Agenda

- WPML Background / Overview
- Program Highlights
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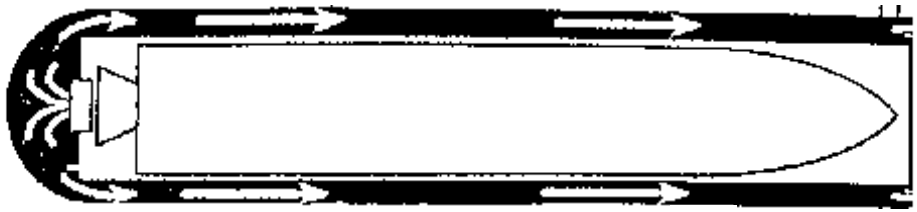
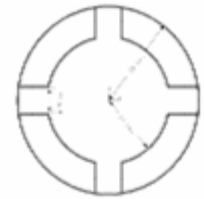
Concentric Canister Launcher (CCL)

Self-Contained Gas Management





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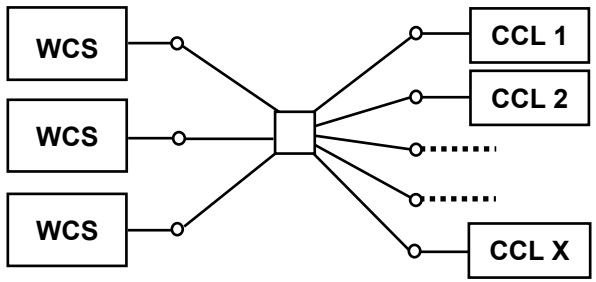
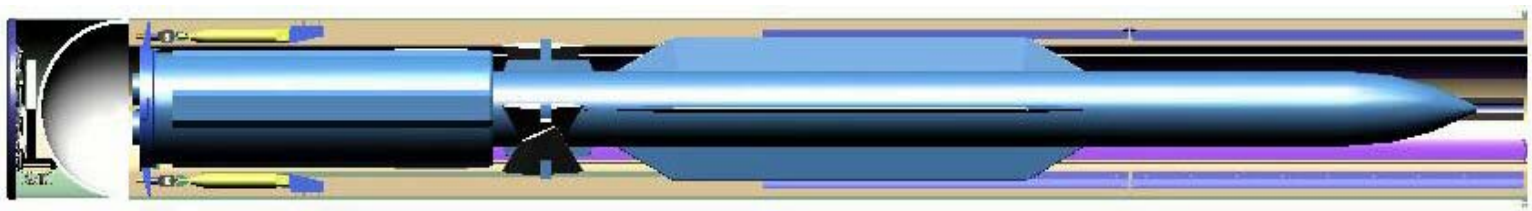
Distributed Electronic Architecture

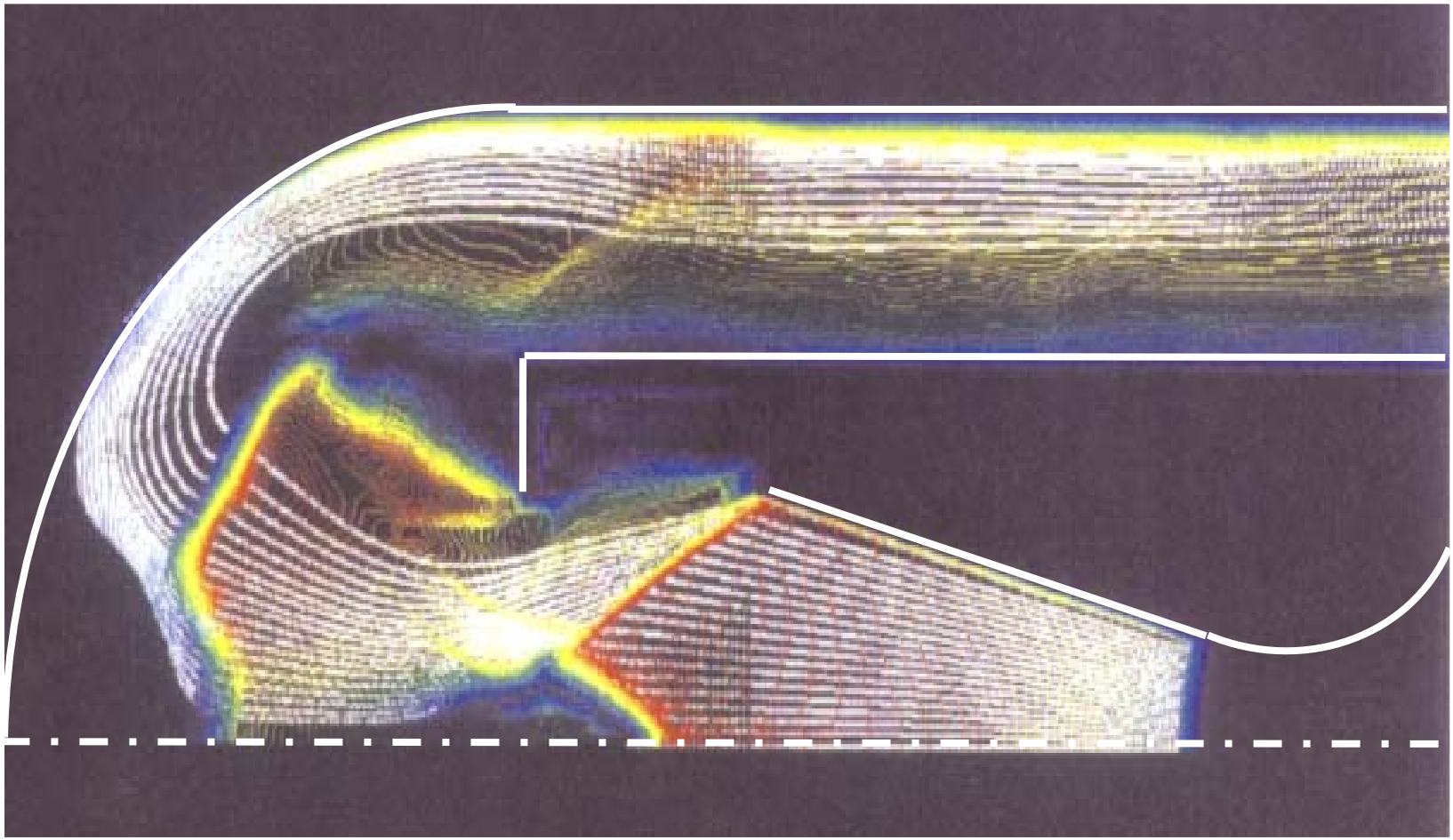


Canister is an All-Up Launcher



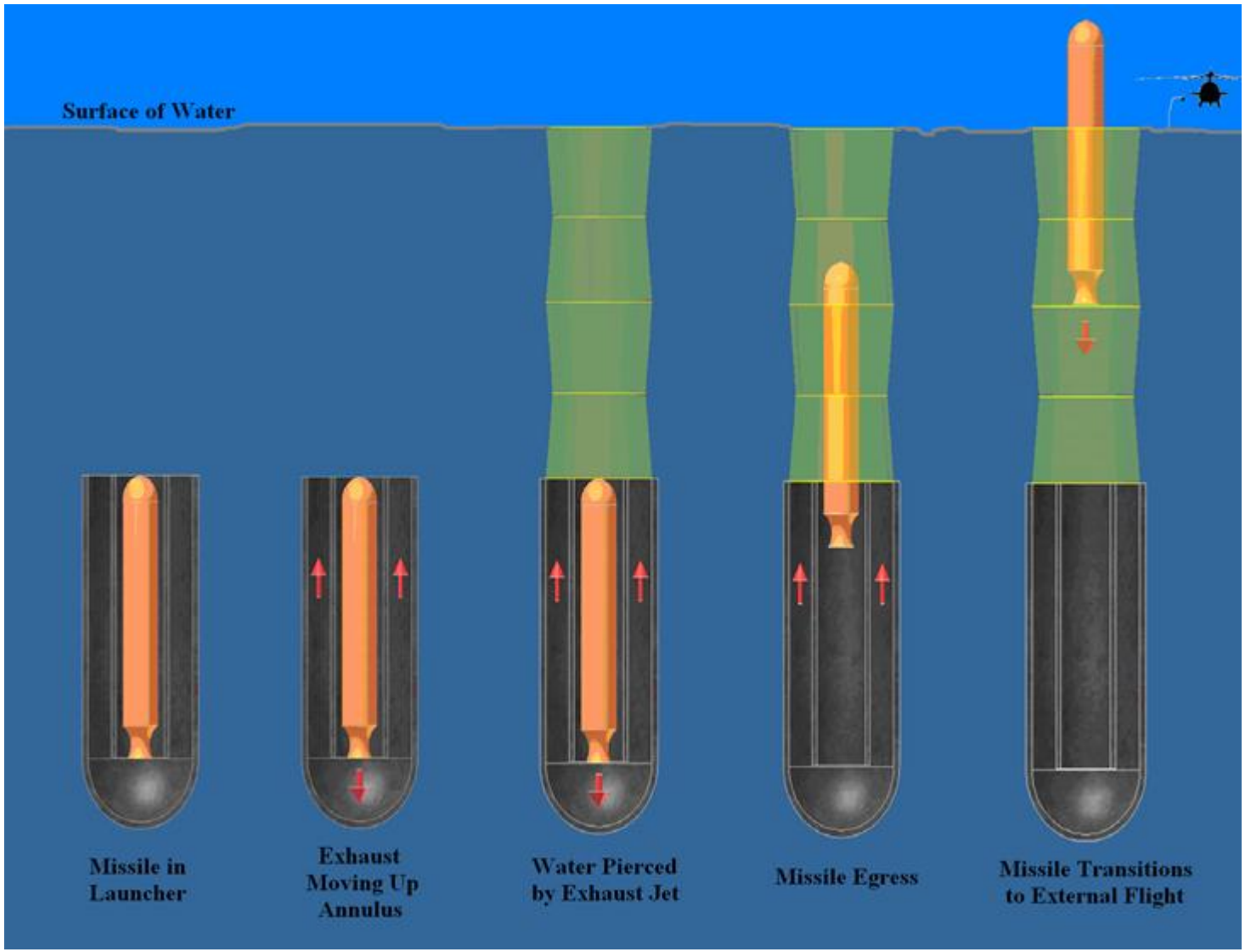
CCL is a "Plug-n-Play" Launch System, Electronically & Mechanically

CFD Computer Result for Flow of Rocket Exhaust through a CCL



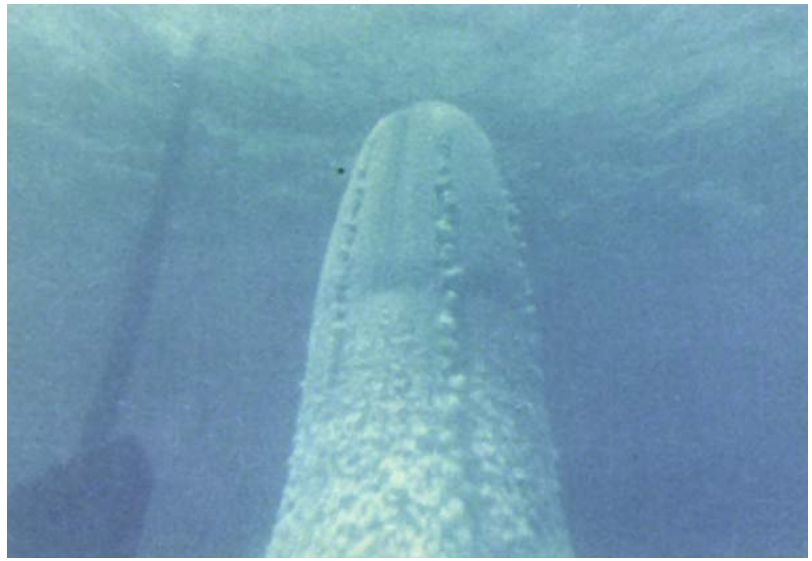
CCL Surface Launch

Water Piercing Missile Launcher Concept



Benefits of WPML Concept

- **Precludes need to pressurize missile for underwater launch**
- **Any existing service missile can be used without modification**



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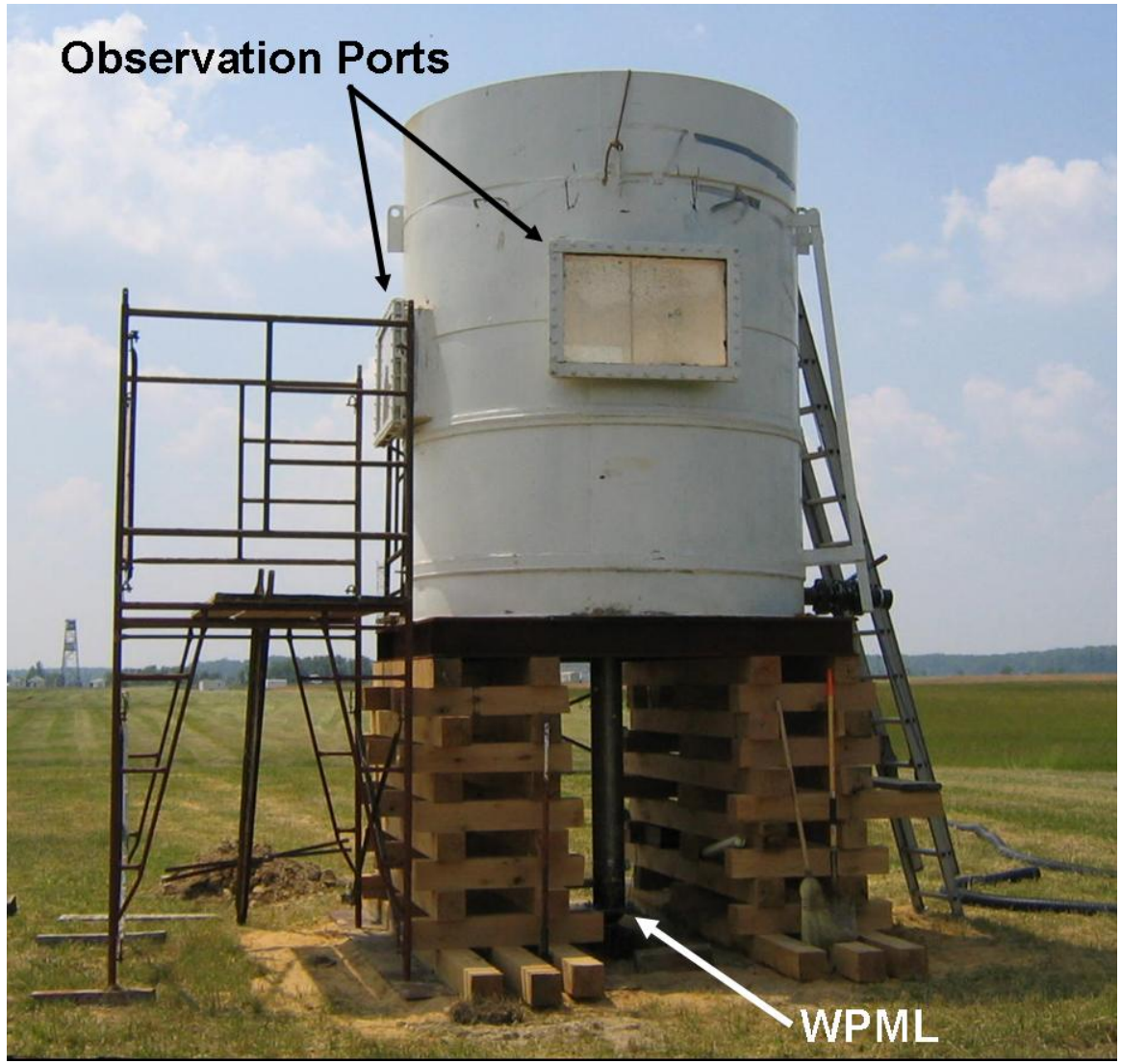
2.75-inch Rocket Motor Tests

- CCLs with 7, 8, and 9” outer diameter
- MK66 (2.75”) rocket motor as the gas source



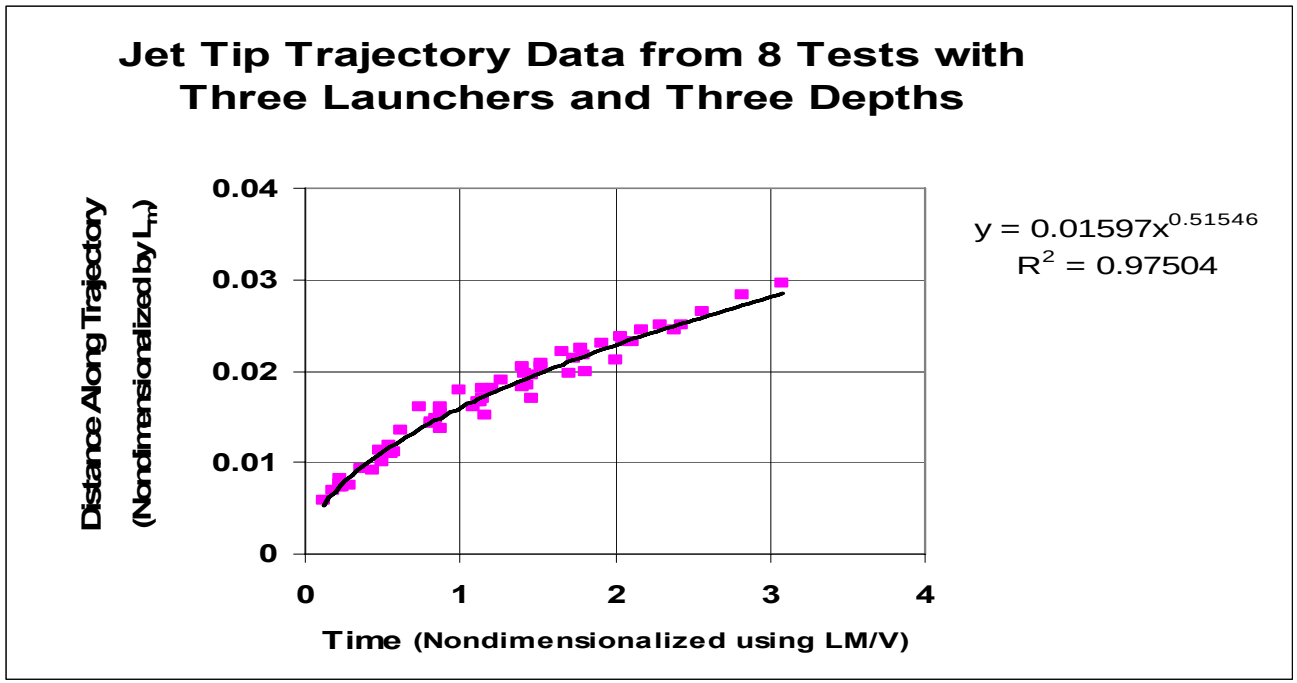
2.75-inch Restrained Rocket Motor Test

2.75-inch Fly-out Experiment

- Modified 5” Navy Hi-Frag Projectile
- Mk66 Provides Thrust

2.75-inch Rocket Motor Flyout Test

Empirical Model for Predicting Jet Tip Trajectory



Formula for trajectory from graph: $y = 0.01597x^{0.5146}$

Let Z be a coordinate along the axis of the launcher starting at the exit plane and ending at the surface of the water,

y (on the graphs above) = Z /Lm

Let t be the time in seconds

x (on the graphs above) = t/(Lm/V)

Substitute this into the equation for the trajectory on the graphs:

$Z/L_m = 0.01597x^{0.5146} = 0.01597(tV/Lm)^{.5146}$

Solve for Z:

$Z=.01597L_m(tV/Lm)^{.5146}$

Final Formula for a Jet Tip Trajectory

$$Z = 0.01597 L_m \left(\frac{tV}{L_m} \right)^{.5146}$$

Z = Jet tip height above the CCL exit

L_m = (Specific momentum flux)$^{3/4}$ / (Specific buoyancy flux)$^{1/2}$, where

Specific momentum flux = Exhaust Area of CCL x Velocity^2 , and

Specific buoyancy flux = g (Volume Flux) (Density of Water-Density of Exhaust)/ (Density of Water), and

Volume Flux = Velocity x Exhaust Area

t = Time in Seconds

V = Exit Velocity

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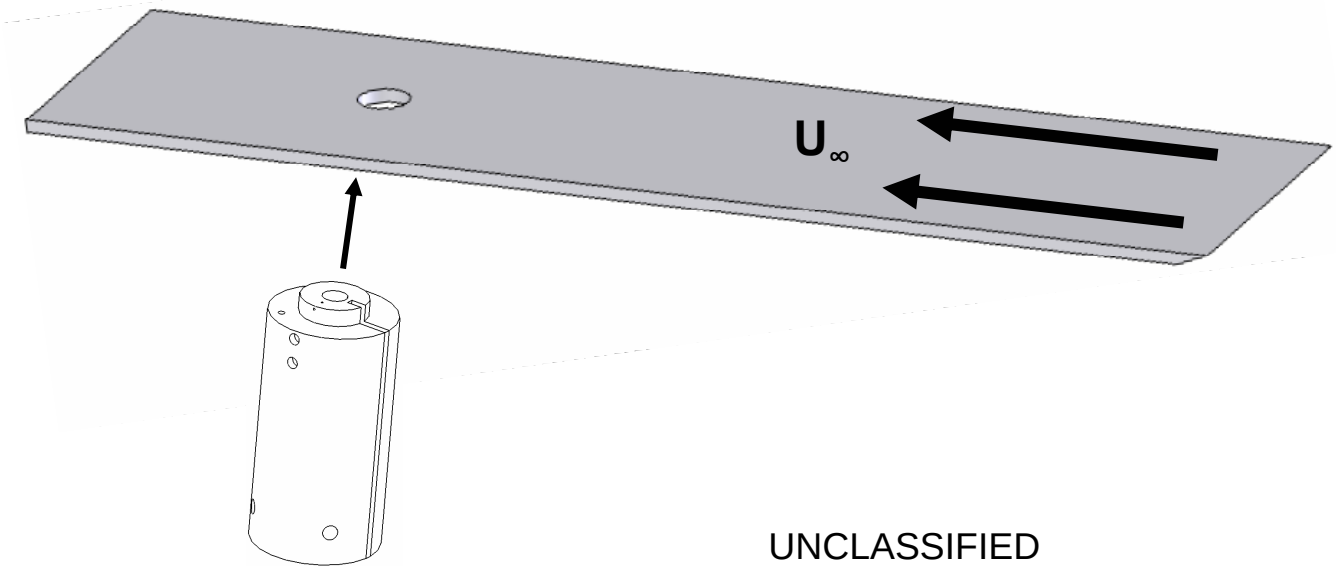
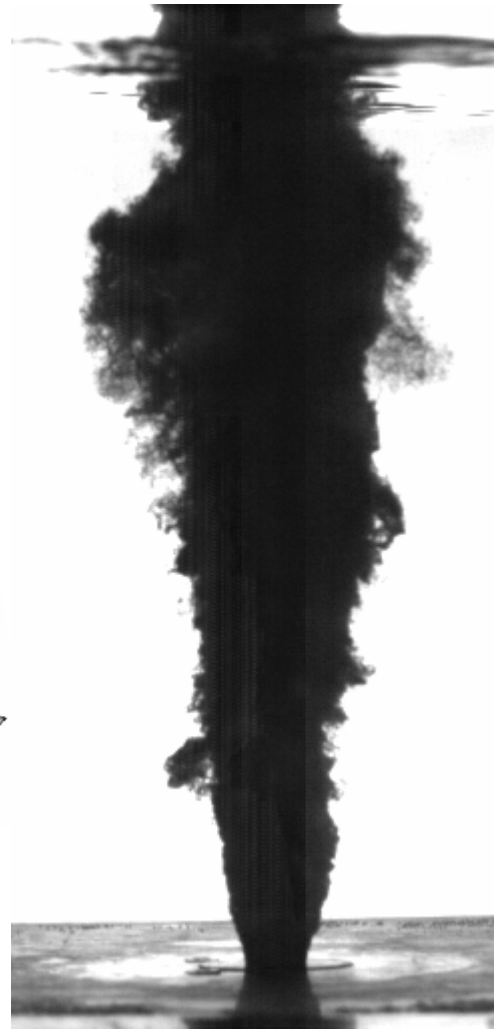
Va Tech Water Tunnel Cross Flow Setup

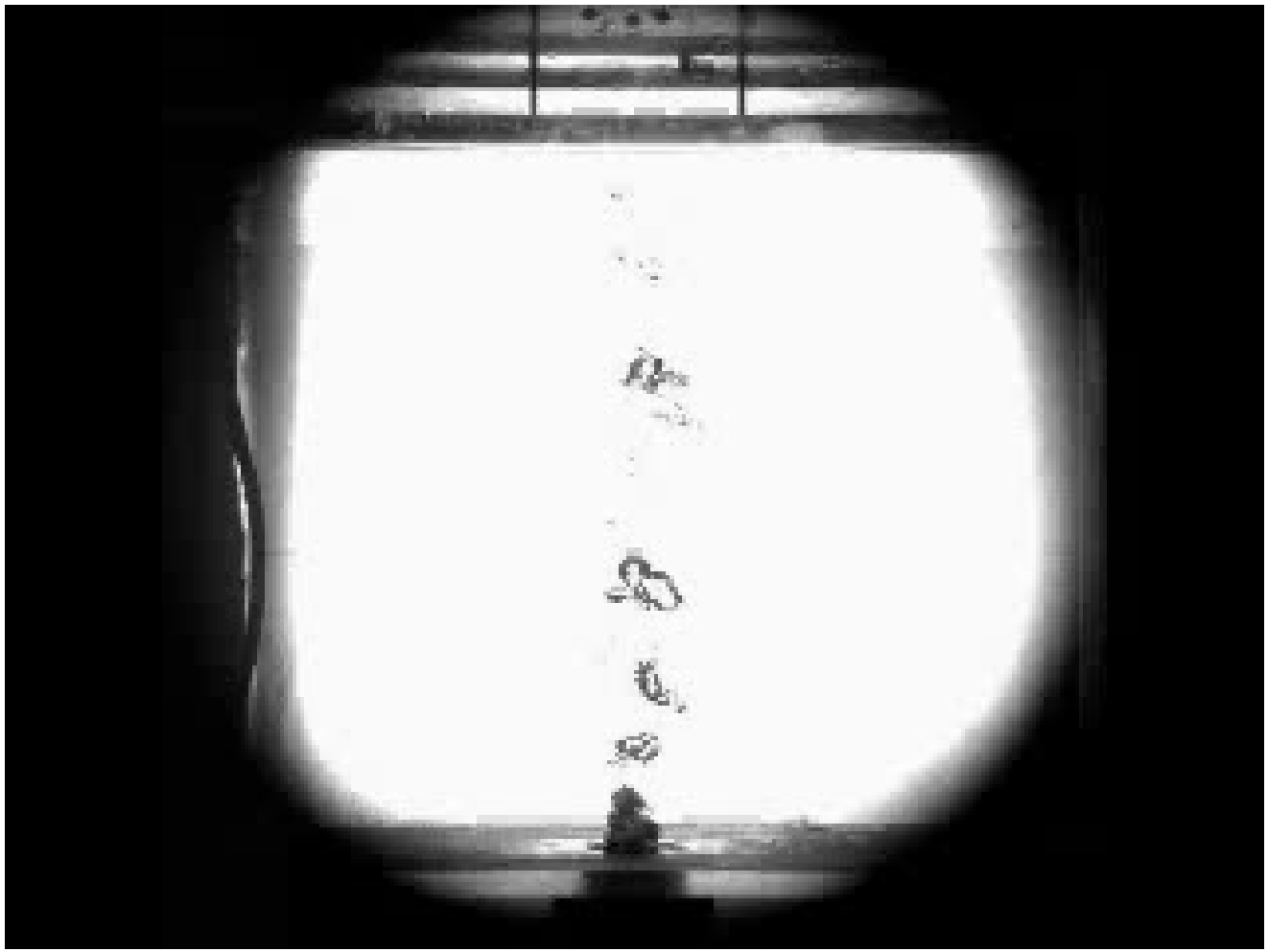
- WPML is flush mounted onto flat plate
- Control of key variables
  - Launcher exit velocity
  - Launch depth
  - Cross flow speed
- Shadowgraph images to record interface position





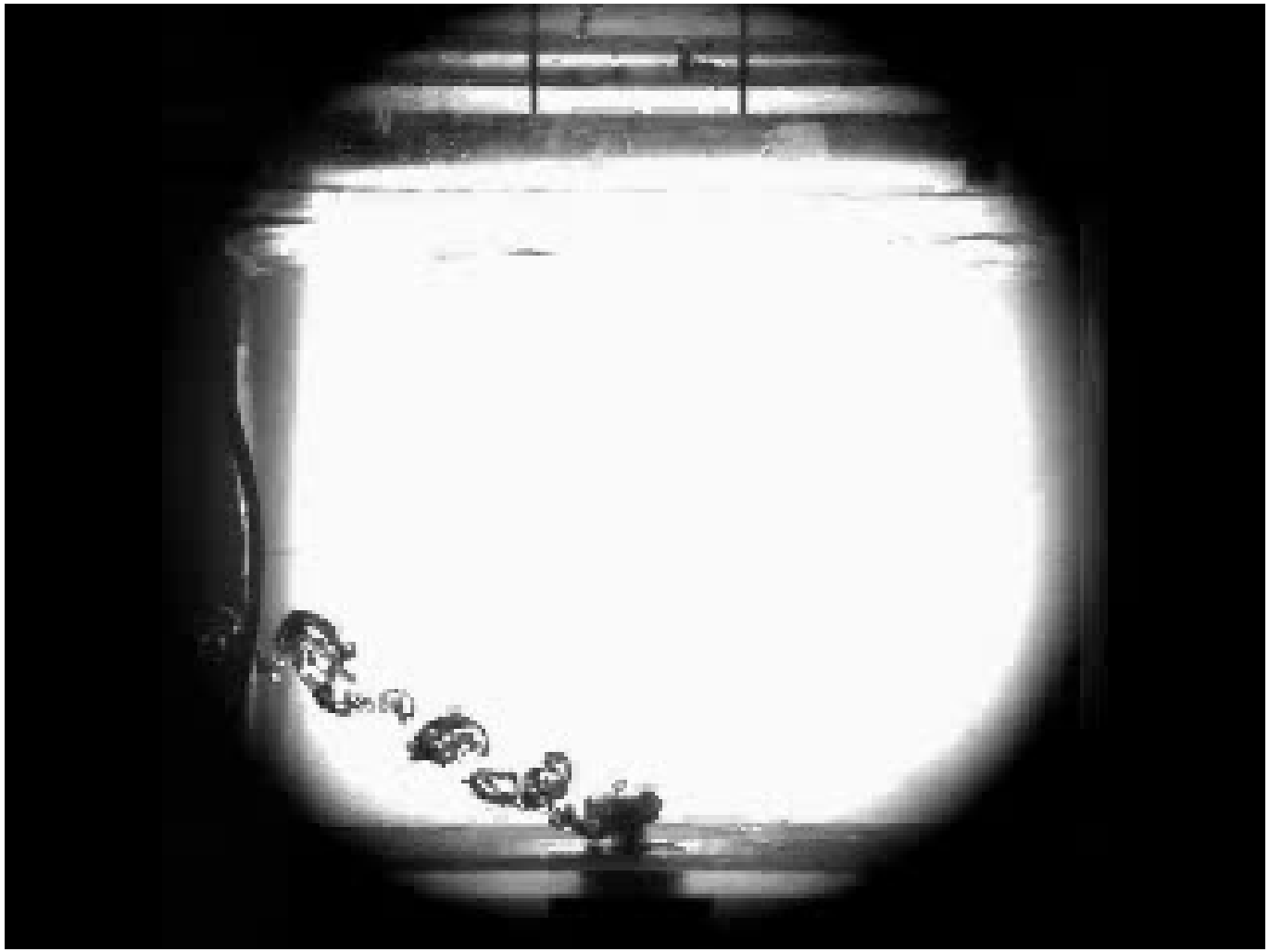
Va Tech Water Tunnel Tests

- Mach # - 2.0
- Cross Flow - 0 knots
- Time to Pierce - 43ms
- Average Jet Velocity – 31 fps



Va Tech Water Tunnel Tests

- Mach # - 2.0
- Cross Flow - 1.36 knots
- Time to Pierce - 48ms
- Average Jet Velocity – 28 fps



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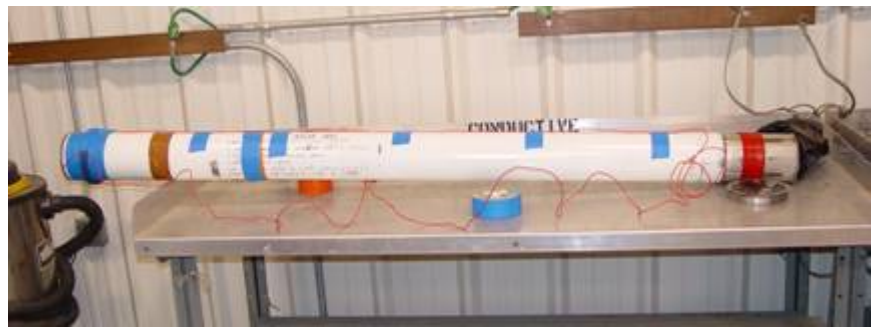
Restrained Rocket Motor Test Series Objective

Objective: Determine the water piercing capability of two different 5-inch diameter rocket motors through restrained firing tests at depths from 10-40 feet

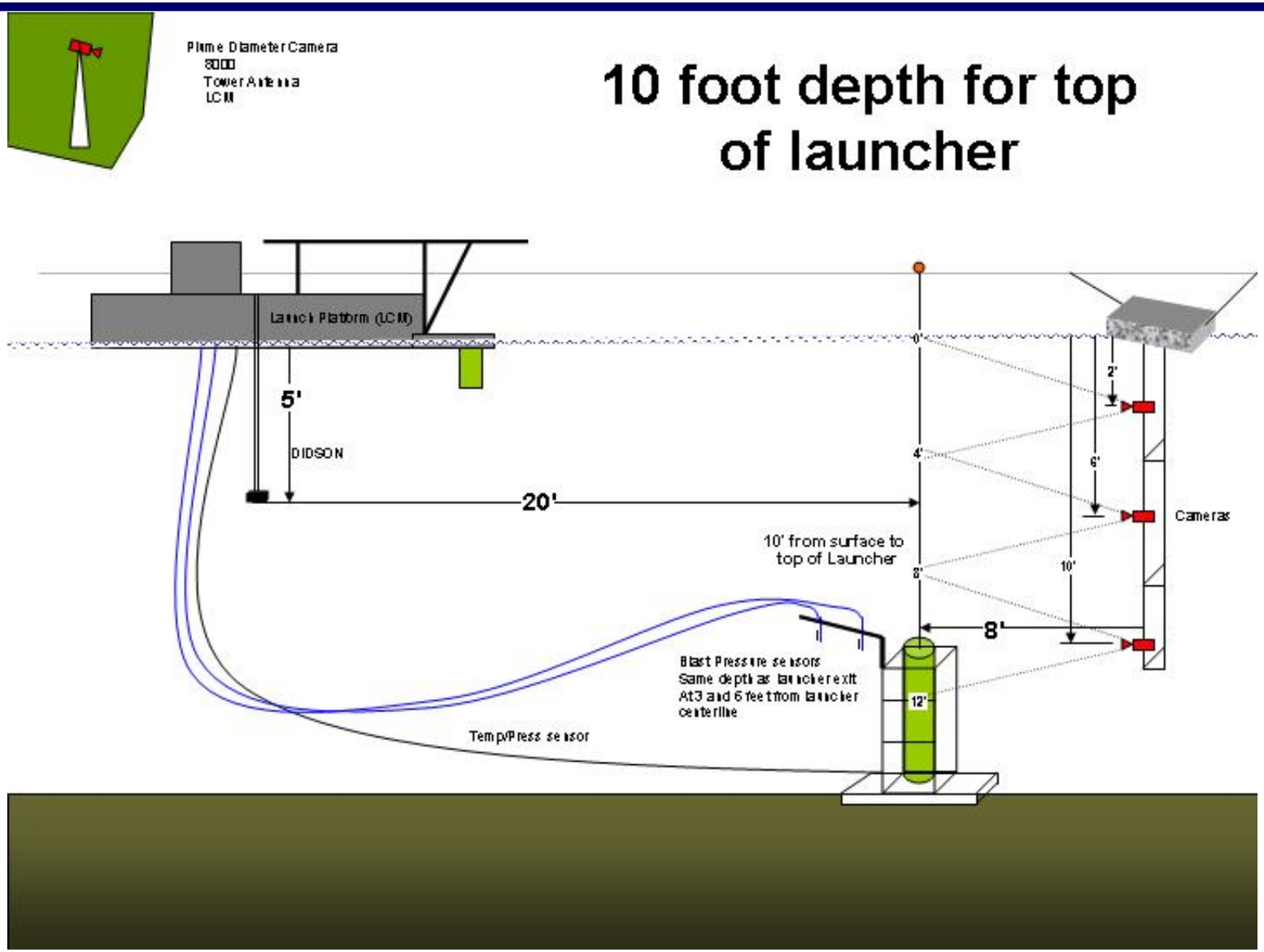
Results will be used to update CFD models and scaling laws

5-Inch Rocket Motors

Rocket Motor	Average Thrust (lbf)	Average Pressure (psi)	Burn Time (Seconds)	Nozzle Throat Area (square in)	Avg. Mass Flow Rate (lbm/s)
JATO	2595	1634	1.35	1.09	12.65
ZUNI	5659	1430	1.53	2.92	24.95



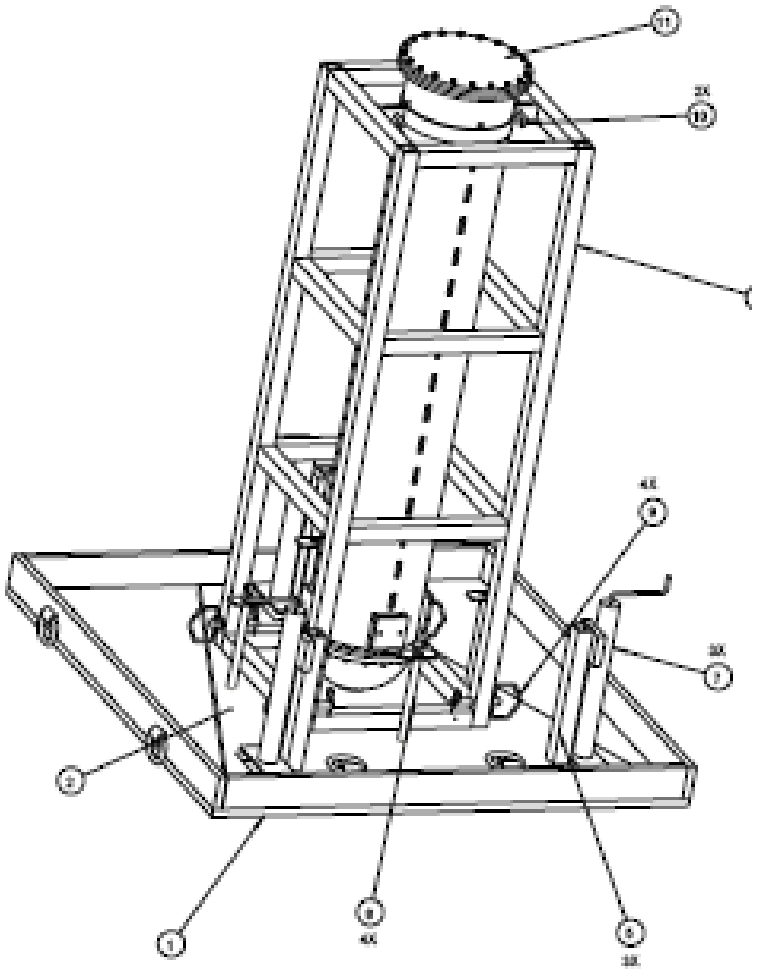
Typical Test Setup

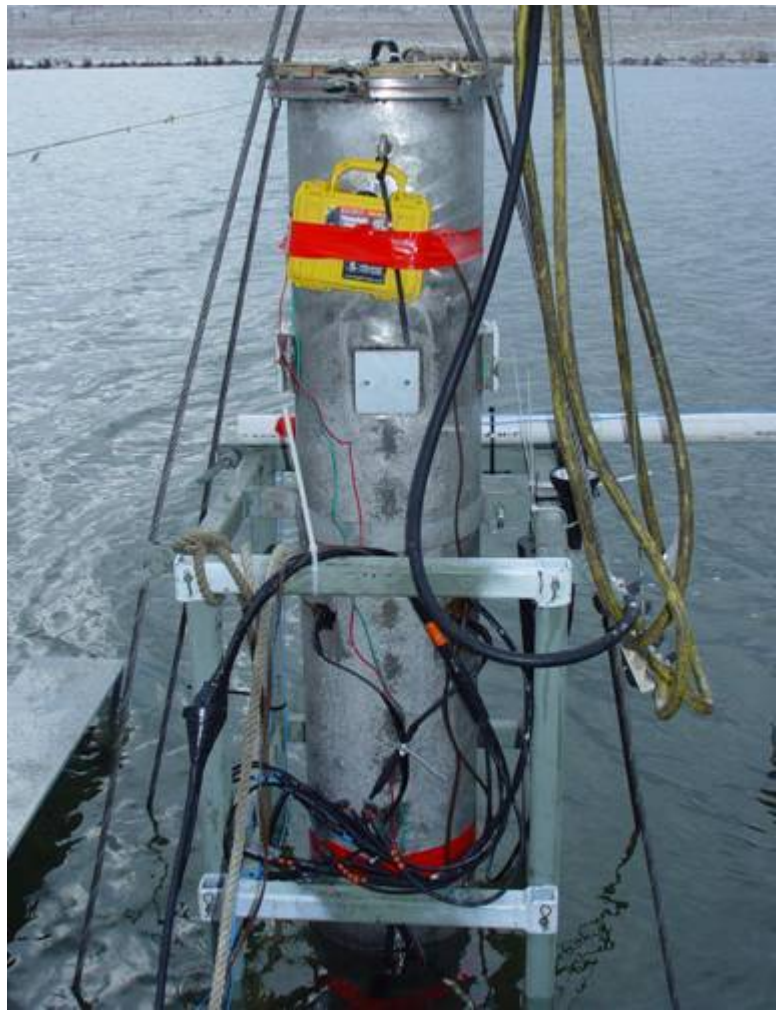


5-Inch Rocket Motor Launchers

Test Hardware Readiness Supporting Test Fixtures

Launcher Cage Platform



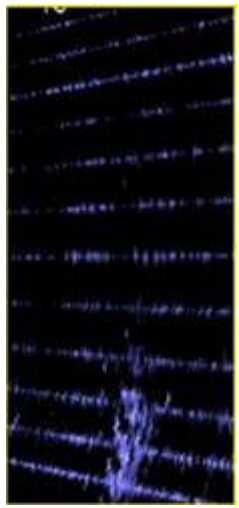


5-inch Rocket Tests Conducted

Test #	Rocket Motor	Depth (ft)	Pierce? (Y/N)
1	JATO	10	Y
2	JATO	20	Y
3	Zuni	20	Y
4	JATO	27	Y
5	Zuni	32	Y
6	JATO	42	N
7	Zuni	40	Y?
8	JATO w/ Plug Nozzle	40	N
9	Zuni	40	Y
10	Zuni w/ Plug Nozzle	40	Y

Test Results – Zuni at 32 feet Above Water Camera – High Speed

Test Results – Zuni at 32 feet DIDSON Acoustic Camera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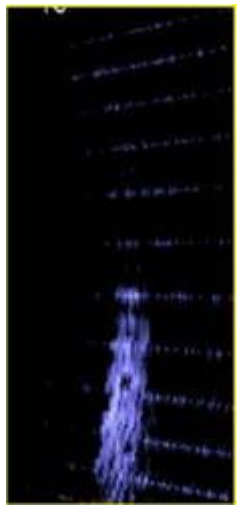
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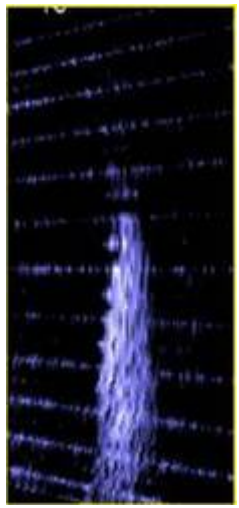
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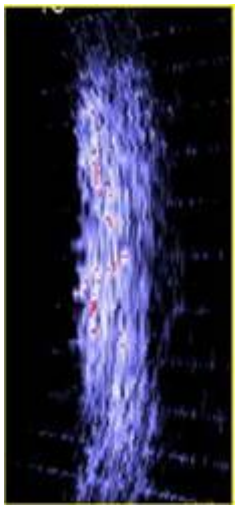
T=0.667


T=0.8333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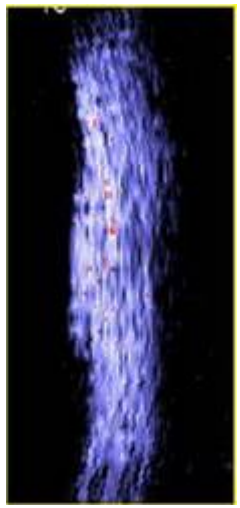
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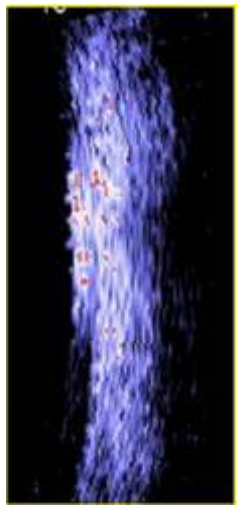
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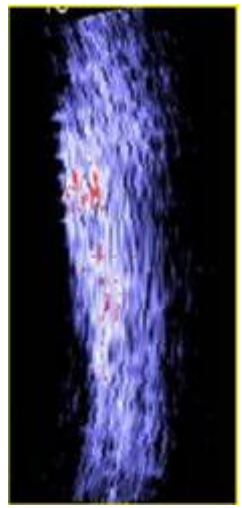
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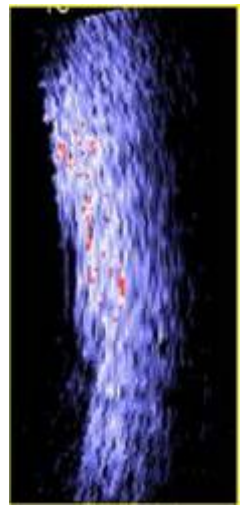
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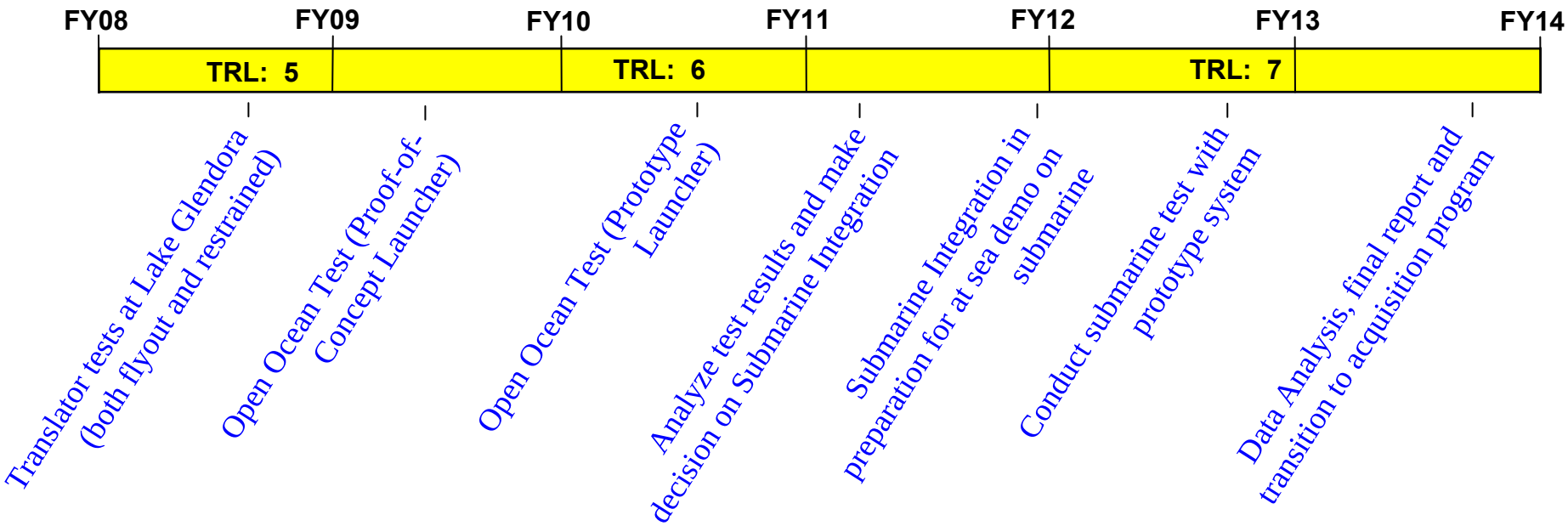
Test Results – JATO at 42 feet Above Water Camera – High Speed

Static Flyout Test – 9/25/07
20 foot depth – JATO Motor

Static Flyout Test – 9/25/07
20 foot depth – JATO Motor

Future Program Plan

- FY08 Translator Tests at NSWC Crane
- FY09, FY10 Open Ocean Fly Out Tests w/Target
- FY11 Data Analysis, Decision on Submarine Integration
- FY12,13 Submarine Test with Prototype System
- FY14 Data Analysis, Transition to Acquisition Program



Summary

- Tests and analysis have shown that the WPML concept is valid

- Continuing to Execute Program Plan
  - FY08 Translator Tests at Lake Glendora
  - FY10 Relevant Environment Test (Underwater Rail at San Clemente Island)

Questions?