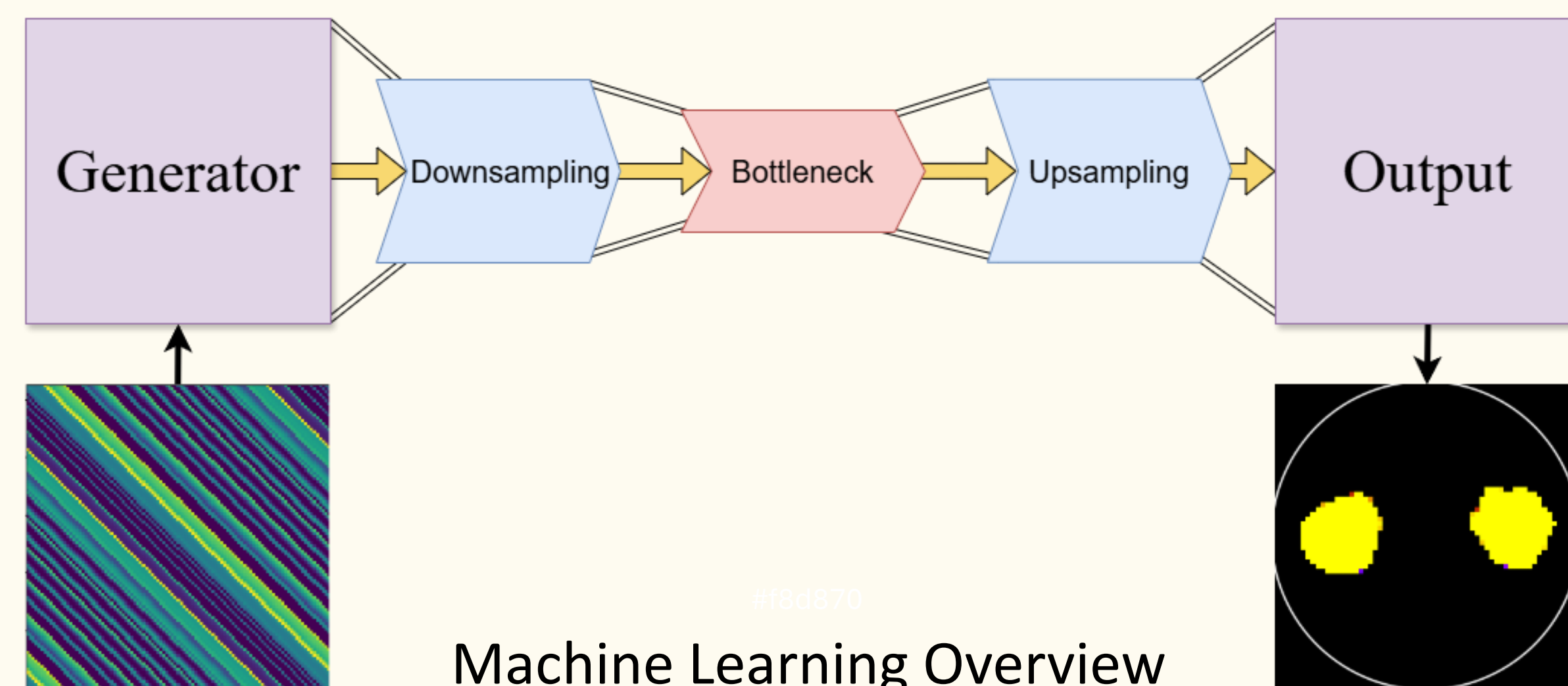


Objective

ECHO continuously estimates cryogenic propellant mass during microgravity by reconstructing cross-sectional images of propellant distribution. An ML algorithm uses capacitance measurements to reconstruct a 2D representation of the internal propellant and determines the propellant configuration. The system then interpolates between stacked cross-sections throughout the tank to infer a mass estimate.

Machine Learning



Encoding Layers:

Extract features from a matrix of input data using kernels.

Decoding Layers:

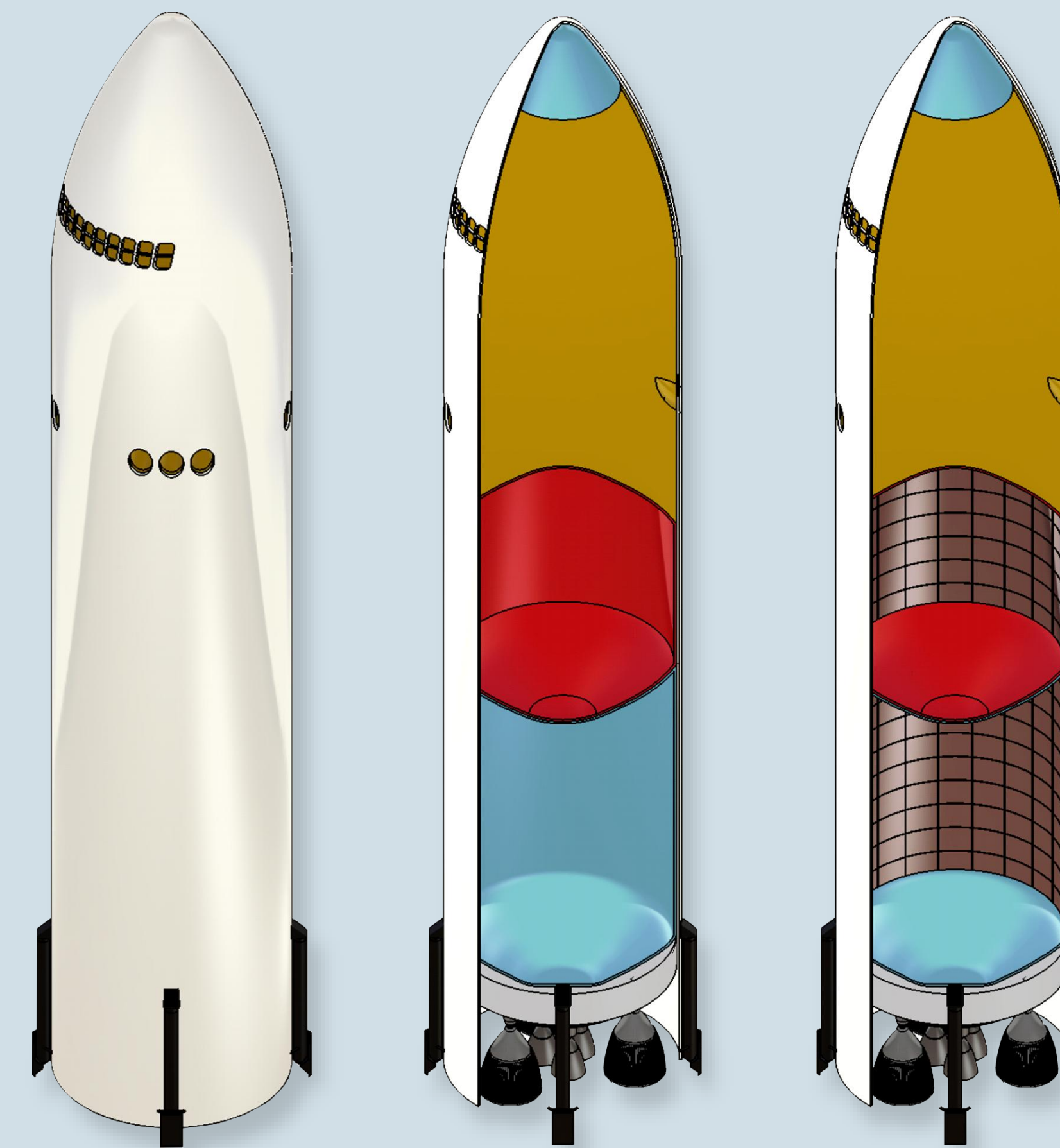
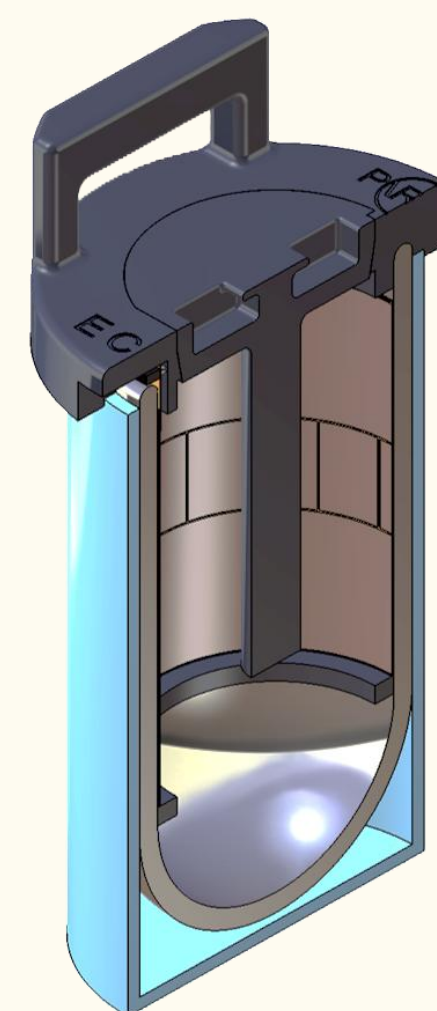
Add nonlinearity to the network with element-wise operations.

Discriminator:

A machine learning algorithm to learn relationships between measurements and reconstructed images. The Discriminator then adjusts weights using stochastic gradient descent.

Current Testing

PARSEC is testing ECHO using flexible PCBs lining the inside of a dewar. Initial scans are being conducted to establish a baseline, before testing with cross-sectional inserts of varying geometries. Results are normalized and passed to ML for reconstruction. These results are analyzed and relevant changes are made in between each test.



HLS Starship Exterior

HLS Starship Interior

Starship with ECHO

Electrical Capacitance Technology

By sending electric signals through a region of interest, ECT technology can use refinement algorithms to reconstruct the interior of the region. This technology is currently limited by quality and computation time, which are issues ECHO plans to solve with ML.



ECT Test Cross Section



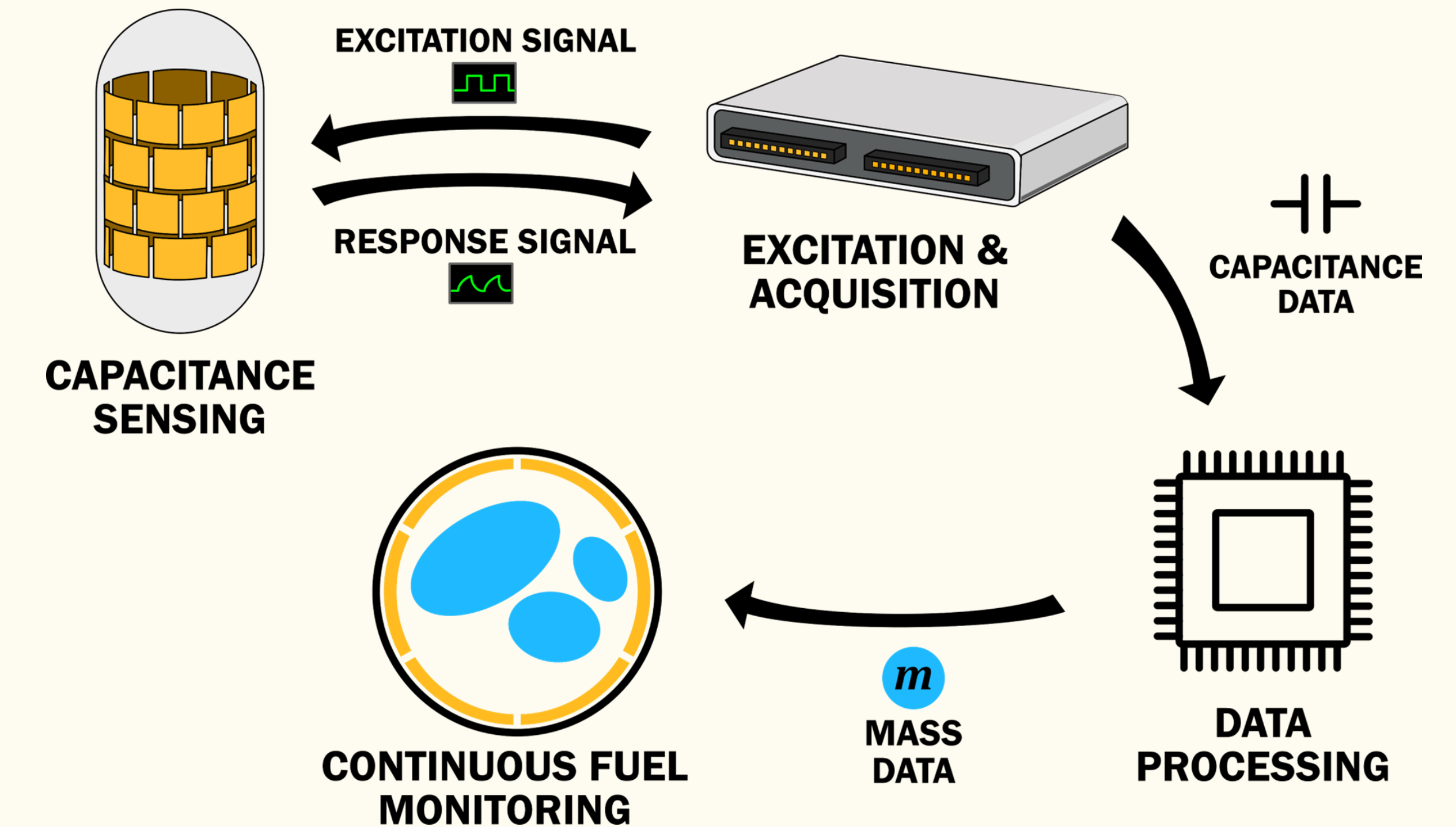
ECT Reconstruction

Budget

Full Projected Cost for NASA: \$99M

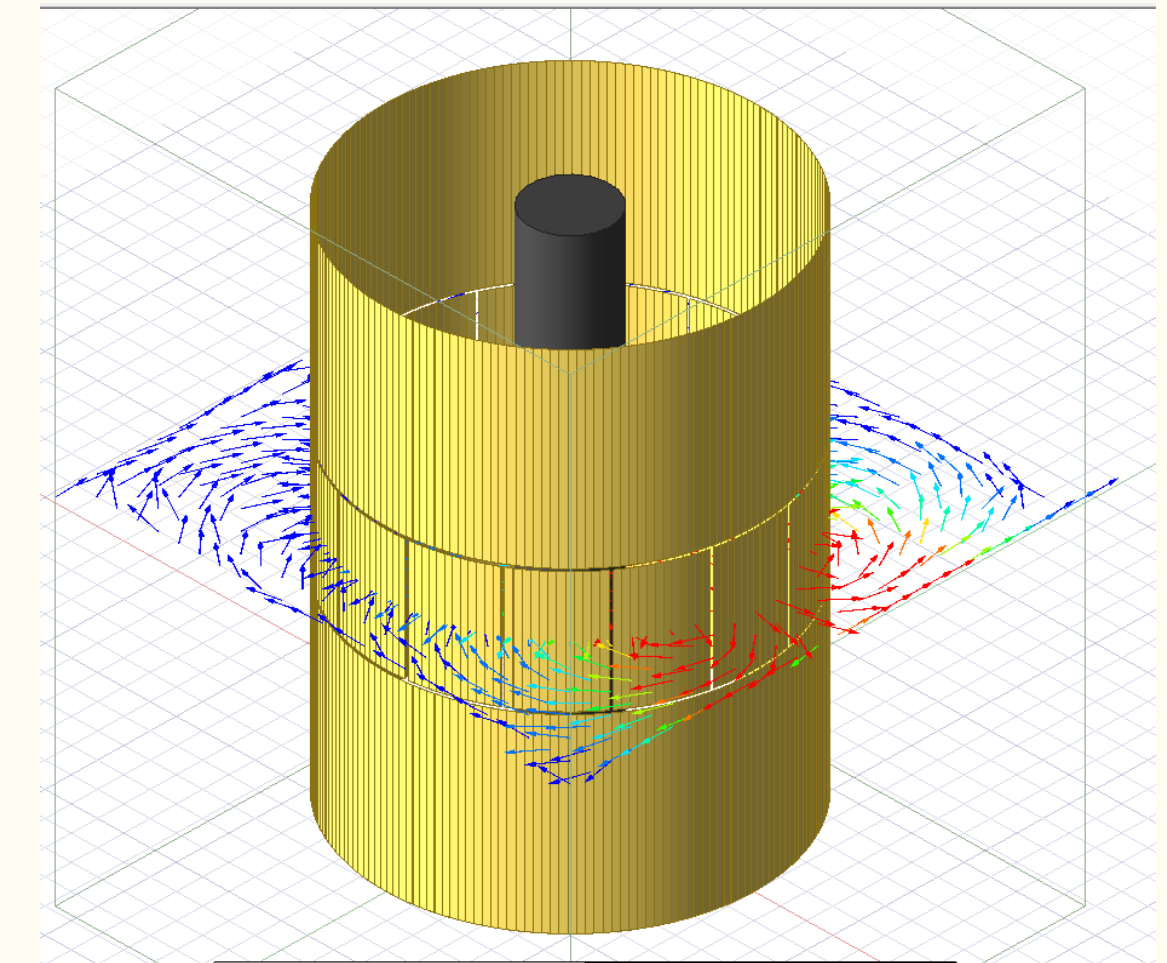
System Design

The ECHO system is designed with electrodes on the interior wall of the tank, reducing noise and increasing accuracy. An ML model is then applied to the data from the consecutive scans to approximate the mass of propellant in the tank.



Simulation Analysis

A simulation setup in ANSYS Maxwell is able to gather more accurate simulated data. The capacitance data is sent to MATLAB to develop idealized rms voltage drops, which is given to the ML algorithm.



Future Steps

- New ML Model
- Layered electrode rows
- New cross-sections
- Cryogenic Testing: TRL 5
- Parabolic Flight Testing: TRL 6
- Environmental Testing: TRL 7

