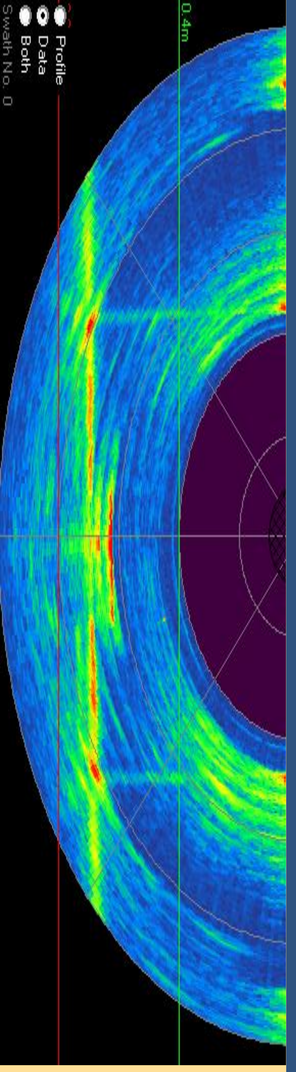
Residual Waste Detection in HLW Tanks

by Dayron Chigin, DOE Fellow

David Roelant, Ph.D. and Dwayne McDaniel, Ph.D., P.E.



ABSTRACT

This research uses commercial sonar technology to monitor residual waste in the United States Department of Energy's (DOE) Hanford Site high-level-waste staging tanks, with primary focus on the detection and imaging of the settled solids at specified areas of interest along the tank surface within a limited amount of time.

BACKGROUND

High-level waste is generated at the US-DOE Hanford Site as a by-product from the processing of nuclear materials.

- Waste is currently stored in 177 underground carbon-steel waste tanks.
- Pulse jet mixers (PJM) are often used to break loose and suspend the solids that have settled at the bottom of the tanks. A typical tank can have six to eight pulse tubes.
- There is a need for instrumentation capable of detecting the clearing of or the failure to clear residual waste at the bottom of each tank where the impingement of the two adjacent wall jets converges, also known as "Region 1" (Figure 4).
- To meet this need, FIU's Solid Liquid Interface Monitor will be used.

Figure 1 (Right) : Solid Liquid Interface Monitor(SLIM)

PAST IMPLEMENTATION

- SLIM (Figure 1) was originally developed to map the sludge/supernate interface within the US-DOE Hanford Site's HLW tanks.
- It improved the methods for mapping solid layers, detecting slow settling solid depth and monitoring the tank filling process.

Figure 2 : SLIM's deploying mechanism for 75ft tanks

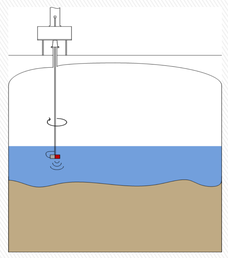


Figure 3 : SLIM"s deployment plan.

MOTIVATION

- SLIM must be capable of recording dynamic movements in Region 1 (red strip) zone between each PJM cycle.

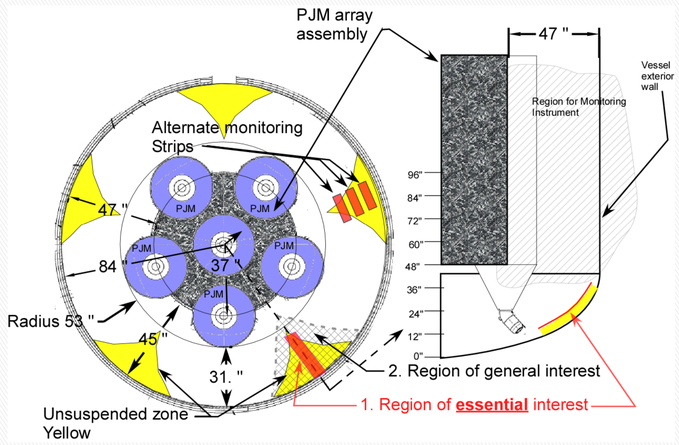
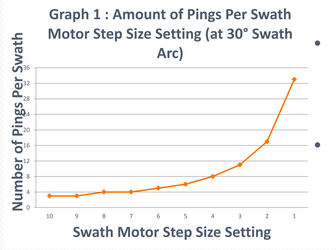
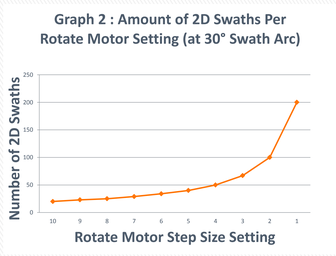


Figure 4 : Technical drawing of mock tank and predicted static areas unaffected by PJM

- The technology will have a limited amount of time (<30secs) to conduct its reading and produce as high resolution as possible.
- SLIM's initial design criteria was not intended to be time-limited.

BENCHMARK TESTING





- Initial benchmark testing was conducted.
- Multiple scans done in order to compile a matrix comprising of time duration and quality of difference scans while varying multiple settings on the device.
- Varied
  - Swath Arc (Set to 30° - 180° in intervals of 30°)
  - Swath Motor Step Size (1-10, 1=highest, 10=lowest, interval of 1)
  - Rotate Motor Step Size (1-10, 1=highest, 10=lowest, interval of 1)

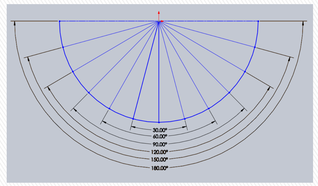


Figure 5 : Swath Arc Setting Range for SLIM

DEVICE OPERATIONS

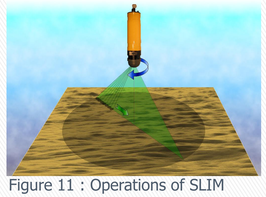


Figure 11 : Operations of SLIM

- SLIM is a dual-axis mechanically rotating sonar.
- Consists of:
  - Acoustic transducer
  - Rotation motor with gearbox
  - Tilt motor
  - Position reference sensor
  - Pressure balancing mechanisms
- Gathers a swath of data in the horizontal plane.
- Rotates transducer through programmed angle around vertical axis.
- Oil-filled device; no user serviceable parts; no semiconductors.
- Hard Anodized Aluminum and Polyurethane Delrin.
- May be deployed in areas of significant radioactivity.

RESULTS

At its highest settings for a 30° Swath Arc (seen in Table 1), SLIM takes approximately 2 minutes to provide an entire 360° scan as seen in the images below. For simplicity, we have placed a typical brick within the tank for initial testing. At the highest resolution setting (Trial 1), SLIM provides each swath with the quality seen in Figure 6. SLIM then rotates continuously, taking various swaths until it is able to compile a point cloud as seen in Figure 7. The 3D Profiler then applies a meshing algorithm to the point cloud as seen in Figure 8.

Table 1 : Time Duration for Varying Settings at 30° Swath Arc

Time	Trial	Rotation	Swath	Arc
~1:56	1	1	1	30
~1.55	2	1	1	30
~1.55	3	1	1	30
~1.57	4	1	1	30
~1.55	5	1	1	30
~32 s	6	3	3	30
~12 s	7	10	10	30
~ 13 s	8	9	9	30
~ 15 s	9	8	8	30
~ 15 s	10	7	7	30
~ 17 s	11	6	6	30
~ 19 s	12	5	5	30
~ 24 s	13	4	4	30
~ 48 s	14	2	2	30

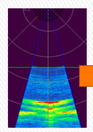


Figure 6: Example of High Quality Swath

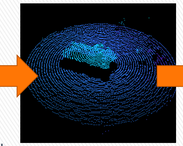


Figure 7: Example of Swath

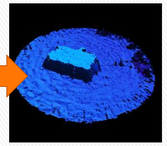


Figure 8: Example of Swath

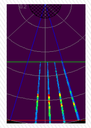


Figure 9 (Right): Example of Low Quality Swath

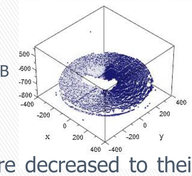


Figure 10 (Right): 3D point grid developed in MATLAB using output ASCII Code from low quality scan.

In order to reduce the amount of time, all settings were decreased to their minimal state. An example of quality for each individual swath at these settings is seen in Figure 9. The low settings provide insufficient data for the manufacturer's 3D profiler to compile a visible point cloud and much less to allow the meshing algorithm to work properly.

FUTURE WORK

- Production of an accurate 3D image using output ASCII data (Figure 10).
- Along with a third party mapping software a secondary mapping algorithm will be produced.
- Estimation of volumes for objects imaged.

CONTACT INFO

Dayron Chigin
DOE Fellow,
Electrical Engineer
Applied Research Center
10555 West Flagler St.,
Suite 2100,
Miami, FL 33174
Email: dchigin@fiu.edu

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