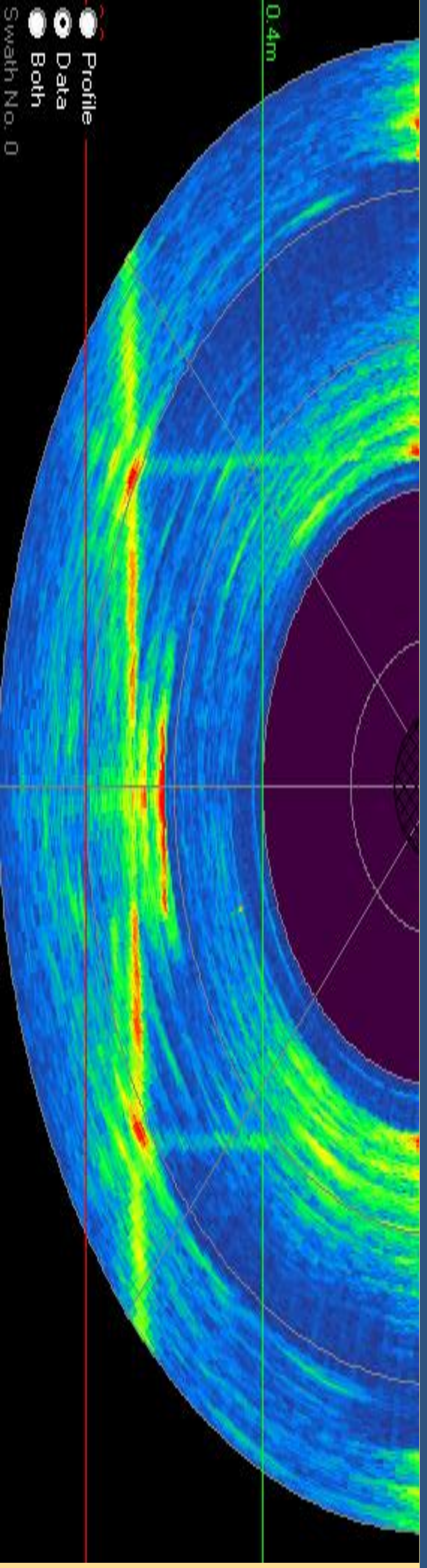

Residual Waste Detection in HLW Tanks

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ABSTRACT

This research uses commercial sonar technology to monitor residual waste in the U.S. 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 & MOTIVATION

- High-level waste (HLW) 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 6-8 pulse tubes.
- The Solid Liquid Interface Monitor (SLIM) must be capable of measuring dynamic movements in Region 1 (red strip) zone between each PJM cycle.

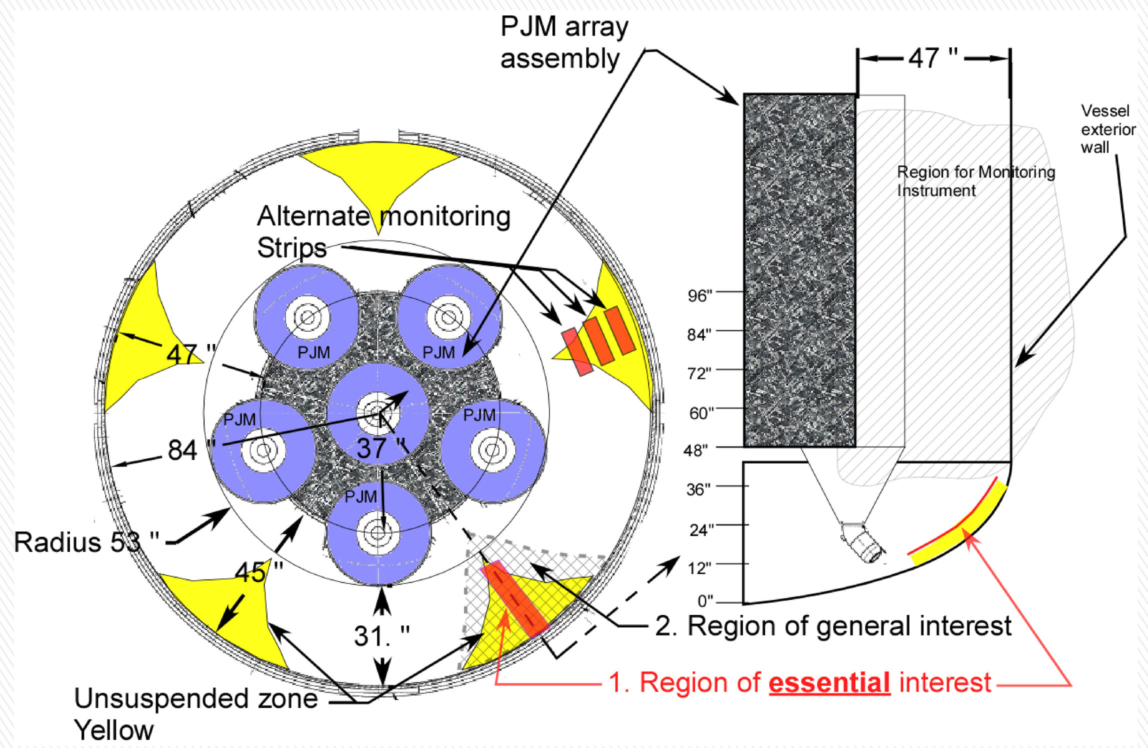


Figure 1: Technical drawing of tank and predicted static areas unaffected by PJM

PAST IMPLEMENTATION

SLIM was originally developed to map the sludge/supernate interface within the U.S. DOE Hanford Site's HLW tanks.

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

Figure 3: Solid Liquid Interface Monitor(SLIM) 3D Sonar

DEVICE OPERATION & BENCHMARK TESTING

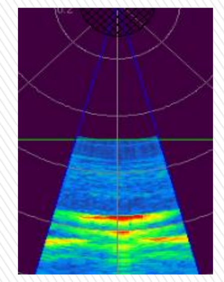


Figure 4: Example of high quality 2D swath image

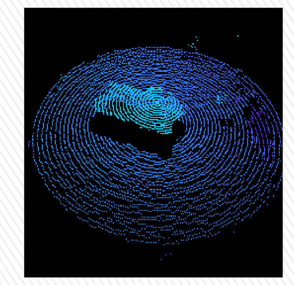


Figure 5: Example of 360 degree compilation of 2D swaths

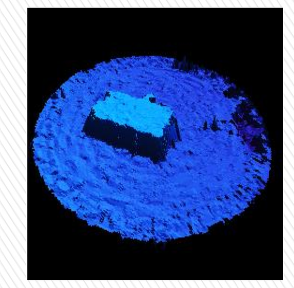


Figure 6: Example mesh applied to compilation of swaths

SLIM is a dual-axis mechanically rotating sonar and consists of an acoustic transducer, rotation motor with gearbox, tilt motor, position reference sensor, and pressure balancing mechanisms and its associated deployment platform.

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

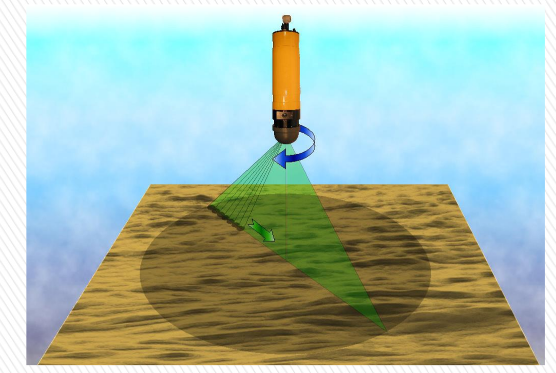
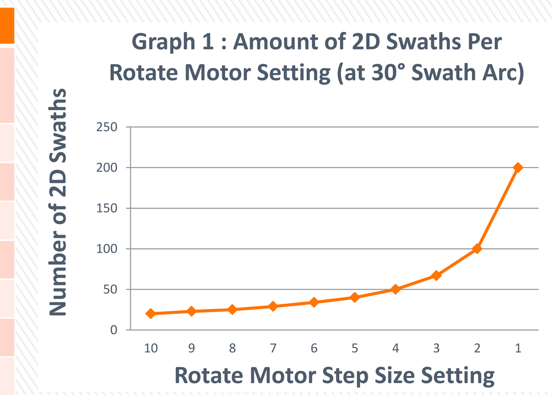


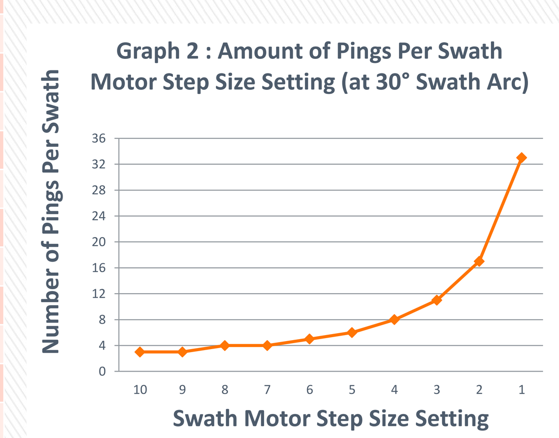
Figure 7: Scanning Movement of SLIM

The sonar gathers a swath of data in the horizontal plane and rotates the transducer through a programmed angle around the 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. Kaolin will be used during mixing operations in order to simulate the physical properties of the expected slurry.

Table 2: Percentages Kaolin

Volume Percentages	% Volume (meters cubed)	Mass of Kaolin Required in kg	Mass of Kaolin in lbs.
1%	0.006207	16.1382	35.57859848
2%	0.012414	32.2764	71.15719697
3%	0.018621	48.4146	106.7357955
4%	0.024828	64.5528	142.3143939
5%	0.031035	80.691	177.8929924
6%	0.037242	96.8292	213.4715909
7%	0.043449	112.9674	249.0501894
8%	0.049656	129.1056	284.6287879
9%	0.055863	145.2438	320.2073864
10%	0.06207	161.382	355.7859848
11%	0.068277	177.5202	391.3645833
12%	0.074484	193.6584	426.9431818
13%	0.080691	209.7966	462.5217803
14%	0.086898	225.9348	498.1003788
15%	0.093105	242.073	533.6789773
16%	0.099312	258.2112	569.2575757
17%	0.105519	274.3494	604.8361742
18%	0.111726	290.4876	640.4147727
19%	0.117933	306.6258	675.9933712
20%	0.12414	322.764	711.5719697





RESULTS

In order to reduce the amount of time needed to image and object, all settings were decreased to their minimal state. An example of quality for each individual swath at these settings is seen in Figure 8. The low resolution 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.

Figure 8 (Right): Example of Low Quality Swath Image

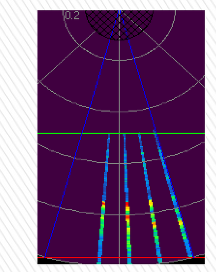
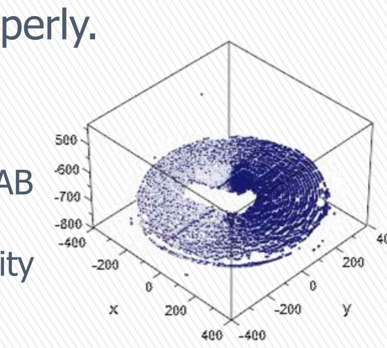


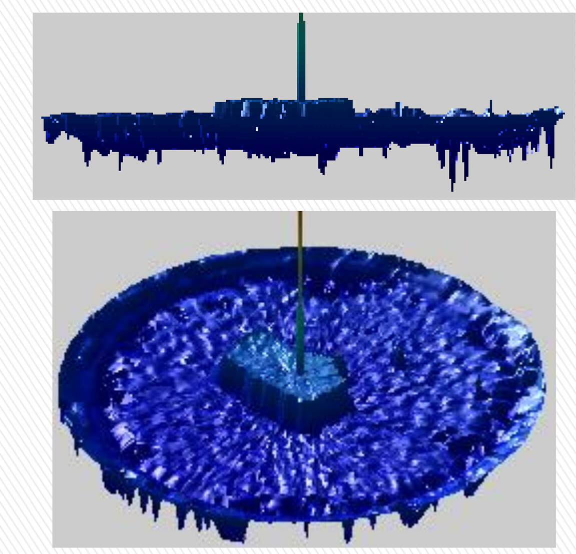
Figure 9 (Right): 3D point grid developed in MATLAB using output ASCII code from low quality scan.



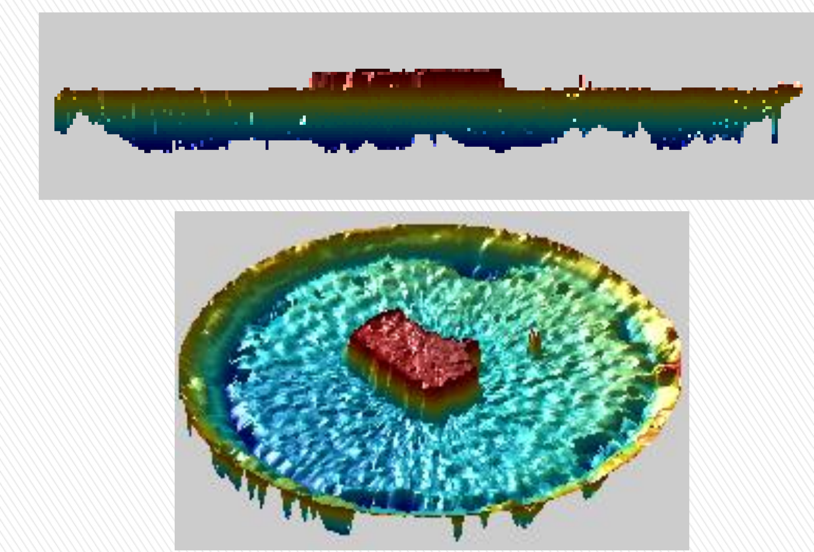
Several filtering algorithms have been applied to each scan in order to remove erroneous spikes and ghosting effects.

Applied Filters

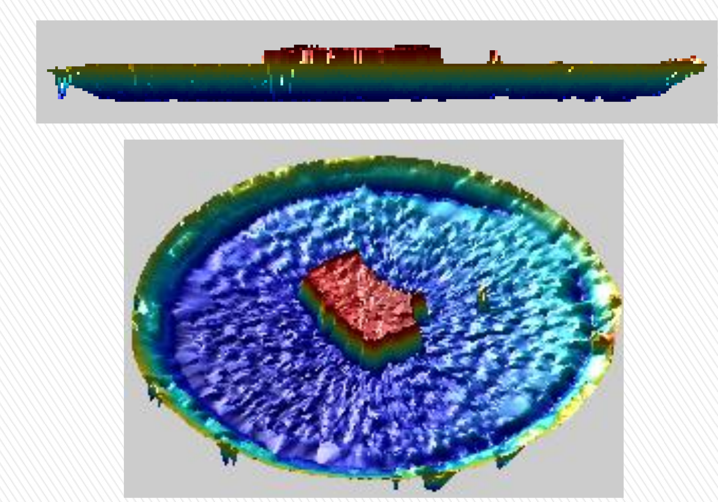
Filter 1: Points near sonar head



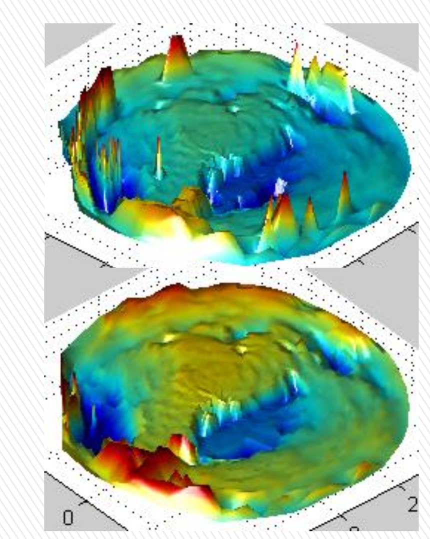
Filter 2: Spikes in neighboring points



Filter 3: Points seen beyond tank bottom



Filter Application: During kaolin mixing



Data has been collected for the mixing process of kaolin. This data consists of scans executed while the pump was active and inactive. The imaging algorithm has also been used with data derived from scans of 3% or less of kaolin. An example of the results can be seen in the image above entitled "Filter Application".

FUTURE WORK

Mixing of kaolin within an experimental tank will be conducted in order to simulate the settling time of the HLW within the tank. The same filtering algorithms will be applied to each of these scans to evaluate the SLIM's efficiency to image solids at the bottom of a tank through increasing volume of kaolin.

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