NDIA Autonomous Vehicle Test and Evaluation Conference

Semi-Autonomous Dispenser Transport Vehicle for Undersea Sensors System Integration Test Results and Lessons Learned

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Outline

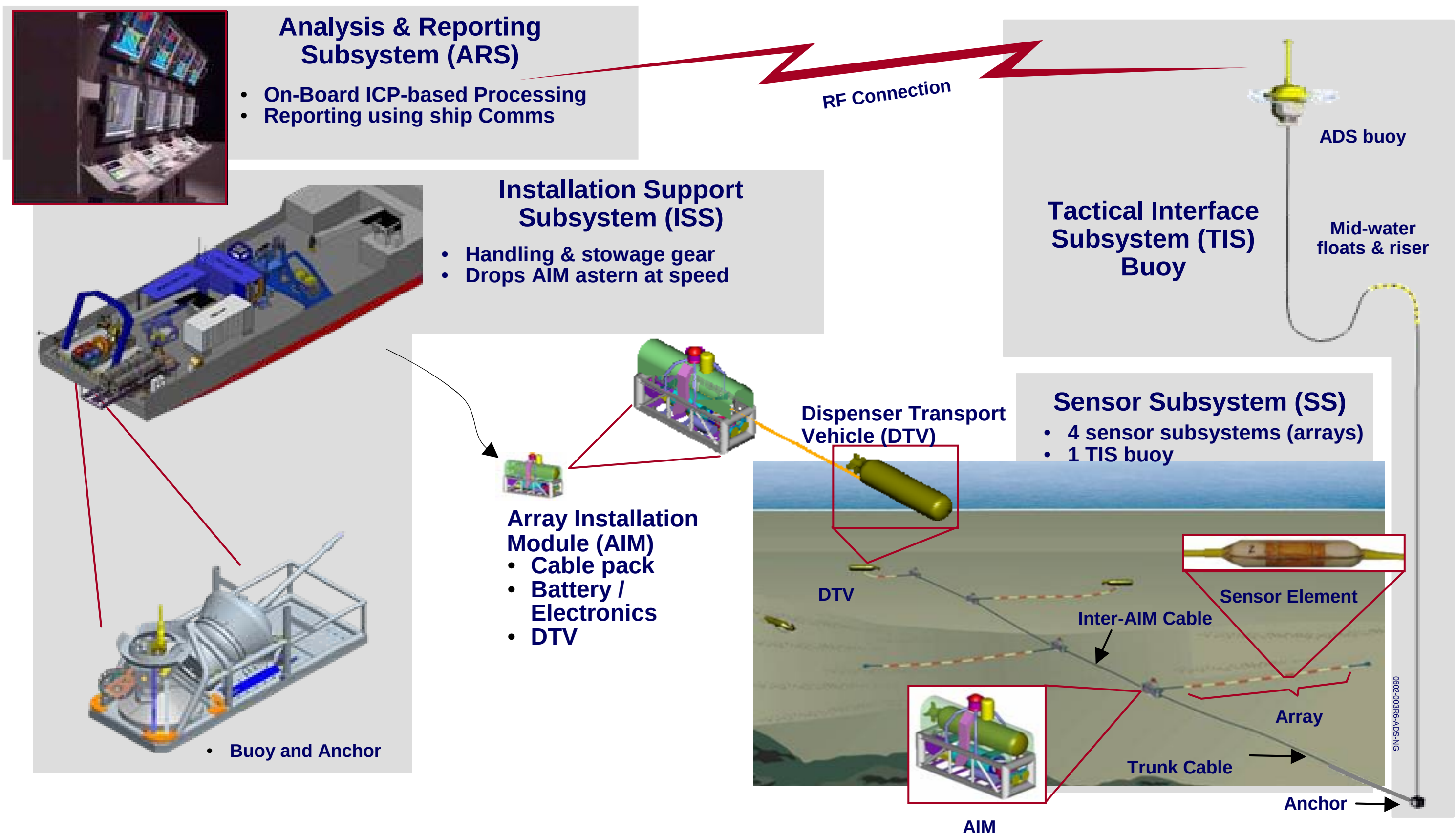
- Introduction
- Background
- Challenges of Delivering Undersea Sensors via LCS
- Development and Characteristics of Dispenser Transport Vehicle (DTV)
- High Level Platform and Design Constraints
- Test and Evaluation
- Lessons Learned and Recommendations

Advanced Deployable System (ADS) Program Overview

- **The primary ADS function is to provide undersea surveillance in shallow littoral waters**
  - ACAT IC POR
  - IOC in 2009
  - Now cancelled
- **ADS program developed multiple semi-autonomous delivery vehicles, known as Dispenser Transport Vehicles (DTV) to install undersea surveillance sensors**
  - Lockheed Martin, Riviera Beach built 8 DTVs in 2007
    - 4 for developmental testing
    - 4 for operational testing

ADS Subsystem Overview

- Purpose: Demonstrate undersea surveillance system for use against enemy submarines in a littoral environment



At Sea Demonstration of Deployable Littoral USW System – Nov 07

ADS System Requirements

- **Detect submarines and surface contacts in the littorals with ability to provide persistent wide area surveillance**
  - Pre-processing in the buoy to reduce bandwidth
  - Contact ID, classification, localization, and tracking done by Fleet STGs on Littoral Combat Ship (LCS)
- **Deployment from LCS – 1st increment**
- **Clandestine delivery – 2nd increment**
- **Array deployment: Semi-autonomous from DTV**
- **Pd: 0.8 – 0.9**
- **Installation time: 4-8 hours / string of 4 arrays + 1 buoy**
- **Installation depth requirement classified**

ADS on LCS CONOPS Overview

- **ADS Mission Module stored in forward deployed area**
- **Module loaded when ordered**
  - Mission Planning was aided by COMUNDERSEASURV
  - The LCS would rapidly go to the Operating Area and install the sensor portion of ADS
    - Rapid installation possible using an AIM – DTV for array placement
  - The LCS with the Analysis and Reporting Subsystem
    - monitored Contacts of Interest and
    - reported to higher authority
  - LCS could be many miles from the sensors and up to 45 miles from the Comms Buoy

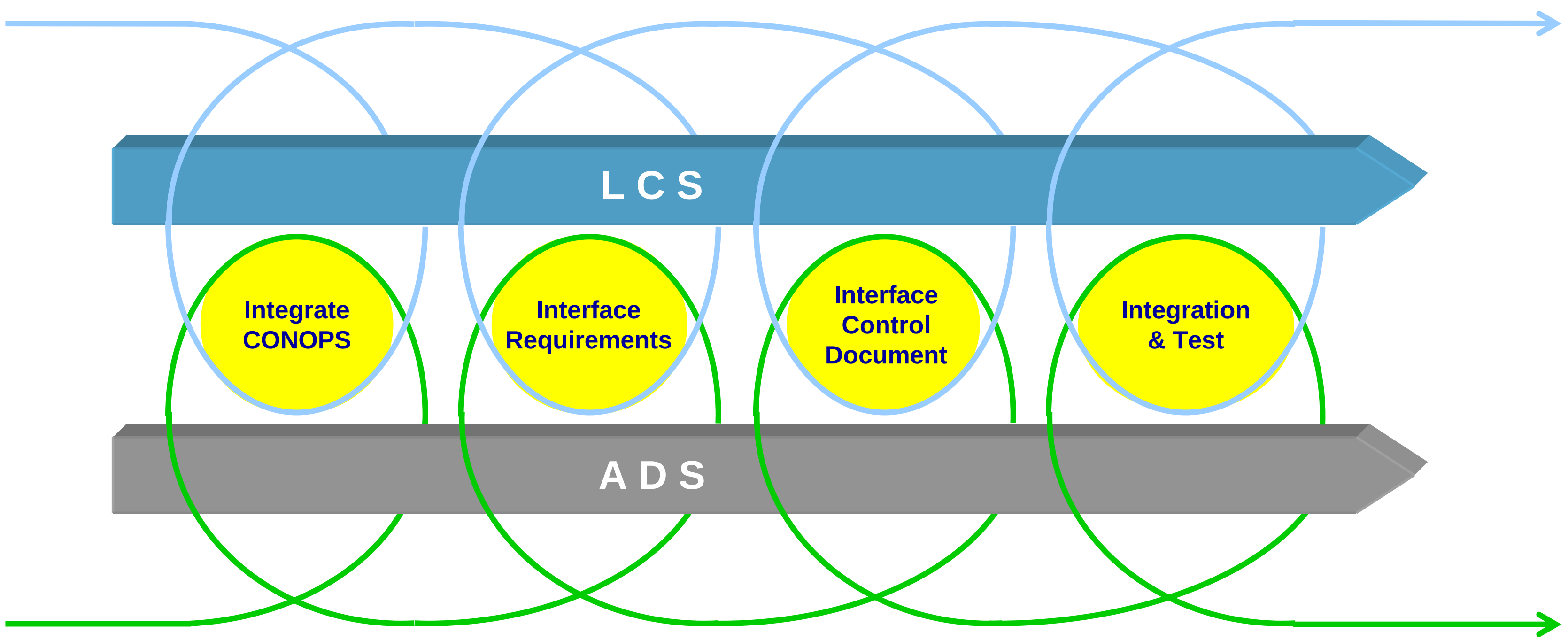
The DTV is vital to making ADS operational.

LCS Program Overview

- Sea Frame handles Mission Modules
- Modules transported to create Mission Packages
- Modules developed to an Interface Control Document
- Floating baseline (hulls differ, storage differ, handling)

Two Sea Frames increased ADS Design Efforts and Risk

Concurrent Spiral Development Touch Points



DTV and Launch & Recovery design were constrained by the selected Delivery Vehicle (LCS) design

AIM-LCS Interface Development

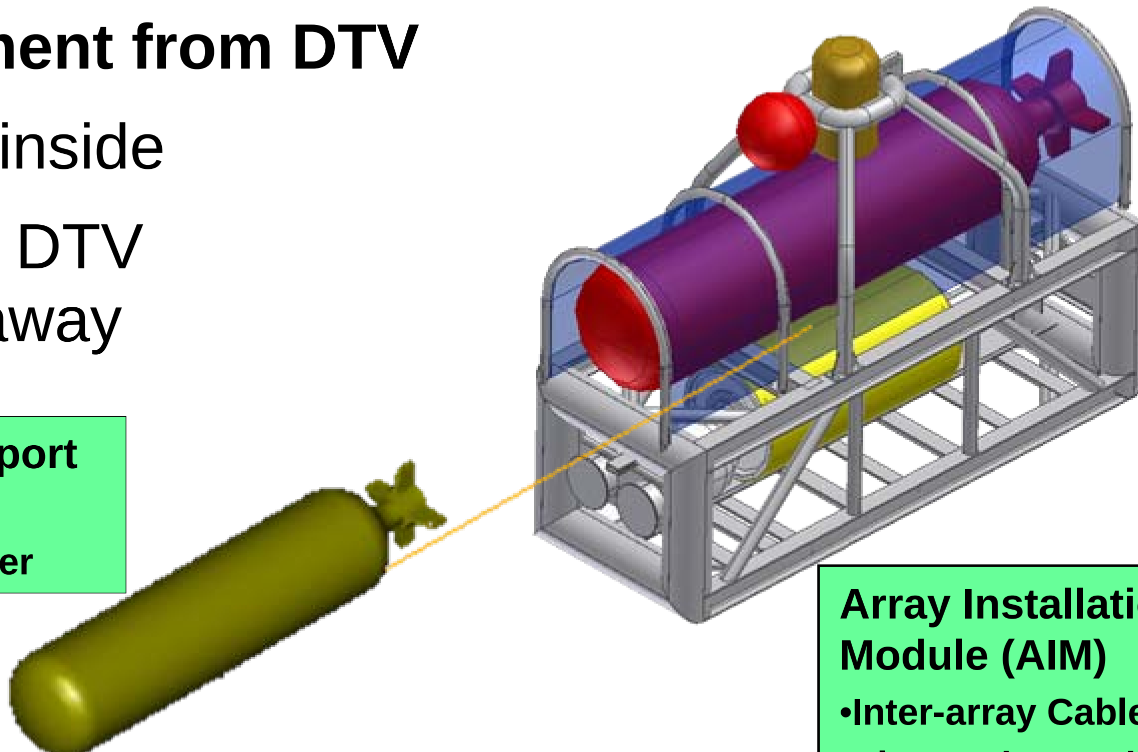
- **The Array Interface Module (AIM) is the LCS Interface**
  - Design Constraints
    - Mission Bay access and space
    - Ability to maneuver / handle ADS equipment from all stowage locations using shipboard transport equipment
    - Topside and Mission Bay environmental conditions (EMI)
    - Deck Strength
    - Electrical, safety (WSESRB)
    - Size, weight, power of AIM impact on DTV
    - Speed, sea state, height at drop, ice, etc.
    - Staging of DTVs versus NAVSEA 901B Shock requirements

Vehicle Design must consider the Host Vessel

Key Design Characteristics

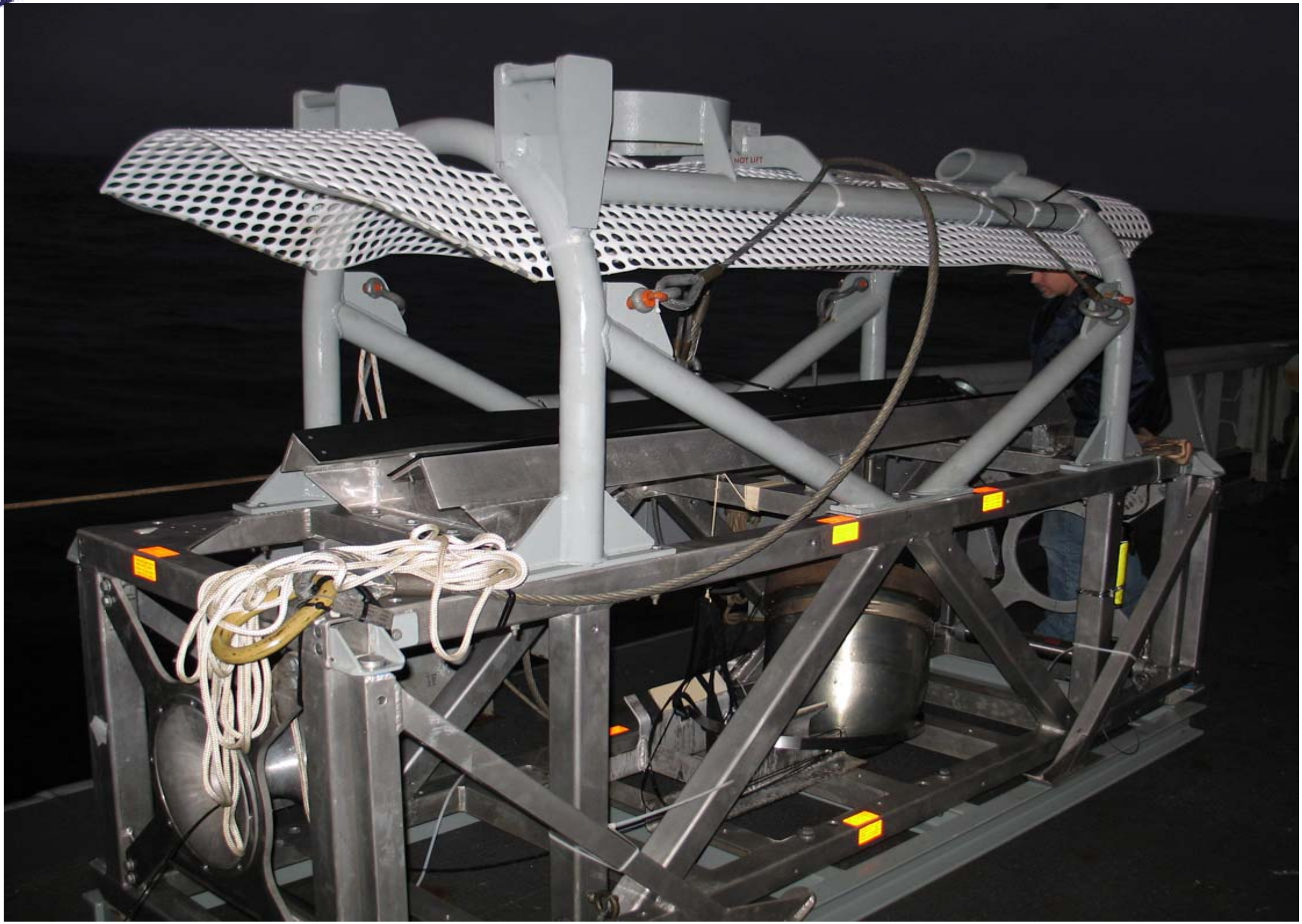
- **AIM has to safely transcend to the ocean floor**
  – Withstanding Shock, Vibration, and Slope
- **Array deployment from DTV**
  – Array coiled inside
  – Pulled out of DTV as it swims away

Dispenser Transport Vehicle (DTV)
•Array and dispenser

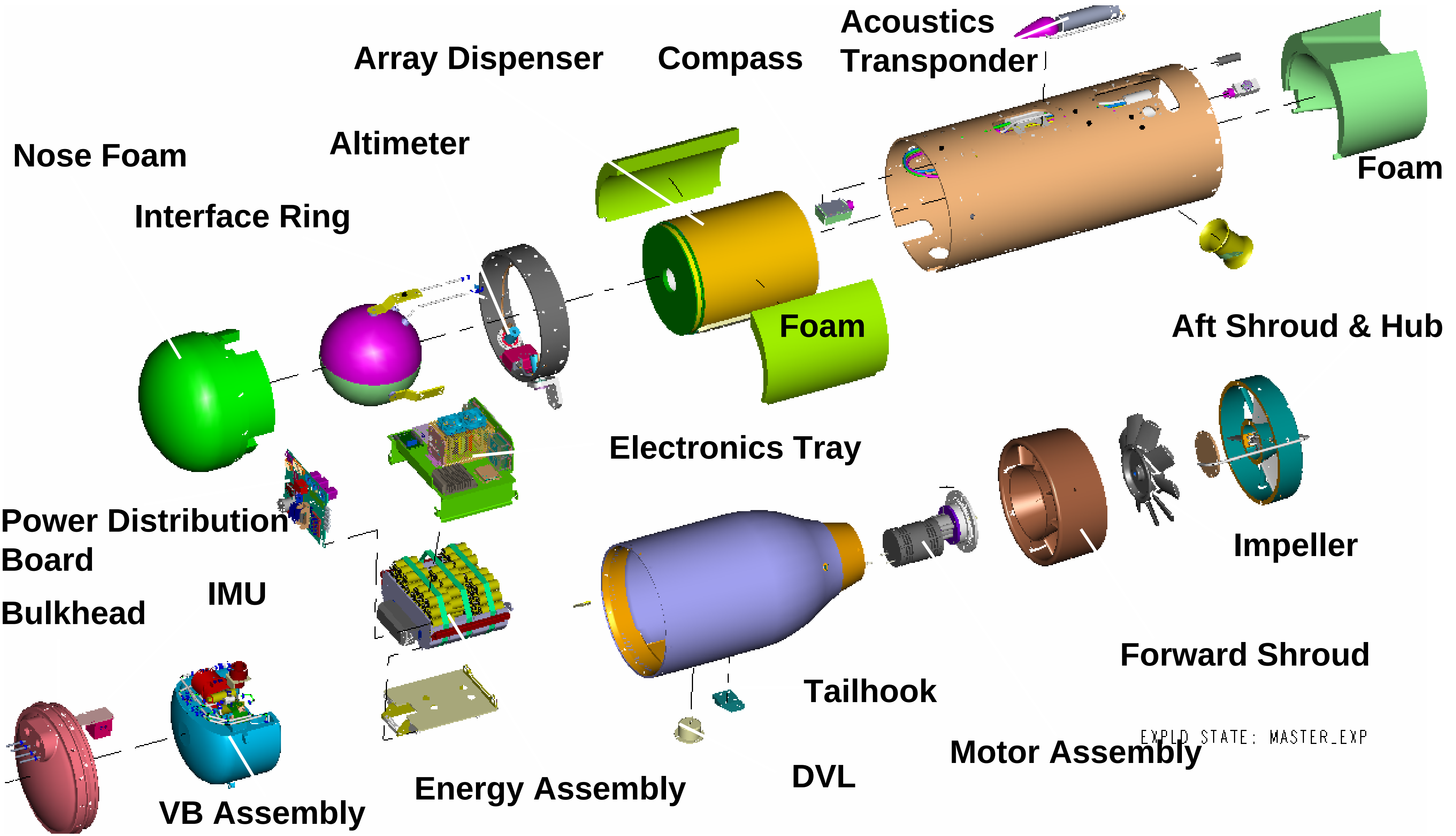


Array Installation Module (AIM)
•Inter-array Cable Pack
•Electronics Node
•DTV

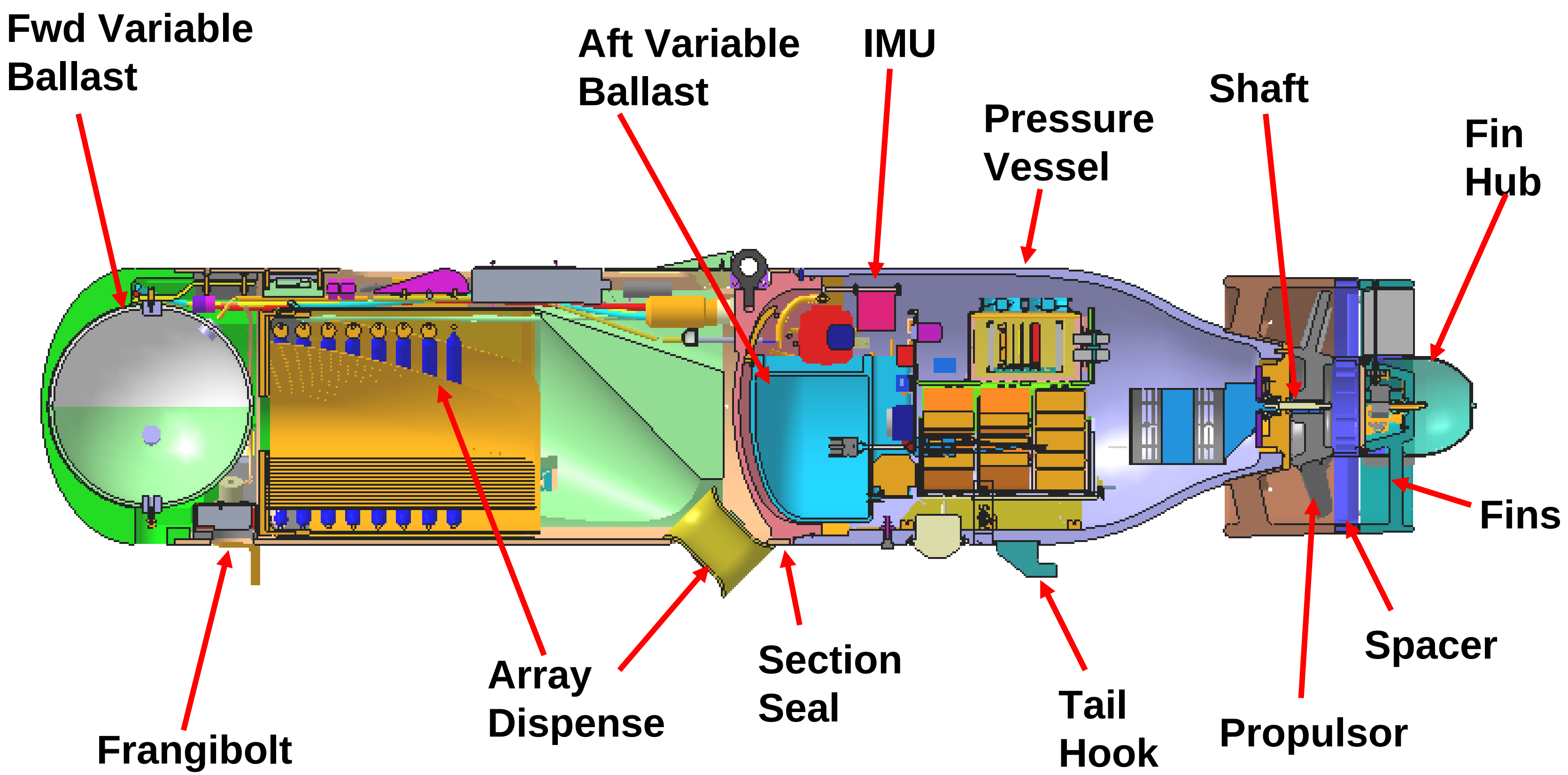
Array Installation Module



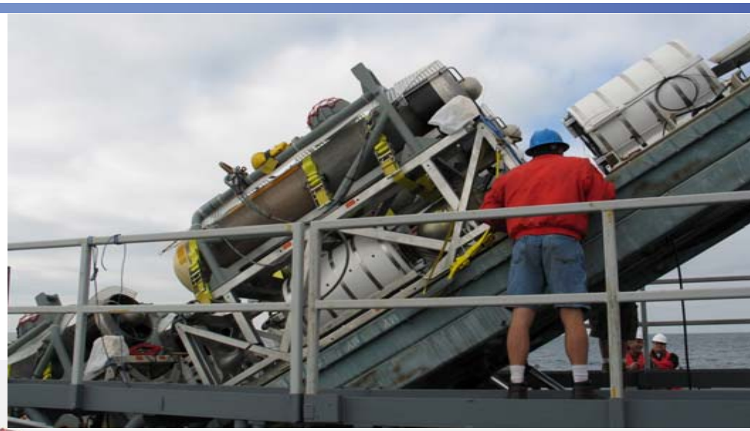
Vehicle Overview



DTV Configuration



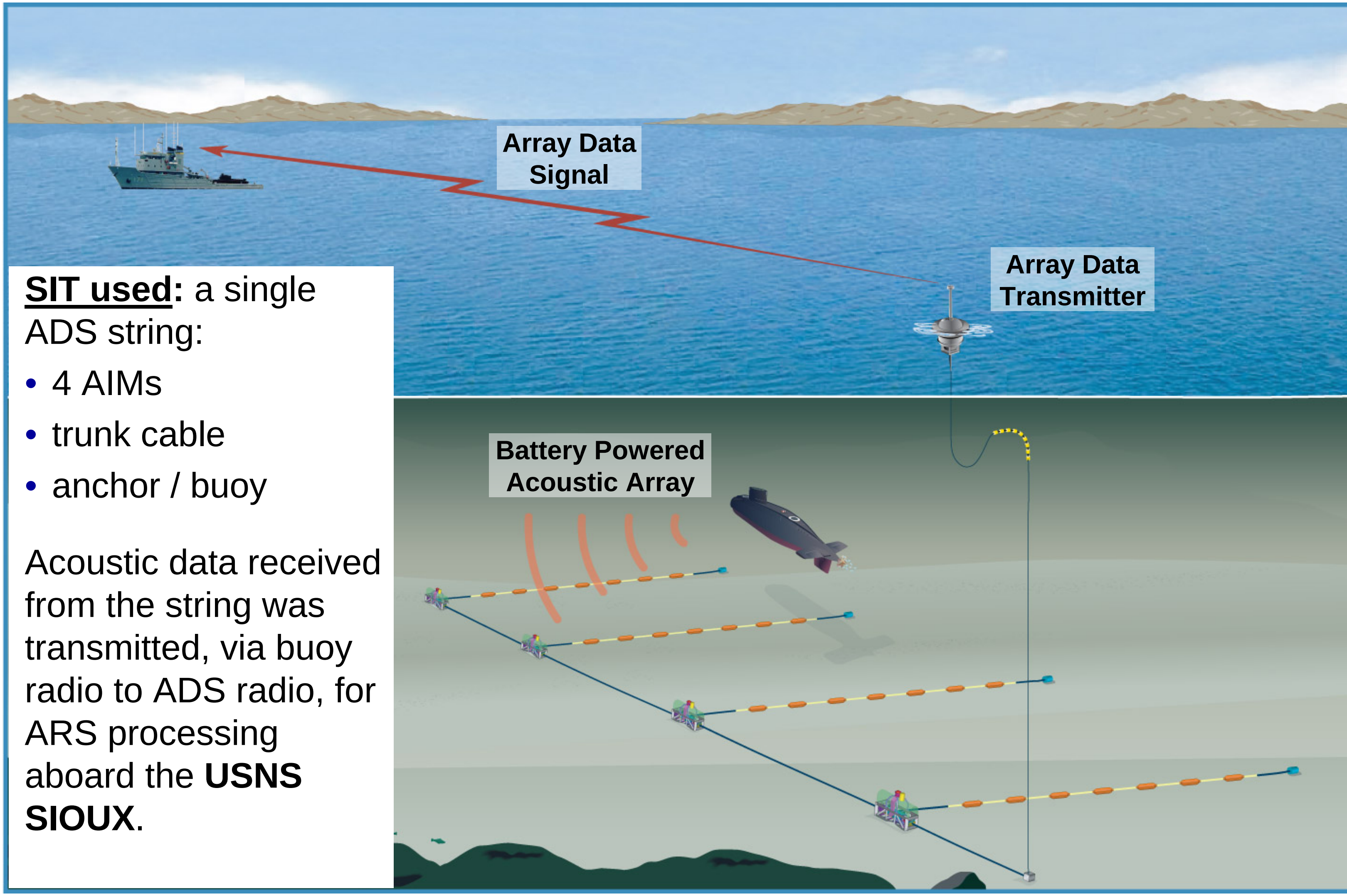
Dispenser Transport Vehicle



Key Developmental Tests

- **Build-up/risk reduction**
  - Modeling & simulation, analysis, and bench testing
- **Ramp test of DTV**
  - Understand shock load and interface
- **Drop test**
  - Verify acceptable shock load
- **Deployment from AIM**
  - Multiple open water tests
- **Control: modeling / at sea demo / re-design**
  - Invaluable contribution of Mr. William Zirke of Penn State
    - Fin spacer and Fin Hub to reduce swirl

System Integration Test (SIT) Overview



<u>SIT used</u>: a single ADS string:

- 4 AIMs
- trunk cable
- anchor / buoy

Acoustic data received from the string was transmitted, via buoy radio to ADS radio, for ARS processing aboard the **USNS SIOUX**.

System Integration Test (SIT)

- **Objective:**
  - "Install an ADS Array (straight) with AIM/DTV"
  - The variance on "straight" impacts localization accuracy
- **6-13 November 2007**
- **Southern California**
- **Sea States 1 - 5**

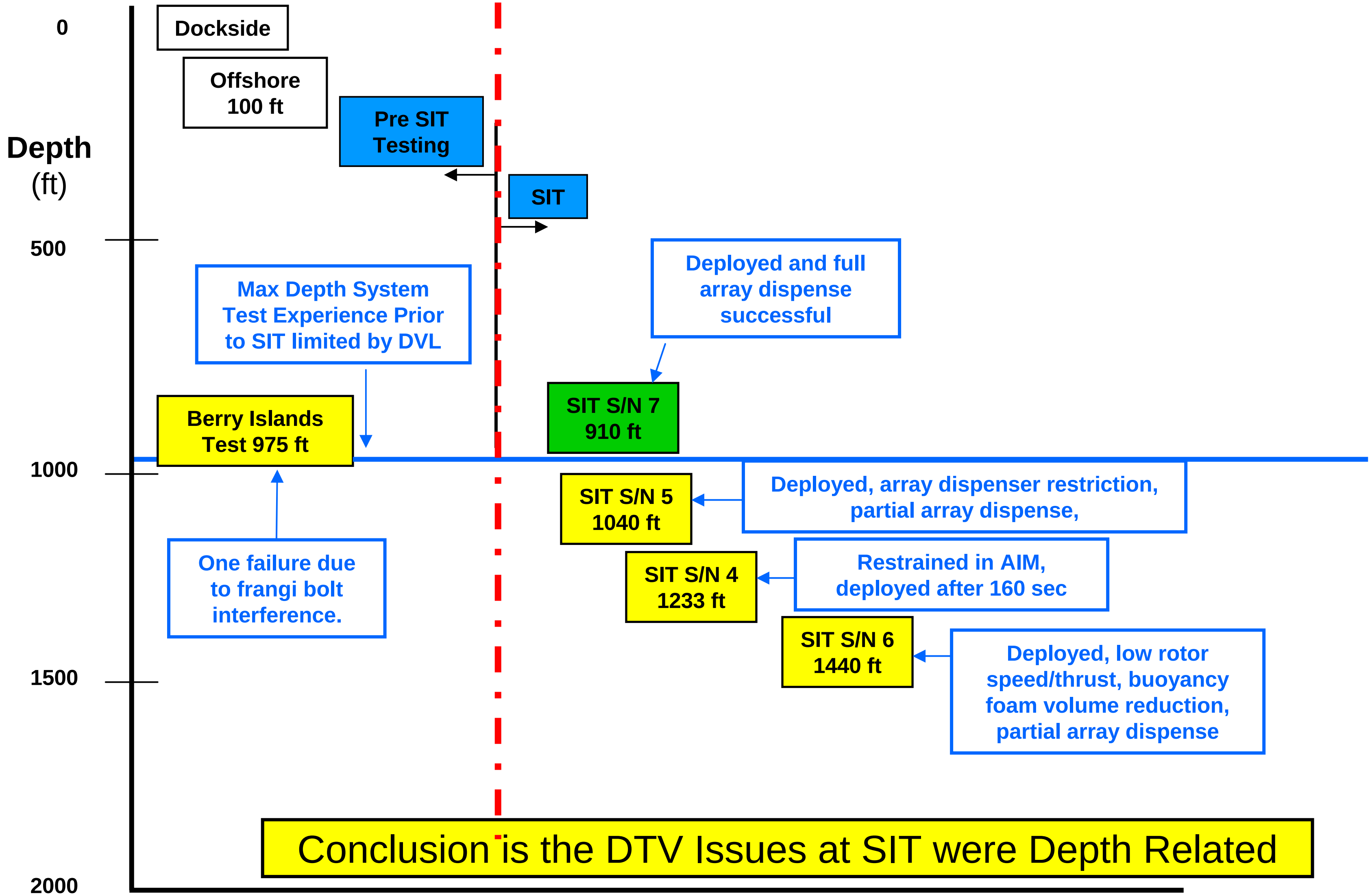
Major System Test Effort
- 62 Test Personnel at Sea

SIT Results

- **DTV anomalies – only 1 of 4 deployed the array properly**
- **Key Events**
  - Initial indications suggested all 4 arrays were successfully installed
  - After the ICP was initialized, determined the arrays did not deploy correctly on AIMs 1 through 3
    - AIM 4 electronics bottle later failed
  - Remote Operated Vehicle (ROV) used extensively
    - Bypassed AIM 4 by splicing cable from Node #3 to the buoy
    - Video confirmed the DTVs 1-3 failed to deploy arrays; each left the AIM, but only deployed a portion of the leader cable
    - Attached line to DTV so ship could pull array out (#1 and #2)
  - Manual deployment too late for SSN tracking (schedule issue); EMATT was used instead

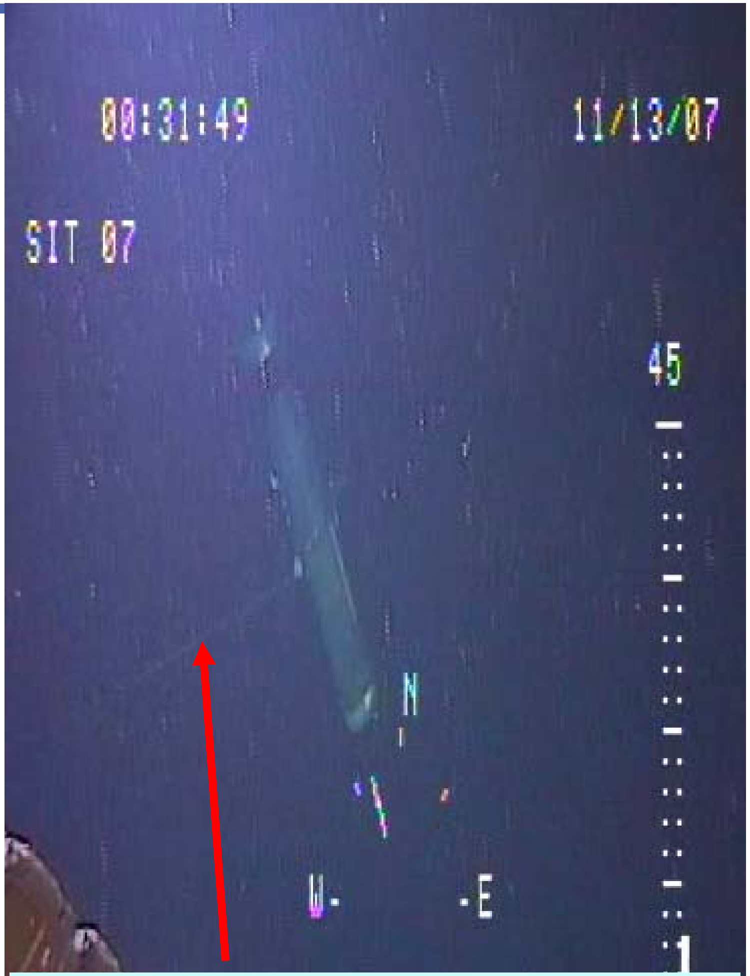
Still Met 83% of Test Objectives at SIT

DTV Post-SIT Study



ROV Video of DTV Operations

DTV on bottom after deployment with leader cable extending behind



DTV being pulled by ship to deploy the array

Lessons Learned from DTV Testing

1. **Vehicle control issues**
   – Must have sufficient Flow over Control Surfaces
   – Modeling did not accurately predict actual flow behavior
2. **Snood foam Compressed at max depth**
   – Design margin for Worst Case
3. **Release method needs to be as simple as possible**
   – Frangible bolts used; design issues / complications caused test failures
   – Issues masked other problems but schedule constraints precluded rerunning the test
4. **Insist on a Full Deployment Test at max depth**
   – Risk is significantly higher by not testing at max depth
5. **Verify pressure ratings of components that are subject to sea pressure**
   – Make this a Critical Design Review focus item
6. **Variable ballast should not have been Timer Controlled**
   – Only works if everything else is working; otherwise causes system failure

Recommendations

- **To re-use the DTV, we would:**

1. Upgrade the foam
   - Ensure all components can withstand sea pressure
2. Strengthen the transom plate
   - Verify components won't bind under pressure
3. Design out the Variable Ballast Control Timer
   - Alter the DTV so the ballast varies as array cable is paid out
4. Reduce shock load on the AIM / Cable Pack
   - Consider the environment
5. Design out the frangible bolts
   - Keep it simple!

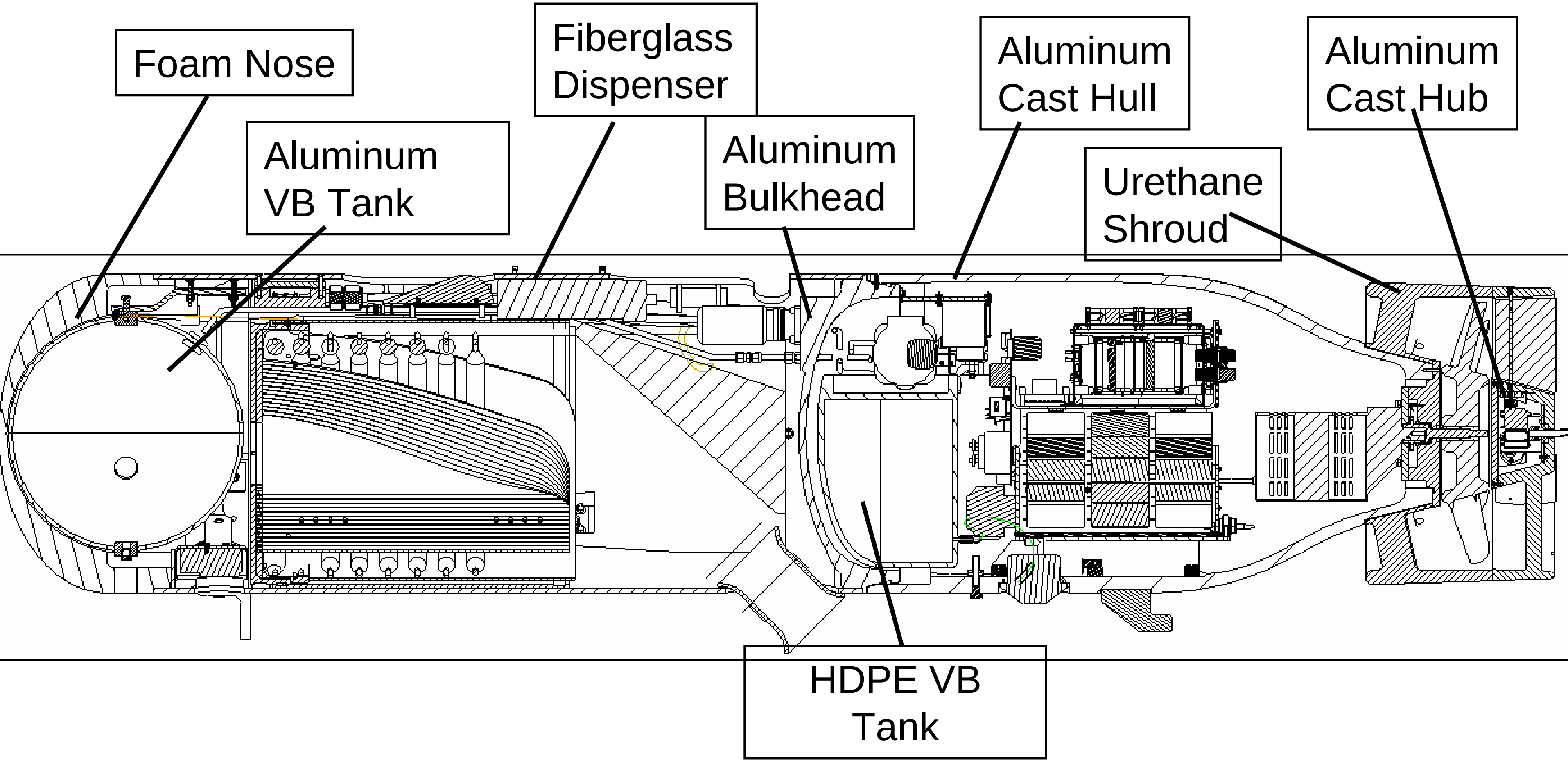
Summary

- **The Dispenser Transport Vehicle is a valid concept**

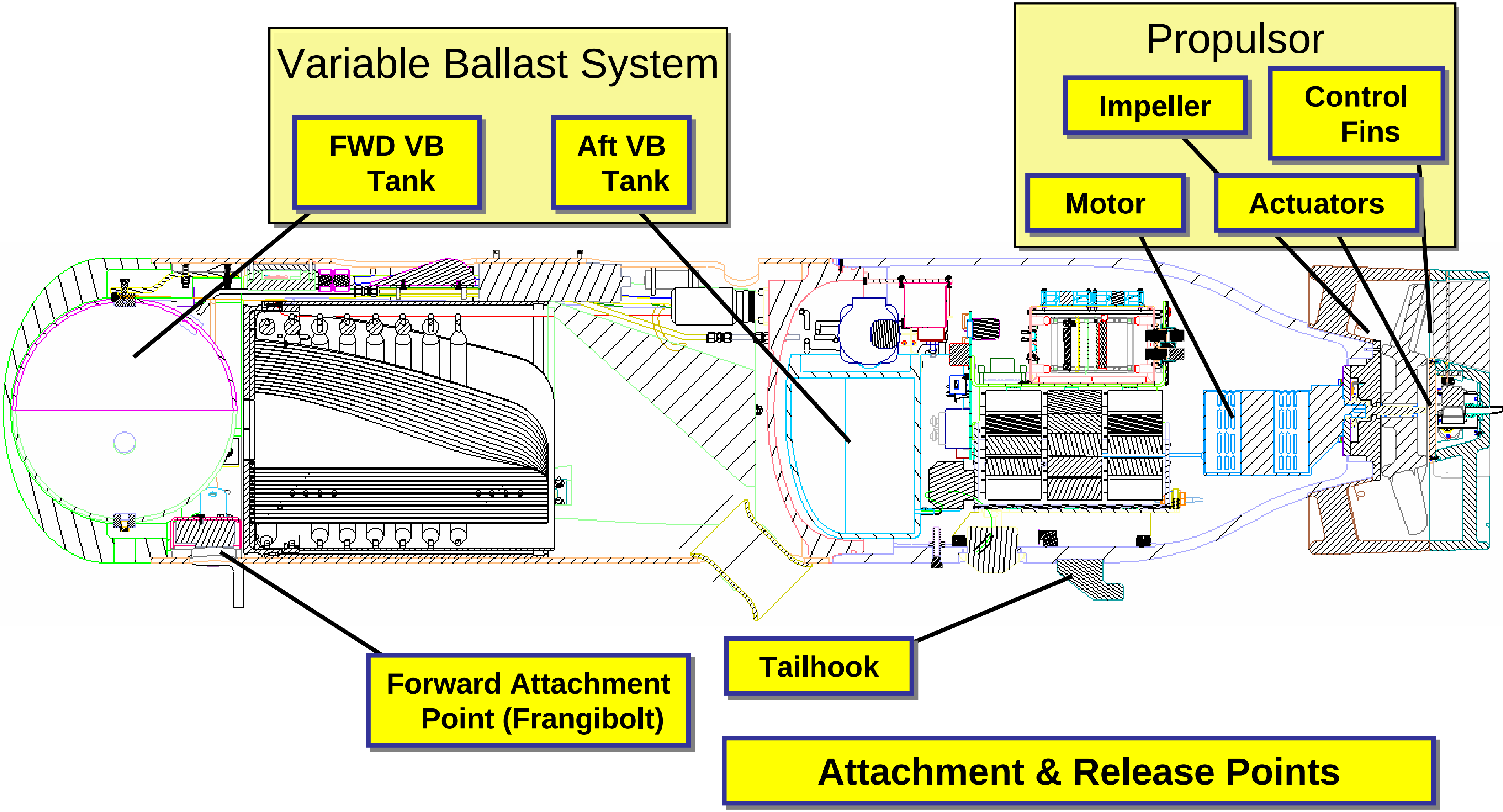
- **Remote installation is still highly desired at some sites and the DTV can be an enabler**
  - Some Design modifications and more testing is required

Backup

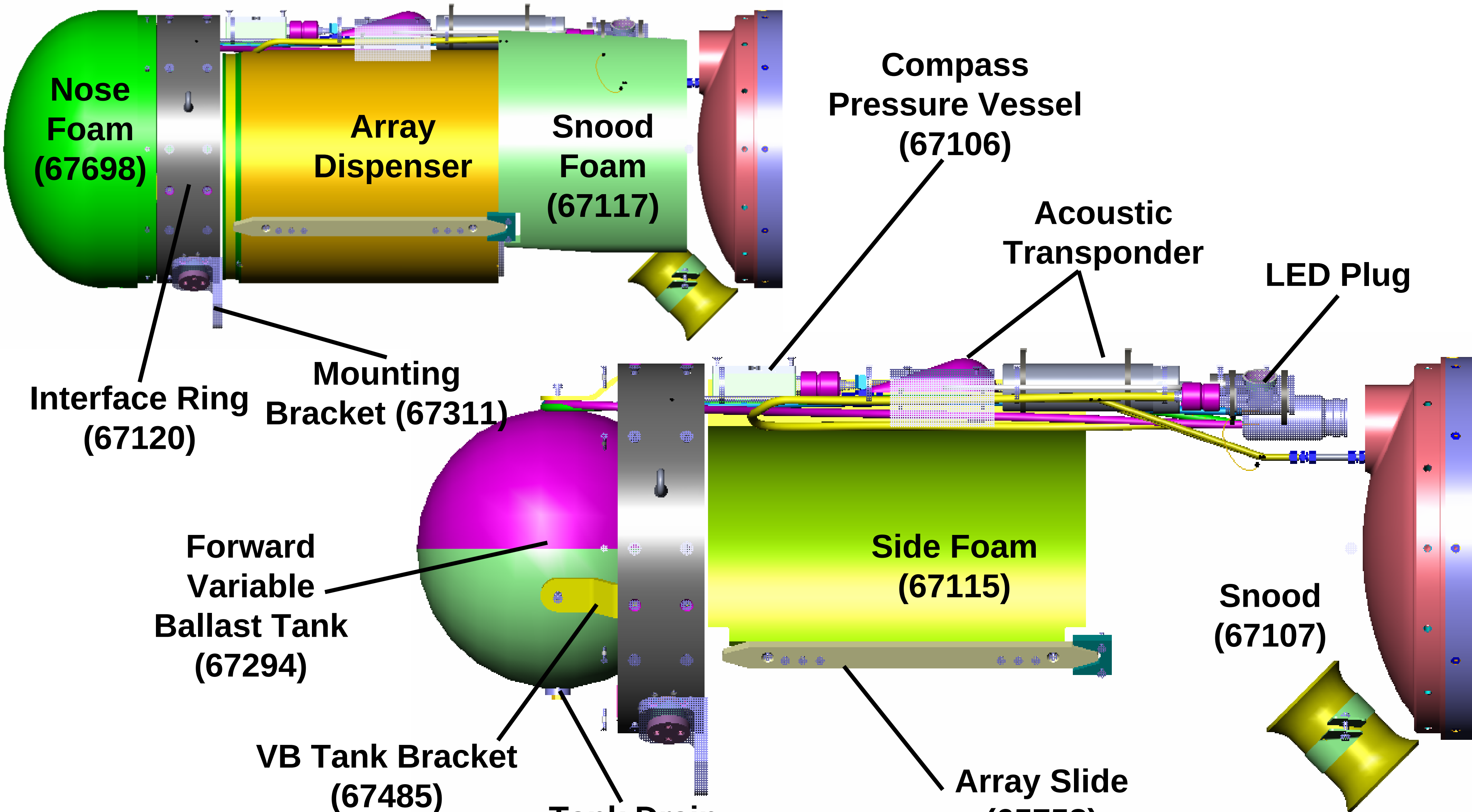
DTV Material



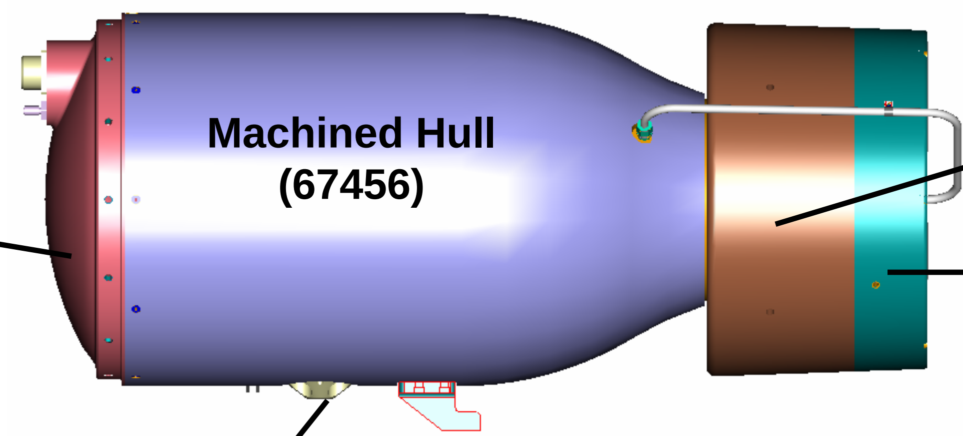
Vehicle Overview

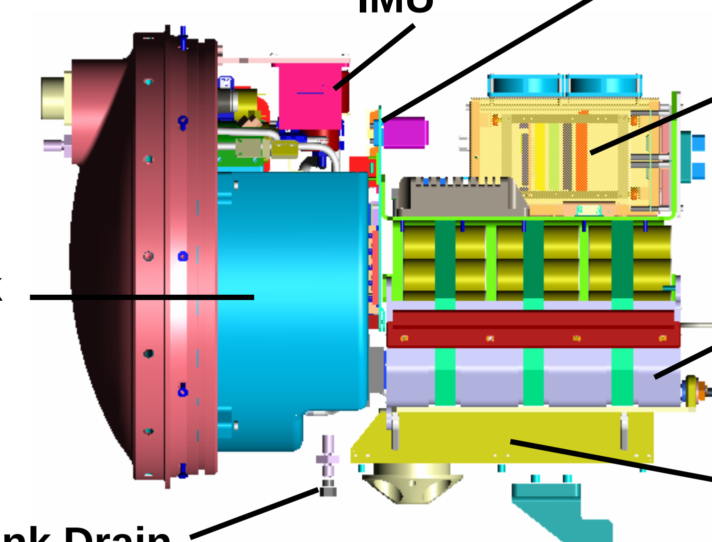


Forward Section



Pressure Vessel





Organizations Involved in SIT

- Program Executive Office Littoral and Mine Warfare (PEO LMW)
- Maritime Surveillance Systems (PMS-485)
- Space and Naval Warfare Systems Center – San Diego (SSC-SD)
- Commander Undersea Surveillance (CUS)
- Commander, Operational Test & Evaluation Force
- Naval Facilities Engineering Service Center (NFESC)
- Johns Hopkins University – Applied Physics Lab (JHU-APL)
- Applied Research Lab – University of Texas (ARL-UT)
- Northrop Grumman
- Lockheed Martin

Organizations Involved in SIT

- Harris Corp
- Raytheon
- EADS
- AMRON
- SYS Technologies
- Science Applications International Corporation (SAIC)
- USNS SIOUX (T-ATF 171), USNS NAVAJO (T-ATF 169)
- USCGC ASPEN
- Sealift Logistics Command Pacific
- Fleet Imaging Center, Pacific, Combat Camera Group
- Fleet Area Control and Surveillance Facility
- National Centers for Environmental Prediction

Lessons Learned from SIT

- **Developmental Testing should rigorously verify each subsystem**
  - The DTV was tested deeper at SIT than in subsystem tests
- **Vigorously defend the T&E Program**
  - Articulate the potential impact of budget and schedule cuts
- **Augment the small government team with Subject Matter Experts**
  - Seek out those pre-eminent in their field

NDIA Requested Contact Data

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