are available at the DOE Research website for the Cooperative Agreement between the U.S. Department of Energy Office of Environmental Management and the Applied Research Center at Florida International University: https://doeresearch.fiu.edu

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PROJECT 4 EXECUTIVE SUMMARY

Over the past two decades, there has been a national need for more careers in the science, technology, engineering and mathematics (STEM) workforce. This shortage is felt not only in the private industry sector but also across many federal agencies including the U.S. Department of Energy (DOE). Within DOE Environmental Management (EM), there is a critical shortage of entry-level STEM personnel. About 60% of the workforce is eligible to retire in 5 years, the average work age is 55 years and only less than 4% of the workforce is less than 30 years of age. The effects are already being felt across DOE-EM and new ways to stimulate interest in STEM are being initiated by the federal government. If this shortage is not addressed, the risks include knowledge gaps (discontinuity of lessons learned) within the department and a lack of skilled personnel to carry out its cleanup mission effectively.

Florida International University (FIU), the largest Hispanic serving research-extensive institution in the continental United States, is one of the nation's leading producers of scientists and engineers from underrepresented groups. In 1995, DOE created a unique partnership with FIU to support environmental cleanup technology development, testing and deployment at DOE sites. This partnership spawned a research center at FIU dedicated to environmental research and development (R&D). The center, now known as the Applied Research Center, has tackled and helped solve problems at many DOE sites.

The DOE-FIU Science and Technology Workforce Development Program (also known as the DOE Fellows Program) was established in 2007 to create a pipeline of minority engineers specifically trained and mentored to enter the DOE workforce in technical areas of need. This innovative program was designed to help address DOE's future workforce needs by partnering with academic, government and DOE contractor organizations to mentor future minority scientists and engineers in the research, development, and deployment of new technologies addressing DOE's environmental cleanup challenges. The main objective of the program is to provide interested students with a unique opportunity to integrate course work, DOE field work, and research work at FIU into a well-structured academic program that leads to entry into DOE EM or other career opportunities. Students selected as DOE Fellows perform research at FIU and at DOE sites, national laboratories, and DOE contractors. Upon graduation and completion of this fellowship, the students are encouraged to apply to join the DOE federal internship programs, apply to DOE contractors, pursue post master's or postdoctoral positions at DOE national laboratories, or apply to private industry in their field of study.

The DOE Fellows Program has inducted a total of 209 minority FIU STEM students since program inception in 2007 up to the most recent induction ceremony held in November 2023. The DOE Fellows induction ceremonies have been attended by DOE EM officials each year, including EM-1's Mr. James Rispoli and Dr. Inés Triay, other DOE-EM managers including Mr. Mark Gilbertson in 2007, Mr. Kurt Gerdes in 2017 and 2018, Mr. Leonard Spearman in 2019, Ms. Nicole Nelson-Jean in 2020, Mr. Todd Shrader in 2021, Nicole Nelson-Jean in 2022 and most recently Gregory Sosson, DOE-EM's Associate Principal Deputy Assistant Secretary for Field Operations in 2023.

The following DOE-EM Fellows are supporting the projects under this cooperative agreement:

Project 1: Brendon Cintas (Graduate, Ph.D., Mechanical Engineering), Bryant Pineda (Graduate, M.S., Mechanical Engineering), Bryan Torres (Graduate, Mechanical Engineering), David Rojas (undergraduate, Mechanical Engineering), Douglas Baptiste (Undergraduate, Civil Engineering), Gabriel Cerioni (Graduate, Ph.D., Mechanical Engineering), Joel Adams (Graduate, Ph.D., Mechanical Engineering), Kevin Yulkowski (Undergraduate, Mechanical Engineering), Nicholas Espinal (undergraduate, Mechanical Engineering), Pedro Chaviano (Graduate, M.S., Mechanical Engineering), Philip Moore (Graduate, M.S., Mechanical Engineering), Rafael Velasquez (Graduate, M.S., Electrical Engineering), and Theophile Pierre (undergraduate, Mechanical Engineering).

Project 2: Aubrey Litzinger (graduate, M.S., Environmental Engineering), Carolyn Cooke (Graduate, Ph.D., Chemistry), Ellie Risher, (Undergraduate, Civil Engineering), Hannah Aziz (undergraduate, Environmental Engineering), Melissa Dieguez (Undergraduate, Biomedical Engineering), and Reann Nicolas (undergraduate, Civil Engineering).

Project 3: Alejandro De La Novela (Graduate, M.S., Computer Science), Aris Duani Rojas (Graduate, Ph.D., Computer Science), Carlos Rios (graduate, M.S., Mechanical Engineering), Fabiola Rivera-Noriega (Graduate, Computer Engineering), and Victor Gonzalez (undergraduate, Mechanical Engineering).

The following ARC researchers are supporting this project and helping the DOE-EM Fellows: Leonel Lagos (Ph.D., PMP®, Mechanical/Civil/Env. Engineering, PI/DOE Fellows Program Director), Ravi Gudavalli (Ph.D., Env. Engineering, Mentor/Program Manager), Angelique Lawrence (M.S., Environmental Science, Technical support), Walter Quintero (M.S., Computer Engineering, IT Support), Jose Rivera (B.S., Civil Engineering, Research Analyst) and Clint Miller (MCSA, MCSE, CompTIA Security +, C|EH, IT Support).

MAJOR ACCOMPLISHMENTS

Task 1: Recruitment Efforts

- FIU conducted two recruitment campaigns during fall 2023 and spring 2024. A total of 6 FIU STEM students were selected to be part of the DOE Fellows Class of 2023 and Class of 2024.
    - Reann Nicolas, Pedro Chaviano, Carlos Rios and Victor Gonzalez were selected to be part of the DOE Fellows Class of 2023 from the fall 2023 recruitment campaign.
    - Ellie Risher and Kevin Yulkowski were selected to be part of the DOE Fellows Class of 2024 from the spring 2024 recruitment campaign.

Task 2: DOE-EM Research Identification and Assignments

- DOE Fellows Hannah Aziz, and Nicholas Espinal graduated with bachelor's degrees in environmental engineering and mechanical engineering, respectively.
- Alejandro De La Noval graduated with a master's degree in computer science and accepted a position as an MSIPP Graduate Research Fellow at Savannah River National Laboratory (SRNL).
- Six (6) DOE Fellows prepared PowerPoint presentations and presented their research accomplishments during FIU's annual research review with DOE-HQ and collaborators from national laboratories and contractors.

Task 3: DOE-EM Fellows Poster Exhibition & Competition

- FIU conducted the 17th Annual DOE Fellows Poster Session on November 7th, 2024. Sixteen (16) DOE-EM Fellows prepared posters which were presented during the poster session. DOE Fellows, Brendon Cintas and Nicholas Espinal, won 2nd and 1st place respectively and received their awards during the induction ceremony.

Task 4: DOE-EM Fellows Induction Ceremony

- FIU conducted the 17th Annual DOE Fellows Induction Ceremony on November 8, 2023 and inducted 12 science, technology, engineering, and math (STEM) minority students into the program.
    - The Department of Energy Office of Environmental Management (DOE-EM) was represented by Mr. Gregory Sosson, DOE-EM's Associate Principal Deputy Assistant Secretary for Field Operations, Ms. Genia McKinley, DOE-FIU Cooperative Agreement Technical Monitor and Mr. Jean Pabon (JP), Program Manager.
    - The Office of Legacy Management was represented by Ms. Jalena Dayvault and Mr. Mark Kautsky. Mr. Kautsky delivered remarks on behalf of DOE-LM's Director, Carmelo Melendez.
    - FIU's administration was represented by Dr. Heather Russell (Vice Provost for Faculty Leadership and Success and Professor of Literature).
    - Dr. Leonel Lagos (DOE Fellows Program Director and Principal Investigator for the DOE-FIU Cooperative Agreement) and Dr. Inés Triay (ARC Executive Director and Interim

Dean of FIU's College of Engineering & Computing) also delivered messages to the new class.

- DOE-EM Fellow, Brendon Cintas, delivered a message to the new Fellows highlighting his personal experience, which he found fulfilling both academically and professionally.

Task 5: Summer Internship Program (SIP)

- Nine (9) summer internship reports were developed based on summer 2023 internship assignments from across the DOE complex. Upon approval from the sites, reports were published online at https://fellows.fiu.edu/internships-reports/#2023.
  - Hannah Aziz - Evaluating Spatial Distribution of Contaminants in the Savannah River Site F-Area using ArcGIS Interpolation Methods
  - Brendon Cintas - Development of a Long-term Surveillance Unmanned Ground Vehicle (LTS-UGV) for Surveillance at the Hanford 200 Area
  - Josue Estrada - Development of Control Software for Autonomous and User-monitored Operation of Lateral Gamma Scanner System
  - Alejandro De La Noval - Using Natural Language Processing for Semantic Search in the Nuclear Domain
  - Aris Duani Rojas - Automatic Monitoring of Water Seepage in the F-Area 3 Basin Cap
  - Nicholas T. Espinal - Development of Robotic Arm for the Purpose of Glovebox Automation to Enhance Nuclear Waste Processing and Worker Safety
  - Aubrey Litzinger - Development of an Integrated Hydrology Spinup Model for the F-Area of Savannah River Site with the ALTEMIS Project
  - Philip Moore - Development of a Pneumatic Manipulator for Off-Riser Sample Retrieval
  - Bryan Torres - Testing of Radiation Resistant High Density Polyurethane Foam
- 15 DOE Fellows participated in 2024 summer internships across the DOE Complex including DOE national laboratories and DOE contractors.

Task 6: Conference Participation and Presentations

- Two (2) DOE Fellows Alejandro De La Noval and Aubrey Litzinger, 2024 Roy G. Post Scholarship recipients, presented posters on Sunday, March 10, 2024, during Session 41 - WM2024 Roy G. Post Scholarship Winner Posters.
- DOE Fellows had an opportunity to meet Dr. Ike White, U.S. Department of Energy Office's Assistant Secretary for Environmental Management, after the keynote speech during the plenary session of the 2024 Waste Management Symposia (WM2024) on Monday, March 11, 2024.
- Thirteen (13) DOE Fellows participated in and presented posters based on their DOE EM research accomplishments. DOE Fellow Bryant Pineda received the best graduate poster award for his poster titled "*Evaluating the Erosion and Corrosion Behavior in Nuclear Waste Transfer Systems*".
- DOE Fellows and FIU students participated in a Round Table with DOE EM Leadership.

- Former DOE Fellow, Olivia Bustillo (Staff Engineer at Drummond and Carpenter) participated in a session 6 Panel: Former Roy G. Post Scholarship Winners Now Leading Our Industry, as well as session 85 Panel: Young Professionals in Nuclear Science and Engineering an International Perspective.
- DOE Fellow Brendon Cintas presented an oral presentation titled *"Development of Long-term Surveillance Unmanned Ground Vehicles for Nuclear Facility Inspections"* during session 39 Integrity and Inspections for HLW Retrieval (2.04a). He also participated in session 62 Panel: Graduating Students and New Engineers - Wants and Needs - Are Companies Even Listening?.
- DOE Fellow Aubrey Litzinger attended the biannual Battelle Chlorinate Conference held from June 2-6, 2024, in Denver, CO.

Task 7: DOE-EM Fellows Lecture Series Forum

- DOE EM Fellows attended a Tech Talk featuring Dr. Hilary Emerson and Dr. Jim Szecsody from Pacific Northwest National Laboratory (PNNL) titled *"Uranium Characterization and Remediation at the Hanford Site"*.
- DOE Fellows attended an info session held by Drummond Carpenter, PLLC which provided information regarding potential opportunities available. Drummond Carpenter, PLLC is an engineering consulting firm that has contracts with DOE EM and LM, NASA, UCOR, among many other clients and is specialized in a variety of engineering disciplines as well as applied research. Former DOE-LM Fellow, Olivia Bustillo, who is now a Sr. Staff Engineer at Drummond Carpenter, PLLC, was in attendance.
- DOE Fellows participated in a D&D Tech Talk featuring Mr. Joseph Sinicrope, titled *"A Case Study: The Strategic Integration of Consensus Standards to Facilitate Fixative Technology Development, Deployment, and Acceptance"*.
- DOE Fellows participated in a D&D Tech Talk featuring Mr. Bryan Steinfeld titled *"Development and Deployment of a ground robotic platform for radiation Radiological Contamination Detection".*
- Additionally, DOE Fellows participated in an AI Robotics Workshop hosted by Florida International University on April 22 - 24, 2024.

PROJECT 4: DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT INITIATIVE

INTRODUCTION

Florida International University (FIU), the largest Hispanic serving research-extensive institution in the continental United States, is one of the nation's leading producers of scientists and engineers from underrepresented groups. In 1995, the U.S. Department of Energy created a unique partnership with FIU to support environmental cleanup technology development, testing and deployment at DOE sites. This partnership spawned a research center at FIU dedicated to environmental R&D. The center, now known as the Applied Research Center, has tackled and helped solve multiple problems at many DOE sites. The DOE-FIU Science and Technology Workforce Development Program is designed to build upon this relationship by creating a pipeline of minority engineers specifically trained and mentored to enter the DOE workforce in technical areas of need. This innovative program was designed to help address DOE's future workforce needs by partnering with academic, government and DOE contractor organizations to mentor future minority scientists and engineers in the research, development, and deployment of new technologies addressing DOE's environmental cleanup challenges.

OBJECTIVES

The DOE-FIU Science and Technology Workforce Development Program has been designed to build upon the existing DOE/FIU relationship by creating a "pipeline" of minority engineers specifically trained and mentored to enter the Department of Energy workforce in technical areas of need. The main objective of the program is to provide interested students with a unique opportunity to integrate course work, DOE fieldwork, and research work at FIU into a well-structured academic program that leads to entry into DOE EM's Pathways Program. Students selected as DOE Fellows perform research at FIU and at DOE sites, national laboratories, and DOE contractors. Graduation and completion of this fellowship leads to employment opportunities with DOE EM, DOE contractors, DOE national laboratories, other federal agencies, and private industry as well as the pursuit of post-master or post-doctoral positions at DOE national labs.

METHODOLOGY

The DOE-FIU Science and Technology Workforce Development Program is comprised of the following components:

- Hands-on work with assigned mentors throughout the year
- Professional development and training
- Paid 20 hours per week research work at FIU's Applied Research Center
- Paid 10-week summer internships at DOE sites, DOE National Laboratories, DOE Headquarters and DOE Contractors
- Tuition waiver for graduate students (master's & PhD)
- Participation and presentation of research at conferences
- Employment opportunities with DOE, DOE national labs or DOE contractors

Project 4 therefore incorporates several tasks that are aligned with these objectives which include:

Task 1: Recruitment Efforts

Recruitment sessions are conducted throughout the year, typically at the beginning of the Spring, Summer and Fall semesters, during which flyers are posted, and tables are setup at FIU's Engineering Center, as well as the Chemistry and Physics building at FIU's Modesto Maidique Campus (MMC) to promote the DOE Fellows Program, targeting eligible undergraduate and graduate minority STEM students who meet the following criteria:

- U.S. Citizen/Permanent Resident Alien (minimum of 4 years permanent residency required)
- Undergraduate students (sophomore/early junior, or senior accepted to FIU graduate school)
- Masters/PhD students (in first or second semester)
- Minimum 3.0 GPA

Classroom visits and presentations are also conducted, and a dedicated DOE Fellows website (*fellows.fiu.edu*) provides information about the program, instructions on how to apply, as well as the required application forms. Several social media platforms are also used to promote the program.

Task 2: DOE-EM Research Identification and Assignments

Once the application window has passed, a review committee evaluates the pool of applicants and invites eligible candidates to be interviewed. Successful applicants then go through the FIU hiring process to begin their research assignments as DOE-EM Fellows, supporting the DOE-related research under the guidance of an assigned mentor.

All new DOE Fellows are required to complete the following health and safety training courses listed below prior to engaging in any laboratory work:

- Laboratory Hazard Awareness
- Hazard Communication (HAZCOM)
- Fire Safety (online or instructor-led)
- Environmental Awareness PT 1 & PT 2
- Small Spills and Leaks
- EPA: Hazardous Waste Awareness & Handling
- Personal Protective Equipment (Lab)
- Safe Use of Fume Hoods
- Safe Use of Emergency Eyewash & Shower
- Chemical Handling Safety - Basic Principles
- Compress Gas Safety Awareness
- Safe Use of Biosafety Cabinets
- Radiation Safety

The DOE Fellows directly support FIU-ARC scientists and engineers in the development and execution of the technical work on the 4 major projects under the DOE-FIU Cooperative Agreement, gaining hands-on research in the areas of waste management, soil/groundwater modeling and research, deactivation & decommissioning, and computer science/IT development for environmental applications, while pursuing their STEM degrees (bachelors, master's and PhDs) at FIU. They also participate in a weekly meeting conducted by the program director, during

which they are each given an opportunity to present their ARC-related research or the work performed during their summer internship.

The research being conducted may be used as the basis for the development of master's thesis and/or Ph.D. dissertation topics for DOE Fellows pursuing graduate degrees, and for Fellows pursuing technical undergraduate degrees, the research also provides senior research project and capstone project opportunities.

Subtask 2.1: Student Research Project: In-Situ 3D Printing of Concrete Structures for Waste Containment

In Year 4, in addition to the technical work conducted under the 4 major DOE-EM projects, DOE Fellow Gabriel Cerioni was assigned to work in collaboration with SRNL scientists to provide support in designing and constructing a 3D printer to assist SRNL and other national labs in evaluating the feasibility of using 3D-printed ultra-high-performance concrete (UHPC) for low level waste (LLW) containers. Details of this research have been summarized in a technical report provided in APPENDIX D: Student Research Project.

Note: The research under this subtask was formerly reported under Project 1: Subtask 18.5.4 – In-Situ 3D Printing Concrete Structures for Waste Containment.

Task 3: DOE-EM Fellows Poster Exhibition & Competition

A poster exhibition/competition is held each year on the day before the annual induction ceremony. The DOE Fellows prepare and present posters in either the undergraduate or graduate session which showcase their research accomplishments in the areas of high-level waste, soil and groundwater, deactivation & decommissioning (D&D), and information technology (IT) in support of the Department of Energy's Office of Environmental Management. Posters may also be based on summer internship activities. The panel of judges is usually comprised of FIU faculty from the College of Engineering and Computing, the College of Arts, Sciences and Education, as well as DOE HQ, national laboratory and contractor personnel.

Task 4: DOE-EM Fellows Induction Ceremony

An annual induction ceremony is held every November to officially welcome the new class of DOE Fellows, preceded by lab tour presentations at the Applied Research Center. In attendance at the ceremony are the new Fellows and their families, ARC staff and students, FIU leadership, faculty and staff, DOE personnel from headquarters, the site offices and the national labs, DOE contractors, and others.

Task 5: Summer Internship Program (SIP)

Every summer, 10-15 DOE Fellows engage in 10-week summer internships during which they are paired with scientists/engineers at DOE facilities across the complex to work on environmental research projects under their guidance and mentorship. The DOE Fellows are required to prepare and submit Summer Internship Technical Reports upon their return to FIU after completion of the internships, which are posted on the DOE Fellows website (http://fellows.fiu.edu) after being reviewed and cleared for public release by their DOE site mentors/scientists.

Task 6: Conference Participation and Presentations

DOE Fellows attend and participate in relevant national and international conferences, including the Waste Management Symposia, the American Chemical Society (ACS), American Nuclear Society (ANS), and American Geophysical Union (AGU), as well as local STEM conferences sponsored by FIU and/or other institutions in the South Florida area. The Fellows submit abstracts and develop student and professional posters as well as oral presentations based on their research conducted at FIU ARC or during their summer internships.

Task 7: DOE-EM Fellows Lecture Series Forum

As part of the DOE Fellows programs, DOE-EM Fellows are required to participate in a DOE-EM Fellows Lecture Series Forum hosted by FIU, where speakers who are DOE-EM staff (sites and HQ) and national lab personnel discuss important DOE-EM topics with the Fellows and other FIU students. Through this forum, it is anticipated that the DOE-EM Fellows will learn about DOE-EM environmental issues directly from DOE scientists and engineers.

Task 8: DOE-EM Fellows and DOE-EM HBCU Collaboration/Integration

This task was created to encourage continuous communication between FIU and DOE MSIPP representatives to obtain input for the MSIPP program and identify potential internship and job opportunities for FIU students in the DOE Fellows program who are nearing graduation. In addition, expanded communication and engagement with DOE-EM HBCU STEM programs will promote more collaborative synergistic research and STEM development efforts between FIU and HBCU universities related to EM technical issues and challenges, and hopefully attract and encourage qualified STEM students to pursue graduate STEM degrees at FIU.

RESULTS AND DISCUSSION

Task 1: Recruitment Efforts

FIU conducted recruitment sessions in the Fall of 2023, as well as the Spring and Fall of 2024. The Fall 2023 recruitment ran until the end of September 2023 and a total of 23 applications were received, of which 17 students were invited for in-person interviews. A total of 4 FIU students were selected to be part of the DOE Fellows Class of 2023. The Spring 2024 recruitment campaign occurred from January 22 to February 23, 2024. There were 16 FIU student applicants of which only two (2) new DOE Fellows were hired as part of the Class of 2024.

Table 1. FIU Students Selected as DOE EM Fellows in FIU Year 4

Recruitment Period	DOE Fellow Name	Degree	Major	DOE Fellow Class
Fall 2023	Reann Nicolas	B.S.	Civil Engineer	Class of 2023
Fall 2023	Pedro Chaviano	M.S.	Electrical Engineering	Class of 2023
Fall 2023	Carlos Rios	M.S.	Mechanical Engineering	Class of 2023
Fall 2023	Victor Gonzalez	B.S.	Mechanical Engineering	Class of 2023
Spring 2024	Ellie Risher	B.S.	Civil Engineering	Class of 2024

Recruitment Period	DOE Fellow Name	Degree	Major	DOE Fellow Class
Spring 2024	Kevin Yulkowski	B.S.	Mechanical Engineering	Class of 2024

FIU conducted the Fall 2024 recruitment from August 26 to September 27, 2024. The selection of eligible candidates for in-person interviews from the Fall 2024 applicant pool will be done in October 2024. FIU also conducted an open house on September 20, 2024, to showcase the research being conducted by the DOE Fellows in support of DOE's environmental cleanup mission. Several labs were featured during this event during which the DOE Fellows and ARC staff presented their on-going research. The images in Figure 1 below show the flyers that were distributed to advertise the Fall 2024 recruitment session and the open house held in September 2024.

Figure 1. DOE Fellows Fall 2024 recruitment flyer (left) and Open House flyer (right).

Task 2: DOE-EM Research Identification and Assignments

The DOE Fellows that have been actively engaged in research, supporting ARC staff in the execution of the various tasks during FIU Year 4, are listed in the following table. Each student's degree level, major, ARC mentor, and assigned project task is also provided.

Table 2. Project Support by DOE Fellows

Name	Degree Level	Major	ARC Mentor	Research Assignment
Alejandro De-La-Novela	M.S. Grad	Computer Science	Dr. Himanshu Upadhyay	Exploratory Data Analysis & Machine Learning Model For Hexavalent Chromium [Cr(VI)] Concentration in The 100-H Area (PNNL)
Aris Duani Rojas	Ph.D. Grad	Computer Science	Dr. Himanshu Upadhyay	Low-Level Waste Identification, Classification & Segregation Using Deep Learning (SRNL)
Aubrey Litzinger	M.S. Grad.	Environmental Eng.	Dr. Pieter Hazenberg	Hydrology Modeling of Basin 6 of The Nash Draw Near The WIPP
Brendon Cintas	Ph.D. Grad	Mechanical Eng.	Dr. Leonel Lagos	Long-Term Surveillance of Nuclear Facilities and Repositories using Mobile Systems
Bryan Torres	Undergrad.	Mechanical Eng.	Dr. Aparna Aravelli	Evaluation of Pipeline Flushing Requirements for HLW at Savannah River
Bryant Pineda	M.S. Grad	Mechanical Eng.	Dr. Aparna Aravelli	Pipeline Corrosion and Erosion Evaluation
Carlos Rios	M.S. Grad	Mechanical Eng.	Dr. Leonel Lagos	Digitalization in Decommissioning
Carolyn Cooke	Ph.D. Grad	Chemistry	Dr. Ravi Gudavalli	Environmental factors controlling the attenuation and release of contaminants in the wetland sediments at Savannah River Site
David Rojas	Undergrad.	Mechanical Eng.	Mr. Anthony Abrahao	Development of Robotic Systems for DOE Sites
Douglas Baptiste	Undergrad.	Civil Eng.	Dr. Mayren Echeverria	Corrosion Protection and Characterization of EM Infrastructure
Ellie Risher	Undergrad.	Civil Eng.	Dr. Pieter Hazenberg	Hydrology Modeling of Basin 6 of The Nash Draw Near The WIPP
Fabiola Rivera	M.S. Grad.	Computer Eng.	Dr. Himanshu Upadhyay	Exploratory Data Analysis & Machine Learning Model for Hexavalent Chromium [Cr(VI)] Concentration in The 100-H Area (PNNL)
Gabriel Cerioni	Ph.D. Grad.	Mechanical Eng.	Dr. Leonel Lagos	In-Situ 3D Printing Concrete Structures for Waste Containment
Hannah Aziz	Undergrad.	Environmental Eng.	Dr. Pieter Hazenberg	Model Development for Fourmile Branch with Specific Focus on the F-Area Wetlands
Joel Adams	Ph.D. Grad	Mechanical Eng.	Mr. Anthony Abrahao	Off-riser Sampler Development & Low-Level Waste Identification, Classification & Segregation Using Deep Learning (SRNL)
Kevin Yulkowski	Undergrad.	Mechanical Eng.	Mr. Mackenson Telusma	Improvement of H-Canyon Concrete Wall Repair Platform
Melissa Dieguez	Undergrad.	Biomedical Eng.	Dr. Yelena Katsenovich	Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments
Nicholas Espinal	Undergrad.	Mechanical Eng.	Mr. Mackenson Telusma	Improvement of H-Canyon Concrete Wall Repair Platform

Name	Degree Level	Major	ARC Mentor	Research Assignment
Pedro Chaviano	M.S. Grad	Mechanical Eng.	Dr. Amer Awwad	Development of a Robotic Vacuum System
Philip Moore	M.S. Grad	Mechanical Eng.	Mr. Mackenson Telusma	Development of Robotic Systems for DOE Sites
Rafael Velasquez	Undergrad.	Electrical Eng.	Mr. Mackenson Telusma	Improvement of Mobile Platform Efficiency
Reann Nicolas	Undergrad.	Civil Eng.	Dr. Ravi Gudavalli	Investigating The Effect of KW-30 (Humate Material) on Co-Contaminant Removal
Theophile Pierre	Undergrad.	Mechanical Eng.	Mr. Anthony Abrahao	Development of Robotic Systems for DOE Sites
Victor Gonzalez	Undergrad.	Mechanical Eng.	Mr. Joseph Sinicrope	Test & Evaluation of Down-selected Intumescent Technologies to Mitigate Contaminate Release during Nuclear Pipe Dismantling

DOE Fellows prepared and presented their DOE-related research or summer internship experiences at the weekly DOE Fellows meetings The schedule of these presentations is provided below.

Table 3. Research Presentation Schedule for DOE Fellow Meetings

DOE Fellow	Date
Gabriel Cerioni	1/29/2024
Bryant Piedra	2/05/2024
Rafael Valesquez	2/12/2024
Douglas Baptiste	2/19/2024
Hannah Aziz	3/04/2024
Fabiola Rivera-Noriega	3/25/2024
Bryan Torres	4/01/2024
Alejandro De La Noval	4/08/2024
Theophile Pierre	4/15/2024
Philip Moore	7/10/2024
Daniel Coelho	7/17/2024

DOE Fellow	Date
Nicholas Espinal	7/24/2024
Joel Adams	8/21/2024
Bryan Torres	9/4/2024
Aris Duani Rojas	9/11/2024
David Rojas	9/23/2024

Six (6) DOE Fellows also participated in the Annual DOE-FIU Cooperative Agreement Research Review held on 9/19/2024, during which they presented their research accomplishments to DOE-HQ personnel and site POCs. Below is the list of DOE Fellows and their presentation titles.

- Nuclear Waste Identification and Classification using Deep Learning - Aris Duani Rojas
- Hydrology Modeling Of Basin 6 Of The Nash Draw Near The WIPP - Aubrey Litzinger
- Digitalization of Decommissioning - Carlos Rios
- Remediation Research on Combination of Reduction and Sequestration Treatment - Melissa Dieguez
- Off-Riser Sampler System - Theophile Pierre
- Test and Evaluation of Foam Fixative Technologies to Mitigate Contaminant Release in 3D Void Spaces for D&D - Victor Gonzalez

DOE Fellows Hannah Aziz and Nicholas Espinal graduated with bachelor's degrees in environmental engineering and mechanical engineering, respectively. Hannah has been accepted into a Ph.D. program in environmental engineering at Northwestern University in Evanston, Illinois and Nicholas has been accepted into a Ph.D. program in mechanical engineering at Georgia Institute of Technology.

Figure 2. DOE Fellows Hannah Aziz (left, with family) and Nicholas Espinal (right) during the Spring 2024 graduation ceremony.

DOE Fellow Alejandro De La Noval graduated with a master's degree in computer science and joined SRNL as a MSIPP Graduate Research Fellow.

Task 3: DOE-EM Fellows Poster Exhibition & Competition

FIU conducted the 17th annual DOE Fellows Poster Exhibition and Competition on November 7, 2023, the day before the DOE Fellows induction ceremony. DOE Fellows prepared and presented a total of sixteen (16) posters based on EM/LM research conducted at FIU and/or at summer internships to be presented at the competition. Judges included Dr. Darina Castillo (General Engineer/Site Manager, DOE-LM), Mr. Joe Aylor (Chief of Staff, United Cleanup Oak Ridge LLC), and Dr. Inés Triay (Executive Director, FIU-ARC) who evaluated the posters and selected first, second and third place winners. The poster competition awards were presented to the winners during the induction ceremony.

Poster titles and authors of posters presented during the poster exhibition:

- Long Term Surveillance Robots Utilizing Intelligence - **Joel Adams**
- Evaluating the Spatial Distribution of Contaminants Over Time in the SRS F-Area & their Potential Fate & Transport - **Hannah Aziz**
- Protective Performance of an Epoxy Coating for the Protection of the HCAEX Tunnel's Concrete Walls at Savannah River Site - **Douglas Baptiste**
- Ultra-High-Performance Concrete for Radioactive Waste Disposal - **Gabriel Cerioni**
- Development of a Long-Term Surveillance Unmanned Ground Vehicle (LTS-UGV) for Nuclear Facilities - **Brendon Cintas**

- AI Large Language Model Semantic Search for the Nuclear Domain - **Alejandro De La Noval**
- Deep Learning-Based Water Seepage Monitoring in F-Area 3 Basin Cap - **Aris Duani Rojas**
- Design Improvements for H-Canyon Wall Crawling Platform: Semi-Autonomous Controls - **Nicholas Espinal**
- Exploring Regional Hydrology Near the WIPP Using Watershed Workflow and the Advanced Terrestrial Simulator - **Aubrey Litzinger**
- Development of a Pneumatic Joint Member for Use in Robotic Manipulators - **Philip Moore**
- Advancing Nuclear Waste Tank Inspection: Robotic Sampling on a Miniature Rover - **Theophile Pierre**
- Erosion and Corrosion in Nuclear Waste Transfer Systems - Experimental and Computational Fluid Dynamic (CFD) Evaluations - **Bryant Pineda**
- Monitoring Hexavalent Chromium (Cr [VI]) Concentration in 100-H Area with Deep Learning - **Fabiola Rivera-Noriega**
- Automated Lateral Pipe Inspection System Integrating Pneumatic Crawler and Mechanized Reel - **David Rojas**
- Developing and Testing Radiation Resistant High Density Polyurethane Foam - **Bryan Torres**
- Camera Module Electronics Streamline for FIU’s Lateral Gamma Scanner - **Rafael Velasquez**

Figure 3. DOE Fellows with Dr. Ravi Gudavalli (Program Manager), Dr. Leonel Lagos (Program Director), judges and external guests.

Figure 4. DOE Fellows presenting posters at the 17th Annual Poster Exhibition/Competition.

FIU will conduct the next annual DOE Fellows poster exhibition on November 12, 2024, along with the DOE Fellows induction ceremony.

Task 4: DOE-EM Fellows Induction Ceremony

FIU conducted the 17th Annual DOE Fellows Induction Ceremony on November 8, 2023 and inducted 12 science, technology, engineering, and math (STEM) minority students into the program. Ten of the students will be supporting the DOE-EM research being conducted at FIU while two will be focused on DOE-LM research activities. The FIU students join 19 current fellows in the university's Science & Technology Workforce Development Program, also known as the DOE Fellows program.

Table 4. DOE Fellows Class of 2023 Inducted During the 17th Annual Induction Ceremony

DOE Fellow	Degree	Major
Bryant Pineda	M.S.	Mechanical Engineering
Carlos Rios	M.S.	Mechanical Engineering
*Daniel Coelho	Ph.D.	Computer Engineering
David Rojas	B.S.	Mechanical Engineering
Fabiola Rivera	B.S.	Computer Science
Grace Cooke	Ph.D.	Chemistry
Melissa Dieguez	B.S.	Biomedical Engineering
Pedro Chaviano	M.S.	Electrical Engineering
Reann Nicolas	B.S.	Civil Engineer
Theophile Pierre	B.S.	Mechanical Engineering
*Valeria Ocampo	B.S.	Biochemistry
Victor Gonzalez	B.S.	Mechanical Engineering

*DOE-LM Fellows.

Figure 5. DOE Fellows Class of 2023 with FIU and DOE Officials during the 17th Annual Induction Ceremony.

Gregory Sosson, DOE-EM's Associate Principal Deputy Assistant Secretary for Field Operations, Genia McKinley, DOE-FIU Cooperative Agreement Technical Monitor and Jean Pabon (JP),

Program Manager represented the Department of Energy Office of Environmental Management (DOE-EM). The Office of Legacy Management was represented by Ms. Jalena Dayvault and Mr. Mark Kautsky. Mr. Kautsky delivered the remarks on behalf of DOE-LM's Director Carmelo Melendez. FIU's administration was represented by Dr. Heather Russell (Vice Provost for Faculty Leadership and Success and Professor of Literature). Dr. Leonel Lagos (DOE Fellows Program Director and Principal Investigator for the DOE-FIU Cooperative Agreement) and Dr. Inés Triay (ARC Executive Director and Interim Dean of FIU's College of Engineering & Computing) also delivered messages to the new class. DOE-EM Fellow, Brendon Cintas, delivered a message to the new Fellows highlighting his personal experience, which he found fulfilling academically and professionally.

The Induction Ceremony events also counted with the participation of DOE-HQ Human Resources staff, Dr. Cheryl Lee. Industrial partners included United Cleanup Oak Ridge (UCOR) represented by Kent Fortenberry (Chief Operating Officer) and Sonya Johnson (Public Affairs and Stakeholder Management Director), as well as Ms. Ryan Overton (Executive Vice President) representing Navarro Research and Engineering.

In addition, during the ceremony, awards were presented to the winners of this year's DOE Fellows Poster Competition held on November 7th, 2023. The winners included Nicholas Espinal (1st place), Brendon Cintas (2nd place), and Shawn Cameron (3rd place). In addition, awards for DOE Fellow of the Year and Mentor of the Year were given. Mr. Shawn Cameron and Ms. Angelique Lawrence (Research Specialist II) were recipients of these awards, respectively.

Figure 6. DOE Fellows Shawn Cameron, Brendon Cintas and Nicholas Espinal receiving awards from Drs. Leonel Lagos (Program Director) and Ravi Gudavalli (Program Manager).

Figure 7. Ms. Angelique Lawrence and Shawn Cameron receiving Mentor of the Year and Fellow of the Year awards from Dr. Leonel Lagos and Ms. Gloria Dingeldein.

Task 5: Summer Internship Program (SIP)

During Year 3, twelve (12) DOE Fellows completed their summer internships across the DOE complex. The DOE Fellows completed summer internships and draft summer internship reports were submitted to summer mentors for review and approval. Approved reports were uploaded to the DOE Fellows website (fellows.fiu.edu) and a link was sent to DOE-HQ.

Table 5. DOE Fellows Summer Internships 2023

DOE Fellow	Site/Contractor	Mentor
Alejandro De-La-Noval	SRNL	Thomas Danielson
Aris Duani Rojas	PNNL	Timothy Johnson
Aubrey Litzinger	LBNL	Zexuan Xu
Brendon Cintas	WRPS	Douglas Reid
Bryan Torres	SRNL	Jenniffer Wohlwend
Gabriel Cerioni (MSIPP)*	SRNL	Christine Langton
Hannah Aziz	SRNL	Hansell Gonzalez
Joel Adams*	ERDC	Jordan Klein
Josue Estrada	WRPS	Douglas Reid
Nicholas Espinal	SRNL	Patrick Folk
Philip Moore	WRPS	Kayle Boomer
Rafael Velazquez*	INL	Kevin Young

Table 6. DOE Fellows Summer Internship Reports 2023

Name	Internship Report Title
Hannah Aziz	Evaluating Spatial Distribution of Contaminants in the Savannah River Site F-Area using ArcGIS Interpolation Methods
Brendon Cintas	Development of a Long-term Surveillance Unmanned Ground Vehicle (LTS-UGV) for Surveillance at the Hanford 200 Area
Josue Estrada	Development of Control Software for Autonomous and User-monitored Operation of Lateral Gamma Scanner System
Alejandro De La Noval	Using Natural Language Processing for Semantic Search in the Nuclear Domain
Aris Duani Rojas	Automatic Monitoring of Water Seepage in the F-Area 3 Basin Cap
Nicholas T. Espinal	Development of Robotic Arm for the Purpose of Glovebox Automation to Enhance Nuclear Waste Processing and Worker Safety
Aubrey Litzinger	Development of an Integrated Hydrology Spinup Model for the F-Area of Savannah River Site with the ALTEMIS Project
Philip Moore	Development of a Pneumatic Manipulator for Off-Riser Sample Retrieval
Bryan Torres	Testing of Radiation Resistant High Density Polyurethane Foam

During Year 4, fifteen (15) DOE Fellows participated in summer internships across the DOE Complex and with their contractors.

Table 7. DOE Fellows Summer Internships 2024

Name	Site	Mentor
Rafael Velasquez†	INL	Kevin Young
Gabriel Cerioni*	SRNL	Christine Langton
Aubrey Litzinger	Drummond Carpenter, PLLC	Joshua “Bud” Davis
Aris Duani Rojas	PNNL	Tim Johnson
Melissa Dieguez	PNNL	Alex Kugler
Bryan Torres	SRMC	Jeremiah Ledbetter
Bryant Pineda	SRNL	Bruce Wiersma/Pavan Shukla
Carlos Rios	SRNL	Michael Tomlin

Name	Site	Mentor
Carolyn Cooke	SRNL	Hansell Gonzalez-Raymat
Victor Gonzalez	SRNL	Evan Koelker/Austin Coleman
Fabiola Rivera	SRNL	Tom Danielson
Brendon Cintas	WRPS	Douglas Reid
David Rojas	WRPS	Douglas Reid
Pedro Chaviano	WRPS	Douglas Reid
Theophile Pierre	WRPS	Douglas Reid

†Partially funded by INL
*Funded by MSIPP

Aris Duani Rojas is participating in a summer internship at Pacific Northwest National Laboratory (PNNL) under the guidance of mentor Dr. Timothy Johnson. His project is focused on solving Physics Inversions using Artificial Intelligence. More specifically, during the events of World War II and the Cold War at the Hanford site, chromium was used as a corrosion inhibitor in the reactor cooling water. However, leakage of the chromium compounds in underground piping and other accidental spillages led to the chromium being deposited into the soil. Over time, these chromium compounds may move into the groundwater and contaminate the Columbia River.

Current solutions to this problem include locating the chromium compounds in the soil, and then moving the solutions out of the soil by diluting them with water and then pumping them out. However, making predictions about the location of the chromium compounds and the expected movement of water requires knowledge of the underlying properties of the subsurface. Physics inversions aim to answer the following question: What subsurface properties would give the readings measured by sensors? The physics inversions aim to figure out the soil characteristics given some sensor readings. This process is extremely slow, computationally expensive, and provides approximate solutions.

Aris's current work has been focused on exploring the use of both Neural Networks and Physics Modeling tools to compute physics inversions in a faster, less computationally expensive, and most precise manner. He successfully computed inversions for simulated data in the desired way (faster, less computationally expensive, precise) over the current inversion solutions. Figure 8 shows a prediction done on the test set sample #25 which shows the Neural Network's capabilities of computing inversions even on unknown data. All predictions of the Neural Network on the test set have reported R^2 scores of at least 0.92 (the highest possible is 1.0), which means that there is a strong linear relationship between the true targets and the model's predictions. This shows good generalization from the learning on the training set to the predictions on the test set. However, if the field data digresses from the distribution of the simulated data by too much, then the Neural Network will struggle to generalize as well as it did in Figure 8 and the test set in general. Aris is currently working on exploring the use of a Physics Simulator to address this issue.

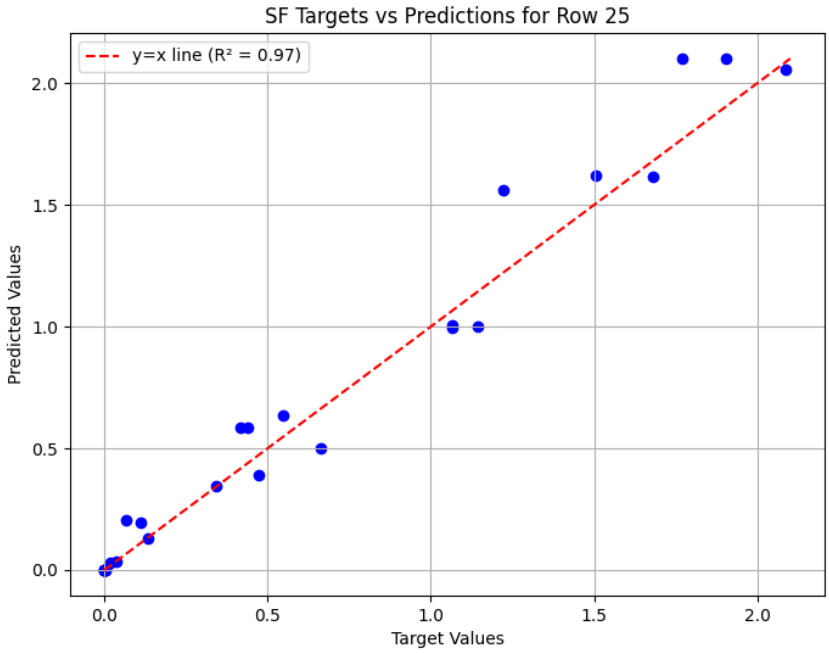


Figure 8. Comparison between the target inversion values and the predicted inversion values.

During his summer internship at Savannah River National Laboratory (SRNL), DOE Fellow **Bryant Pineda** is working under the mentorship of Pavan Shukla on a project titled "*Establishing Standardized Application of Vapor Corrosion Inhibitors for Soil Side Protection of Aboveground Storage Tanks*". The characteristic of corrosion within the metal class is a natural decaying occurrence that affects the performance, structural integrity, and overall efficiency of functionality. Aboveground Storage Tank (AST) operators are currently experiencing an increase of corrosion on the ground floor layer of the tanks due to ineffective corrosion mitigation methods, inadequate monitoring systems, and severe environmental impact. The response thus far for the process of mitigation is the usage of Cathodic Protection (CP) within the parameters of the tanks. Studies have shown that the system to delay corrosion ineffectively and be interrupted by the materials composition of the tank pad. For this reason, several tank operators are shifting to the use of Vapor Corrosion Inhibitors (VCI) to stabilize and delay the effects of corrosion on this specific layer to prevent any leakage of contaminants from being environmentally alternating. VCI has not been adequately standardized to meet the needs of the AST due to various environmental factors. There are multiple errors that can alter the corrosion impact at the ground floor level; for this reason, the proposal is to design an effective method to qualify and modify the VCI properties to the specific conditions required by the operators. These experiments will provide a guide and analysis of various properties that naturally change the rate of corrosion, including salt level, sand pad quality, water containment, and moisture content, allowing for an understanding of the capability and quality the VCI offers. Standardizing the methods of VCI usage will provide informative and applicable experimental results that could be repeatable and enhanced to fit the requirements of the AST floor layer for effective corrosion mitigation.

Figure 9. Carbon steel coupons experimental setup.

Figure 10. Carbon steel (ER) probes (bottom), before corrosion (top), and after corrosion.

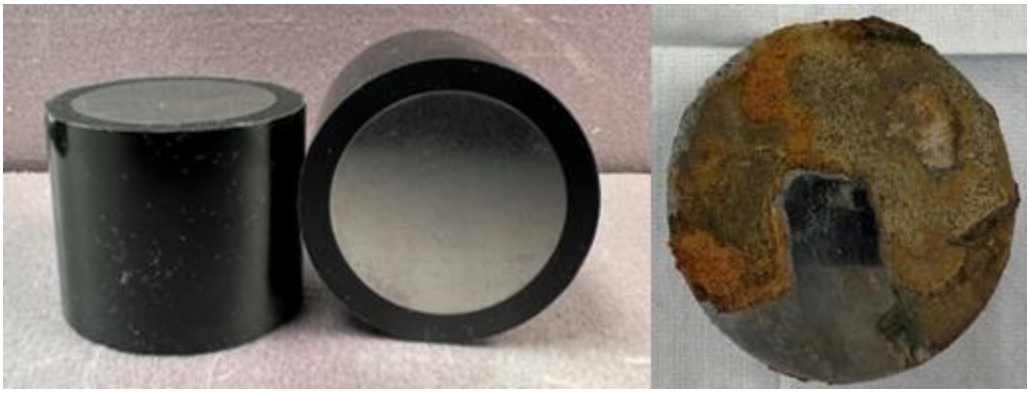


Figure 11. Carbon steel coupons before corrosion (left), and after corrosion (right).

Carols Rios's project at SRNL during his summer internship is to design a robot end arm to dilute and dispose of plutonium stored in modified waste drums and outfit it with a tamper indicating device meant to ensure that the contents of the drum have been checked and secured. Multiple tools already exist that the arm cycles through during the inspection and loading process. The tool being designed is meant to autonomously remove the tamper indicating device before the final loading and storing stage. Throughout the summer, Carlos has been using an iterative design process, where he created an original base design using his mechanical knowledge as well as references to other tools designed for different purposes in the same project. At the moment, Carlos is finishing the final design assembly in 3D modeling software and is currently working on 3D printing and assembling a prototype to test on the robotic arm.

The new tool Carlos is designing for the inspection and loading of plutonium and involves specially designed waste drum, dubbed a CCO (Criticality Control Overpack), that holds the radioactive material within an inner shell inside, titled a CCC (Criticality Control Container), to prevent leakage. A tamper indicating device is installed on it once the CCO/CCC assembly is inspected to indicate that the drum and its contents are secured and have not been tampered with.

The Tamper Indicating Device, or TID for short, is the focus of his robotic arm tool. The step in the plutonium disposal and storage process that he has been given control over involves the removal of said device so the tool can properly store the waste drum, as the devices are meant to be reused. It consists of a plastic injection molded piece that hooks onto the bolt holding the drum closed, while an aluminum shaft is crimped after being inserted into the plastic piece, which folds the metal into the part to prevent removal. Carlo's tool is meant to secure the TID and uncrimp the shaft to allow for removal of the TID.

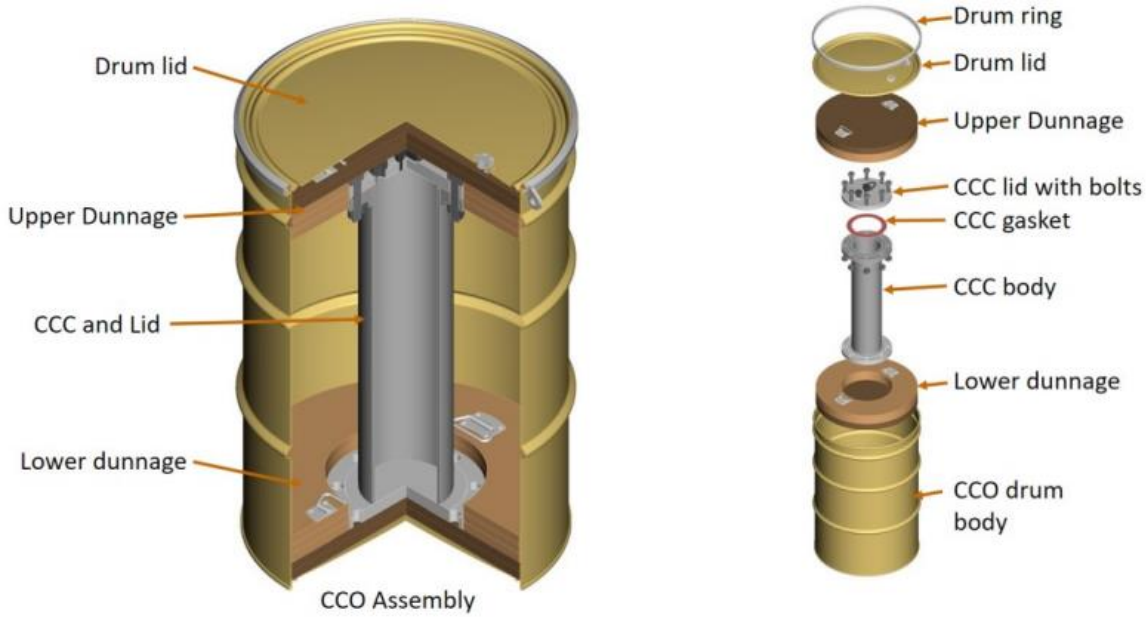


Figure 12. CCO and CCC diagram.

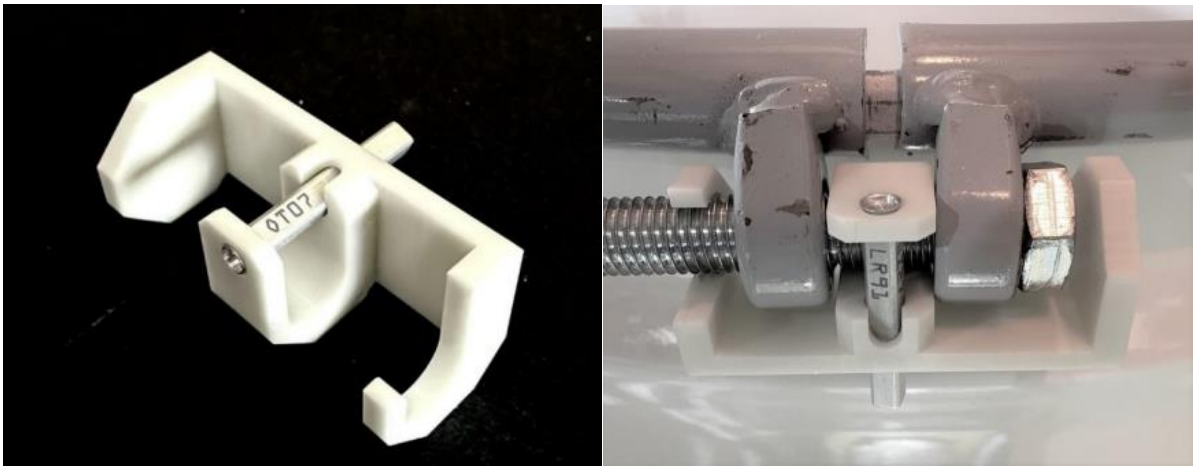


Figure 13. Tamper Indicating Device (TID) with shaft and TID installed on CCO.

At SRNL, DOE Fellow **Fabiola Rivera-Noriega** is currently working under the guidance of Thomas Danielson to build an algorithm that is able to locate the best places to test for Radon in Aiken County. Radon is the leading cause of lung cancer in non-smokers and a significant indoor air concern. Originating from natural uranium and thorium in the soil, radon's indoor accumulation is influenced by geology, temperature, barometric pressure, and building construction. Fabiola will be finding the places that are high in radon based on the amount of discovered uranium near it.

Current radon risk mapping is done at the county level, often based on limited and uncontrolled in-home measurements. Counties like Aiken, designated as low risk, still have over 10% of residents exposed to harmful radon levels. Modern mapping strategies should use a combination of aerial spectral gamma measurements and geological maps. Voluntary at-home test kits in Aiken County have detected radon levels over 18 times the EPA's action level. To improve risk mapping resolution and specificity, her work will use statistics and data analysis to identify correlations between uranium measure, different rock formations, elevation levels, and regions within Aiken County. So far, principal component analysis, clustering, and correlation methods like Kendall's Tau have been used to work on this project.

The Annulus Vacuum Crawler Project aims to enhance tank inspection and cleaning operations with a highly maneuverable and efficient robotic crawler. This project focuses on developing, manufacturing, and deploying the Crawler. A comprehensive testing plan includes evaluating obstacle maneuverability, verifying suction power, ensuring seamless system integration, and conducting additional tests for further refinement.

At FIU, **Pedro Chaviano** is developing a remote-operated method for cleaning and inspecting nuclear storage tanks at the DOE's Hanford site. This remote-operated cleaning tool will be deployed through the 24” tank risers to clean the Double-Shell Tank while providing video feedback. The goal of Pedro’s internship at WRPS is to enhance tank inspection and cleaning by improving the crawler's design, maneuverability, and performance. During the internship, Pedro will test the robot to identify and address navigation

challenges and ensure its air consumption meets site requirements. The goal is to refine the system's reliability, effectiveness, and safety for real-world applications.

The Annulus Vacuum Crawler Project is developing a robotic crawler to improve inspection and cleaning in tank environments, focusing on design refinement and performance enhancement. Throughout the internship, Pedro investigated and performed trials to determine the most reliable deployment strategies. The tests included assessing and improving obstacle maneuverability, verifying, and enhancing suction power, ensuring seamless system integration, and identifying and implementing further refinements. The results will evaluate performance, system integration, and optimization. They will offer essential data for continuous improvement, ensuring the system's reliability and effectiveness.

Figure 14. Cold Tank Mockup at WRPS (left) and DOE Fellow Pedro Chaviano at the Mockup (right).

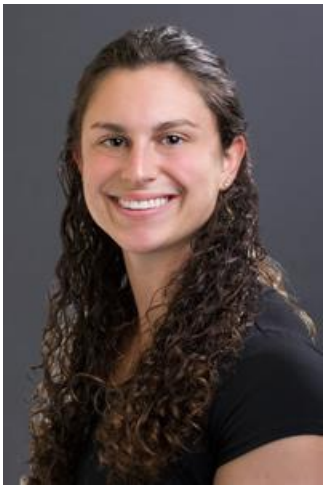
During a summer internship with Drummond Carpenter, PLLC, DOE Fellow **Aubrey Litzinger**, assisted in applying RESRAD-OFFSITE modeling to help develop the Waste Acceptance Criteria (WAC) for the Environmental Management Disposal Facility (EMDF) at the Oak Ridge Reservation (ORR). Aubrey specifically worked on improving the meat transfer factor in the RESRAD model to better account for beef, poultry, and eggs in radionuclide dose calculations. This was important for accurately assessing radiation exposure from food pathways. In addition to technical modeling, Aubrey assisted in tasks directly tied to DOE Order 435.1, which governs the management and disposal of radioactive waste. Aubrey worked to ensure that all aspects of the WAC complied with the strict safety, environmental,

and health guidelines set forth by DOE 435.1, including documentation, compliance verification, and adherence to long-term waste management standards.

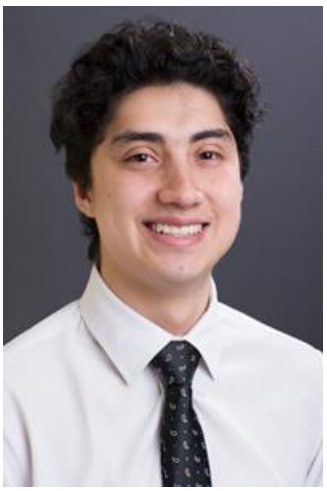
Brendon Cintas's (DOE Fellow) aim during his summer internship with WRPS was to improve worker health and safety practices by adapting off-the-shelf robotic systems to suit Hanford needs. The focus on this project builds upon last year's proof-of-concept deployment, focusing on the needs of stakeholders from the WRPS Industrial Hygiene and Radiation Control organizations to implement, test, and deploy sensors that would assist workers in conducting routine surveillance operations to emergency response. Additionally, the robot includes a slew of new safety features that assist the operator, such as obstacle detection and awareness, facilitating maneuvers that actively avoid impacts to objects and personnel. Lastly, the robot has been equipped with a fully functional, custom user interface that transmits and displays real-time information about the robot's telemetry and its environment, such as ammonia levels and dose readings.

Figure 15. Clearpath Jackal equipped with a 3D Lidar, Depth Camera, and Wireless Telemetry at Hanford Cold Test Facility (CTF).

At SRMC, DOE Fellow **Bryan Torres** had the opportunity to be part of Process and Regulatory Engineering Group at the Defense and Waste Processing Facility (DWPF). During this summer internship, he worked on different tasks, including calculating the theoretical maximum flow rate of a new transfer for the recycled precipitate of DWPF to H-Tank Farms. This project encompassed reviewing previous calculations, analyzing scrolls and engineering drawings to identify the piping network and path, graphing pump curves, and drafting technical documents like a Technical Design Request for Design Services. Although my calculations were for scoping purposes, Bryan worked closely with the appropriate Tank Farm Design Authority Engineer to provide all the necessary references to confirm my results. During his time at SRMC, Bryan also worked on other tasks analyzing and computing data and reviewed technical and safety documents to identify administrative controls preventing the implementation of automation of transfers.



This summer, **Carolyn Cooke** researched the effect of pH on the adsorption of iodide onto minerals that are found in the F-Area aquifer. The aim of this study is to better understand the mobility and attenuation of radioiodine in F-Area. Minerals were selected based on XRD spectra of aquifer sediment samples from the upper aquifer zone, tan clay confining zone, and lower aquifer zone, and the sample pH values were set from 3-9. A literature review was conducted for the individual minerals adsorption with iodide and iodate, and the results of the experiment are expected to reflect the k_d values found in the literature. Moreover, minerals with higher anion exchange capacities are expected to be better sorbents for iodide and iodate than minerals with lower anion exchange values.



During the summer internship, **David Rojas** had the opportunity to work on a sonar project, specifically assisting with the integration of the gimble mechanism for orienting the sonar. He was responsible for the calibration of the sonar equipment and participating in the data collection process. He also played a key role in processing and analyzing the data using Python and the Open3D library. Throughout the testing phase, David fine-tuned the settings of the sonar to optimize its resolution and accuracy. This included adjusting the parameters to better detect the varying materials inside the tank, such as differentiating between the rock, foam-brick combination, and the wooden plank. He also contributed to the visualization efforts by refining the post-processing scripts that converted raw sonar data into 3D models.

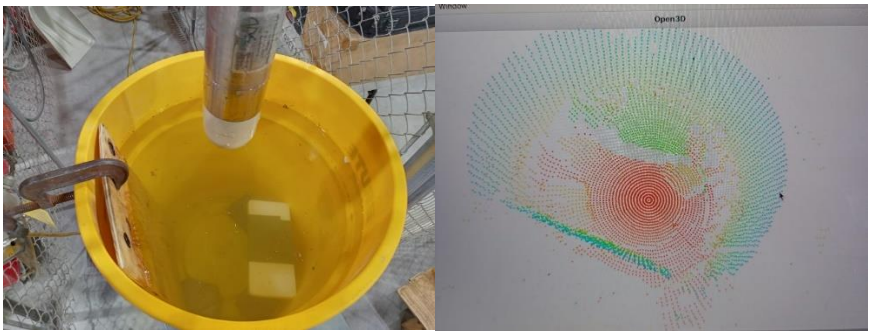


Figure 16. Objects inside 50-gallon Tank mimicking Hanford Tanks (left), sonar scan (right).

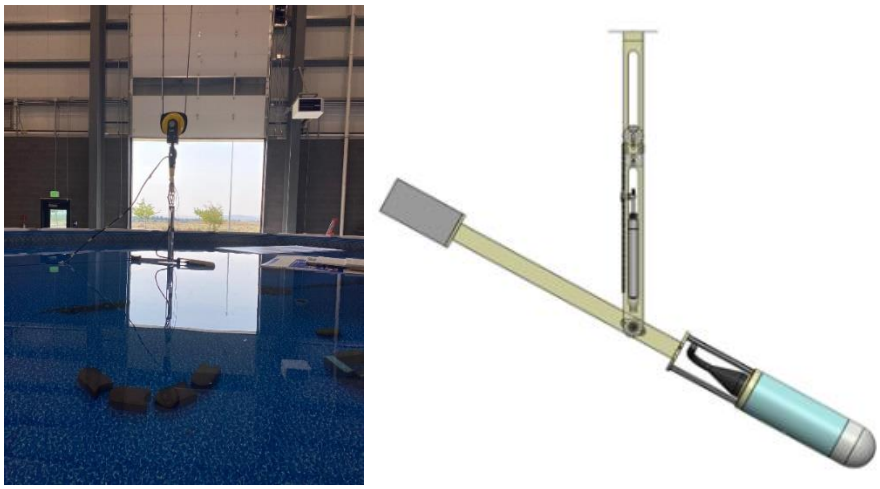


Figure 17. Sonar attached to crane for deployment (left), Sonar attached to the gimble (right).

During summer 2024, DOE Fellow **Melissa Dieguez** participated in a summer internship at Pacific Northwest National Laboratory (PNNL), located in Richland WA. She worked on a research project that is focused on cyanide mobilization testing in soil and groundwater under the mentorship of Dr. Alex Kugler, Earth Scientist, as well as Dr. Hilary Emerson, Environmental Engineer, and Mr. Andrew Plymale, Biologist.

In attempting to immobilize Cs-137 in the underground storage tanks located at the Hanford Site, sodium ferrocyanide and nickel sulfate were used to precipitate Cs-137. The remaining solution was then transferred for storage which has led to some inadvertent discharge of ferrocyanide-containing solutions. Ferrocyanide is not commonly considered to be environmentally hazardous; however, it can release free cyanide under certain circumstances, which is an environmental pollutant. The purpose of this project is to test whether remediation treatments tested as part of the Deep Vadose Zone project affect the state of the cyanide present in the soil. Melissa conducted experiments to mimic the previous batch studies conducted while analyzing the effects of the cyanide on these treatments.

Figure 18. Batch samples treated with Molasses (left), difference in chemical and physical characteristics after the injection of Poly-PO4 for the CPS treatment (center and right).

This summer DOE Fellow **Rafael Valesquez** participated in an internship with IEC and worked with engineers as they planned for the removal of radioactive Calcine from tanks in INL. He worked on two tasks this internship and designed the drawings for a cellular repeater and aiding in the HoloLens model development. The Cellular repeater involved meeting engineers and tradespeople in planning out a system to bring cell phone service inside the testing facility. The HoloLens model involved me learning to access and modify a 3D model of the testing facility to add interactive features visible from Microsoft HoloLens. With the former, he got to experience traditional design engineering roles while the latter exposed me to VR development.

"Going around Idaho was fun. It is a beautiful state with lots of outdoors to experience. I got to see more of the places I went last year and even got to travel to new places," said Rafael Valesquez reflecting on his internship experience.

Figure 19. DOE Fellow at Idaho Potato Museum during his summer internship.

During his summer internship at WRPS, **Theophile Pierre** had the opportunity to work with the Off Riser Sampler System (ORSS), focusing on various demonstrations and hands-on activities. Here are the key highlights:

- **July 16th ORSS Demonstration:** The day featured a demonstration of the pneumatic hammer on a concrete block, highlighting its impact and precision.
- **Intern Interactions:** An image captured an FIU intern interacting with the ORSS, highlighting the collaborative aspect of the internship.
- **End Effector Demonstrations:** Demonstrated the end effector, emphasizing its versatility and functionality.

Figure 20. Demonstration of pneumatic hammer on concrete block.

Theo said that this internship provided valuable hands-on experience with robotic systems and their applications.

Task 6: Conference Participation and Presentations

15 DOE Fellows attended and presented posters based on their research at WM2024 held in Phoenix, AZ from March 10 - 14, 2024. Two (2) DOE Fellows Alejandro De La Noval and Aubrey Litzinger, 2024 Roy G. Post Scholarship recipients, presented posters on Sunday, March 10, 2024, during *Session 41 WM2024 Roy G. Post Scholarship Winners Posters*.

Table 8. Roy G. Post Foundation Scholarship Recipients 2024

DOE Fellow	Abstract ID	Title
Alejandro De La Noval	24590	Using Natural Language Processing for Semantic Search in the Nuclear Domain
Aubrey Litzinger	24668	Exploring the Surface and Subsurface Hydrology Near the Waste Isolation Pilot Plant Using Watershed Workflow and the Advanced Terrestrial Simulator

Figure 21. DOE Fellows Alejandro De La Noval and Aubrey Litzinger with other winners.

DOE Fellows had an opportunity to meet Dr. Ike White, U.S. Department of Energy Office's Assistant Secretary for Environmental Management, after the keynote speech during plenary session on Monday March 11, 2024.

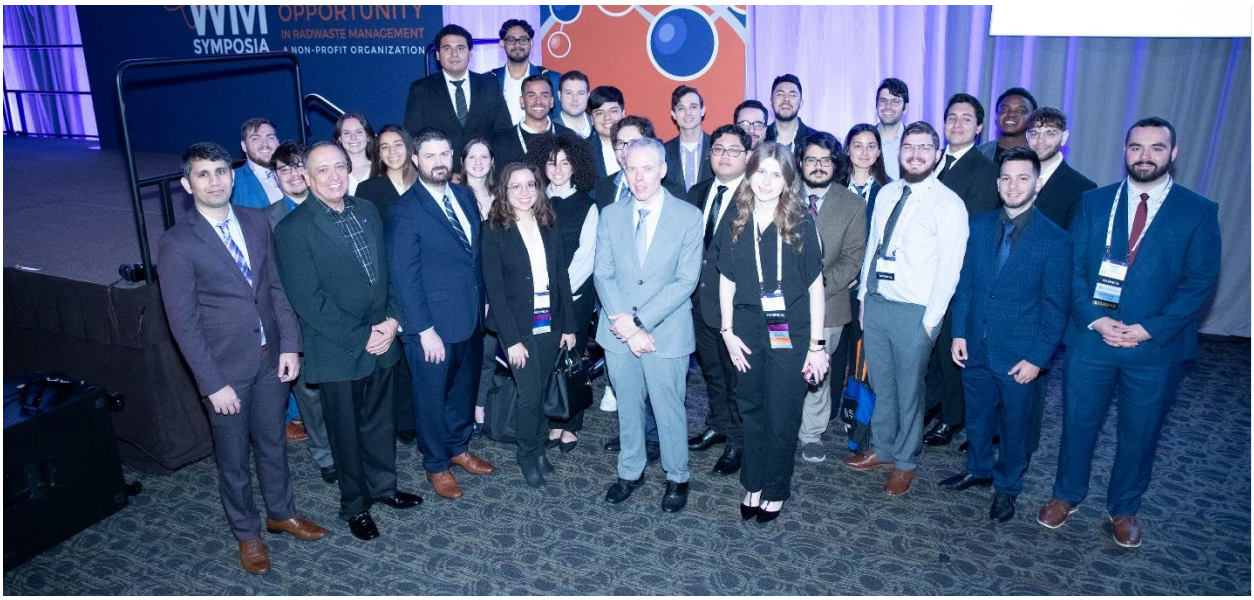


Figure 22. DOE Fellows and MSIPP students with Dr. Ravi Gudavalli (Program Manager), Dr. Leonel Lagos (Program Director), Dr. Ike White (Assistant Secretary for Environmental Management, DOE-EM) and Mr. Jeffrey Avery (Principal Deputy Assistant Secretary EM-2, DOE-EM).

Thirteen (13) DOE Fellows participated in session 042 Student Poster Competition: Future Industry Leaders on Monday, March 11, 2024 and presented posters based on their DOE-EM research accomplishments. DOE Fellow Bryant Pineda received the best graduate poster award for his poster titled "*Evaluating the Erosion and Corrosion Behavior in Nuclear Waste Transfer Systems*".

Table 9. DOE Fellows Participation at WM2024 Student Poster Competition

DOE Fellow	Abstract ID	Title
Aris Duani Rojas	24614	Deep Learning-Based Water Seepage Monitoring in F-Area 3 Basin Cap
Brendon Cintas	24694	Development of a Long-term Surveillance Unmanned Ground Vehicle (LTS-UGV) for Surveillance at the Hanford 200 Area
Bryan Torres	24695	Testing of Radiation Resistant High Density Polyurethane Foam
Bryant Pineda	24741	Evaluating the Erosion and Corrosion Behavior in Nuclear Waste Transfer Systems
David Rojas	24722	Lateral Gamma Scanner Deployment for Hanford's Single-Shell Tanks
Fabiola Rivera	24639	Monitoring Hexavalent Chromium and Remediation Technology with Deep Learning
Gabriel Cerioni	24691	3D printed Concrete Waste Container design
Hannah Aziz	24684	Evaluating the spatial distribution of contaminants over time in the Savannah River Site F-Area and their potential fate and transport
Joel Adams	24709	Continuous Surveillance of Nuclear Facilities Using Multiple Robot Platforms
Nicholas Espinal	24677	Design Improvements and Electronic Packaging for Current H-Canyon Wall Crawling Platform
Philip Moore	24704	Development of a Pneumatic Joint-Member for Use in an Off-Riser Sampling System for Hanford's Waste Tanks
Rafael Velasquez	24729	Camera Module Electronics Streamline for FIU's Lateral Gamma Scanner
Theophile Pierre	24679	Advancing Radioactive Waste Management: Developing an Innovative Sampling Mechanism for Enhanced Hanford Site Remediation

Figure 23. DOE Fellow Bryant Pineda won the best graduate poster at WM2024.

DOE Fellows participated in various other sessions as described below:

- Former DOE Fellow, Olivia Bustillo (Staff Engineer at Drummond and Carpenter) participated in a session 6 Panel: Former Roy G. Post Scholarship Winners Now Leading Our Industry Mon, March 11, 2024.
- DOE Fellow Brendon Cintas presented an oral presentation titled *"Development of Long-term Surveillance Unmanned Ground Vehicles for Nuclear Facility Inspections"* during session 39 Integrity and Inspections for HLW Retrieval (2.04a).
- DOE Fellow Brandon Cintas participated in session 62 Panel: Graduating Students and New Engineers - Wants and Needs - Are Companies Even Listening?
- Former DOE Fellow, Olivia Bustillo participated in session 85 Panel: Young Professionals in Nuclear Science and Engineering an International Perspective.
- Additionally, DOE Fellows and FIU students participated in a Round Table with DOE EM Leadership.

Figure 24. DOE Fellow Brendon Cintas during panel session (left); DOE Fellows and FIU students at roundtable with EM leadership (right).

Figure 25. DOE Fellows and FIU student with Dr. Leonel Lagos, Dr. Ravi Gudavalli, Mr. Jeffrey Avery (Principal Deputy Assistant Secretary EM-2, DOE-EM), Mr. Greg Sosson (Associate Principal Deputy Assistant Secretary, Office of Field Operations EM-3).

DOE Fellow Aubrey Litzinger attended the Battelle Chlorinated Conference from June 2-6, 2024, in Denver, Colorado. This conference is a premier event addressing the latest developments in the assessment, remediation, and management of chlorinated and complex contaminated sites. The conference this year featured 477 platform presentations, 550 poster presentations, and 8 technical panels. Key topics included innovative technologies for site characterization, monitoring, risk assessment, and remediation strategies. In addition, several sessions covered advancements in bioremediation, chemical treatment, emerging contaminants, and sustainable solutions.

Figure 26. DOE Fellow Aubrey Litzinger (far left) at the 2024 Battelle Chlorinated Conference in Denver, Colorado with *(from left to right)* Tony Finding (COO, Brownfield Science & Technology); Chad Drummond (Principal Engineer & President) and Olivia Rockett (Professional Geologist) of Drummond Carpenter, PLLC (SDVOSB).

Task 7: DOE-EM Fellows Lecture Series Forum

DOE Fellows participated in several Tech Talks hosted by Florida International University (FIU) as outlined below:

- DOE Fellows attended a D&D Tech Talk on October 18, 2023, featuring Dr. Thomas Danielson from Savannah River National Laboratory. The title of his talk was *"Natural Language Processing for Event Discovery, Extraction, and Inferential Forecasting"*.

- DOE Fellows participated in a Tech Talk on January 16, 2024, with Dr. Hilary Emerson and Dr. Jim Szecsody from Pacific Northwest National Laboratory (PNNL) titled *"Uranium Characterization and Remediation at the Hanford Site"*.
- DOE Fellows participated in a D&D Tech Talk on April 16, 2024, featuring Mr. Bryan Steinfeld titled *"Development and Deployment of a ground robotic platform for radiation Radiological Contamination Detection"*.
- DOE Fellows participated in a D&D Tech Talk focusing on D&D topics relevant to the DOE EM Complex. On July 16, 2024, FIU featured a Tech Talk from Joseph (Joe) Sinicrope, the title of the talk is *"A Case Study: The Strategic Integration of Consensus Standards to Facilitate Fixative Technology Development, Deployment, and Acceptance".*

DOE Fellows participated in an info session held on February 13th, 2024, by Drummond Carpenter, PLLC. Former DOE-LM Fellow, Olivia Bustillo, who is now a Sr. Staff Engineer at Drummond Carpenter, PLLC, visited FIU to host a seminar so that the DOE Fellows could learn about opportunities available to them. Drummond Carpenter, PLLC is an engineering consulting firm that has contracts with DOE EM and LM, NASA, and UCOR, among many other clients and is specialized in a variety of engineering disciplines as well as applied research.

DOE Fellows participated in an AI & Robotics Workshop hosted by Florida International University on April 22 - 24, 2024. The Technology Innovation Hub: Applied Robotics and Artificial Intelligence for Nuclear Decommissioning Workshop serves as a collaborative platform where industry leaders, academic heads, faculty, and students can engage in insightful discussions to better understand the Robotics/AI landscape.

Task 8: DOE-EM Fellows and DOE-EM HBCU Collaboration/Integration

FIU maintains continuous communication with DOE MSIPP representatives for input for the MSIPP program and/or internships and job opportunities for FIU students. FIU will expand communication and engagement with DOE-EM HBCU STEM programs to promote collaborative synergistic research and STEM development efforts between FIU and HBCU universities related to EM technical issues and challenges. Out of these relationships, FIU hopes to identify qualified STEM students interested in pursuing graduate STEM degrees at FIU.

CONCLUSIONS

This innovative workforce development program was officially established in March 2007. This project is successfully meeting its objectives by providing research training and mentoring for students from underrepresented groups on environmental problems at DOE sites, in addition to providing several new formal recruitment and retention mechanisms for qualified students from underrepresented groups to pursue advanced studies, research training, and eventual career placement at DOE sites.

Figure 27. DOE Fellows Infographic.

Two hundred and nine (209) FIU STEM students have been inducted into the program and have completed 224 internships since 2007. Twenty-Three (23) DOE Fellows were hired by DOE EM, DOE national labs and contractors. One hundred and five (105) DOE Fellows have been hired by private industry and government agencies. Additional information about the entire program and the DOE Fellows can be found on the website.

https://fellows.fiu.edu/.

ACKNOWLEDGEMENTS

U.S. DOE Cooperative Agreement provided funding for this research #DE-EM0005213. FIU's Applied Research Center would like to acknowledge the commitment of DOE-EM to this specific workforce development program and to all the research being conducted as part of the Cooperative Agreement. The partnership between DOE EM and FIU has resulted in the development and training of outstanding minority STEM students that will benefit this country as a whole.

APPENDIX A: FIU YEAR 4 ANNUAL RESEARCH REVIEW PRESENTATIONS

The following documents are available at the DOE Research website for the Cooperative Agreement between the U.S. Department of Energy Office of Environmental Management and the Applied Research Center at Florida International University:
https://doeresearch.fiu.edu/SitePages/Welcome.aspx

FIU Year 4 Annual Research Review Presentations:

1. FIU Research Review - Project 1
2. FIU Research Review - Project 2
3. FIU Research Review - Project 3 - D&D IT ML
4. FIU Research Review - Project 4
5. FIU Research Review - Project 5
6. FIU Research Review - Project 4-5 – Carlos Rios
7. FIU Research Review - Project 4-5 – Fellow Aris
8. FIU Research Review - Project 4-5 – Fellow Aubrey
9. FIU Research Review - Project 4-5 – Fellow Melissa
10. FIU Research Review - Project 4-5 – Fellow Ocampo
11. FIU Research Review - Project 4-5 – Fellow Victor
12. FIU Research Review - Project 4-5 – Fellow Theophile
13. FIU Research Review - Wrap Up - Project 1
14. FIU Research Review - Wrap Up - Project 2
15. FIU Research Review - Wrap Up - Project 3 – D&D IT ML
16. FIU Research Review - Wrap Up - Project 4
17. FIU Research Review - Wrap Up - Project 5

APPENDIX B: DOE FELLOWS IN GRADUATE PROGRAMS

DOE Fellows in STEM Graduate Programs - Ph.D.

DOE Fellow	Discipline	Degree	Research Topic Based on DOE EM projects	Year of Graduation
Charles Castello	Electrical Engineering	Ph.D.	Soil/Groundwater - Sensor Development for Field Measurement of Mercury	2011
Claudia Cardona	Environmental Engineering	Ph.D.	Remediation of the uranium-contaminated subsurface in the deep vadose zone via NH_3 gas injection	2017
Hansell Gonzalez-Raymat	Chemistry	Ph.D.	Unrefined humic substances as a potential low-cost remediation method for groundwater contaminated with uranium in acidic conditions	2018
Sebastian Zanlongo	Computer Science	Ph.D.	Multipurpose All-Terrain Robotic Platform for D&D	2018
Roger Boza[2]	Computer Science	Ph.D.	Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies	
Silvina Di Pietro	Chemistry	Ph.D.	Ammonia Gas Treatment for Uranium Immobilization at DOE Hanford's Site	2021
Cristian Acevedo		Ph.D.	*Note[1]*	
Emma Lopez		Ph.D.	*Note[1]*	
Reiner Hernandez		Ph.D.	*Note[1]*	
Eric Inclan		Ph.D.	*Note[1]*	
Bryant Thompson		Ph.D.	*Note[1]*	
Alejandro Garcia		Ph.D.	*Note[1]*	
Orlando Gomez	Physics	Ph.D.	*Note[1]*	
Alejandro Hernandez	Chemistry	Ph.D.	*Note[1]*	
Phuong Pham	Chemistry	Ph.D.	Interaction of iodine species with OrganoClays and Granulated Activated Carbon	2022
Mariah Doughman	Chemistry	Ph.D.	Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments	2024
Aurelien Meray[2]	Computer Science	Ph.D.	Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies	2024
Juan Morales	Public Health	Ph.D.	Accumulated Metalloestrogens Analysis for Health Risk Assessment and Watershed Toxicology Management in Tims Branch, SRS	2024
Joel Adams	Mechanical Engineering	Ph.D.	Long Term Surveillance of Nuclear Facilities and Repositories	2025 (anticipated)

DOE Fellow	Discipline	Degree	Research Topic Based on DOE EM projects	Year of Graduation
Brendon Cintas	Mechanical Engineering	Ph.D.	Experimental analysis of flushing criteria for waste transport operations	2025 (anticipated)
Caridad Estrada	Environmental Engineering	Ph.D.	*Note*[1]	
Gabriel Cerioni	Mechanical Engineering	Ph.D.	In-Situ 3D Printing Concrete Structures for Waste Containment	2027 (anticipated)
Carolyn Grace Cooke	Chemistry	Ph.D.	Interaction of iodine species with Organoclays and Granulated Activated Carbon	2027 (anticipated)
Hannah Aziz	Environmental Engineering	Ph.D.	*Note*[1]	
Nicholas Espinal	Mechanical Engineering	Ph.D.	*Note*[1]	

[1] *Note: student is pursuing graduate level degree at another academic institution/department.*
[2] *Student left the DOE Fellows program before completion of their doctoral degree.*

DOE Fellows in STEM Graduate Programs – Masters

DOE Fellow	Discipline	Degree	Research Topic Based on DOE EM projects	Year of Graduation
Jose Vazquez	Environmental Engineering	Master	Effects of temperature and pH on volatilization of mercury after chemical reduction	2009
Amy Pahmer	Engineering Management	Master	Non-Thesis Option	2010
Duriem Calderin	Biomedical Engineering.	Master	Modeling of Loose Contamination Scenarios to Predict the Amount of Contamination Removed	2010
Leydi Velez	Industrial Engineering	Master	Decision Modeling Tools D&D Surveillance & Maintenance	2010
Serkan Akar	Biomedical Engineering	Master	Design and Development of an Enzyme-Linked Biosensor for Detection and Quantification of Phosphate Species	2010
Amaury Betancourt	Environmental Engineering	Master	Soil/Groundwater - Modeling of Mercury Contamination at ORNL	2011
Denny Carvajal	Biomedical Engineering	Master	Soil/Groundwater – Bacteria Interaction due to Polyphosphate Injection at Hanford	2011
Edgard Espinosa	Mechanical Engineering	Master	Waste Processing - CFD Modeling of NuVison's Power Fluidic Technology/Process Remote Stack Characterization System	2011
Elsa Cabrejo	Environmental Engineering	Master	Soil/Groundwater - Modeling of Mercury Contamination at ORNL	2011
Melina Idarraga	Environmental Engineering	Master	Dissolution rate of natural meta-autunite: effects of aqueous bicarbonate, pH and temperature	2011
Merlin Ngachin	Environmental Sciences	Master	Waste Processing - Baltman-Lattice Method to Model HLW	2011
Stephen Wood	Mechanical Engineering	Master	Modeling of Pipeline Transients: Modified Method of Characteristics	2011
William Mendez	Engineering Mngmt.	Master	Development of Remote Stack Char. System	2011
Eric Inclan	Mechanical Engineering	Master	Mesh adaptation for use in Lattice Boltzmann code	2012

DOE Fellow	Discipline	Degree	Research Topic Based on DOE EM projects	Year of Graduation
Kanchana Iyer	Biomedical Engineering	Master	Non-Thesis Option	2012
Lee Brady	Mechanical Engineering	Master	Non-thesis option	2012
Lilian Marrero	Environmental Engineering	Master	Soil/Groundwater - Modeling of Mercury Contamination at ORNL	2012
Mario Vargas	Mechanical Engineering	Master	Kinematic Control of Remote Stack Characterization System	2012
Melissa Sanchez **	Environmental Engineering	Master	Non-thesis option	2012
Yulyan Arias**	Environmental Engineering	Master	Non-thesis option	2012
Elicek Delgado-Cepero	Electrical Engineering	Master	Structural Health Monitoring Inside Concrete and Grout Using the Wireless Identification Sensing Platform	2013
Heidi Henderson	Environmental Engineering	Master	Surface water and contaminant transport within the Oak Ridge National Laboratory	2013
Jaime Mudrich	Mechanical Engineering	Master	Development of a Coupling Model for Fluid-Structure Interaction using the Mesh-free Finite Element Method and the Lattice Boltzmann Method	2013
Janty Ghazi	Electrical Engineering	Master	Control, through Sensors and LabVIEW, of the Asynchronous Pulsing Unit	2013
Jose Matos	Mechanical Engineering	Master	Development of improved Bodies for a Peristaltic Crawler for Radioactive Pipeline Unplugging	2013
Mariela Sliva	Engineering Management	Master	Non-Thesis Option	2013
Joel McGill*	Environmental Engineering	Master	Non-Thesis Option	2014
Paola Sepulveda	Biomedical Engineering	Master	Investigating the Role of a Less Uranium Tolerant Strain, Isolated from the Hanford Site Soil, on Uranium Interaction in Polyphosphate Remediation Technology	2014
Revathy Venkataraman	Computer Science	Master	Performance Evaluation of Mobile Applications with KMIT Technology Web Services	2014
Valentina Padilla	Environmental Engineering	Master	Non-Thesis Option	2014
Andrew De La Rosa*	Computer Science	Master	Non-Thesis Option	2015
Dayron Chigin*	Electrical Engineering	Master	Non-Thesis Option	2015
Maximiliamo Edrei	Mechanical Engineering	Master	Investigation of Mixing Times of Sparged Bingham plastic type fluids as applied to the Pulse Jet Mixing Process	2017
Natalia Duque	Environmental Engineering	Master	Non-Thesis Option	2017

DOE Fellow	Discipline	Degree	Research Topic Based on DOE EM projects	Year of Graduation
Robert Lapierre*	Chemistry	Master	Mineral characterization after uranium sequestration by pH manipulation using NH_3 gas	2017
Alejandro Garcia	GeoScience	Master	The influence of biofilm formation on the SIP response of Hanford vadose zone sediment	2018
Mohammed Albassam	Water resource Engineering	Master	Effect of Frequent Atmospheric Events on Flow Characterization in Tims Branch and its Major Outfalls	2018
Joseph Coverston	Mechanical Engineering	Master	Evaluation of Pipeline Flushing Requirements for HLW at Hanford and Savannah River	2019
Joshua Nunez	Mechanical Engineering	Master	The applications of intumescent technologies in support of D&D activities across the DOE complex	2019
Ryan Cruz	Cyber Security	Master	Non-Thesis Option	2019
Amanda Yankcoskie*	Environmental Engineering	Master	Non-Thesis Option	2020
Jason Soto	Mechanical Engineering	Master	Design of Robotic Inspection Platform for Structural Health Monitoring	2020
Ron Hariprashad	GeoScience (Hydrogeology)	Master	Modeling of Surface Water Flow and Contaminant Transport in the Tims Branch Ecosystem	2020
Tristan Simoes-Ponce	Mechanical Engineering	Master	D&D Technology Demonstration & Development and Technical Support to SRS's 235-F Facility Decommissioning	2020
Alexis Vento	Environmental Engineering	Master	Fate of Actinides in the Presence of Ligands in High Ionic Strength Systems	2021
Jeff Natividad	Mechanical Engineering	Master	Evaluation of Coatings for the H-Canyon Exhaust Tunnel	2021
Edward Nina*	Mechanical Engineering	Master	Non-Thesis Option	2020
Michael Thompson	Electrical Engineering	Master	Structural health monitoring of pipelines in radioactive environments through acoustic sensing and machine learning	2020
Gisselle Guiterrez	Environmental Engineering	Master	Digital Elevation Model and Hydrologic Network	2022
Lorryn Adnrade*	Environmental Engineering	Master	Fate of Actinides in the Presence of Ligands in High Ionic Strength Systems	2022
Ryan Ocampo*	Civil Engineering	Master	Evaluation of Coatings for the H-Canyon Exhaust Tunnel at the Savannah River	2022
Raymond Piloto*	Electrical Engineering	Master	Pipeline corrosion and erosion evaluation	2022
Olivia Bustillo	Environmental Engineering	Master	Use of Apatite for Uranium Sequestration at Old Rifle Site	2023
Josue Estrada	Mechanical Engineering	Master	Development of Inspection Tools for DST Tanks	2023
Christian Dau*	Computer Science	Master	Analysis of Image Data using Machine Learning/Deep Learning	NA

DOE Fellow	Discipline	Degree	Research Topic Based on DOE EM projects	Year of Graduation
David Mareno*	Cyber Security	Master	Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies	NA
Aubrey Litzinger	Environmental Engineering	Master	Model Development (for Basin 6 of the Nash Draw near the WIPP)	2024
Rohan Shanbhag	Computer Science	Master	AI for EM Problem Set (Soil and Groundwater)	NA
Sebastian Story	Mechanical Engineering	Master	Development of Inspection Tools for Primary Tanks	2023
Stevens Charles	Environmental Engineering	Master	Note1	NA
Alejandro De La Noval	Computer Science	Master	Deep Learning Based Spatial-Temporal Analysis on Groundwater Chromium Concentration	Anticipated 2024
Philip Moore	Mechanical Engineering		Development of an Off-Riser Sampling System for Hanford Waste Tanks	2024
Bryant Pineda	Mechanical Engineering	Master	Pipeline Corrosion and Erosion Evaluation	Anticipated 2025
Rafael Valesquez	Electrical Engineering	Master	Improvement of Mobile Platform Efficiency	Anticipated 2026
Theophile Pierre	Mechanical Engineering	Master	Development of Robotic Systems for DOE Sites	Anticipated 2026
Fabiola Rivera	Computer Engineering	Master	Exploratory Data Analysis & Machine Learning Model for Hexavalent Chromium [Cr(VI)] Concentration in The 100-H Area (PNNL)	Anticipated 2026
Bryan Torres	Mechanical Engineering	Master	Evaluation of Pipeline Flushing Requirements for HLW at Savannah River	Anticipated 2026

**This student left the DOE Fellows program before completion of their master's degree.*

***This student left the DOE Fellows program but completed their master's degree at FIU.*

APPENDIX C: DOE FELLOWS EMPLOYMENT

DOE Fellows Hired by DOE-EM, Contractors and National Laboratories

First Name	Last Name	Employer
Edgard	Espinosa	DOE EM Office of Nuclear Materials Disposition
Merlin	Ngachin	Waste Control Specialists (Texas) and currently hired by Argonne National Lab
Rubymir	Romero	Bechtel Power
Lee	Brady	DOE EM office of Deactivation and Decommissioning
Duriem	Calderin	Columbia-Energy Environmental Services (Richland, WA), AREVA NP (Richland, WA), Pacific Northwest National Lab (PNNL), and currently at IAEA
Charles	Castello	Oak Ridge National Laboratory (ORNL) -Energy & Transportation Science Division
Rosa	Ramirez	DOE EM International Programs
Stephen	Wood	Oak Ridge National Laboratory (ORNL)
Nicole	Anderson	National Energy Technology Laboratory (NETL)
Hansell	Gonzalez	Savannah River National Laboratory (SRNL)
Adamandios	Manoussakis	Sandia National Laboratory
Silvina	Di Pietro	National Nuclear Security Administration (NNSA)
Juan	Morales	Savannah River National Laboratory (SRNL)
Tristan	Simoes-Ponce	Savannah River National Laboratory (SRNL)
Roger	Boza	INL
Jeff	Natividad	WRPS
Olivia Hilda	Bustillo	Drummond Carpentar
Mariah	Doughman	PNNL
Josue	Estrada	WRPS
Phuong	Pham	Savannah River National Laboratory (SRNL)
Sebastian	Story	LANL
Alejandro	De La Novela	SRNL
Melissa	Dieguez	PNNL
Aubrey	Litzinger	Drummond Carpenta

DOE Fellows Hired by Federal, State and Local Governament Agencies

First Name	Last Name	Employer
Serkan	Akar	Department of Commerce
Denisse	Aranda	NASA
Alex	Henao	Internal Revenue Services
Jose	Vazquez	Department of State
Amaury	Betancourt	Florida Department of Environmental Protection
Cindy	Cerna	Naval Sea Systems Command
Jennifer	Borges	Florida Department of Transportation
Elsa	Cabrejo	Dade County Environmental Department (Miami, Fla)

Alessandra	Monetti	Department of Defense – Office of the Secretary of Defense, Army Corp of Engineering
Kanchana	Iyer	Department of Health & Human Services
Alexander	Lopez	Florida Department of Transportation
Melissa	Sanchez	Florida Department of Environmental Protection
Frank	Silva	Department of State
Kiara	Pazan	U.S. Corps of Engineers
Jesse	Viera	U.S. Marine Corps
Christine	Wipfli	U.S. Dept of Defense
Sarah	Bird	U.S. Dept of Defense
Christopher	Strand	FAA
Mohammed	Albassam	City of Coconut Creek

DOE Fellows Hired by Private Industry

First Name	Last Name	Employer
Danny	Brenner	General Electric
Ramon	Colon	Bouygues Civil Works Florida
Henry	Diaz	Lockheed
Raul	Dominguez	Kimley-Horn and Associates, Inc.
Erica	McKinney	Boeing Company
William	Mendez	Boeing Company
Amy	Pahmer	Mount Sinai Medical Center
Giancarlos	Pena	Caribe Utilities of Florida, Inc
Jose	Rivera	FIU's Applied Research Center
Leydi	Velez	PriceSmart Inc
Sandra	Zapata	Johnson & Johnson
Melina	Idarraga	Nova Consulting Inc.
Dasney	Joseph	General Electric
Victor	Uriarte	Intel Corporation
Denny	Carvajal	Mount Sinai Medical Center
Rinaldo	Gonzalez Galdamez	Crane Aerospace and Electronics
Nadia	Lima	HJ Foundation
Jose	Matos	Beckman Coulter
Mario	Vargas	Boeing Company
Yulyan	Arias	CH2M Hill
Maite	Barroso	Sikorsky Aircraft
Givens	Cherilus	Florida Power & Light
Elicek	Delgado	Motorola
Janty	Ghazi	Kiewit Power
Heidi	Henderson	CPH Inc.
Sheidyn	NG	Regeneron Pharmaceuticals
Shina	Rana	Florida Power & Light
Claudia	Cardona	STEM
Nel	Ciurdar	Burns & McDonnell

First Name	Last Name	Employer
Lilian	Marrero	MWH Global
Joshua	Midence	Creativity, Value, Logic
Carol	Moreno-Pastor	Cummins
Jaime	Mudrich	Beckman Coulter
Ximena	Prugue	BRG Sports
Paola	Sepulveda	StryKer
Jennifer	Arniella	Permasteelisa North America
Francisco	Bolanos	Beckman Coulter
Dania	Castillo	HDR
Dayron	Chigin	Florida Power & Light
Joel	McGill	BND Engineers
Lucas	Nascimiento	Raytheon
Raul	Ordonez	Texas Instruments
Valentina	Padilla	Brown & Caldwell
Mariela	Silva	Conoco Phillips
Gabriela	Vazquez	Florida Power & Light
Revathy	Venkataraman	TradeStation
Michael	Abbott	Magic Leap Inc
Michelle	Embon	Kimley-Horn and Associates, Inc.
Mariana	Evora	King Engineering Associates, Inc
Eduardo	Garcia	UTC Aerospace Systems
Steve	Noel	Goldman Sachs
Sasha	Philius	HaikuTech Europe B.V.
Brian	Castillo	StryKer
John	Conley	Florida Power & Light
Andrew	De La Rosa	Lockheed
Jorge	Deshon	Lockheed
Maria	Diaz	Nova Consulting Inc.
Maximiliano	Edrei	Huntington Ingalls Newport News Shipbuilding Company
Janesler	Gonzalez	Velossa Tech
Meilyn	Planas	Florida Power & Light
Ryan	Sheffield	Applied Physics Laboratory
Aref	Shehadeh	Nova Consulting Inc.
Alexis	Smooth	Nexant
Sebastian	Zanlongo	Johns Hopkins University, Applied Physics Laboratory
Michael	DiBono	Microsoft
Ron	Hariprashad	RS&H
Ripley	Raubenolt	SCS Engineering
Sarah	Solomon	County of Los Angeles Department of Public Works
Joseph	Coverston	Pennsylvania State University Applied Research Laboratory
Ryan	Cruz	Lockheed
Katherine	Delarosa	Advanced Environmental Laboratories

First Name	Last Name	Employer
Christopher	Excellent	FPL
Ximena	Lugo	Kimley-Horn and Associates, Inc.
Joshua	Nuñez	Dayton-Granger, Inc.
Alex	Rivero	General Electric
Jason	Soto	SIA Solutions LLC
Patrick	Uriarte	iRobot
Alexis	Vento	SCS Engineering
Derek	Gabaldon	Rolls-Royace
Gisselle	Gutierrez	Kimley-Horn and Associates, Inc.
Daniel	Martin	FIU's Applied Research Center
Michael	Thompson	Raytheon
Rocio	Trimino Gort	A&P Consulting Transportation Engineers, Corp.
Adrian	Muino	Lockheed Martin
Eduardo	Rojas	Kinetic Engineering and Accident Reconstruction
Desmond	Sinnott	Florida Power and Light
Philip	Moore	Florida Power and Light

APPENDIX D: STUDENT RESEARCH PROJECT

TECHNICAL REPORT

Design of a Concrete 3D Printer

FIU Collaborators:
Gabriel Cerioni (DOE Fellow)
Ravi Gudavalli, Ph.D. (Research Scientist)
Leonel Lagos, Ph.D., PMP® (Principal Investigator)

SRNL Collaborators:
Christine Langton

Submitted to:
U.S. Department of Energy
Office of Environmental Management
Under Cooperative Agreement No. DE-EM0005213

DISCLAIMER

TABLE OF CONTENTS

Executive Summary

This report describes the development and implementation of a 3D concrete printer designed for manufacturing waste containment vessels. A 3D concrete printing system was developed and optimized to begin testing of Ultra-High-Performance Concrete (UHPC) containers for radioactive waste storage. Traditional storage methods using carbon steel and stainless-steel containers face degradation challenges due to water infiltration in below-grade storage. The system developed utilizes a gantry-style framework with three degrees of freedom and incorporates an auger-based extrusion system, enabling precise material deposition with UHPC. The developed 3D printing system, combined with UHPC's superior hydraulic properties, presents a promising alternative to traditional steel containers. The printer features a 5ft³ build volume and accommodates various nozzle configurations for experimental flexibility. A concrete mixture was formulated using locally sourced materials, incorporating silica fume, slag, methyl cellulose, and other admixtures to achieve optimal printing characteristics and structural integrity. The system demonstrated reliable performance through multiple test prints, with successful resolution of technical challenges including lead screw coupling failures and extrusion inconsistencies. Future developments will focus on ROS2 integration, computer vision systems, and advanced toolpath generation algorithms. This research establishes a foundation for further development of 3D-printed concrete waste containment vessels, with potential applications extending beyond nuclear waste storage.

Introduction

Low Level radioactive waste has been generated at Savannah River Site as a byproduct of the environmental remediation activities being conducted at the site. Traditionally, carbon steel and stainless-steel drums and boxes have been used to store and dispose of radioactive waste. These steel containers contain low level waste (LLW) and are placed in below-ground environments where they are exposed to water infiltration, causing the container to rust and degrade over time, leaching radioactive contaminants into the surrounding environment. However, a promising alternative manufacturing process gaining attention in the construction industry is 3D Concrete Printing (3DCP), known for its ability to produce complex geometries, reduce construction cost / waste, and improve safety. This method can also be combined with Ultra-High-Performance Concrete (UHPC). UHPC offers excellent hydraulic properties, with low porosity and conductivity, resulting in minimal ion diffusion. These characteristics make UHPC an ideal candidate for the containment of radioactive waste and debris. Coupled with 3D printing, or Additive Manufacturing (AM) in various industries, UHPC is now being explored as a potential replacement for traditional steel containers. Leveraging 3D printing technology enables the creation of custom-designed containers tailored to specific waste types, offering a cost-effective and flexible solution. Moreover, 3D printers can be deployed in remote locations or spaces with limited room for traditional containers. This project aims to design and construct a 3D printer to

assist SRNL and other national labs in evaluating the feasibility of using 3D-printed UHPC for LLW containers.

At Florida International University (FIU), investigation into the use of 3D printed concrete as a viable waste encapsulation method requires the design and production of a concrete 3D printer. This 3D printer should have a large print volume, compared to traditional 3D printing, to allow for the creation of large-scale objects for accurate testing. Additionally, the printer should be capable of accepting various nozzle systems to facilitate the broad range of experiments that will be conducted. In parallel to the printer, a 3D printable concrete mixture will be developed using ingredients local to FIU for comparative analysis.

Objectives

The objective of this project is to produce 3D printed concrete containers to assist the DOE national labs in researching the feasibility of using 3D-printed UHPC for LLW containers as a viable form of waste encapsulation. The project involves:

- the design of a system capable of precisely delivering concrete for Additive Manufacturing methods, and
- the development of a 3D-printable concrete mixture adequate for waste disposal.

System Development

Mechanical Design

Various types of 3D printers are used for concrete construction, each suited to specific needs. Gantry-based printers are ideal for large structures, while robotic arm and delta printers excel at creating complex ones. Rotational printers are specialized for circular structures, and mobile printers offer on-site flexibility at the cost of precision. Hybrid printers combine technologies for versatility but come with higher complexity and cost. Due to its simplicity of design and ability to accommodate large loads and print volumes, while maintaining high accuracy, a gantry style printer was selected. The printer is designed to hold 1 cubic foot of concrete to be used during printing. Additionally, the printer must incorporate a print area of 5ft x 5ft to allow for large-scale models. The beginning phases involved the use of Computer Aided Design (CAD) software to design and construct the full printer. All components of the printer were modeled and assembled into a functional virtual prototype as shown in Figure 1.

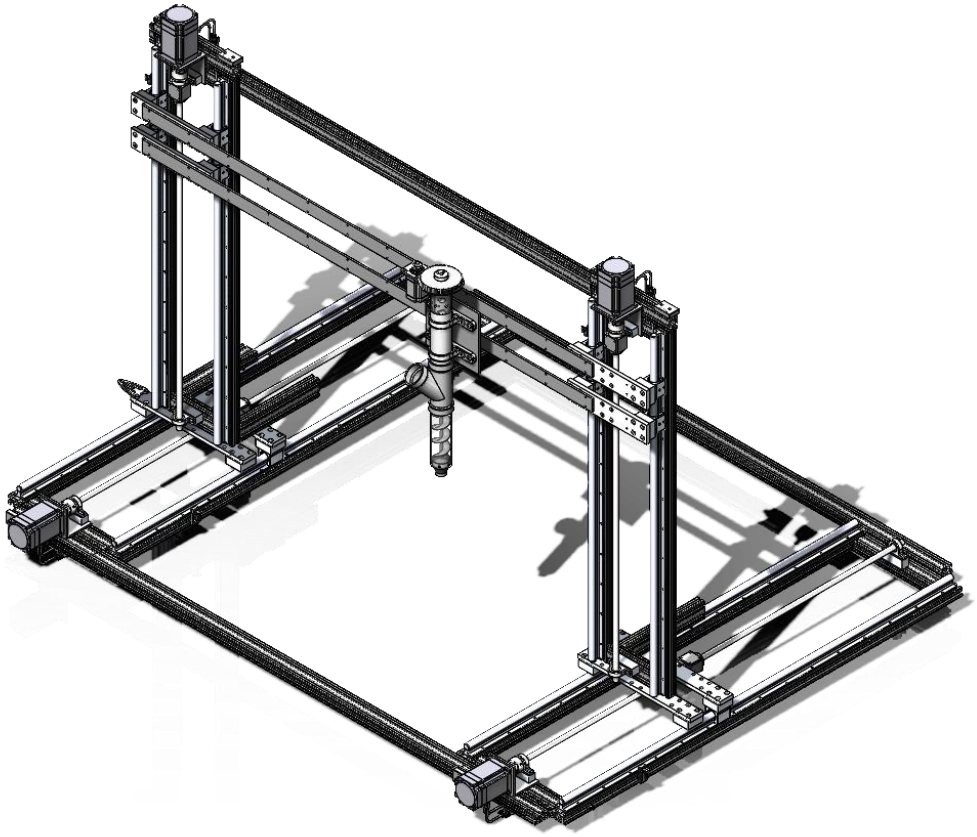


Figure 1. CAD of fully assembled 3D concrete printer.

This system was inspired by commercially used concrete printers for home construction. Modeled components were then used to produce blueprints for manufacturing and 3D printing. Figure 2 shows some of the components manufactured in house, laying on top of the parts blueprint, for the 3D printer.

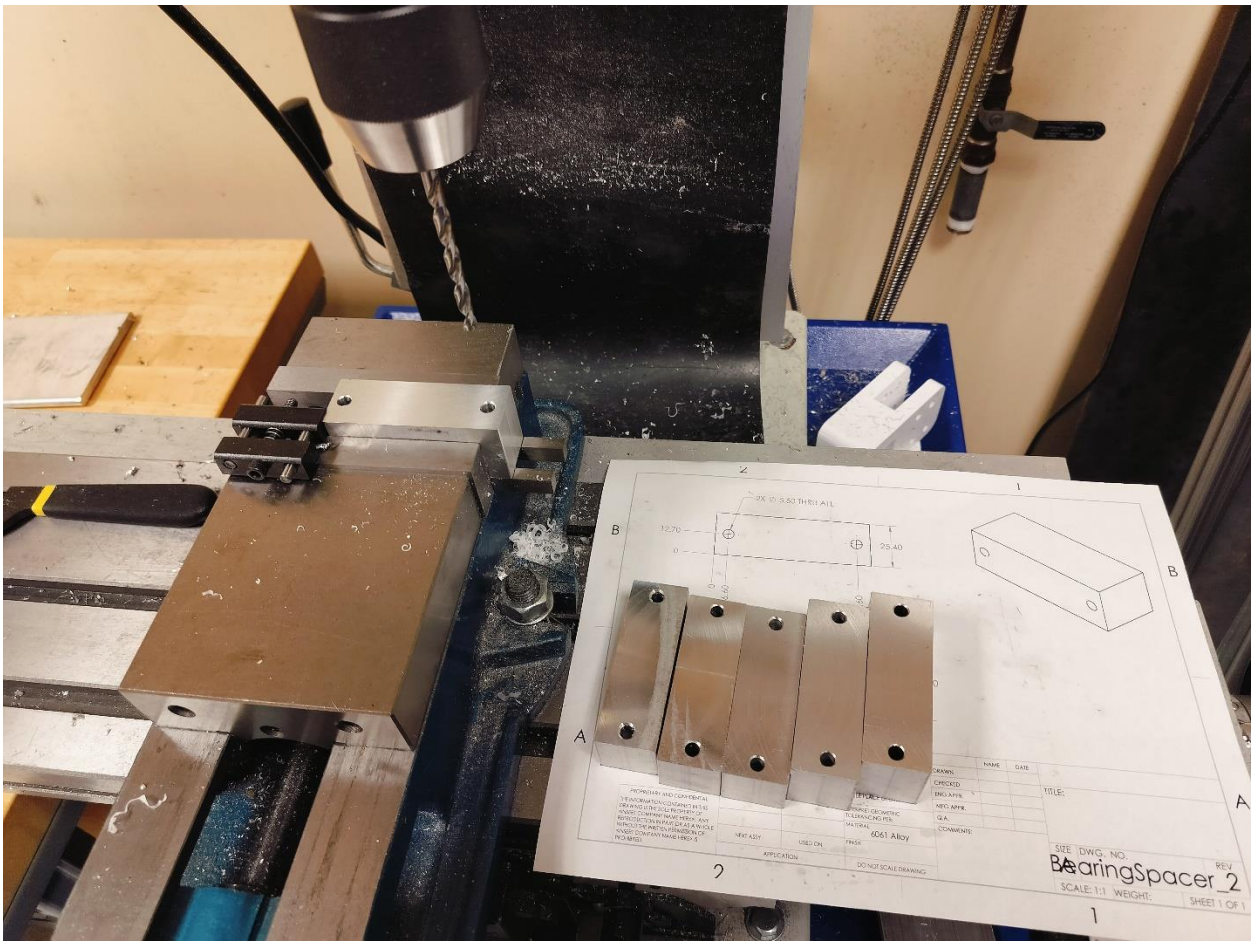


Figure 2. Metal parts manufacturied with the in-house mill.

The printer was developed using an iterative approach, beginning with a two degree of freedom (2DoF) prototype system, shown in Figure 3. The 2DoF system is mounted to a wooden table that houses the computer, control systems, and power. This system was used as a proof of concept as well as a development platform for the extrusion and control systems referenced in later sections. The full printer's framework utilizes aluminum extrusions for modularity and ease of assembly, complemented by linear guide rails for precise motion control improved rigidity. Using

Equation 1, the general equation to calculate Torque required to lift a load, it was determined that a NEMA 32 stepper motor along with a 16mm Lead screw will be capable of lifting the required load. The required load for the system was calculated at 250lbs. This incorporates the weight of a cubic foot of concrete, the linear system, and the nozzle. A safety factor of 0.2 was introduced on top of the estimated load and used for component and material selection. A lead screw was selected for this application, instead of a ball screw, due to the self-locking nature of lead screws. This self-locking nature will prevent damage to the system, printed objects, and personnel if a power outage should occur during printing. Additionally, this allows the system to maintain position more accurately. This self-locking nature can be determined with a similar equation to the lifting force,

as shown in Equation 2. If the torque required to lower the load is positive, the lead screw is considered self-locking.

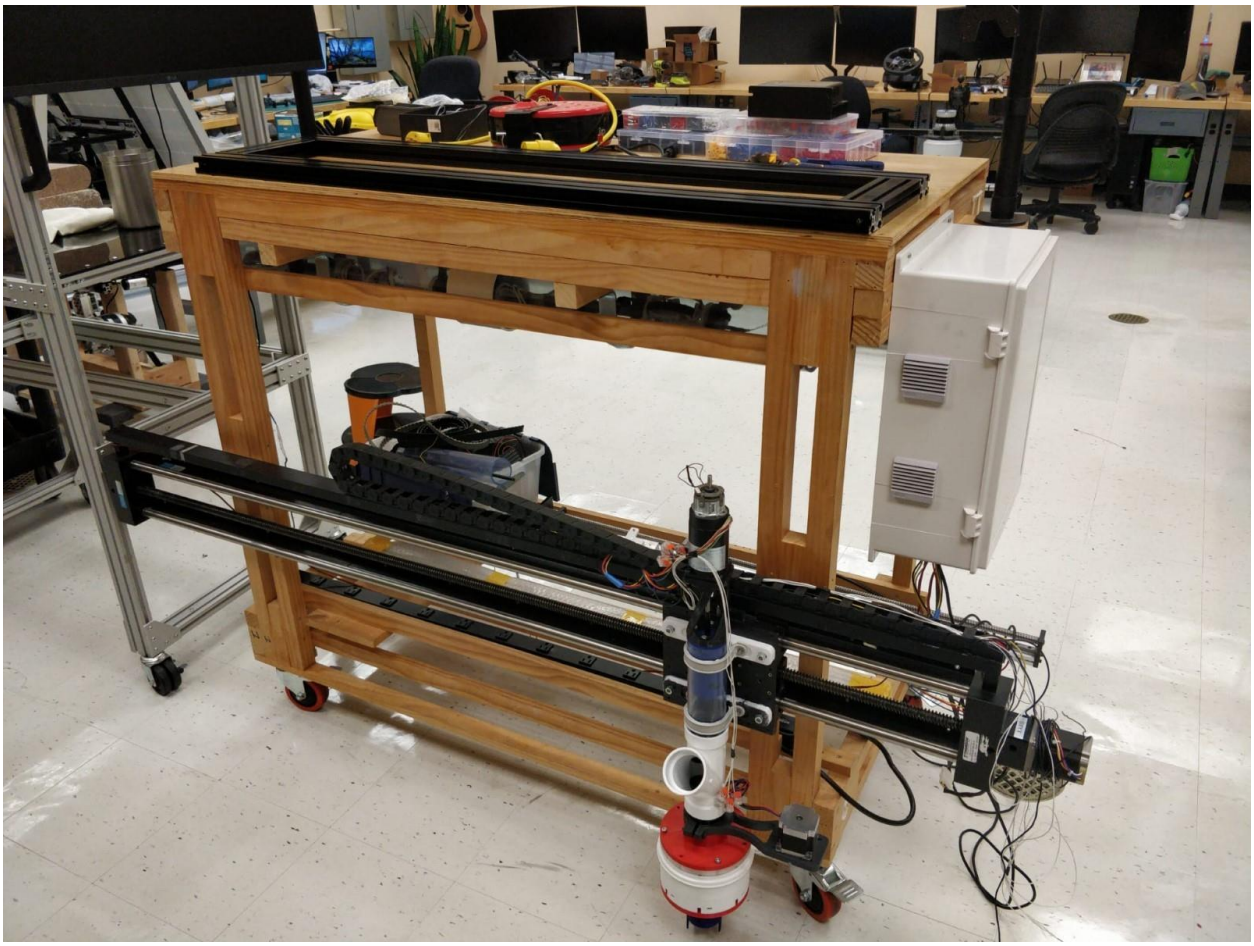


Figure 3. 2DoF system mounted to a control table.

Equation 1 Torque to Raise Load:

$$T_R = \frac{F \cdot d_m}{2}\left(\frac{l + \pi f d_m \sec\alpha}{\pi d_m - f l \sec\alpha}\right) + T_c$$

Equation 2 Torque to Lower Load:

$$T_L = \frac{F \cdot d_m}{2}\left(\frac{-l + \pi f d_m \sec\alpha}{\pi d_m + f l \sec\alpha}\right) + T_c$$

Figure 4. Fully Assembled Concrete 3D printer.

Throughout the year, several key mechanical improvements were implemented to enhance system reliability and performance. Initial testing revealed vulnerabilities in the lead screw assemblies, which were addressed by replacing the original grub screws with higher-grade steel components. A comprehensive cable management system with protective sheathing was installed to prevent interference and ensure safe operation. The integration of limit switches with custom-designed noise-reducing circuits significantly improved position accuracy and system protection. Figure 4 shows the fully assembled printer with the nozzle attached to the system. Behind the printer is the table with the computer used to control the system, send commands, show debugging logs, and create Geometric Codes (G-Codes) for object printing. Additionally attached to the table is the control box which houses the power supplies for the system and the microcontroller that interprets G-Code commands into motor motion.

Extrusion System

Various types of designs were evaluated for the extrusion system. A pneumatic extrusion uses compressed air to drive a piston, while screw (auger) extrusion rotates an auger to move material through the nozzle. Peristaltic pump utilizes a flexible hose and rollers to squeeze the material, like a tube of toothpaste. Piston extruder utilizes a piston driven by a lead screw [2]. The final design implements an auger-based system shown in Figure 5. This configuration was selected due to its simplicity of design, precise flow control, and ability to allow for continuous feeding of material. The extrusion system is designed to separate into 2 halves that can be easily cleaned of concrete to prevent seizing of the nozzle components. Additionally, the nozzle tip can be easily replaced to accommodate nozzles of varying diameter. The nozzle offers the capability to be attached to a pump and print continuously. Similar to the full system, the nozzle was also initially designed in CAD, shown in Figure 5 (A). Figure 5 (B) shows the assembled nozzle mounted onto the completed system.

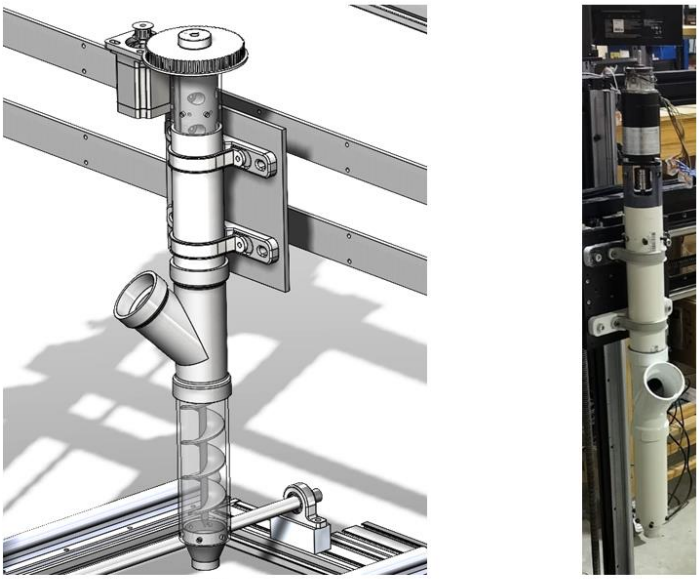


Figure 5. (A) CAD model of auger style nozzle; (B) Fully assembled nozzle.

Control System

The printer operates using an open-source motion control system common in industrial and consumer CNC applications. The control architecture incorporates multi-axis coordination capabilities, enabling the production of 3D objects with high precision. The control system allows for real-time flow rate and motion adjustments to ensure consistent material deposition throughout the printing process and accommodate a wider range of material rheology. The system fully integrates with standard G-code protocols, allowing for compatibility with common slicing and toolpath generation software. Additionally, custom Python scripts were developed to enhance functionality, providing advanced features such as automated calibration and parameter

optimization. The microcontroller utilized has the capacity to accept more motors or sensors for future implementations. Figure 6 shows the internals of the control box housing the controller, drivers, and Power Supplies for the system.

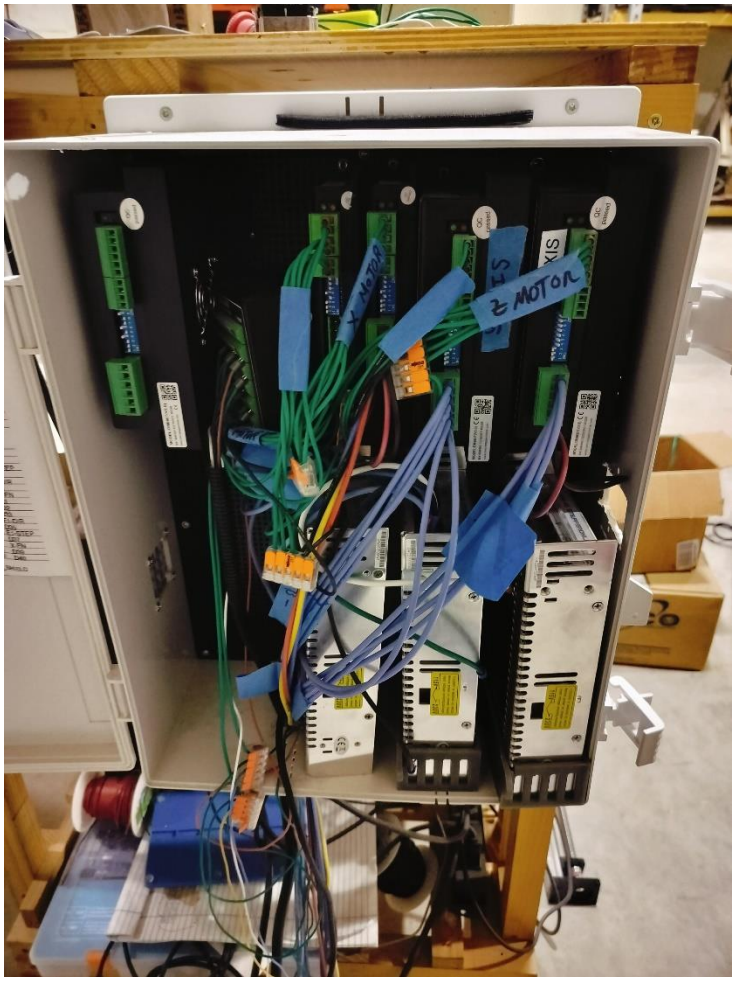


Figure 6. Inside View of Control Box.

Material Development

Concrete Mixture

A specialized concrete mixture was developed using locally sourced materials to achieve optimal printing characteristics. The formulation went through multiple iterations to balance:

- Green body strength
- Consistent extrusion
- Set time control

Based on literature review conducted a test mixture was developed. This mixture incorporated silica fume, slag, Methyl cellulose, High Range Water Reducer (HRWR), and a glucose set retarder

among other ingredients. The silica fume and Methyl cellulose were incorporated to improve the green body strength of the concrete [3]. The slag, a byproduct of the iron smelting industry, was used as a cement replacement and pozzolan. This allows the mix to produce more Calcium Silica Hydrate (CSH) which improves the strength of the concrete while also reducing its carbon footprint due to the reduced cement requirement. Additionally, due to the slags particle size it helps reduce shrinkage that causes cracking during the curing process [4]. To precisely control the workability, without the need to change water content, the HRWR was incorporated. HRWR allows for improved rheological performance of the concrete mixture without introducing more water than needed for hydration of cement [5]. This allows for a reduction in the amount of water used, as compared to typical concrete mixtures. Less water within the concrete contributes to higher final strength. To prevent the mixture from setting within the nozzle and during the extrusion process the set retarder was dosed into the mixture to allow for at least an hour of open time. The open time is critical to proper layer adhesion, maintaining rheological performance, and allowing for time to clean the nozzle before material begins to set [6] . Figure 7 shows a 3D printed wall after being subjected to a 3 Point bend. The nonuniform jagged failure is indicative of a strong layer bond as the break does not only propagate through the layer interface [7].

Figure 7. Fracture interface of 3D printed wall after 3 point bend test.

Results and Discussion

System Performance

The printer demonstrated reliable operation across multiple test prints. The successful implementation of motion controllers, software, and hardware enabled smooth and precise movement control throughout the printing process. Material was repeatably and precisely deposited due to the high degree of control afforded by the software. The ability to modify printer parameters while printing proved to be invaluable to retain object quality regardless of variations in material rheology. The extrusion system demonstrated exceptional reliability in material flow control and maintained consistent extrusion rates during printing sessions. The design prioritized accessibility for cleaning and maintenance, a crucial factor for working with cementitious materials.

Material Optimization

Testing demonstrated reliable performance with an optimized mixture. The extrusion remained consistent throughout print operations, and the concrete mixture achieved strong layer-to-layer bonding essential for structural integrity. The setting behavior was well-controlled, allowing for optimal print timing, layer adhesion, and cleaning.

Challenges and Solutions

During development, several technical challenges were successfully addressed. Early issues with lead screw coupling failures were resolved through material analysis and selection of higher-grade components. Extrusion inconsistencies were eliminated through the implementation of motor control refinements. Initial material testing ran into challenges with motor stalling during printing. This was attributed to poor material rheology causing the motor to reach its torque limit when trying to extrude material. Initial mixes were stiff and did not hold together when subjected to shear forces. As shown in Figure 8, the material was being extruded in an inconsistent manner due to motor stalling from excessive forces required to extrude mix. The quantity of methyl cellulose in the mixture was reduced as well as pre-hydrating of the Methyl Cellulose before incorporating into the mix significantly improved print results. During testing of the full machine, the printer would randomly halt operation and enter a failsafe mode. Debugging the system showed that the limit switches were randomly triggering when motors drew high currents. To combat the noise being introduced from the motors a high pass filtering circuit used to reduce noise was incorporated into the limit switches and false triggers were significantly reduced.

Figure 8. Poorly 3D printed wall due to unoptimized printable mixture.

Future Development

Future development efforts will focus on several key areas of enhancement. Integration with ROS2 will enable more sophisticated motion control, path planning capabilities, and sensor integration. A comprehensive computer vision system can be incorporated to provide real-time quality monitoring and feedback control. Specialized toolpath generation algorithms will optimize printing strategies for complex geometries, varying material properties, and non-plainer 3D printing. Material parameter control systems, such as force sensor and admixture doping at the nozzle, will be introduced to provide more precise adjustment of rheological properties and printing parameters during printing. The nozzles will incorporate a gear reduction to allow for extruding of stiffer mixes. Additionally, integration with robotic arm systems is planned to increase system flexibility and expand the range of achievable geometries.

Conclusion

The 3D Concrete Printer combines mechanical engineering principles, materials science, and control systems to create a versatile and reliable printing platform. The gantry-style framework, featuring three degrees of freedom and an auger-based extrusion system, proved capable of precise material deposition for Additive Manufacturing. The mechanical system demonstrated robust performance through the implementation of high-grade components and noise-reducing circuits, while the specialized concrete mixture achieved the desired balance of printability, structural integrity, and setting behavior. The integration of Ultra-High-Performance Concrete (UHPC) with locally sourced materials resulted in a formulation that not only meets the technical requirements for 3D printing but also shows promise for radioactive waste containment applications, providing better resistance to water infiltration and improved long-term storage capabilities. Technical

challenges encountered during development were addressed through iterative improvements to both hardware and material components. Lead screw coupling failures were addressed with improved material selection. While material extrusion challenges resulted in the development of optimized concrete mixtures for 3D printing.

As the technology continues to evolve through planned enhancements such as ROS2 integration, computer vision systems, and advanced toolpath generation algorithms, the system's capabilities and applications are expected to expand further. This research has laid a strong foundation for future developments in 3D printing technologies to continue research into concrete waste containment vessels. Potential implications are foreseen to extend beyond nuclear waste storage to other applications requiring precise concrete printing capabilities.

Supplemental Information

DOE Fellow Gabriel Cerioni, in collaboration with Theophile Pierre, on their own initiative prepared a MS PowerPoint presentation to share the knowledge of subtractive and additive manufacturing techniques and design methodologies with the other DOE Fellows, based on the knowledge gained during their summer internships. This PowerPoint presentation, titled "SOLIDWORKS AND 3D PRINTING CRASH COURSE", provides a comprehensive overview of design and manufacturing principles. The presentation emphasizes the importance of proper planning and introduces the concept of "fit, form, and function". It covers various manufacturing methods including casting, injection molding, traditional/subtractive manufacturing, and additive manufacturing (AM). The presentation introduces CAD design techniques, using SOLIDWORKS as an example, emphasizing the importance of fully defined sketches (avoiding "blue lines") and proper design intentions. It explores configurations in SOLIDWORKS, subassemblies, and advanced mating options. Additionally, there is a section on 3D printing, particularly FDM (Fused Deposition Modeling) and SLA (Stereolithography) processes, discussing design considerations like overhangs, build orientation, and material selection. The presentation also covers subtractive manufacturing processes available at ARC, including considerations for design and manufacturing such as material choice, complexity, tolerance, and cost. This technology knowledge transfer is of great benefit not only to the other Fellows, but to the FIU ARC scientists as well. The presentation is provided in the APPENDIX at the end of this report.

Acknowledgments

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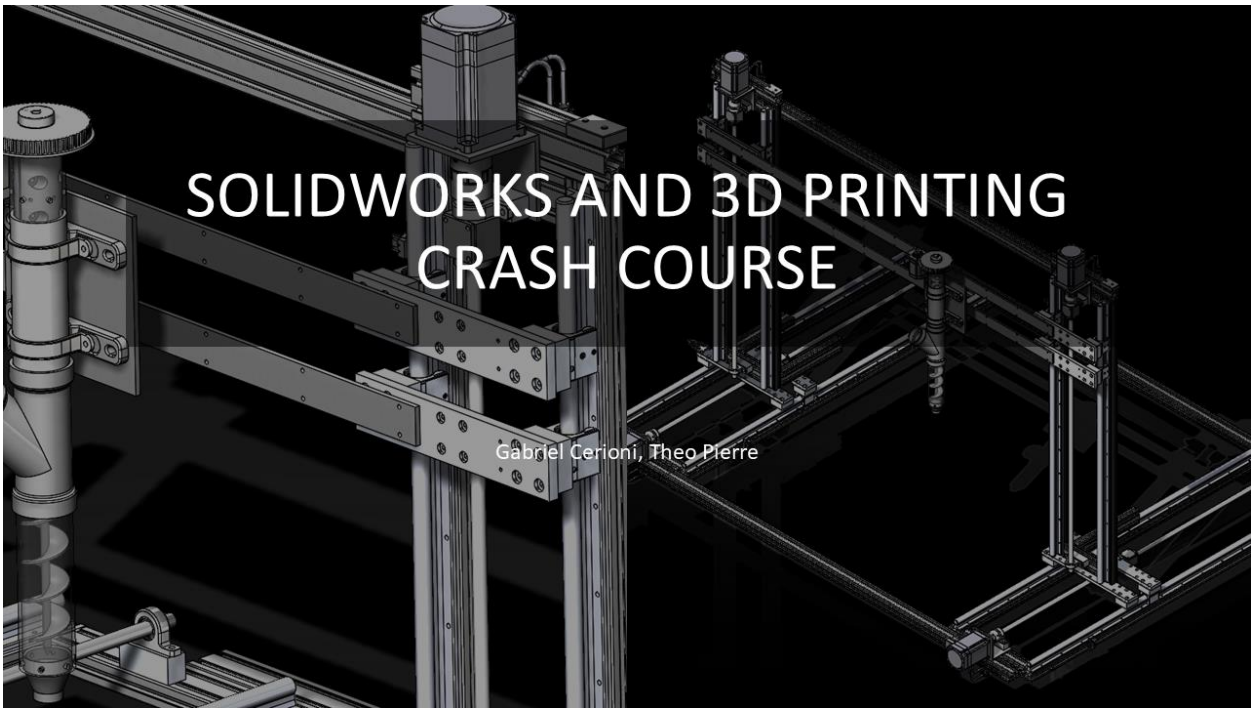
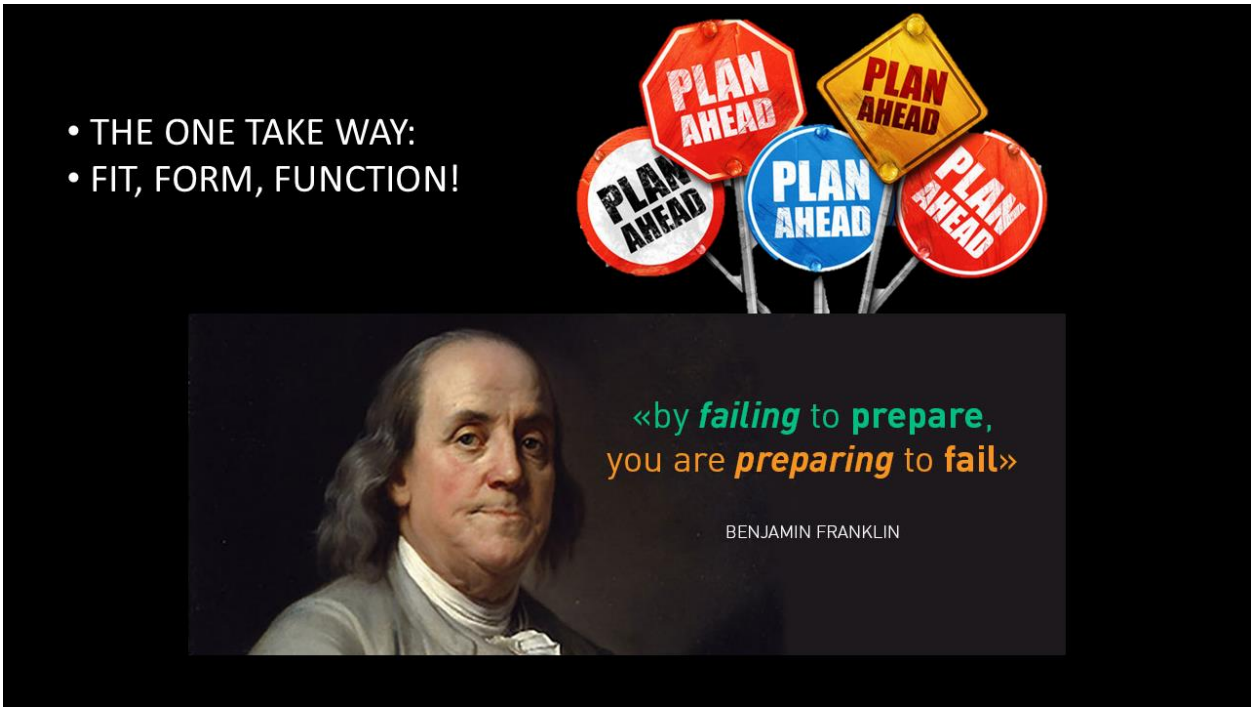
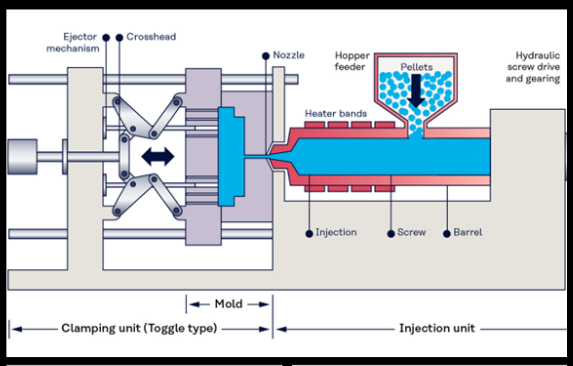
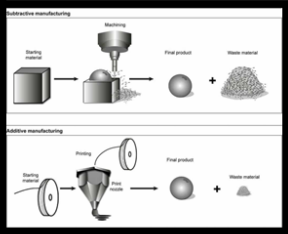
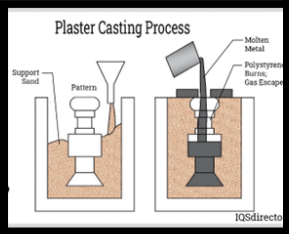
APPENDIX


SOLIDWORKS AND 3D PRINTING
CRASH COURSE
Gabriel Cerioni, Theo Pierre


• THE ONE TAKE WAY:
• FIT, FORM, FUNCTION!
PLAN AHEAD
PLAN AHEAD
PLAN AHEAD
PLAN AHEAD
PLAN AHEAD
«by failing to prepare,
you are preparing to fail»
BENJAMIN FRANKLIN







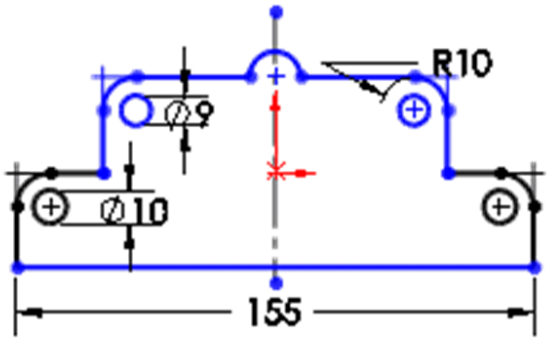
Manufacturing in Mind

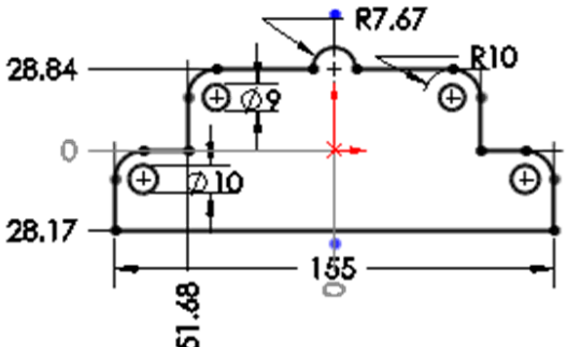
Manufacturing method will limit your part

- Casting
- Injection mold
- Traditional / Subtractive Manufacturing
- Additive Manufacturing (AM)

NO BLUE LINES!

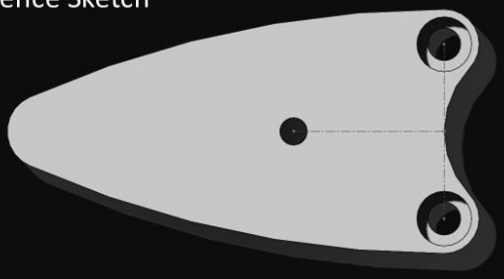
- Underdefined Sketch in Solidworks
- Fully define your sketch

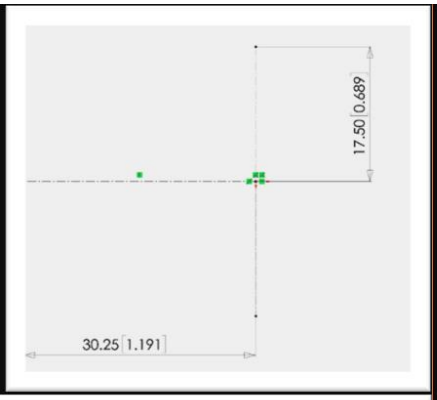


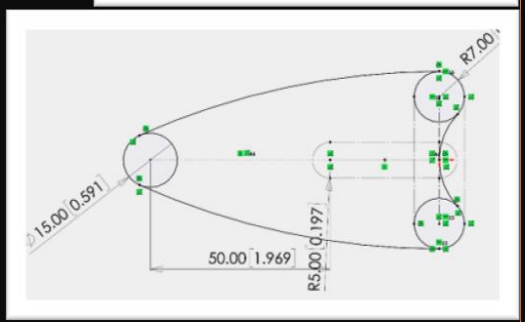


SKETCHING FOR FUTURE CHANGES

- Design Intentions
  - What's important in your design?
- Reference Sketch

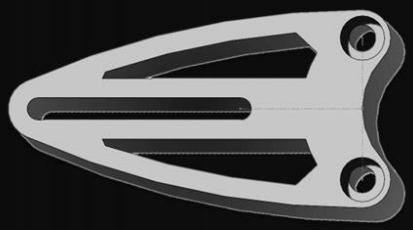


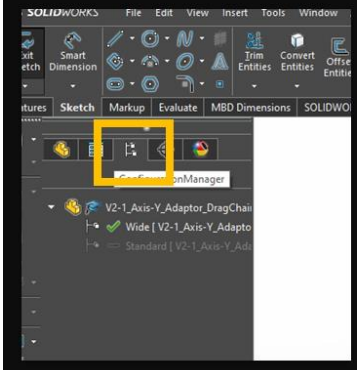


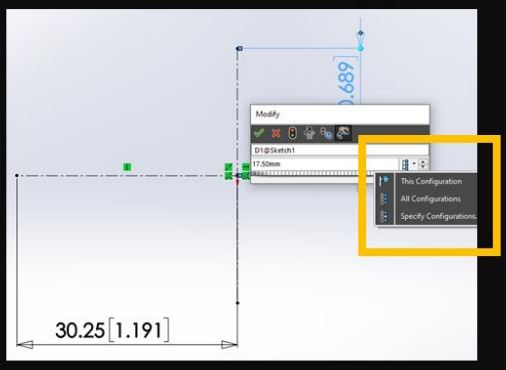


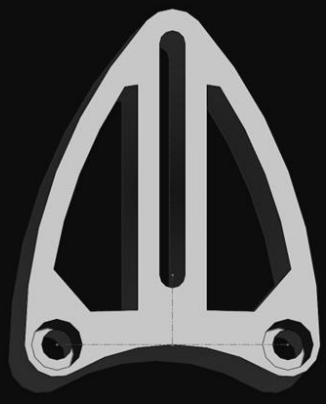
CONFIGURATIONS

- Powerful
- Great way to create variations on similar parts/Assemblies



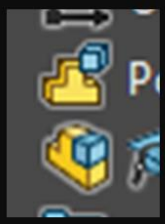


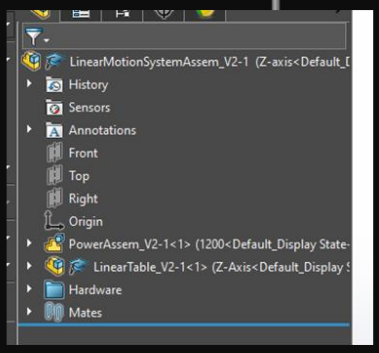


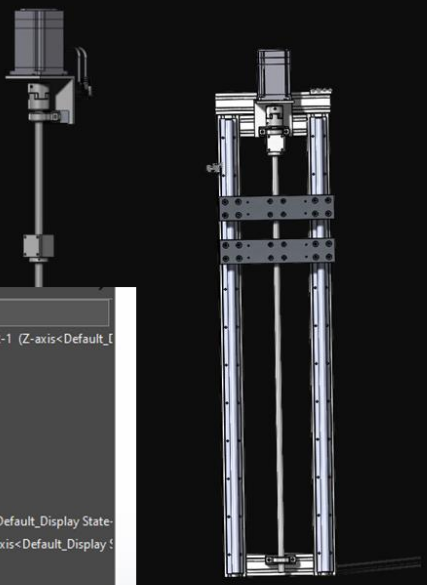


Subassemblies

- Assemblies within assemblies
- Configurations
- Use folders to stay organized
- Flexible / Rigid



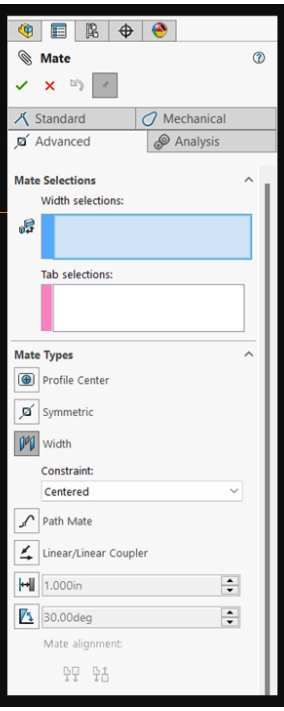


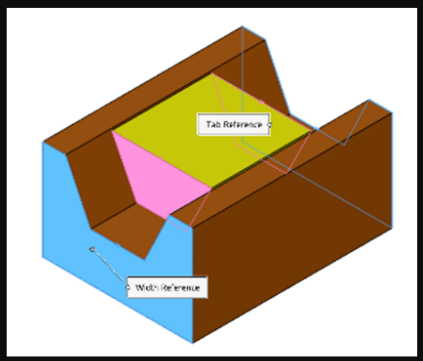


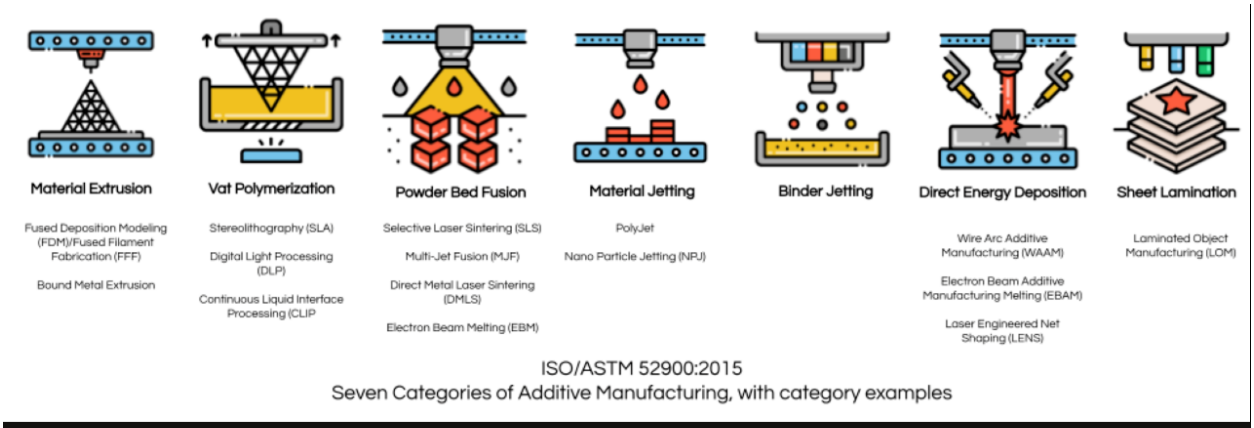
Advanced Mates

Width mate

- Aligns parts between surfaces





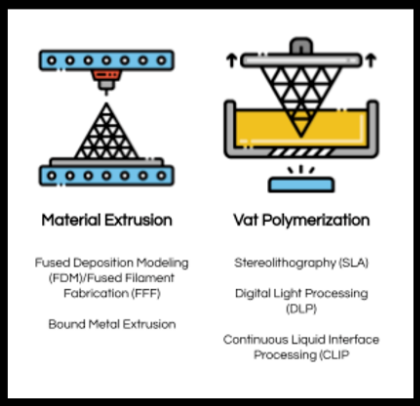


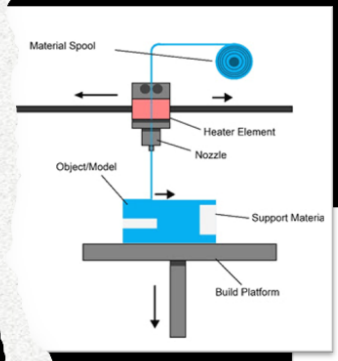
ISO/ASTM 52900:2015
Seven Categories of Additive Manufacturing, with category examples

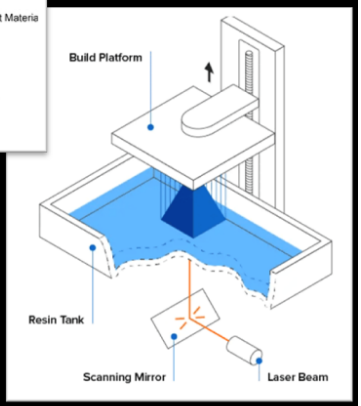
3D Printing (AM)

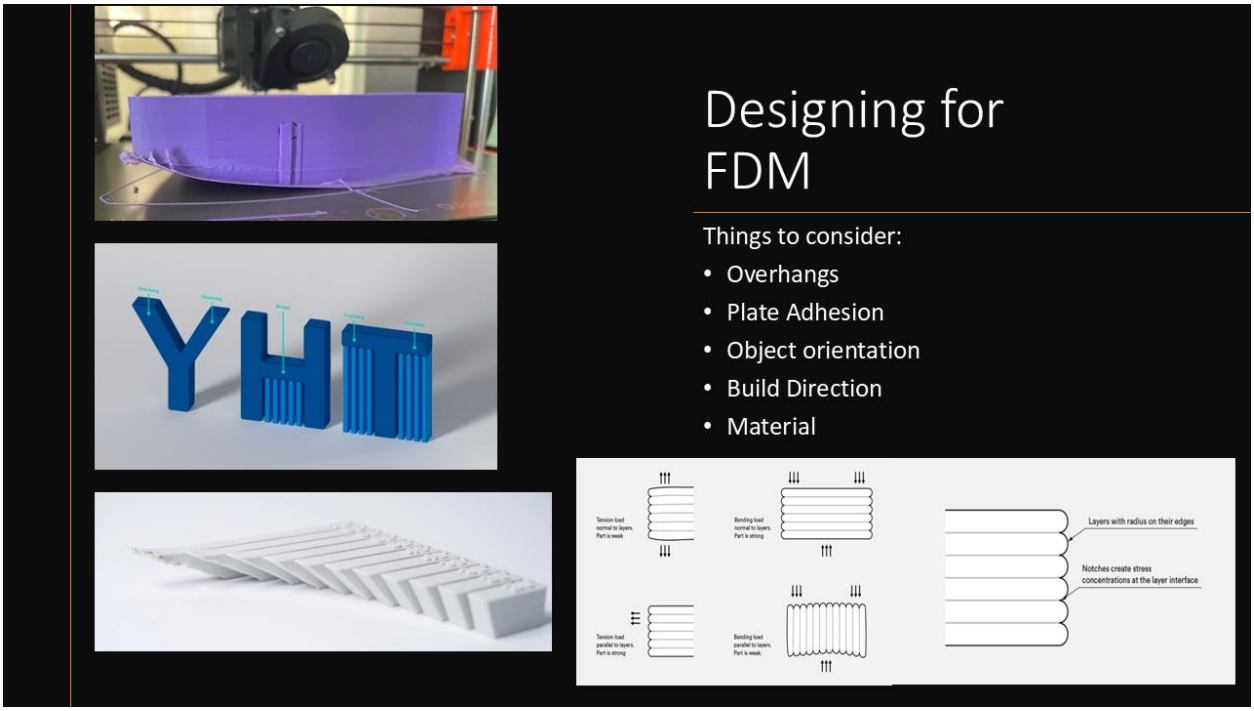
Types of AM processes

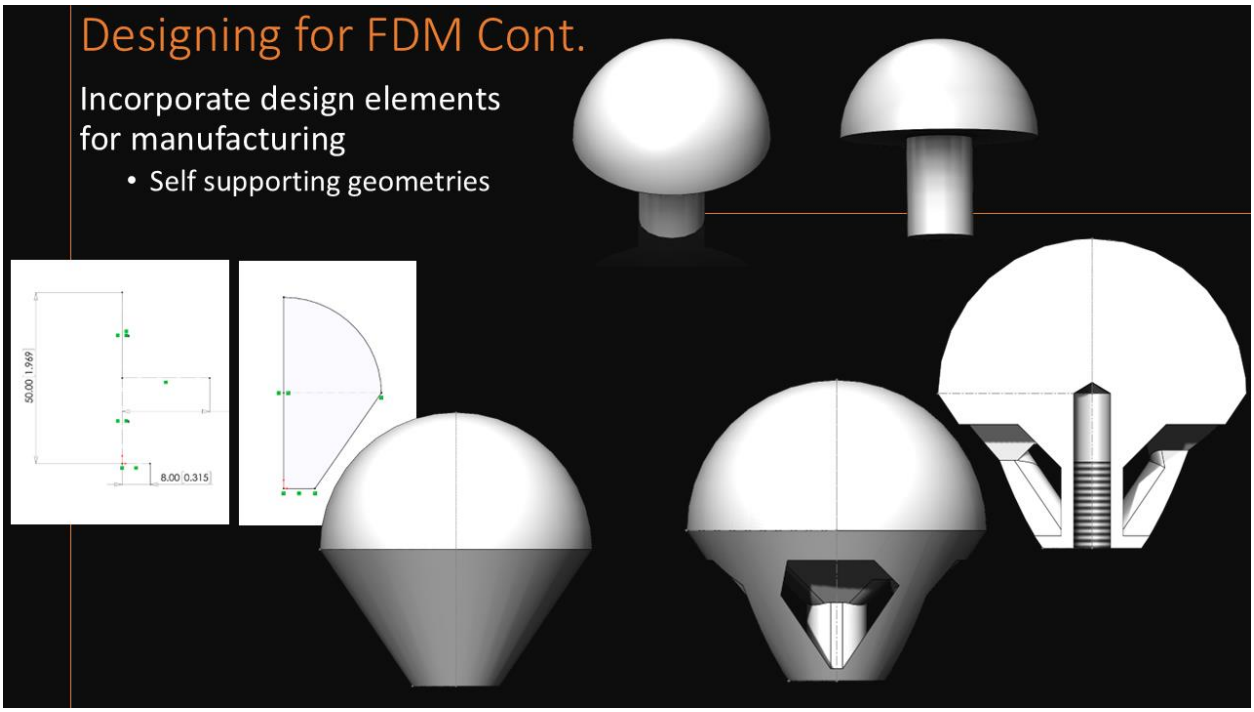
AM at ARC





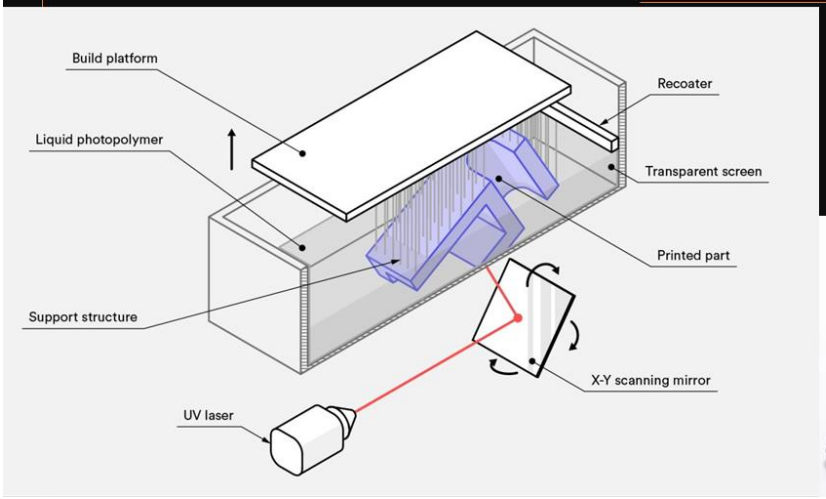


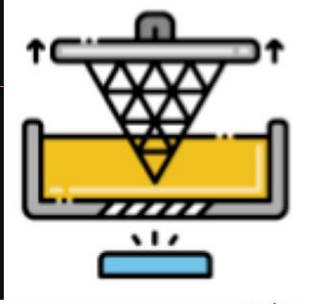

Designing for FDM
Things to consider:
• Overhangs
• Plate Adhesion
• Object orientation
• Build Direction
• Material
Layers with radius on their edges
Notches create stress concentrations at the layer interface

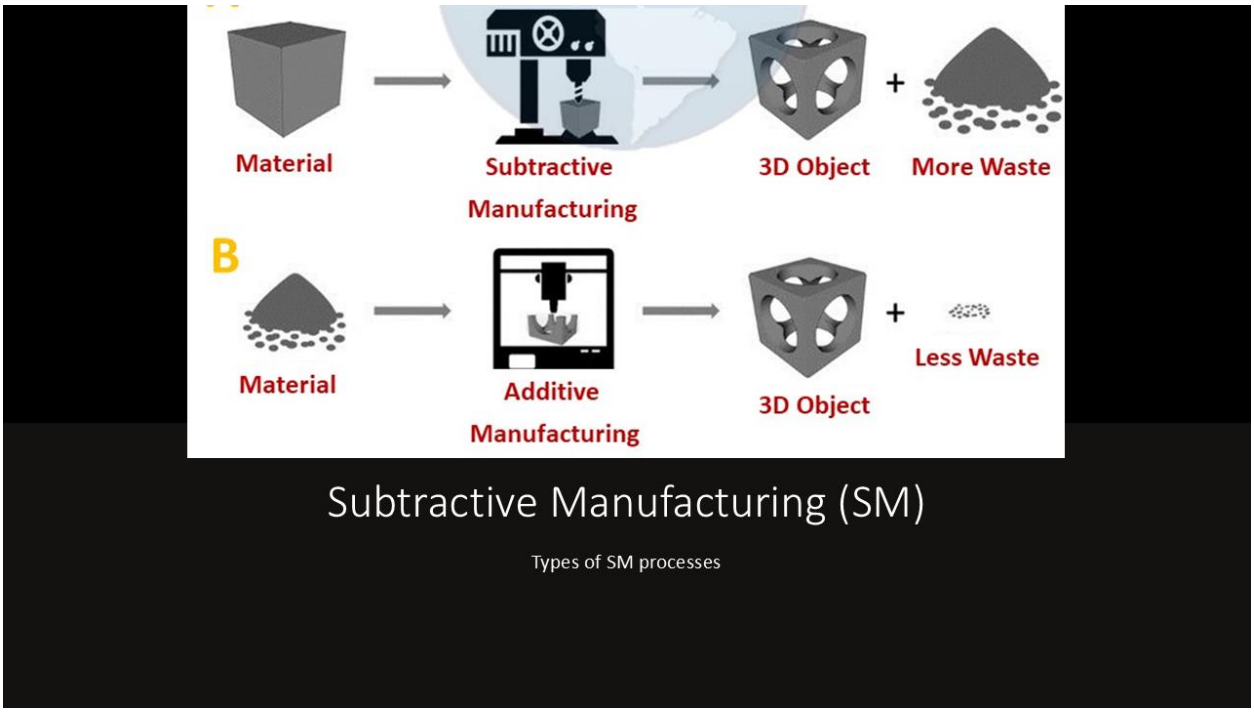

Designing for FDM Cont.
Incorporate design elements for manufacturing
• Self supporting geometries
50.00 1.969
8.00 0.315

Things to Remember

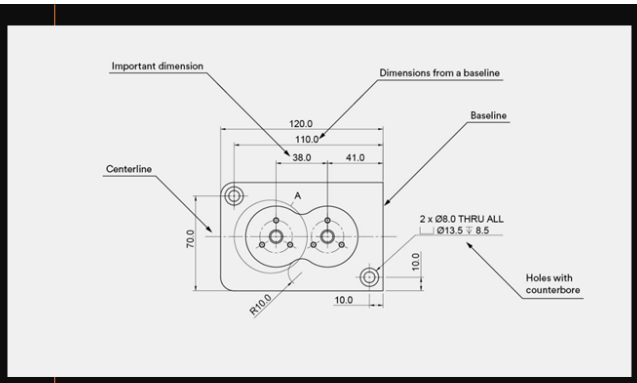
- Part of object facing build surface
- Supports
- Post processing

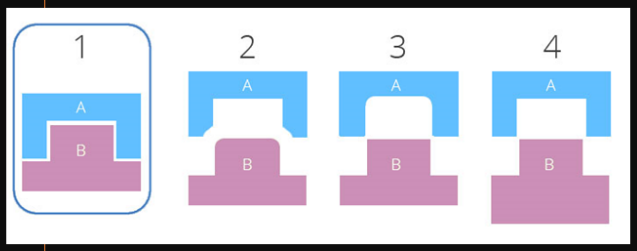





Material
Subtractive
Manufacturing
3D Object
More Waste
B
Material
Additive
Manufacturing
3D Object
Less Waste
Subtractive Manufacturing (SM)
Types of SM processes


SM at ARC
CNC





Designing for Manufacturing

Things to consider:

- Does it have to be in metal?
- Complexity?
- Tolerance
- Reducing cost
- CNC = Production; Manual = One-off

Closing Remarks

- Have fun
- What can you improve?
- Thank you
- Questions?

Sources

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