PROJECT TECHNICAL PLAN

Project 1: Chemical Process Alternatives for Radioactive Waste

For the period September 17, 2013 to May 17, 2014

CONTRACT NO. DE-EM0000598

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INTRODUCTION

The U.S. DOE Hanford Site has the largest number of high-level waste (HLW) storage tanks and the largest volume of HLW in the United States. The safe storage, retrieval, treatment, and disposal of approximately 53 million gallons of highly toxic, high-level radioactive waste stored in Hanford's 177 underground tanks are a national priority. Retrieval and treatment of waste from these tanks pose a considerable challenge.

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Florida International University has been conducting research on several promising alternative processes and technologies that can be applied to address several technology gaps in the current waste retrieval and conditioning plans. Specifically, FIU has been involved in: analysis and development of alternative pipeline unplugging technologies to address potential plugging events; modeling and analysis of the pulse-air mixing process using the computational alternative of lattice Boltzmann method (LBM); and evaluation of alternative HLW instrumentation for in-tank applications.

The activities described in the Continuation Application (CA) document for FIU Year 4 were planned for a period of performance from May 18, 2013 to May 17, 2014. However, two no cost extensions were executed by DOE-EM for FIU Year 3, which extended the end of the FIU Year 3 period of performance to September 16, 2013. Therefore, the period of performance for the FIU Year 4 activities described in this Project Technical Plan is shortened to 8 months, September 17, 2013 to May 17, 2014. The scope of some tasks has been affected/reduced due to the shortened period of performance and will be re-evaluated as FIU approaches the May 2014 timeframe. The affected scope may transfer to FIU Year 5.

The affected tasks from the CA for this project include the following:

- Subtask 2.2 – Postponed until FIU Year 5
- Subtask 2.4 – Removed due to changes in Hanford Site needs
- Task 15 – Removed and replaced with Task 18 (Technology Development and Instrumentation Evaluation)
- Subtask 15.1 – Removed due to changes in Hanford Site needs
- Subtask 15.2 – Renumbered to subtask 18.1
- Subtask 18.2 – Added due to changes in Hanford Site needs
- Task 17 – Renamed (Advanced Topics for Mixing Processes)

- Subtask 17.2 – Removed and will be considered for FIU Year 5
- Task 19 – Added (Pipeline Integrity Analysis)
- Subtask 19.1 – Added due to changes in Hanford Site needs

OVERVIEW OF WORK ACCOMPLISHED DURING FY12 (FIU YEAR 3)

- Completed experimental validation of improvements to the peristaltic crawler (November 2012). Completed initial engineering-scale testing using the modified peristaltic crawler for pipeline unplugging (May 2013).
- Completed set-up and preliminary engineering-scale testing of the asynchronous pulsing system for pipeline unplugging (May 2013).
- Completed integration of the mesh generation with appropriate boundary conditions in the 3D MRT LBM for simulation in complex geometries. Also completed the investigation of multiphase LBM models for non-Newtonian fluids and turbulence modeling (May 2013).
- Completed literature review on plug prevention methods (January 2013).
- Presented papers and posters at the 2013 Waste Management Symposia (February 2013):
    - Implementation of Surface Wetting Effects in Computational Fluid Dynamics Simulations Using the Lattice Boltzmann Method (13364), Seckin Gokaltun, Dwayne McDaniel, David Roelant.
    - Design Advances of Innovative Unplugging Technologies for High-Level Waste Pipelines (13341), Amer Awwad, Tomas Pribanic, Jose Varona, Dwayne McDaniel, Seckin Gokaltun, Jairo Crespo.
    - High-Level Waste Pipeline Unplugging Technologies: Asynchronous Pulsing System (Student Poster), Jennifer Arniella (DOE Fellow), Amer Awwad.
    - Computer Simulations of Multiphase Flow Systems Applied to Transfer of High-Level Waste (Student Poster, Francisco Bolanos (DOE Fellow), Seckin Gokaltun.
    - Computational Simulation and Evolution of High-Level Waste Pipeline Plugs at Hanford (Student Poster), Dania Castillo (DOE Fellow).
    - Development of Improved Bodies for a Peristaltic Crawler for Unplugging of Hanford Waste Transfer Pipelines (Student Poster), Jose Matos (DOE Fellow).
    - Improved Third Generation Peristaltic Crawler for Removal of High-Level Waste Plugs in Hanford Site Pipelines (Student Poster), Gabriela Vazquez (DOE Fellow), Tomas Pribanic.
    - Hydrogen in Pipes and Ancillary Vessels in Waste Treatment Plant at the Hanford Site (Student Poster), Janty Ghazi (DOE Fellow), James Poppiti (DOE HQ EM-23), Leonel E. Lagos.
    - A Lattice Boltzmann Method for the Analysis of Gas Behavior in Hanford Tanks (Student Poster), Jaime Mudrich (DOE Fellow), Seckin Gokaltun.
    - Acoustic Pulse Reflectometry For Identifying Pipeline Properties At Hanford Site (Student Poster), Lucas Nascimento (DOE Fellow).

- Development of a Mechanical based System for Dry Retrieval of Single-Shell Tank Waste at Hanford (Student Poster), Ximena Prugue, (DOE Fellow), Amer Awwad, Leonel Lagos.

TECHNOLOGY NEEDS

The implementation of advanced technologies to address challenges faced with baseline plans for HLW operations is of great interest to the Hanford Site. Specifically, the use of field-deployable or in-tank technologies, as well as advanced computational methods can improve the retrieval, transport and conditioning processes of HLW. FIU has worked with site personnel to identify four focus areas related to technology and process improvement needs that can benefit from FIU's core expertise in areas related to HLW operations.

Focus Area 1: Alternative technologies and computational modeling for HLW pipeline plug prevention

Slurry transfer of HLW between storage tanks or treatment facilities is a common practice performed at the Hanford Site. Changes in the chemical and/or rheological properties of the HLW slurry during the transfer process may lead to the formation of blockages inside the pipelines. To reduce the risk of plugging, predictive tools have been developed that attempt to provide information regarding critical parameters that affect plug formation. These tools, however, do not consider precipitation, chemical reaction kinetics and other dynamic processes that can influence plug formation. Last performance period, FIU initiated the development of a multi-physics model using COMSOL that can address these shortcomings and simulate the coupled flow and chemistry kinetics. This tool will provide a more comprehensive evaluation of the factors that can contribute to pipeline plug formation.

In the event that a plug does form, current commercially available pipeline unplugging technologies do not provide results that are cost-effective, reliable, and safe in DOE's aging, pressure-limited HLW pipeline systems. Prior year investigations by FIU have closed the gap on what is commercially available, and their respective capabilities. The need for additional technology development to provide site engineers with a toolbox of viable unplugging techniques is still necessary to ensure that plugged lines are not abandoned in place, which has been the practice in the past.

Focus Area 2: Stable, computational method to accurately and effectively model complex, multi-phase, HLW processes

Researchers are developing numerical techniques to address the shortcomings of current computational fluid dynamic (CFD) modeling of HLW. The lattice Boltzmann method (LBM) is an alternative CFD technique that can solve for complex multiphase flow problems that occur during operations at various DOE sites such as sediment bed formation and bubble generation. Several needs for a computational method for modeling HLW processes were developed during discussions with site engineers and include the capability to: simulate three-dimensional geometries; solve for thermal fields in a multiphase fluid with high density ratios; import complex geometries; use parallel computers in order to reduce computation times; and accurately model phase changes and bubble formations.

Focus Area 3: Technology development and innovative instrumentation evaluation for HLW tanks

As the Hanford Site prepares for retrieval operations, improved instrumentation will be required to ensure appropriate mixing and delivery of waste to meet the Waste Treatment and Immobilization Plant (WTP) waste acceptance criteria. Until WTP comes online in 2019, space in double-shell tanks (DST) is limited. Tank waste is also held in staging tanks prior to being sent for vitrification at WTP and understanding the amount of solids in both the DSTs and staging tanks is of critical importance. FIU has worked with several site engineers to identify the fundamental technology requirements for instrumentation that can be used to identify solid layers in tanks and quantify the amount of residual solid waste in staging tanks.

Additionally, Hanford engineers have a need to develop technologies that can provide inspection and possibly repair capability for their DSTs. Small amounts of waste have been found in the annulus of AY-102, prompting the need for developing inspection tools that can identify the cause and exact location of the leak. The inspection tools will have to navigate through complex cooling channels of the DST refractory pad and provide visual feedback of the tank bottom. FIU is currently working with the site to obtain the technology requirements and assist in the development of alternative approaches for the inspection tools.

Focus Area 4: Structural integrity analysis for HLW pipelines

Understanding the current and future status of the structural integrity of the waste transfer system at Hanford is of paramount importance to DOE, engineering contractors and the local community. Currently, the tank contractor, Washington River Protection Solutions, LLC (WRPS), has implemented a Fitness-for-Service program that focuses on evaluating the structural integrity of waste transfer system components including primary piping, encasements, and jumpers when they are removed for disposal. Data specific to erosion and corrosion of the components can be evaluated to develop and improve on estimates of their erosion and corrosion rates. FIU has recently started working with engineers from WRPS to collect, organize and conduct analysis of the data obtained thus far, from the non-destructive and destructive evaluation of the transfer components. The objective is to assist WRPS in providing more realistic estimates to the remaining useful life of the components and incorporate those estimates into future design plans.

TASK DESCRIPTIONS

Based on the aforementioned technology and research needs, four tasks have been identified for this next performance period. FIU will work with Hanford Site personnel, national laboratory contacts, and collaborators from industry and academia to identify shortcomings of the baseline approach and past research efforts. This knowledge will be incorporated into the planning and execution of these tasks detailed below.

Note: Task numbers are not continuous because task numbers have been assigned chronologically over the past 5 years and several tasks have been completed.

TASK 2 – PIPELINE UNPLUGGING AND PLUG PREVENTION

Subtask 2.1 Development of Alternative Unplugging Technologies

Over the past few years, FIU has found that commercial technologies do not meet the needs of DOE sites in terms of their ability to unplug blocked HLW pipelines. FIU has since undertaken the task of developing alternative methods/technologies with the guidance from engineers at the national laboratories and site personnel. The new approaches that are being investigated include an asynchronous pulsing system (APS) and a peristaltic crawler system (PCS). Both technologies utilize lessons learned from previous experimental testing and offer advantages that other commercially available technologies lack.

Objectives

The objective of this task is to continue the experimental testing of the two novel pipeline unplugging technologies: APS and PCS. Experimental results obtained previously, have demonstrated the scenarios in which the technologies could be the most effective. Further testing applying slight improvements from lessons learned will allow for conducting unplugging operations in engineering-scale testbeds. Successful completion of these efforts will demonstrate the technologies viability for future deployment and operation at DOE Sites.

Specific subtasks include:

- Complete the investigation of the asynchronous pulsing system’s ability to unplug engineering scale pipelines.
- Complete experimental testing of the navigational capabilities of the PCS in a 460-ft testbed.
- Complete experimental testing of the unplugging and inspections capabilities of the PCS in an engineering scale testbed.

Benefits

The technologies developed under this task will provide DOE HLW site engineers with a cost-effective toolbox to remediate pipeline plugging. In the past, some of the pipelines have plugged during waste transfers, resulting in schedule delays and large additional costs. Also, DOE employees and contractors have cited that pipeline plugging is one of the major issues that can result in unplanned outages at the Hanford WTP together with their economic and political costs. The availability of validated pipeline unplugging tools/technologies is crucial for efficient and effective operation of all DOE HLW transfers (within Hanford tank farms, between tank farms, to WTP and within WTP). Successful future deployment of the new technologies will result in major cost savings by avoiding costs of potential plugs and minimization of risk to scheduled milestones and the environment.

Subtask 2.2 – Computational Simulation and Evolution of HLW Pipeline Plugs

When HLW is transported for processing or storage, there is a potential risk for the transport lines to plug, causing significant delays, increasing operation costs and creating hazardous conditions for personnel and the environment. A significant amount of research has been conducted to prevent plug formation in pipelines that includes critical velocity testing and the conditioning of waste particles prior to transport. In this task, FIU will extend on previous research to develop a multi-physics model using CFD software that could simulate the coupled flow and chemistry kinetics and evaluate the factors that can contribute to pipeline plug formation.

Objectives

The objective of this task is to develop computational models describing the build-up and plugging process of retrieval lines. In particular, the task will address plug formation in a pipeline, with a focus on the multi-physical (chemical, rheological, mechanical) processes that can influence the formation. The main focus during this performance period will be to develop a 2D multi-phase model that could simulate solids deposition and plug formation in a pipeline. The model results will be validated with the available experimental data and the established critical velocity correlations. The influence of chemical interactions on the plug development process will then be investigated by coupling the multi-phase model with the chemical reactions module.

Benefits

The models and future experimental studies developed under this task will extend on existing research aimed at preventing the formation of plugs in HLW transfer and processing lines. The finding of this research will provide site engineers with a better understanding of how plugs can form and will assist in developing design guidelines for waste transport.

TASK 17 – ADVANCED TOPICS FOR MIXING PROCESSES

Subtask 17.1 – Multiple-Relaxation-Time, Lattice Boltzmann Model for High-Density Ratio, Multiphase Flows

This task will use the knowledge acquired at FIU on implementing the lattice Boltzmann model (LBM) for multiphase flow modeling to improve the capabilities of the multi-phase LBM multiple-relaxation-time (MRT) computer program generated during FY12 in order to obtain simulations at the engineering-scale with appropriate physics captured for the fluid-structure interactions. Focus will be given to bubble generation simulations in nuclear waste tanks that exhibit non-Newtonian fluid characteristics.

Objective

The objective of this task is to provide the sites with mathematical modeling, validation, and testing of computer programs to support critical issues related to HLW retrieval and processing. FIU engineers work directly with site engineers to plan, execute, and analyze the results of applied research and development. Specific subtasks include:

- Develop a computer program to simulate the bubble flow dynamics in non-Newtonian fluids that show Bingham plastic behavior.
- Implement the correct open boundary conditions for multiphase LBM program to investigate fluid injection simulations.

Benefits

The proposed tasks under this program at FIU-ARC will provide the necessary data and computational tools for the engineering staff at the sites to use in order to predict various scenarios that can occur during operations at DOE sites that involve multiphase flows involving waste sludge that acts as Bingham plastic. Successful completion of the tasks will result in time and cost savings and risk minimization leading to increased environmental safety in the operations at the DOE sites.

TASK 18 – TECHNOLOGY DEVELOPMENT AND INSTRUMENTATION EVALUATION

Subtask 18.1 – Evaluation of FIU's Solid-Liquid Interface Monitor for Rapid Measurement of HLW Solids on Tank Bottoms (New)

For the next period of performance, FIU will test the SLIM technology at FIU for its performance in imaging and quantifying settled solids at the bottom of mixing tanks. More specifically, FIU will analyze the image resolution and the resolution of the height of solids layers in the bottom of mixing tanks during a very limited time window (e.g., 20 seconds) out of the 95-second, total cycle time of the pulsed jet mixers. Tradeoff analyses will be done between number of points along 2-D slices, number of 2-D slices, angles subtended by 2-D slices and resolution of solids in regions of interest. The initial experiments will assess the ability of the system to image quickly in water, small quantities of solids in small regions of interest on the tank bottoms. Should SLIM demonstrate feasibility in rapidly imaging small amounts of solids in the mixing tanks, then additional testing will be done with solid-liquid slurries. FIU will work with site engineers again to develop the experimental test plan for SLIM with the slurries.

Objective

The objective is this subtask task is to evaluate the Solid-Liquid Interface Monitor for its ability to rapidly image and quantify solids left at the bottom of mixing tanks in small regions of interest. Should initial tests with water and stationary settled solids prove successful, then more testing will be planned and performed to demonstrate the ability of the system to be deployed in a tank with HLW solid-liquid slurries.

Benefits

The need for pre-qualification of waste feed to be provided to WTP dictates the need for improved in-tank and ruggedized, field-deployable technologies for assessing the physical, chemical and rheological properties of the mixture prior to retrieval. Due to the expected transfer of waste in 1 million gallon batches, the potential for large variances in feed characteristics will constrain process throughput and efficiency. Technologies that are being evaluated under this task will provide viable alternatives to costly sampling and laboratory analysis by enabling engineers the ability to assess waste feed conditions, mixing tank conditions and adjust the mixing and preparation as necessary prior to transfer.

The Solid-Liquid Interface Monitor, utilizing a commercial 3-D sonar imaging technology, will allow site engineers to evaluate the solids left at the bottom of mixing tanks and hence the effectiveness of the pulsed jet mixers in these black cell tanks used in conditioning HLW for WTP.

Subtask 18.2 – Development of Inspection Tools for DST Primary Tanks (New)

As part of the Hanford double-shell tank (DST) integrity program review, engineers at Hanford are investigating robotic technologies for the evaluation of Tank 241-AY-102. The technologies are intended to provide video feedback of the tank refractory and base pad so that an assessment can be made regarding the structural integrity of the tank bottom. There are three paths of access: 1) refractory air slots though the annulus, 2) 4-in annulus air supply pipe to central plenum, and 3) 6-in leak detection pit drain from the central sump. Currently, engineers at Hanford have requested information from industry regarding their capability to inspect the tank insulating refractory pad and provide visual feedback as well as potential for conducting repairs.

Objective

The objective of this task is to develop an inspection tool that can provide visual feedback of DST bottoms from within the insulation refractory pads. FIU engineers will work directly with site engineers to develop alternative designs based on specified performance criteria. Specific subtasks include:

- Develop/investigate design concepts that will allow for the navigation of a remotely controlled device through the refractory pad channels and provide visual feedback.
- Down select from the proposed concepts based on feedback from site engineers and develop a proof-of-concept demonstration of the proposed design.

Benefits

The newly proposed subtask will provide alternative solutions for monitoring the structural integrity of the bottoms of the DSTs. Tools developed in this subtask will allow for the detection of potential leaks allowing site engineers to obtain the necessary information that is needed to generate viable approaches for repair.

TASK 19 – PIPELINE INTEGRITY AND ANALYSIS

Subtask 19.1 – Pipeline Corrosion and Erosion Evaluation (New)

The United States Department of Energy Hanford Site Tank Farm has implemented a Fitness-for-Service (FFS) program for the Waste Transfer System. The FFS program, based on API-579-1/ASME FFS-1, examines structural parameters of the waste transfer systems in order to develop erosion/corrosion rates for relevant system components. The FFS information is acquired from opportunistic evaluations of pipelines that have been removed from service. FIU-ARC engineers will work closely with key Hanford HLW personnel on analyzing the data from various system components, determining wear rates and identifying key parameters that contribute to the wear rates.

Objective

The objective of this task is to provide the sites with analysis of data obtained from primary and secondary pipelines as well as components in jumper pits, evaporators, and valve boxes. Information regarding initial and current thickness for various components will be obtained, in addition to transfer history, and wear rates will be determined. Specific subtasks include:

- Collect information from relevant transfer lines including: line location, line material and size, waste transferred, service dates.
- Determine wear rates and conduct analysis on erosion/corrosion information from pipelines and components by comparing current measurements (acoustic/caliper) with nominal thicknesses.
- Conduct a comparative analysis on lines with similar materials and service provided.

Benefits

The newly proposed task will provide information that will assist engineers with understanding the failure potential of HLW transfer components due to corrosion and erosion. This information can assist in determining if and when lines need to be removed, saving time and resources on the unneeded excavation of transfer lines. This information will also assist engineers with designing new transfer systems by establishing more detailed/accurate guidelines governing the life expectancy of the transfer system and its components.

FIU YEAR 4 TASK EXECUTION PLANS

Overall Project Management Task

This task will focus on the control and monitoring components of the project. This task will perform quarterly report development, client interaction, progress tracking, and the development of the final report.

Subtask 2.1.1 – Engineering scale testing of the asynchronous pulsing system

During this performance period, the engineering scale unplugging tests will continue after the instrumentation system has been updated. The engineering scale testbed will consist of an instrumented 3” diameter 270-foot long pipeline having multiple 90° elbows. Test trials will be conducted by placing a plug in the middle of the pipeline (135’ from either end) and will utilize different nominal static pressures, frequency of pulses and percentage of air in the pipeline to determine the most effective combination of static pressure and pulse frequency. Computational fluid dynamic (CFD) models that were validated in the previous performance period will be used to extrapolate the test results to longer pipe lengths. The models were developed at FIU using a 1-dimensional code based on the Method of Characteristics. Additional models developed using the commercial CFD package, Fluent, will also be used to model cases with air entrained in the system.

Subtask 2.1.2 – Engineering scale testing of the peristaltic crawler system

Navigational and unplugging tests using a 460-ft engineering-scale testbed will be completed in this subtask. Tests will include measuring the navigational speed of the crawler in straight pipeline sections as well as through pipelines coupled with 90° elbows. Limitations resulting from the pulling force required to carry the tether from the inlet point to the crawler location will be evaluated. Additionally, unplugging tests will be conducted using clay based plugs. Plug erosion rates will be recorded to determine the effectiveness of the technology. The visual feedback provided by the on-board camera will also be tested to determine its effectiveness in providing the conditions inside the pipeline during unplugging operations.

Subtask 2.2.1 – 2D Multi-physics model development

This subtask will focus on developing a 2D multi-physics model that can predict plug formation using the simulation software, COMSOL. The model development will consist of integrating two interfaces: a) mixture flow interface and b) chemistry interface. The mixture flow interface will be used to simulate two phase flow (sludge and water) in a pipeline whereas the chemistry interface will be used to simulate chemical kinetics in the multi-phase mixture. First, the mixture flow interface will be solved to determine the solids deposition pattern along the pipe length. A parametric study will be performed to investigate the solids settling along the pipe length as a function of velocity. The results will be validated with the known critical velocity correlations as well as available experimental data. Next, the flow interface will be coupled to the chemistry interface to investigate the influence of waste chemistry dynamics on the plug formation process. The results obtained by solving the coupled multi-physics model will provide better insights into the influence of chemical reactions, precipitation, etc. on the plug build-up process.

Subtask 17.1.1 – Bubble dynamics simulations in non-Newtonian fluids using the lattice Boltzmann method

The capability of the three-dimensional MRT LBM code will be expanded into simulations of multiphase flows with non-Newtonian fluids in complex geometries. The focus will be given to Bingham plastics since the waste at the Hanford Site is of that type. The expression of the shear stress proposed by Papanastasiou will be used as a function of the local stress value to remove the discontinuity in its definition. The local shear-rate effect will be incorporated into the multiphase LBM by modifying the equilibrium distribution function. The viscosity definition for the non-Newtonian fluid will be updated. The accuracy of the LBM code for the effect of the non-Newtonian properties of sludge on the bubble dynamics will be verified for complex geometries that resemble waste storage tanks.

Subtask 17.1.2 – Lattice Boltzmann method for the simulation of fluid and gas injections in non-Newtonian fluids

Appropriate boundary conditions will be implemented in the LBM program in order to investigate the capability of LBM to simulate fluid and gas injections into waste tanks that have non-Newtonian fluids. This effort will help in understanding the requirements for LBM to evaluate the performance of pulse-jet mixers. The inflow and outflow boundary conditions have been shown for the single-phase LBM; however, for multiphase flows, the methods proposed for the single-phase flow may not work. It becomes difficult especially in the two-distribution-function approach that is followed in this task since the density and velocities are obtained from two different distribution functions. Possible options found in the literature will be examined and implemented in the LBM code and the results will be verified for jet injection type problems.

Subtask 18.1.1 – Initial testing of SLIM for functional requirement of rapid imaging of settled solids in select regions of mixing tanks

This subtask will focus on initial testing of the SLIM sonar component to assess its ability to rapidly image regions of interest on the bottom of tanks and thereby quantify the feasibility or infeasibility of the SLIM for imaging (hence quantifying) solids during a short time associated with the suction phase of the pulse jet mixer cycle. This will involve tradeoff analyses of the number of data points taken in each 2-D slice, number of 2-D slices, angles subtended by each 2-D slice, ability to sample (image) small regions of interest on the tank bottoms, and ability to quantify the amount of solids left in these regions. This effort will be focused on optimizing the sonar software and imaging performance for this task.

Subtask 18.1.2 – Testing of SLIM for feasibility for deployment in mixing tanks

This subtask will be performed only if the results of subtask 18.1.1, the preliminary functional testing of the sonar in SLIM, meets the performance measures that are of interest to Hanford engineers. Given the ability to rapidly (~20 to 30 seconds) image and quantify solids in regions in the bottom of mixing tanks, then this task will add realistic mixing of solid-liquid slurries to the testing of SLIM. Tests done years ago at FIU demonstrated that SLIM is able to perform in highly caustic (pH>14) and in a harsh nuclear radiation environment. The challenge will be to image the settled solids layer accurately and quickly during the suction phase of the pulse jet mixers.

Subtask 18.2.1 – Development of conceptual designs for DST refractory pad inspection

This subtask will focus on preparing multiple conceptual designs of robotic-type systems that can navigate through the air channels in the DST refractory pads. The overall objective will be to provide video feedback of the tank bottom and locate potential areas of structural failure. Design challenges will include maneuvering through 1.5 inch by 1.5 inch channels and turning at sharp 90° angles, all without damaging the refractory pad. FIU engineers will work with site engineers at Hanford to develop alternative approaches based on lessons learned from previously used inspection devices. With input from the site engineers, one design will be down selected, based on potential for success.

Subtask 18.2.2 – Validation of conceptual design

Based on information gathered in subtask 18.2.1, efforts for this subtask will focus on providing information that validates the selected design concept. Depending on the design, validation may include providing simulations of how the robotic device would function, complete with boundary constraints imposed by the channels. It may also involve manufacturing a prototype to provide a proof-of-concept and demonstrate the principles of operation. This effort will also provide site engineers with information that can assist in developing additional inspection tools that may be useful in other tanks or waste processing systems.

Subtask 19.1.1 – Data analysis of waste transfer components

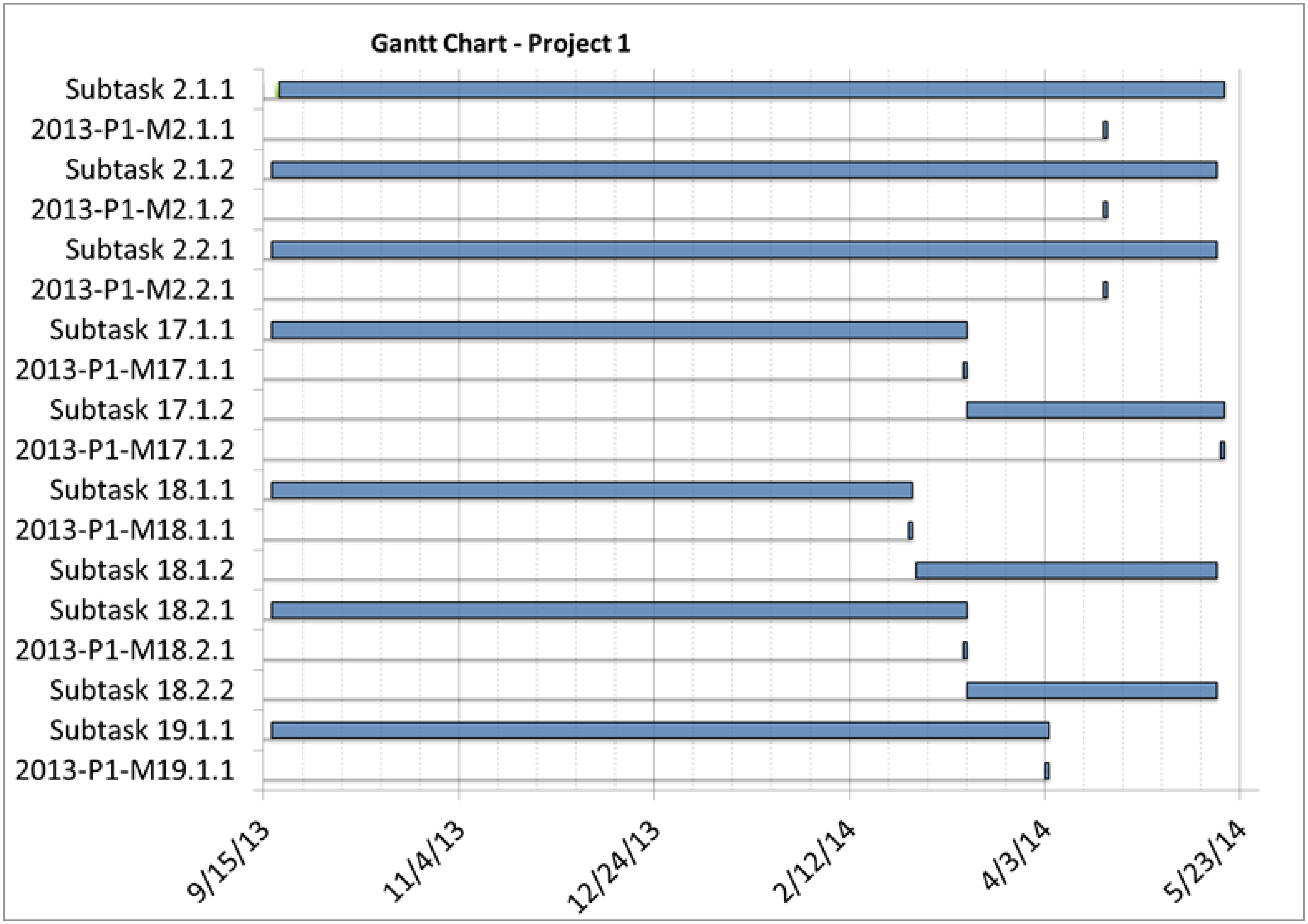
This subtask will focus on obtaining wall thickness measurements and general operation and material information on various components of the waste transfer system at Hanford. The information and data collection will include the following components:

- 241-SY Farm
    - SN-278, SN-285, SN-286 (primary)
    - SN-285, SN-286 (secondary)
- 241-AW Farm to 241-AP Farm
    - SL-509, SL-510, SN-609, SN-610 (secondary)
- 241-AY Farm

        - PW-4531 (secondary)
- 242-A Evaporator
    - Jumper J-13A, Jumper 13-K, Jumper 18-4, Jumper C-4&5, Jumper 19-5
- 241-AW-02E Pit
    - Jumper B-2, Jumper 1-4
- C-Farm POR 104 Valve Box
    - Flow nozzles and jumpers

Once the data has been collected, analysis will be conducted to determine wear rates for each system component. A comparative analysis on components with similar service functions, service life and material properties will be conducted. A report based on all components evaluated will be prepared and sent to site representatives and DOE-HQ personnel.

Task Schedule



Project Milestones

Milestone No.	Milestone Description	Completion Criteria	Due Date
2013-P1-M2.1.1	Engineering scale pipeline unplugging using APU with upgraded instrumentation	Summary email sent to Hanford contacts and DOE HQ	4/18/2014
2013-P1-M2.1.2	Engineering scale pipeline unplugging testing using PCS with upgraded components	Summary email sent to Hanford contacts and DOE HQ	4/18/2014
2013-P1-M2.2.1	Complete 2D multi-physics model development integrating the flow and chemistry interfaces	Summary email sent to Hanford contacts and DOE HQ	4/18/2014
2013-P1-M17.1.1	Bubble dynamics simulations in non-Newtonian fluids using the lattice Boltzmann method	Summary email with simulation results sent to Hanford contacts and DOE HQ	3/14/2014
2013-P1-M17.1.2	Lattice Boltzmann method for the simulation of fluid and gas injections in non-Newtonian fluids	Summary email with simulation results sent to Hanford contacts and DOE HQ	5/9/2014
2013-P1-M18.1.1	Complete functional testing of SLIM to assess imaging speed and ability to quantify solids on tank bottoms	Summary email with preliminary data analysis results sent to Hanford contacts and DOE HQ	2/28/2014
2013-P1-M18.2.1	Complete proposed conceptual designs	Summary email with proposed concepts sent to Hanford contacts and DOE HQ	3/14/2014
2013-P1-M19.1.1	Complete data analysis of waste transfer system components	Summary email sent to Hanford contacts and DOE HQ	4/4/2014

Deliverables

Client Deliverables	Responsibility	Acceptance Criteria	Due Date
Draft Project Technical Plan	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	10/17/2013
Quarterly Progress Reports (all tasks and projects combined)	Principal Investigator	Acknowledgement of receipt via E-mail two weeks after submission	End of Q1, Q2, Q3,Q4
Draft Year End Report (ALL TASKS)	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	6/30/2014
Draft Test Plan for Subtask 2.1.1	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	11/15/2013
Draft Test Plan for Subtask 2.1.2	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	2/21/2014
Draft Topical Report for Subtask 2.1.1 and 2.1.2	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	5/16/2014
Draft Summary Report for Subtask 2.2.1	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	5/2/2014
Draft Topical Report for Subtask 17.1	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	5/16/2014
Experimental Test Plan for Subtask 18.1.2	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	4/25/2014
Draft Summary Report for Validation of Conceptual Design Subtask 18.2.2	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	5/9/2014
Draft Summary Report for Subtask 19.1.1	Project Manager	Acknowledgement of receipt via E-mail two weeks after submission	5/2/2014

COMMUNICATION PLAN, ISSUES, REGULATORY POLICES AND HEALTH AND SAFETY

Communication Plan

The task has some elements that require significant information from the site in order to proceed with the tasks. Therefore, the communication with the clients and relevant experts at Hanford & SRS is a critical component of the task. The mode of communication will be e-mails, telephone/conference call, and meeting at the site. Though site-specific contact persons have been identified, constant communication will be maintained with client stakeholders at DOE HQ and the Hanford sites to ensure all parties involved are aware of the task progress.

Information Item	Client Stakeholder	When?	Communication Method	Responsible Stakeholder
Status Update Teleconferences	Hanford POC (R. Mendoza, T. Sams, L. Thompson, WRPS) DOE EM-21	Monthly	Phone call	Project Manager
EM-HQ Status Update Phone Call	DOE EM Liaison to FIU	Bi-Weekly	Phone call	Principal Investigator
Quarterly Report	DOE EM-21 WRPS	End of Q1, Q2, Q3,Q4	E-mail	Principal Investigator
Annual Year End Report	DOE EM-21, WRPS	45 days after completion of performance period	E-mail	Principal Investigator/ Project Manager
Deliverables, Milestones	Hanford POC (R. Mendoza, T. Sams, L. Thompson, WRPS) DOE EM-21	At completion of Deliverable, Milestone	E-mail	Project Manager/ Principal Investigator

Anticipated Issues

Every year, South Florida has a 6-month hurricane season. Twice in the past decade FIU has been closed 1-2 weeks due to hurricane storm damage. Care will be taken to minimize the impacts on the overall schedule of milestones and deliverables due to hurricanes.

Regulatory Policies and Health and Safety

Since laboratory experiments will be conducted on this project, FIU will ensure test plans are developed and reviewed that cover staff health and safety issues. The nature of waste simulants is that they are chemically the same as HLW and therefore highly caustic and hence hazardous. In addition, FIU will set up, operate, and dismantle experimental test beds using proper procedures from FIU and that comply with standards issued by the Occupational Safety and Health Administration (OSHA). In order to minimize hazards, individuals will require documentation of all needed online and classroom health and safety training prior to their being authorized to work in the lab, on equipment, or on the test beds. Further, mandatory training is provided to these individuals on workplace safety multiple times:

- Safety training at the time of initial assignment.
- Safety training prior to assignment involving new exposure situation (e.g., new equipment or technology).

The Department of Health and Safety at FIU also provides other training relevant to specific tasks or subtasks. Either FIU EHS or FIU ARC may request an audit by FIU EHS of safety documentation, lab set up and procedures when there are any concerns by any staff working on the task.