Simulating Side Scan Sonar as a MOOS app using NVIDIA OptiX

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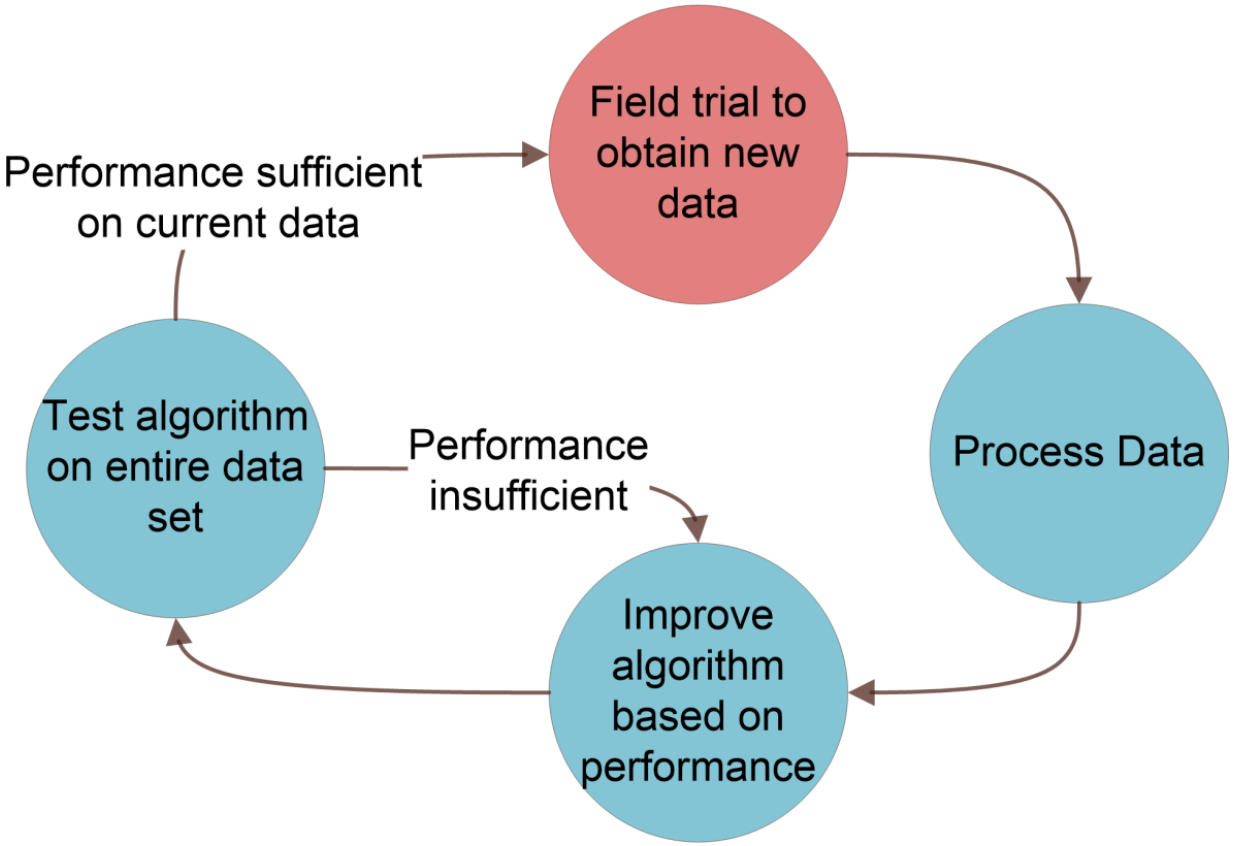
Funded by

Defence Science and Technology Organisation

Motivation

	REMUS 100	REMUS 600
		
Length	1.6m	3.25m
Diam	190mm	324mm
Weight (air)	38.5kg	240kg
Endurance	8-10hrs (typ.)	24hrs (typ.)
Speed	2.4m/s	2.1m/s
Max Depth	100m	600m
Sonar	900 + 1800 kHz side scan	200 + 400 kHz Synthetic Aperture

Iterative Development Procedure



Chapple, Philip B. "Unsupervised detection of mine-like objects in seabed imagery from autonomous underwater vehicles." *OCEANS 2009, MTS/IEEE Biloxi-Marine Technology for Our Future: Global and Local Challenges*. IEEE, 2009.

Simulation Constraints

- High fidelity sonar data
- Including artefacts from platform motion
- Enable transition from post-mission to on-board

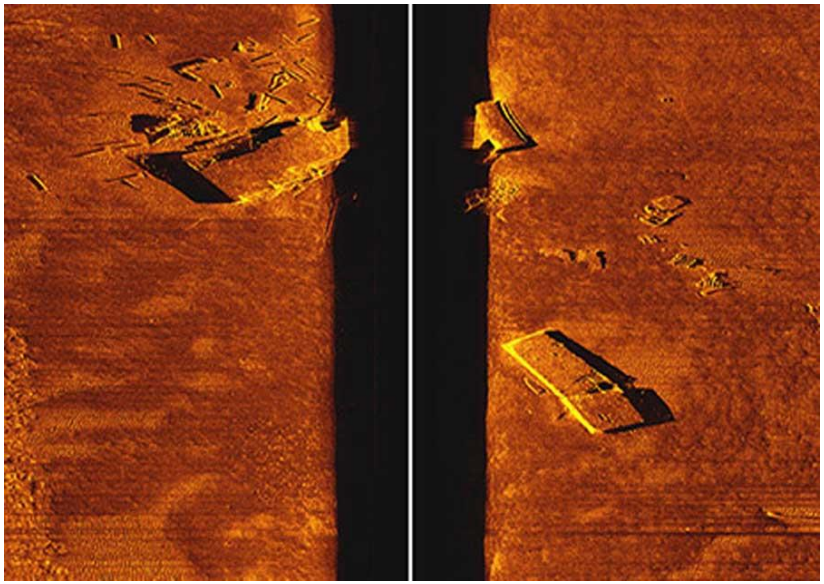
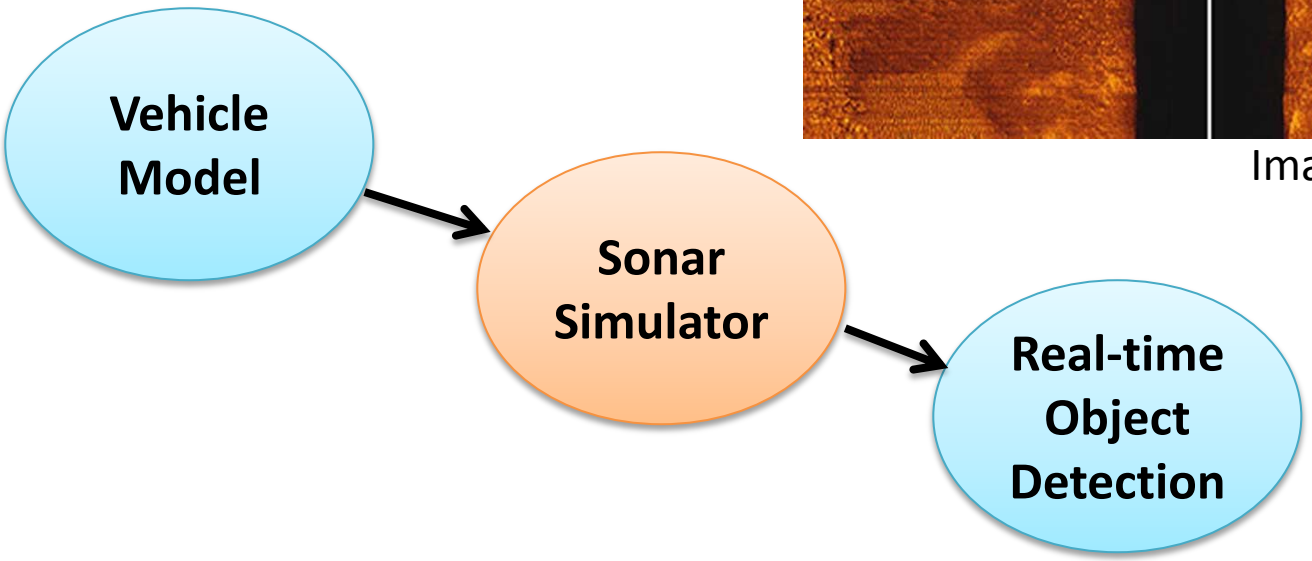
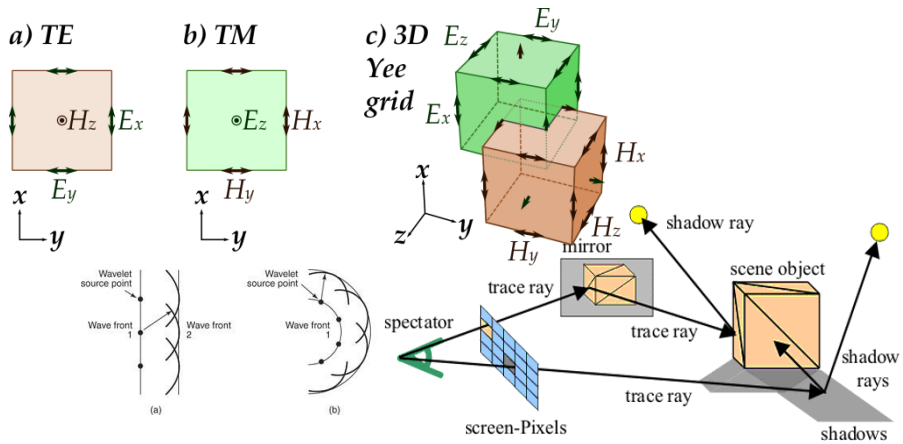


Image: EdgeTech



Where to start?



Real time Constraint

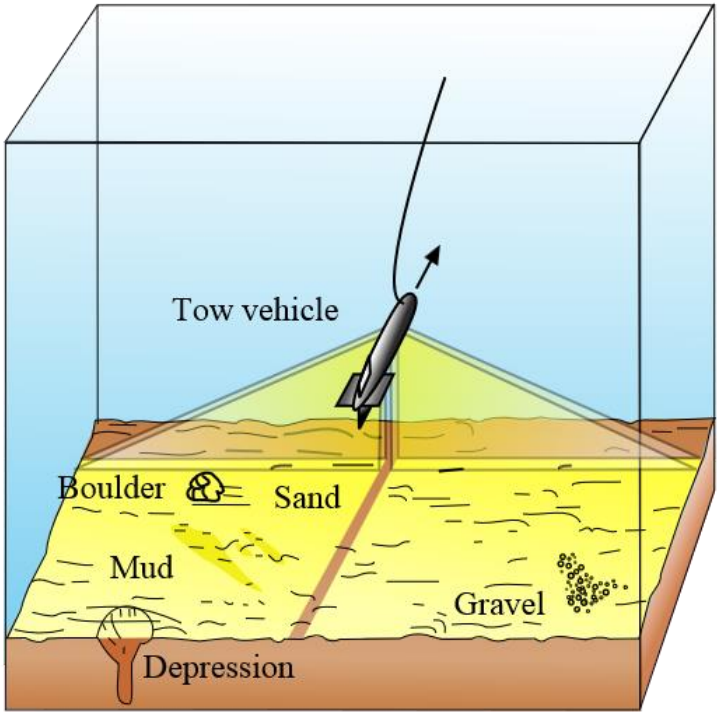
+ relaxed accuracy requirements

+ Need for unique flexibility

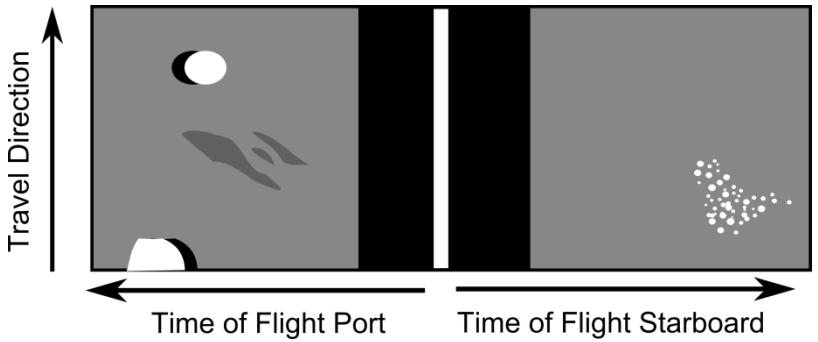
NVIDIA OptiX

Side Scan Basics

- Vertically aligned fan beam
- Vehicle motion defines one image axis
- Time of flight defines second axis

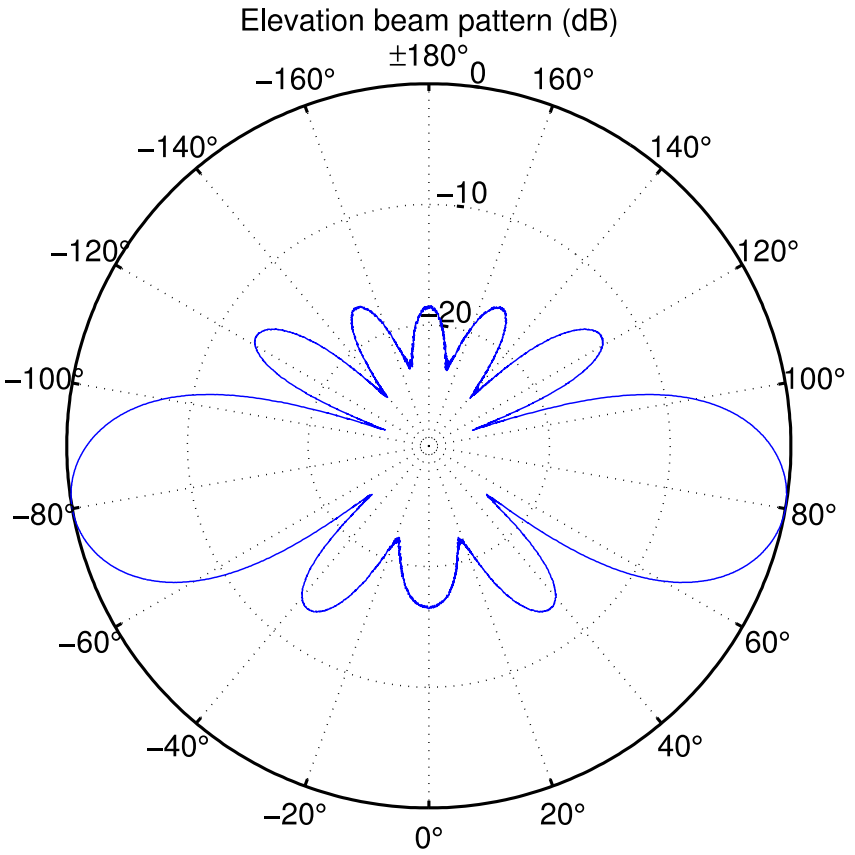


- Objects form highlight-shadow pairs



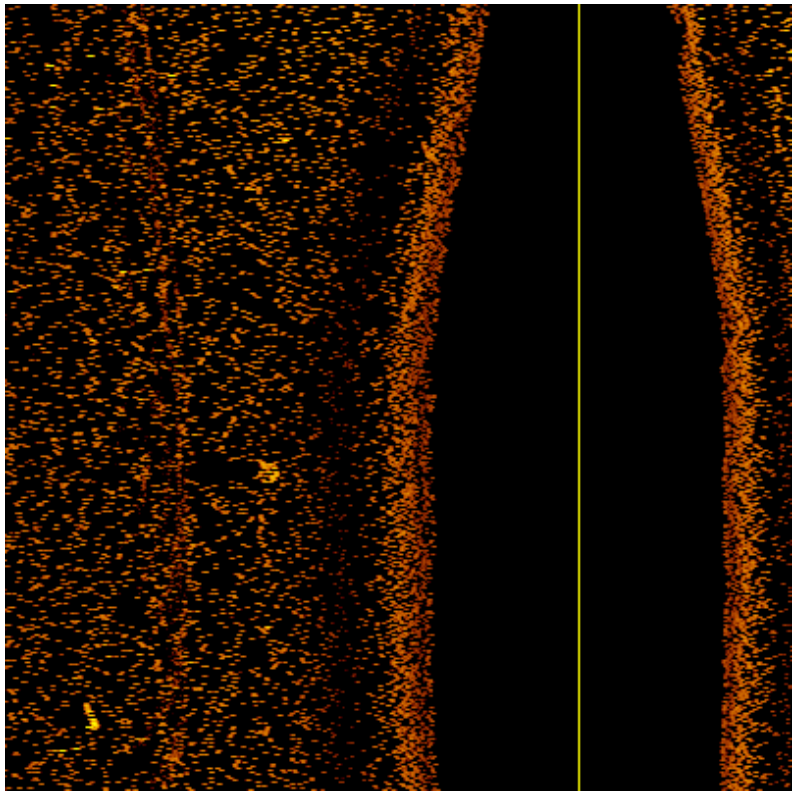
Side Scan Beam Pattern

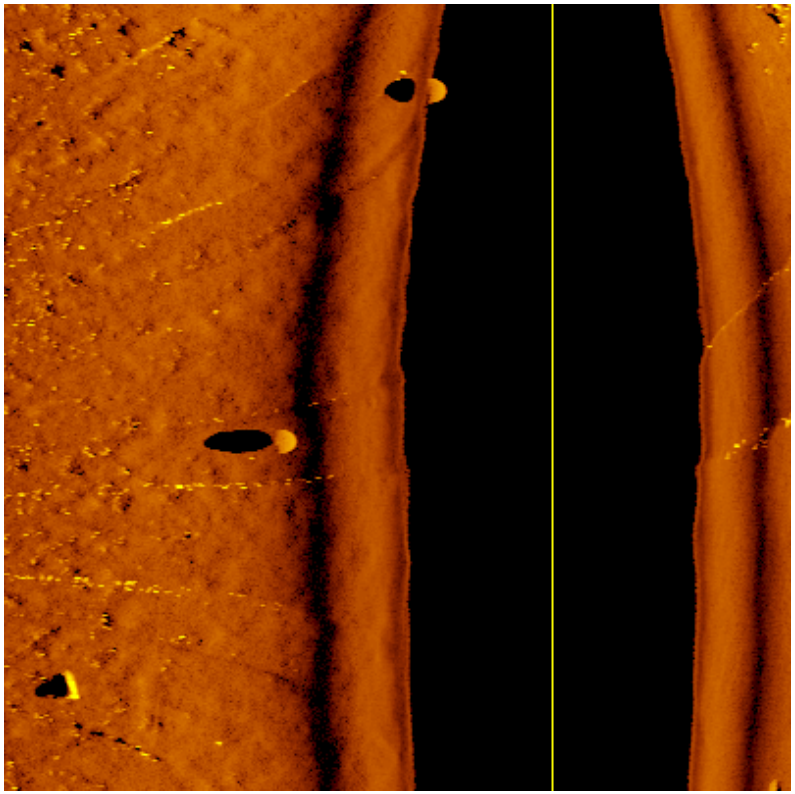
- Measured beam patterns are difficult
- Theoretical beam pattern from aperture size
- Import from csv
- Easily configurable



Sample Distribution

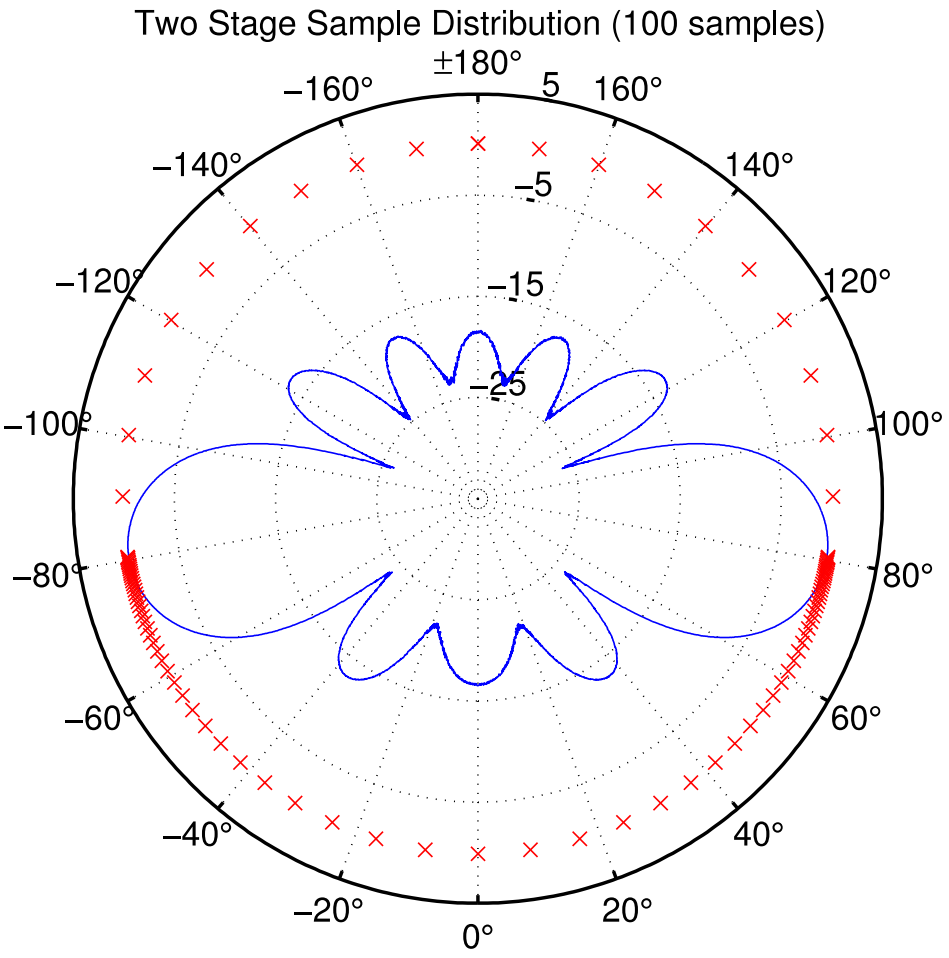
- Infinite samples → exact solution
- Finite samples → approximate solution





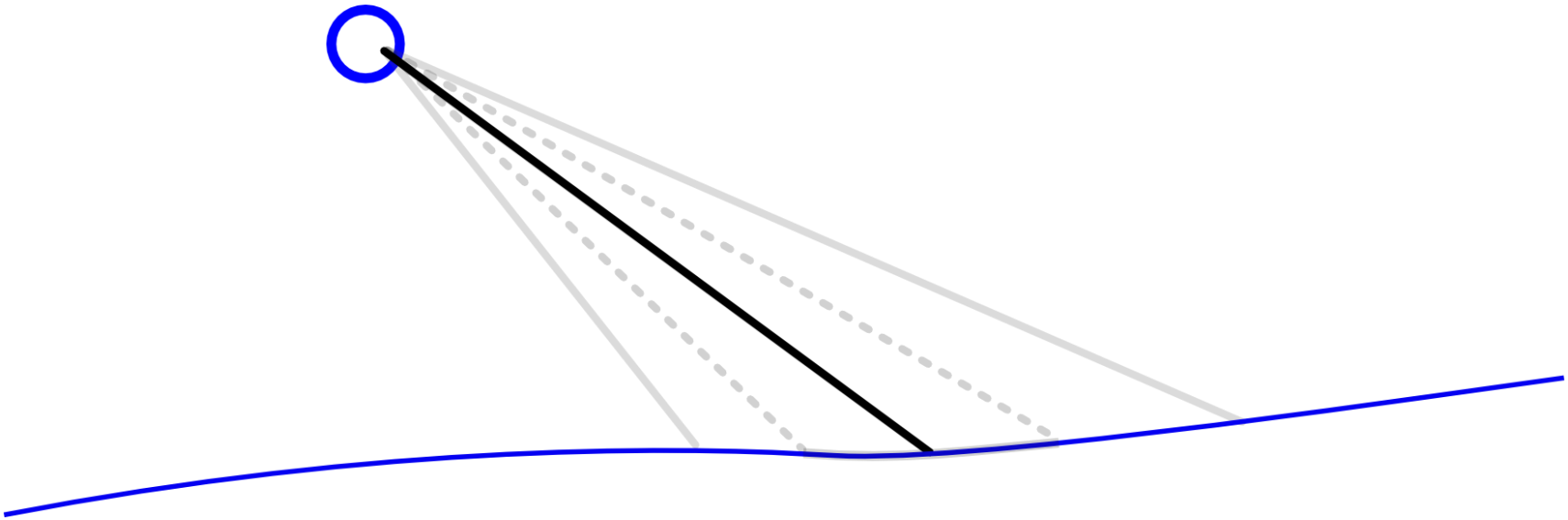
Sample Distribution

- Not limited to only increasing samples
- Samples are chosen to favour areas of greater information
- Sea floor out to max range is most significant
- Information ∝ range



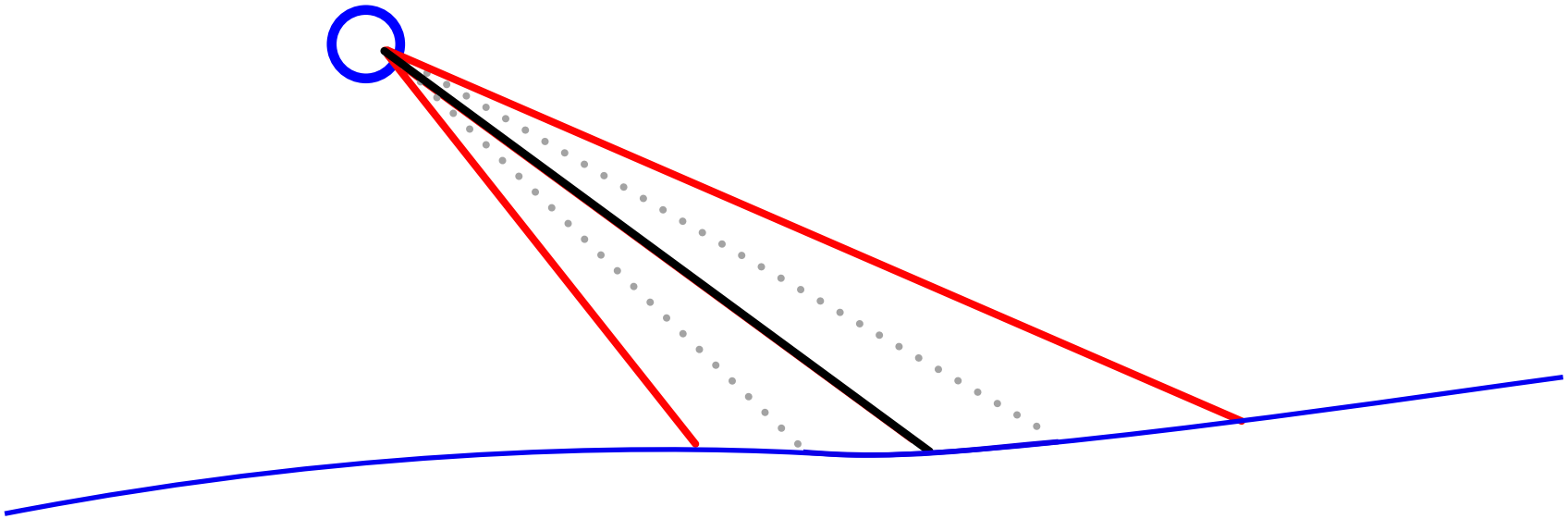
Sample Weighting

- Easy to determine energy density at intersection point
- density @ point × area = intensity of area
- To determine the area the single general ray (black) is approximating…



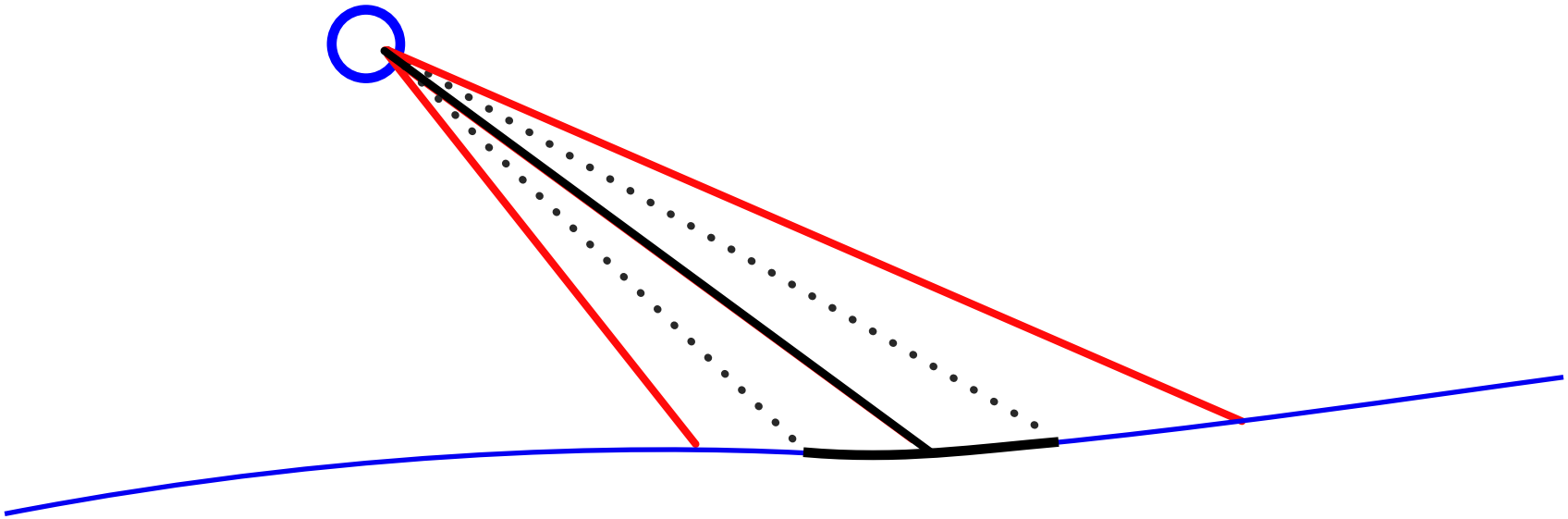
Sample Weighting

- Consider the two rays on either side (red)



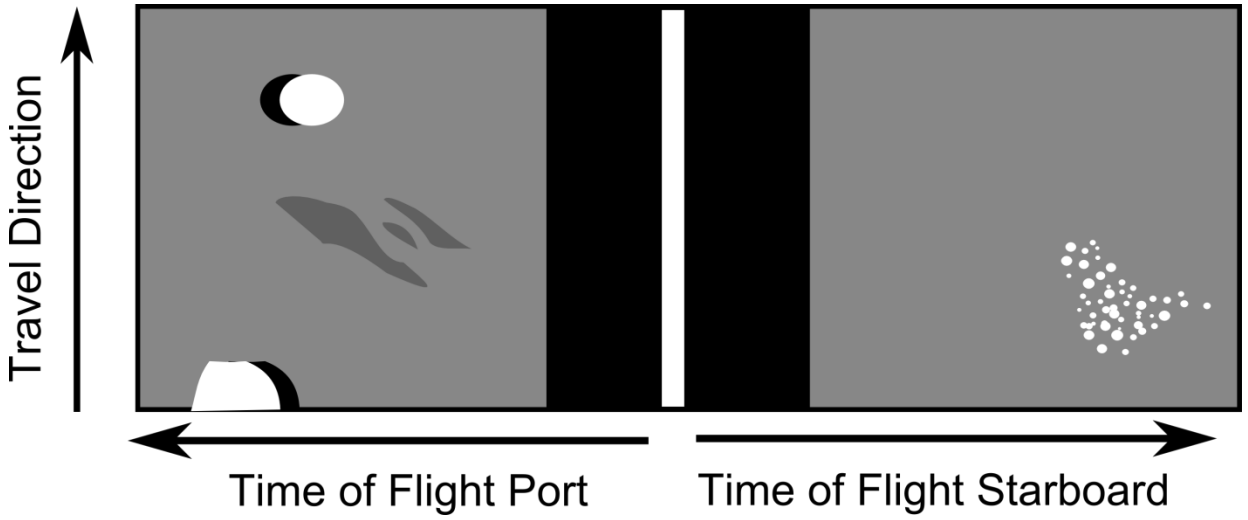
Sample Weighting

- Consider the two rays on either side (red)
- Projecting perpendicular to the ray
- $A \propto r^2\theta^2$



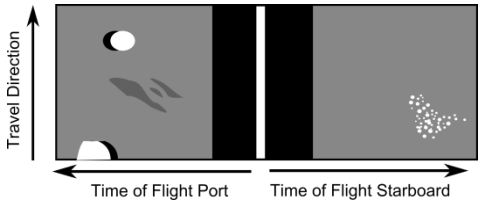
Producing an image from the samples

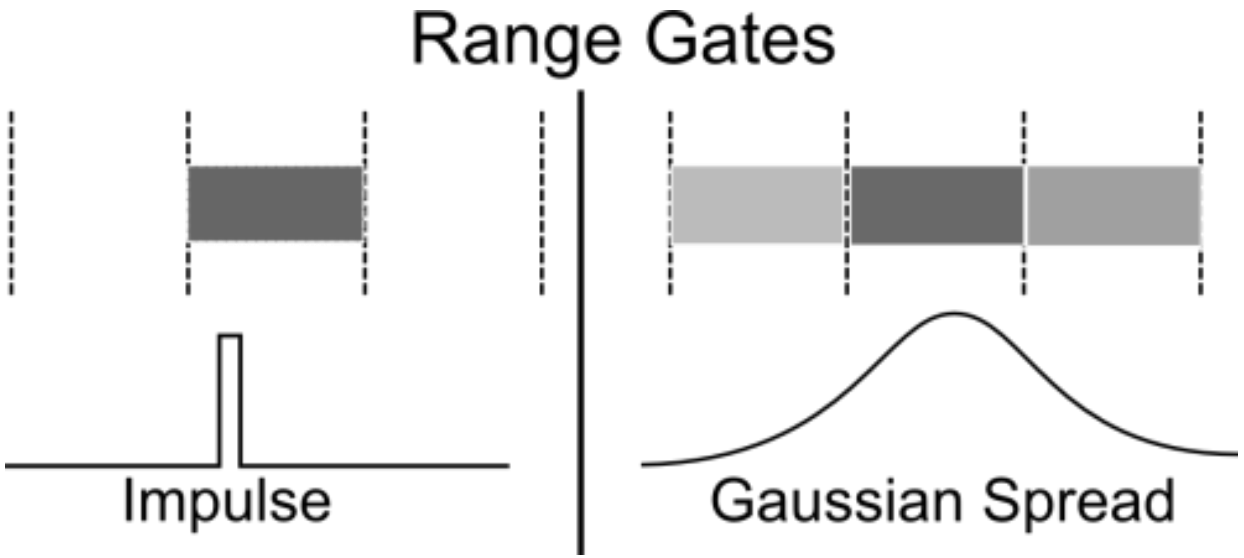
- Time of Flight based mapping



Producing an image from the samples

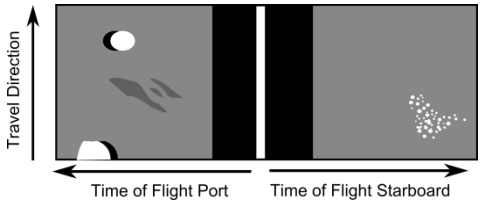
- Time of Flight based mapping
- Pulse shape (Gaussian time spread)

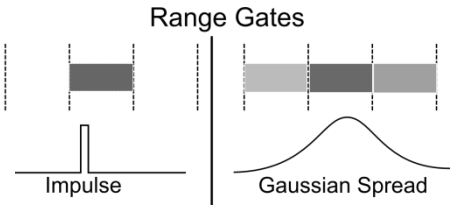


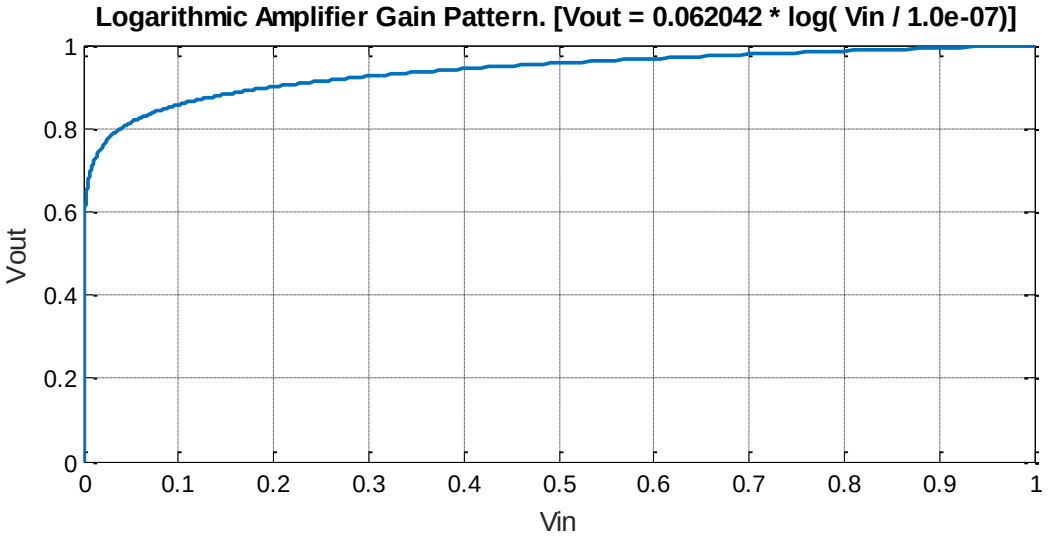


Producing an image from the samples

- Time of Flight based mapping
- Pulse shape (Gaussian time spread)
- Logarithmic amplifier

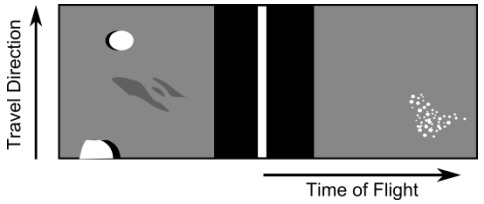


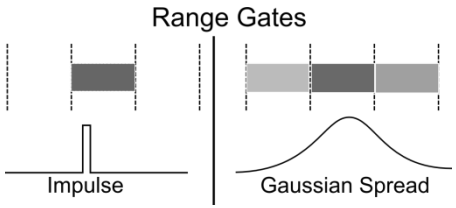


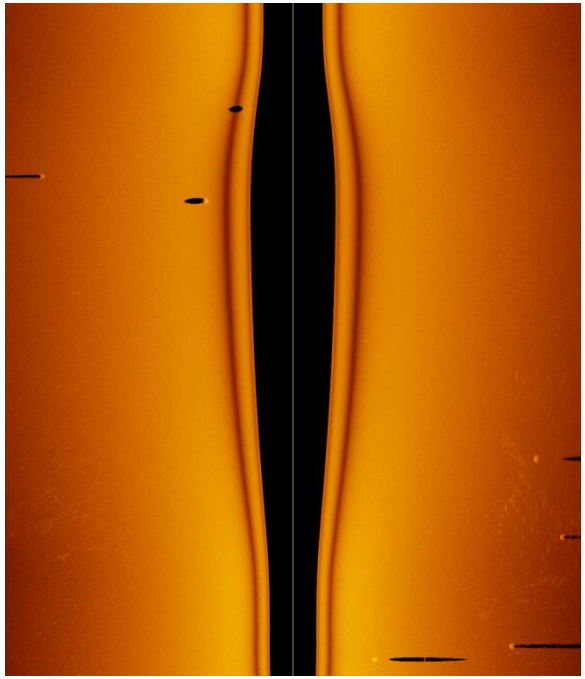


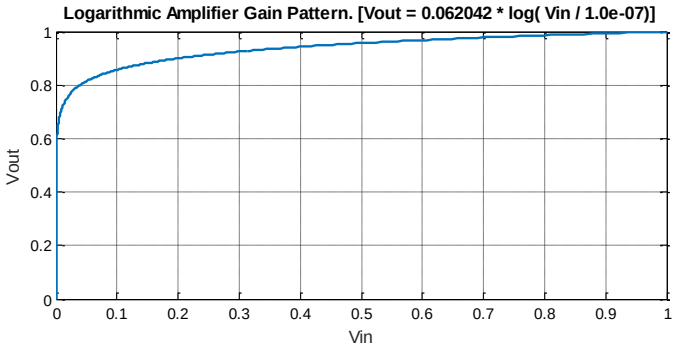
Producing an image from the samples

- Time of Flight based mapping
- Pulse shape (Gaussian time spread)
- Logarithmic amplifier
- Thermal noise





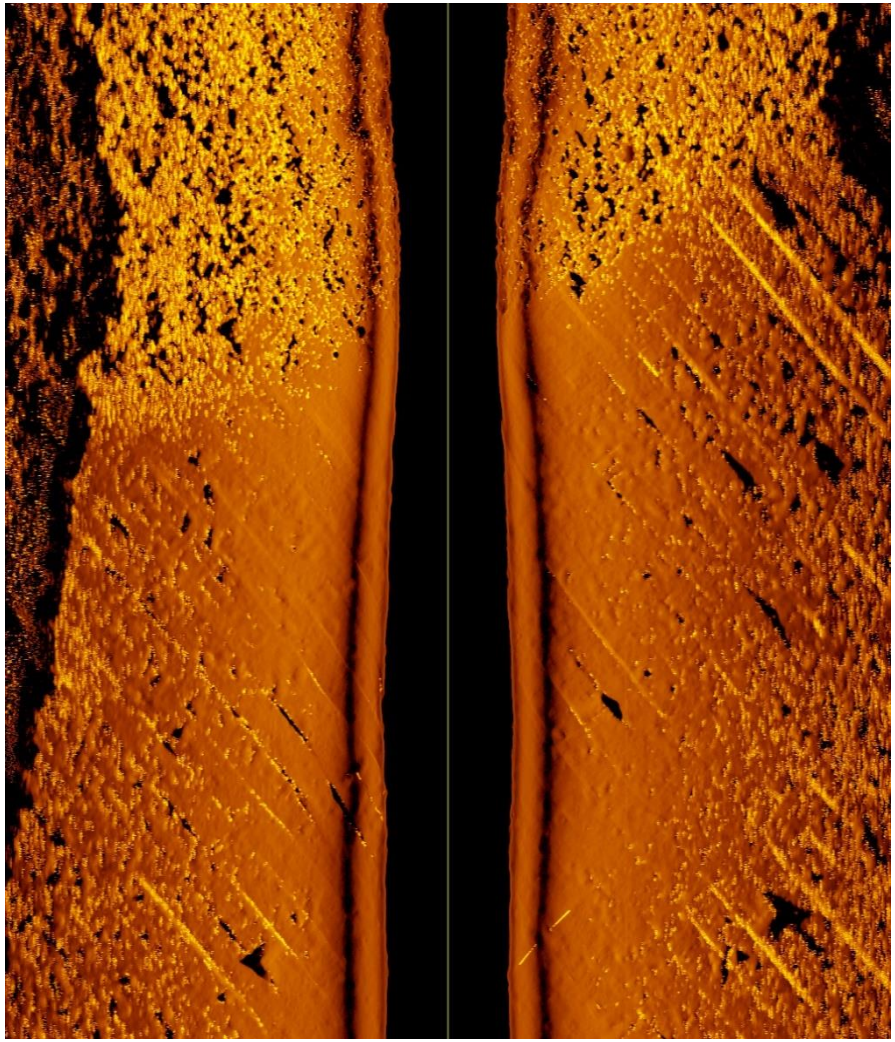




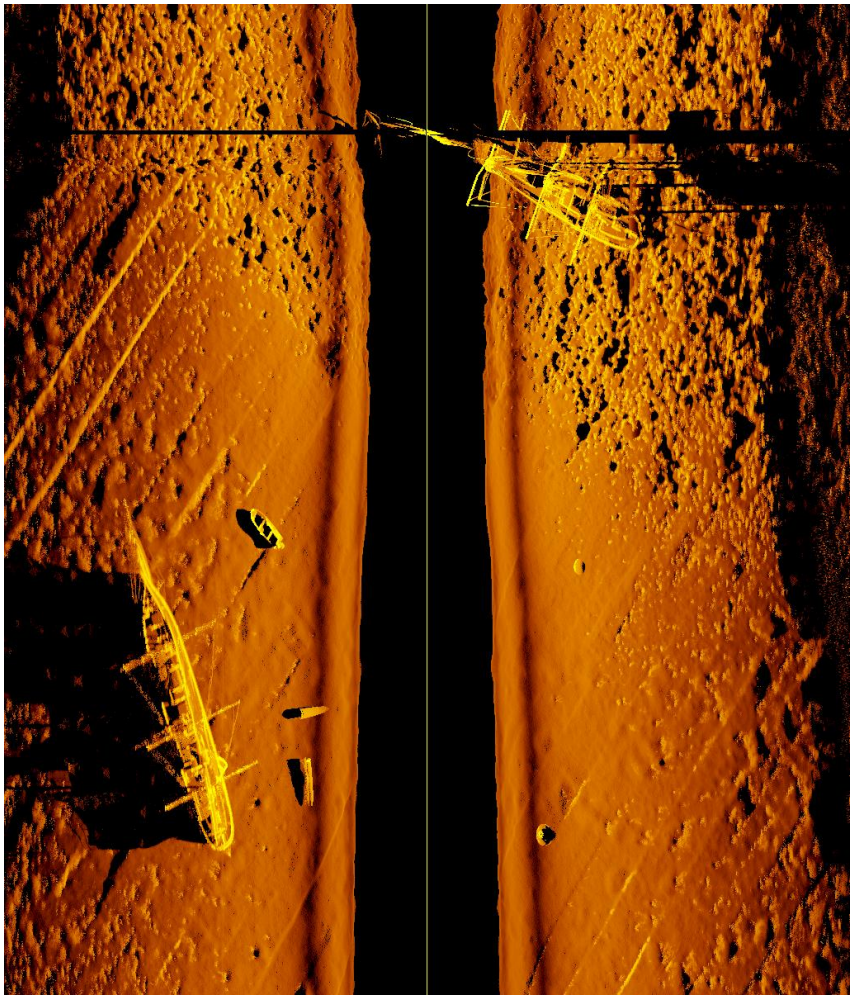
Virtual Environment

Beall, Chris, et al. "Bundle adjustment in large-scale 3D reconstructions based on underwater robotic surveys." *OCEANS, 2011 IEEE-Spain*. IEEE, 2011.

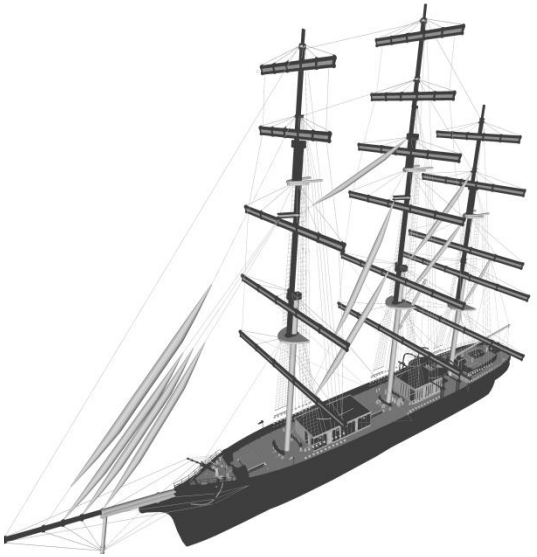
Results – Standalone Simulation



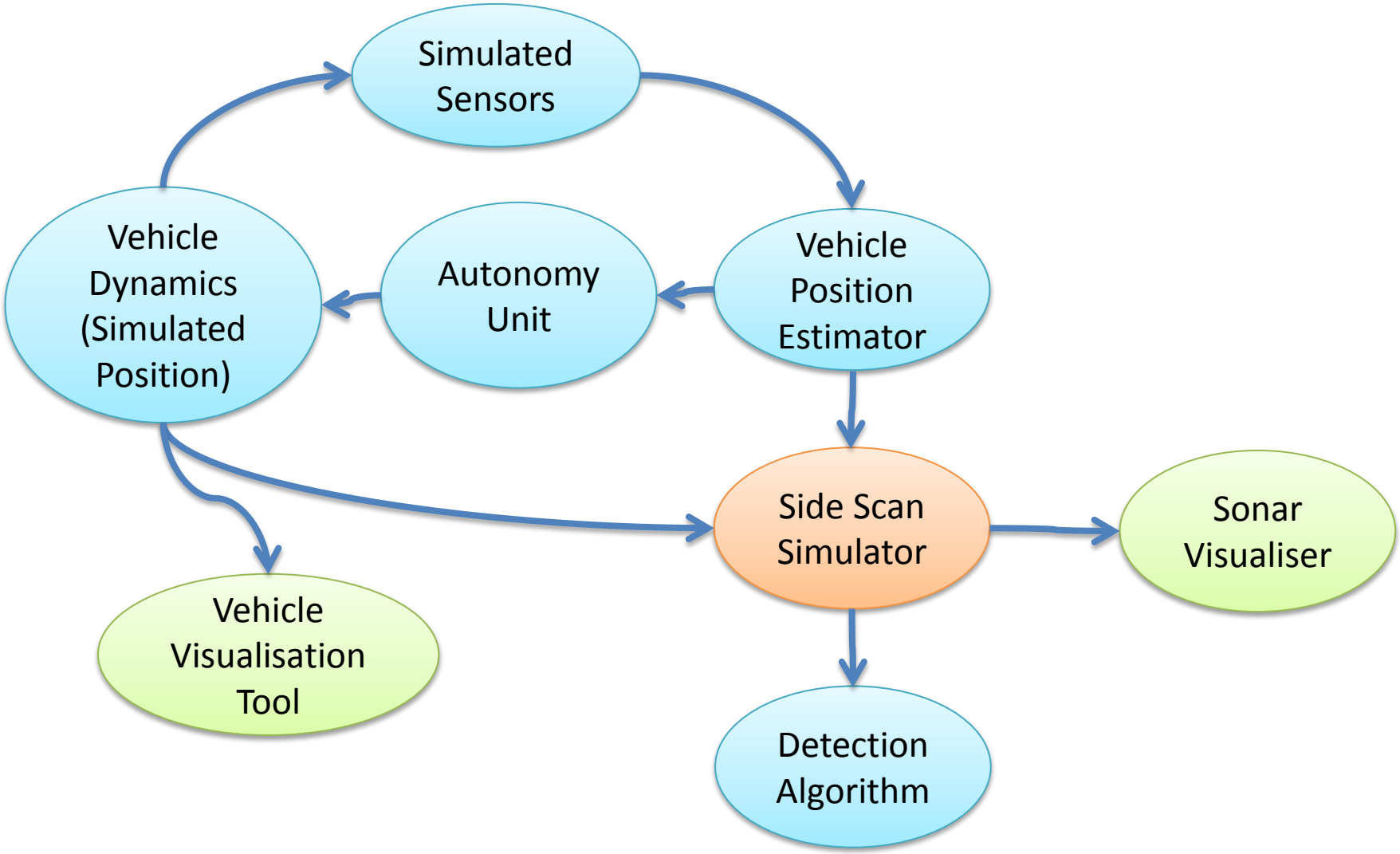
Complex Object Simulation



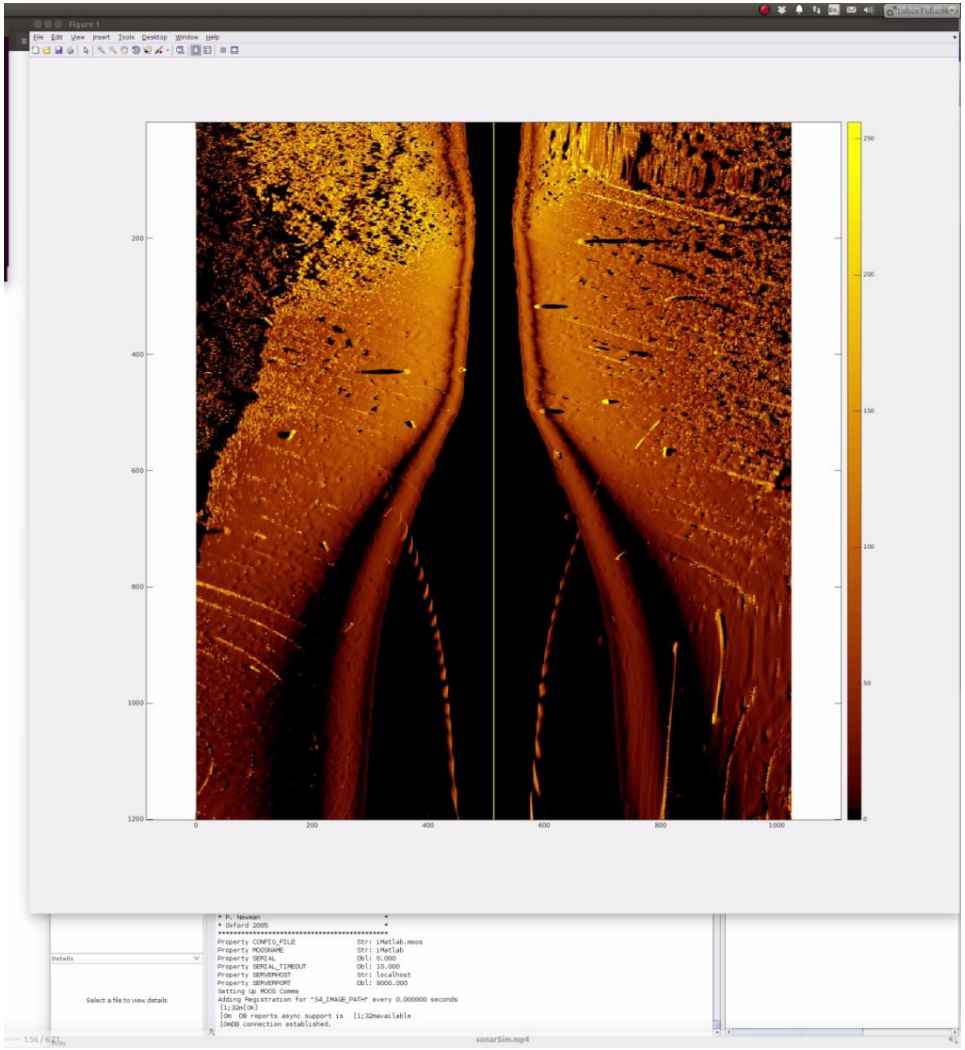
- Vertices: 206113
- Faces: 389552
- File size: 36.5 MB

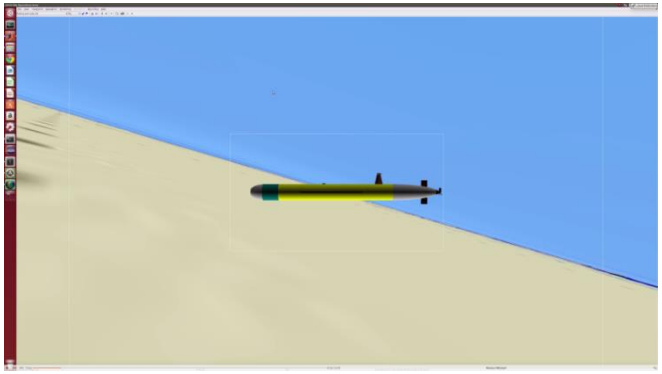


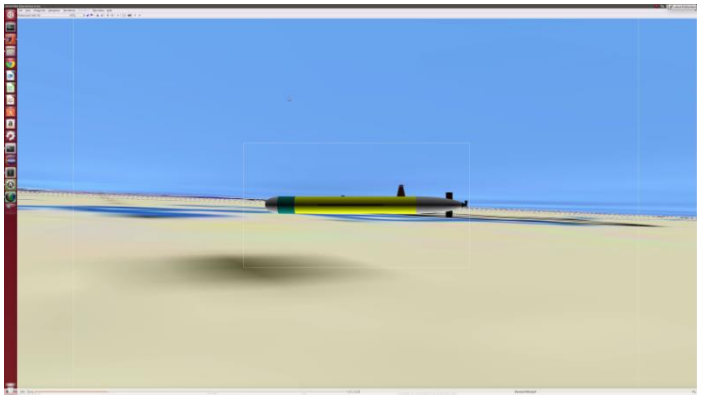
The Role of MOOS



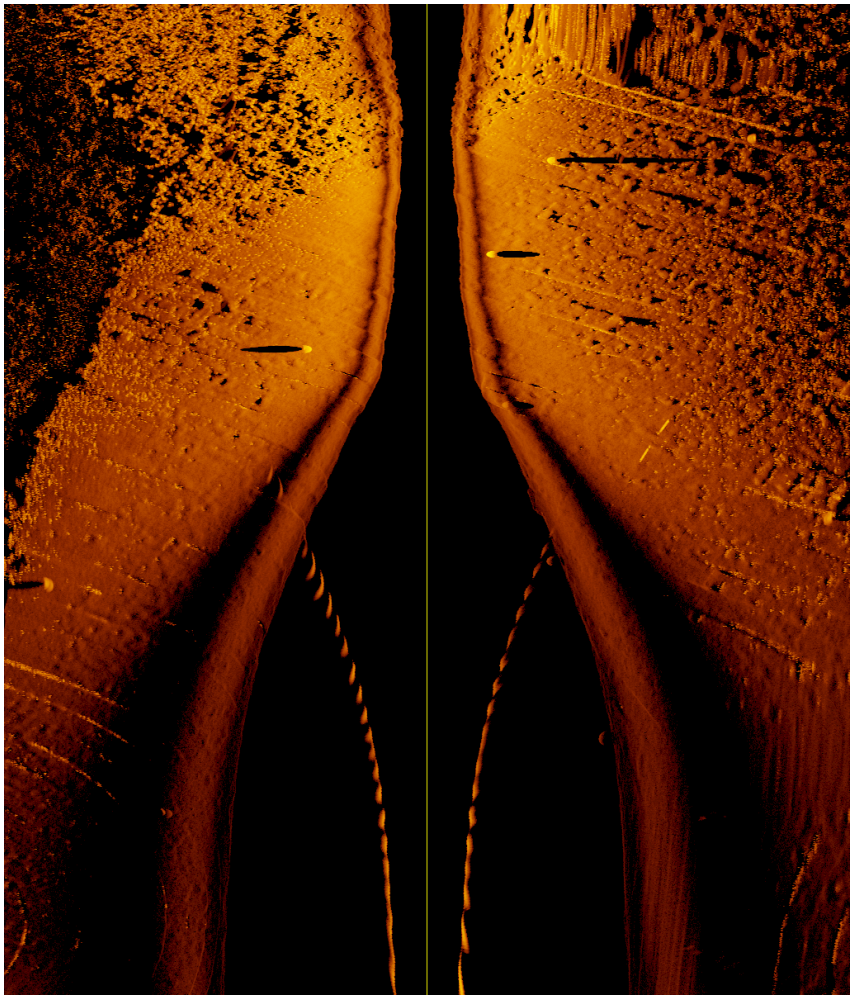
MOOS Visualisation Tools

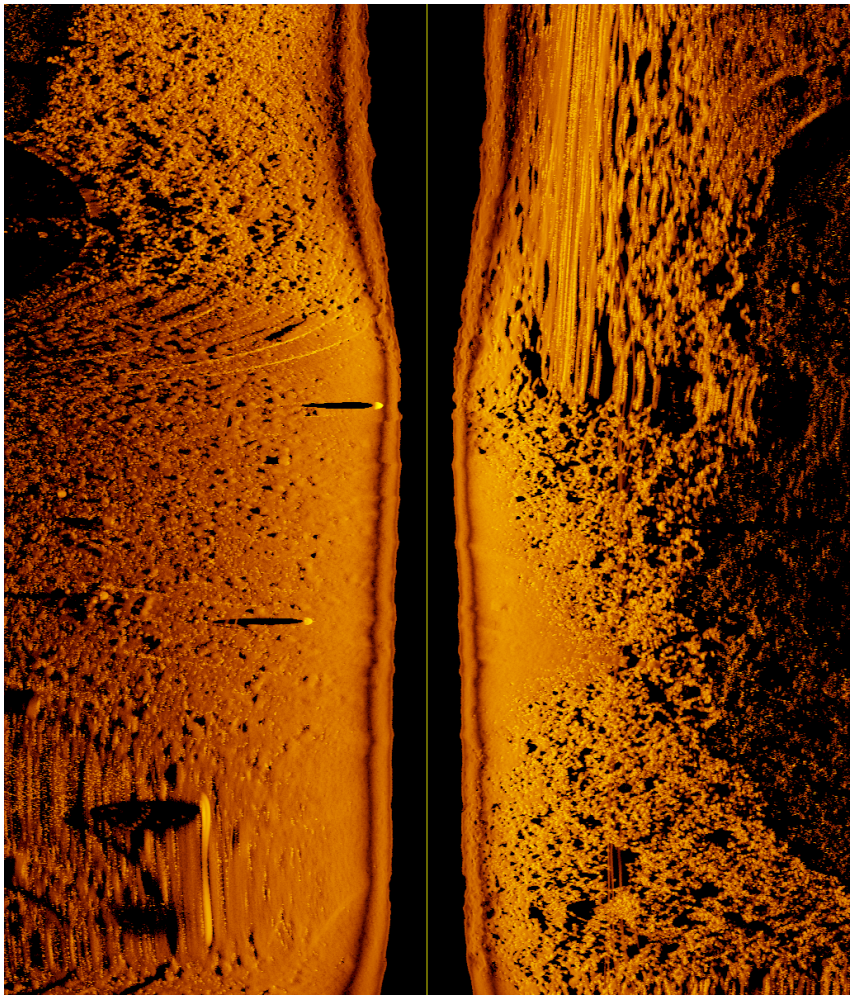




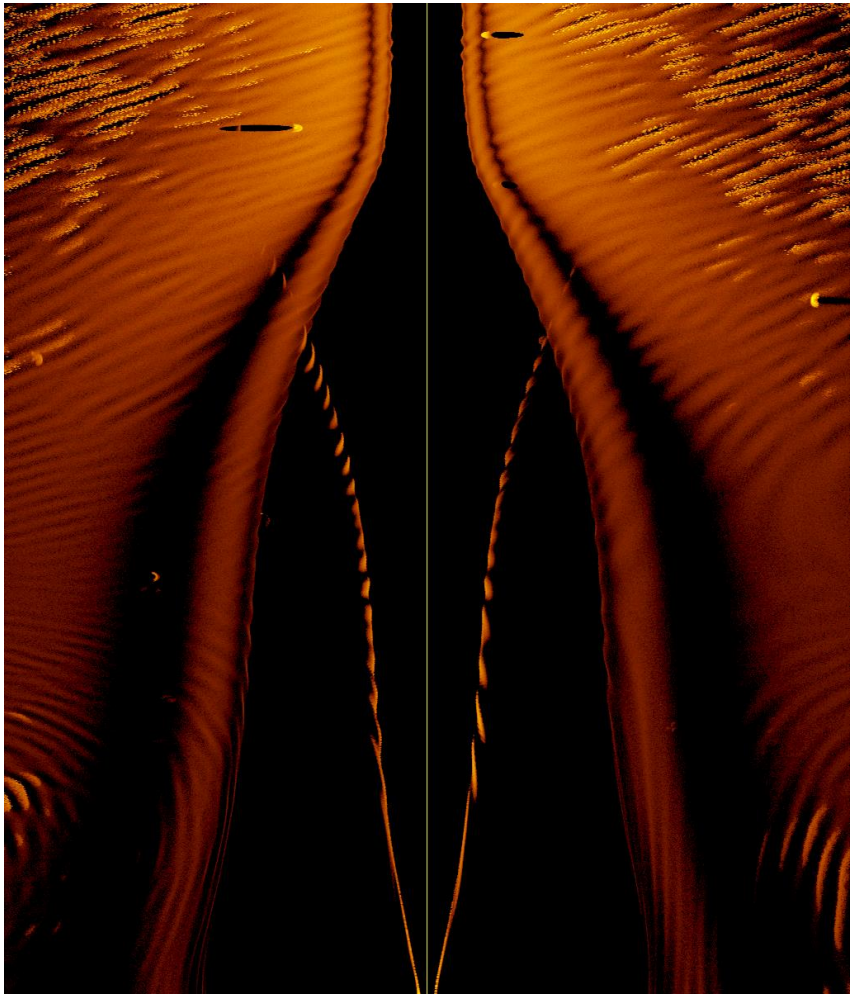


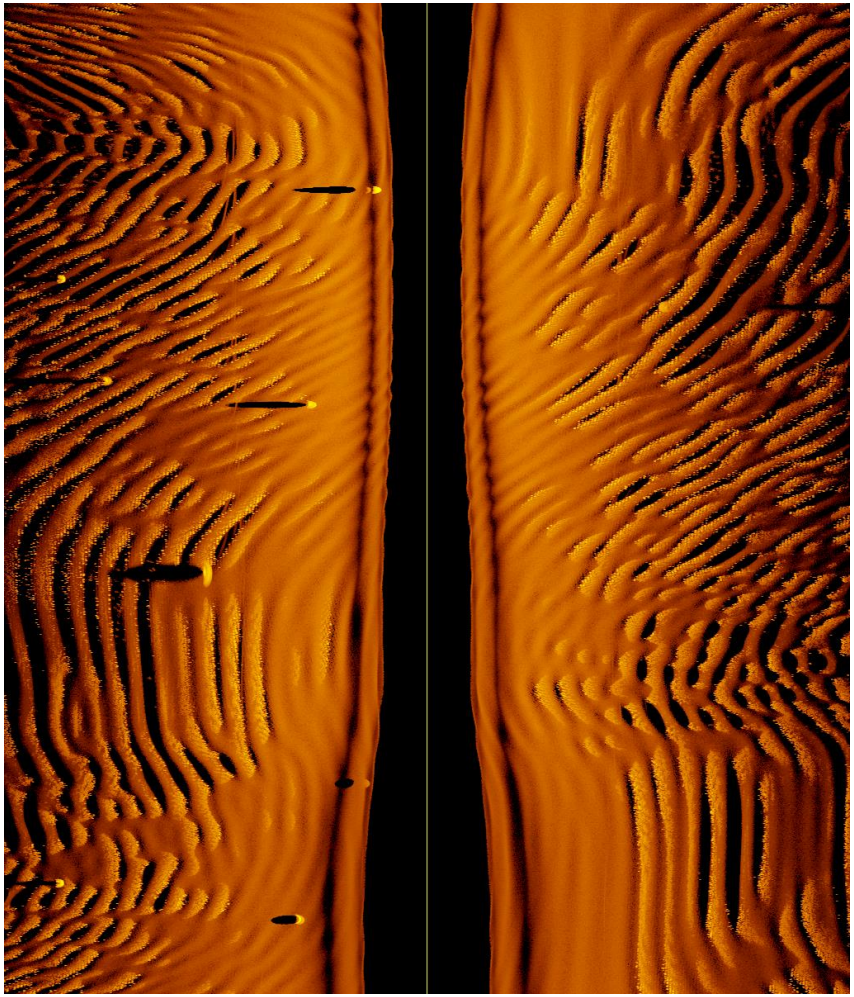
Integration with MOOS





A Different Bottom Type





Result - Video