NDIA Systems Engineering Conference

A New Strategy for Submarine Payload Integration

The VIRGINIA Multi-Mission Payload Module

John Pavlos - Electric Boat

GENERAL DYNAMICS
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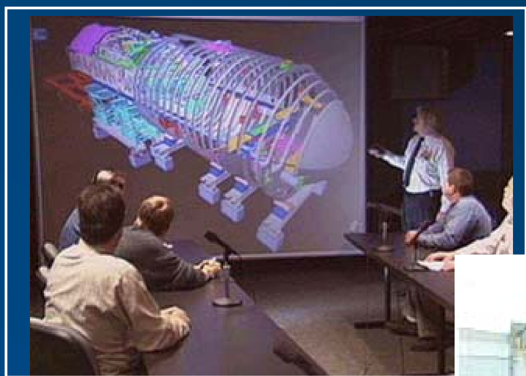
NDIA NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

ELECTRIC BOAT

Premier Resource for Submarine Design and Construction Technology

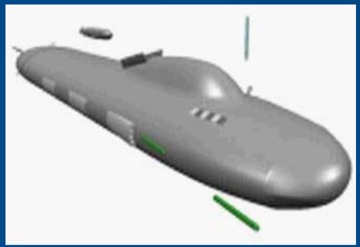


Engineering & Design

Construction

Sea Trials & Test

Life-Cycle Support

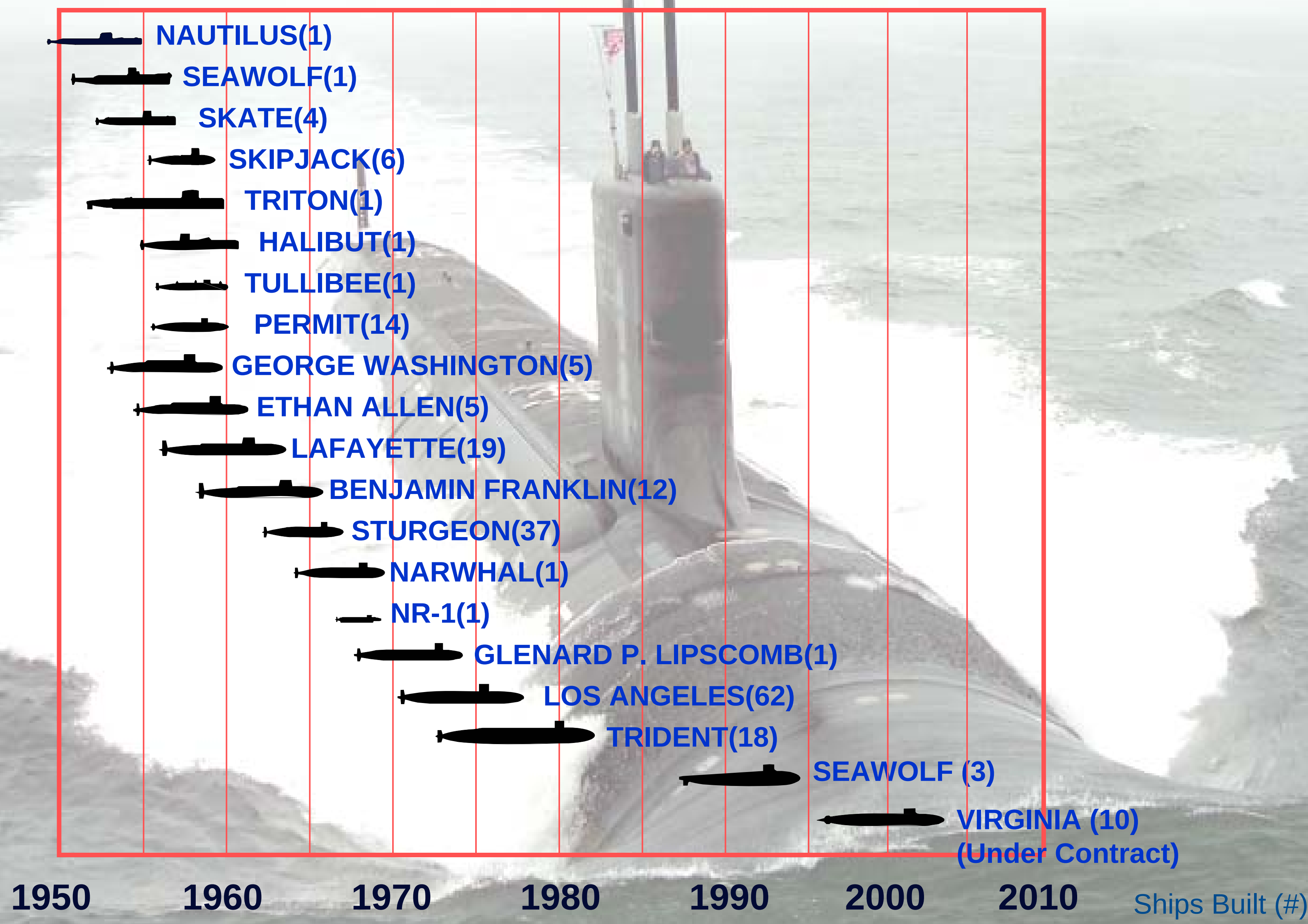


Advanced Development

Electric Boat
Locations and Staffing (As of October 7, 2006)

CONNECTICUT	
Operations and Support	3,901
Engineering	3,456
RHODE ISLAND	
Quonset Point Facility	1,907
Newport Engineering	53
NEW YORK	
Knolls Atomic Power Lab	183
GEORGIA	
Kings Bay Trident Base	125
WASHINGTON	
Bangor Trident Base	108
Puget Sound NSY	250
WASHINGTON, D.C.	**15**
VIRGINIA	**365**
UK / Australia / Other	**68**
TOTAL	10,431

Nuclear Powered Submarines



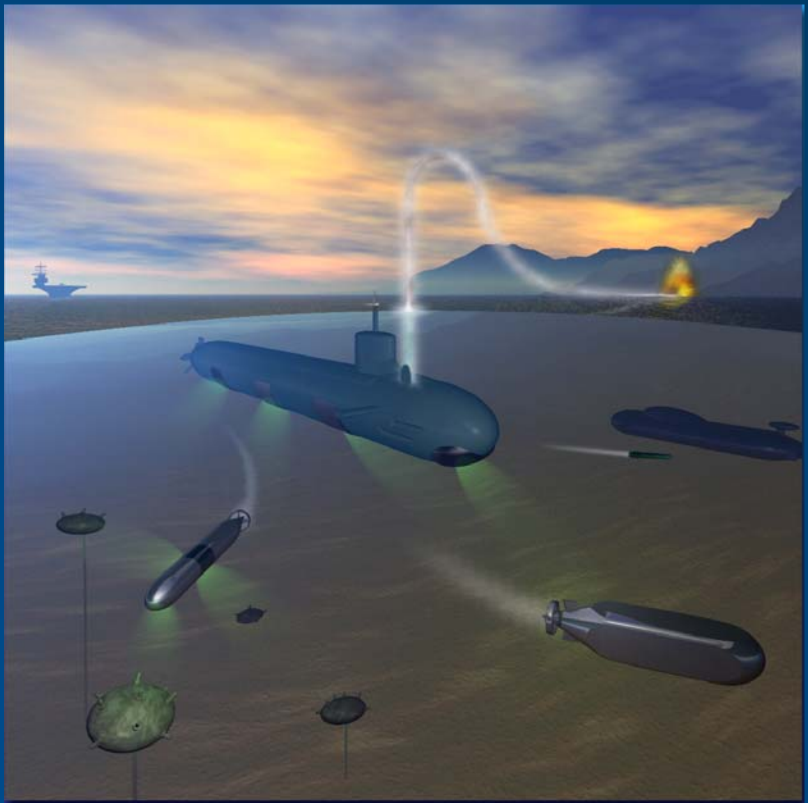
The VIRGINIA Class Submarine is One of the Most Complex Systems in Production

- Electric Boat: Prime contractor and lead design yard
- Awarded 10 ships of an anticipated 30-ship class – valued at $13B
- Lead ship SSN 774 VIRGINIA delivered October, 2004

	M1 Tank	Boeing 777	VIRGINIA Class Submarine
Weight (T)	65	250	7,800
Length (Ft.)	25	200	377
Number Systems	25	40	200
Crew Size	4	10	113
Patrol Duration (Hr.)	24	8-14	2,000
Number of Parts to Assemble	14,000	100,000	1,000,000
Assembly Man-hours/Unit	5,500	50,000	>10,000,000
Production Time (Mo.)	7.5	14	55
Production Rate (Units/Yr.)	600	72	0.5-3

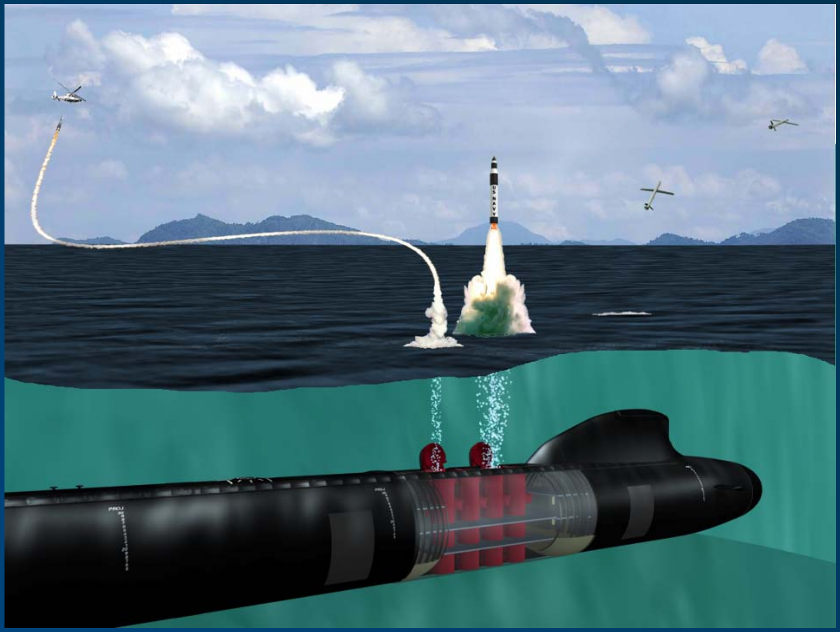
Challenge: Moving From Today's Capability to Tomorrows Mission Needs

Today's Capability

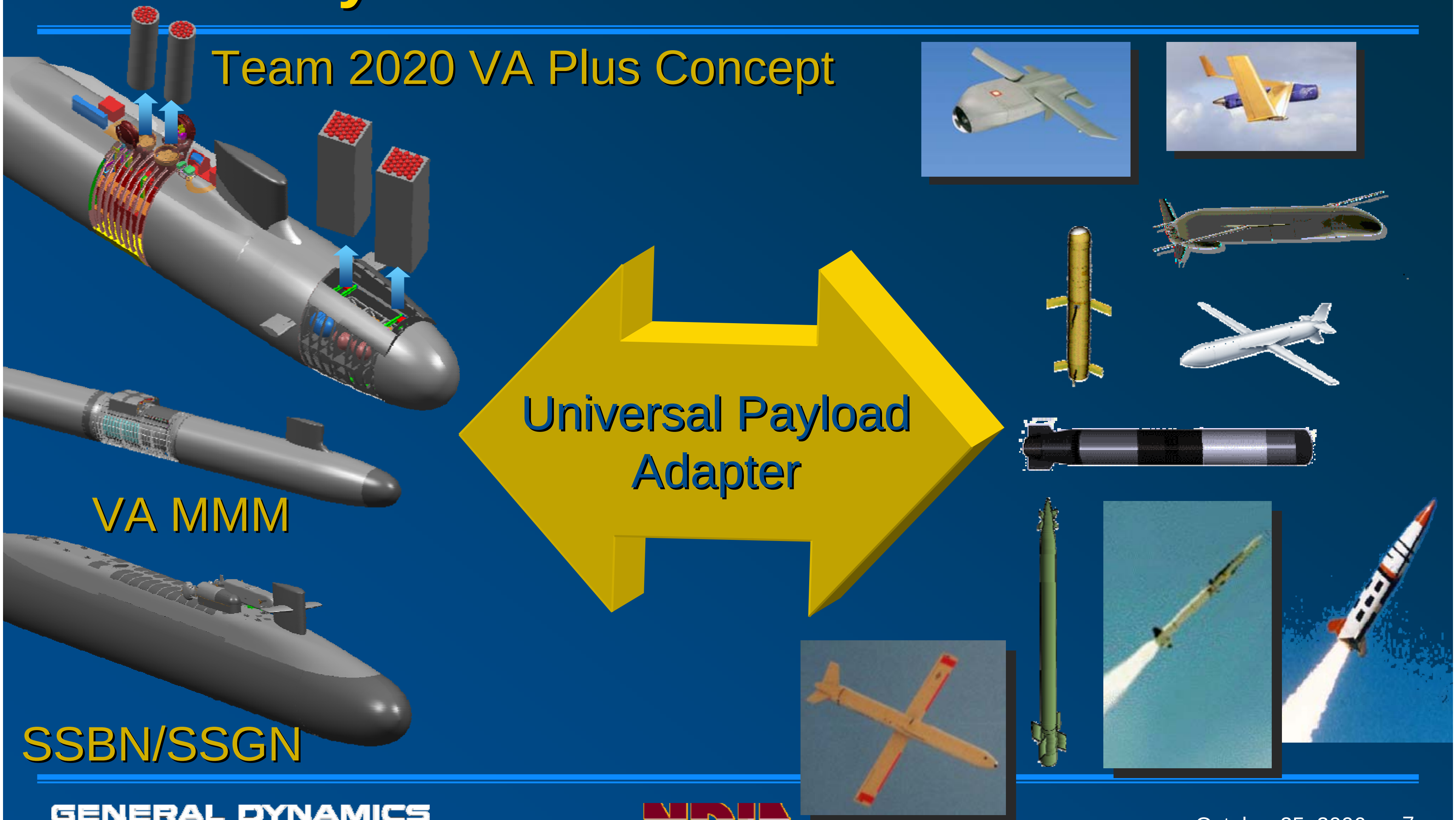


Battle Group Support | Mine Warfare | Anti-Ship Warfare | Surveillance & Intelligence | Strike Warfare | Special Warfare | Anti-Submarine Warfare

Tomorrow's Capability



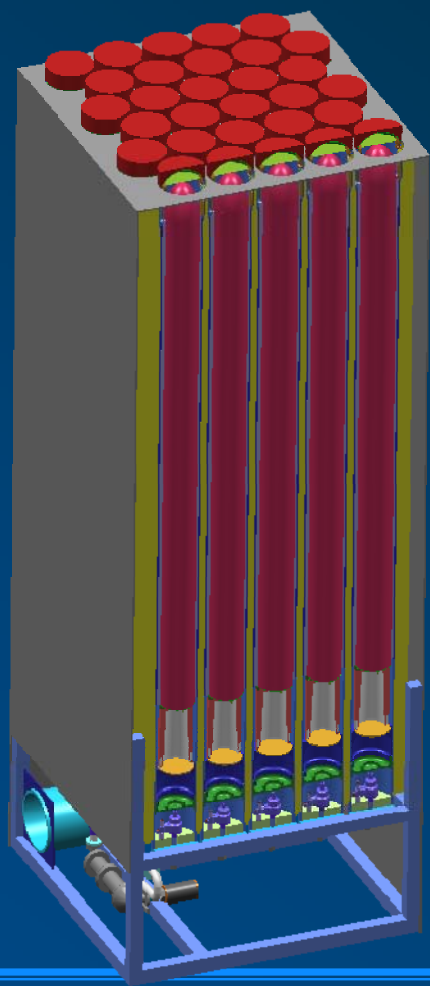
The Concept Was to Minimize the Impact to the Payload and the Platform



Key Technologies Can Enable the Concept

Conceptual Requirements

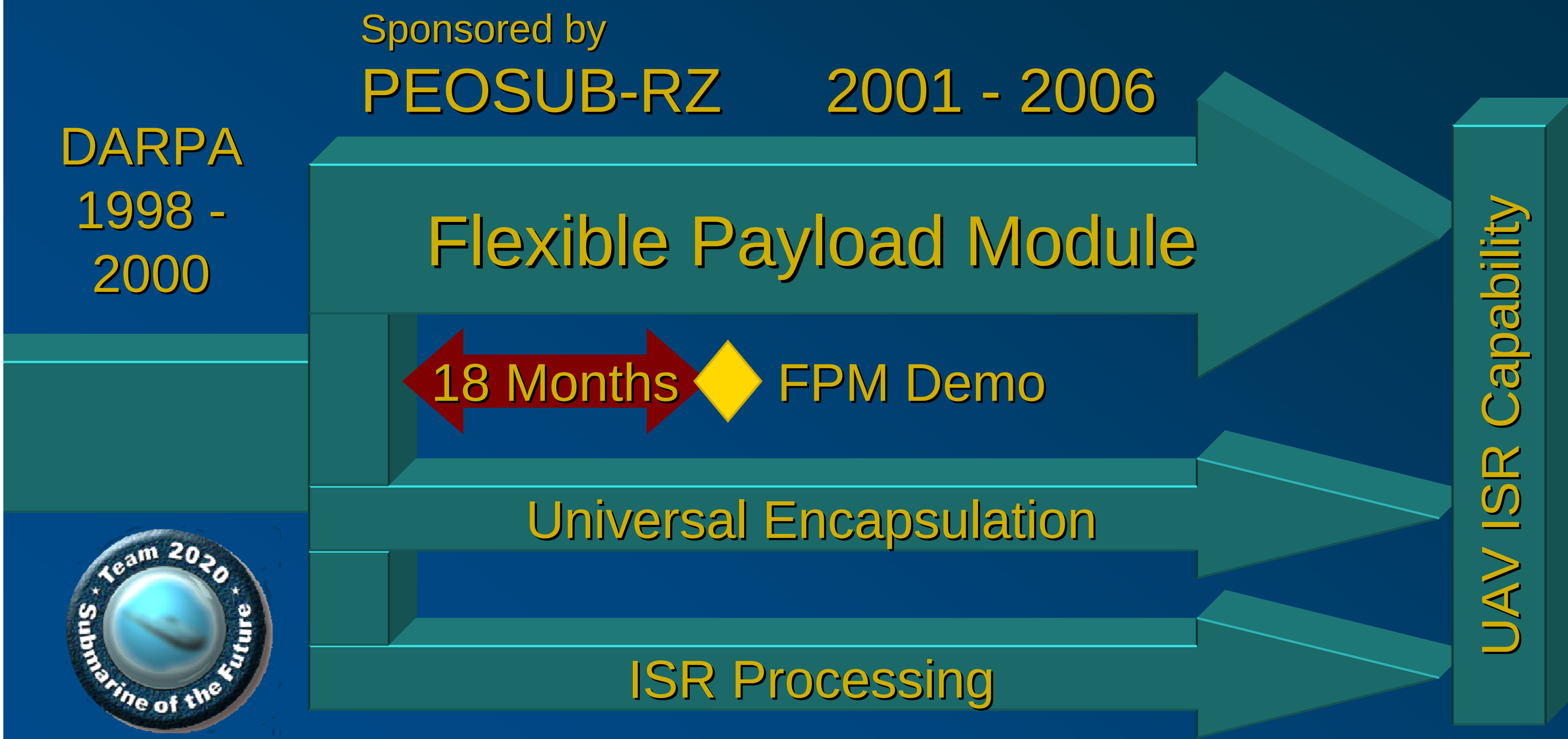
- Standardized Interface
- External Payload Enabler
- High Payload Density
- Fast Logistics
- Reloadable, Recoverable, Reusable
- Adaptable to Many Sizes and Shapes
- Work in conjunction with a payload capsule



Key Technologies

- Composite Structure
- Compact Expendable Hatch
- Shock Mitigation
- Network-Based Control System
- Wireless Communications
- Inductive Power Transfer

Payloads and Sensors Studies Transitioned into Risk Reduction Demonstrations

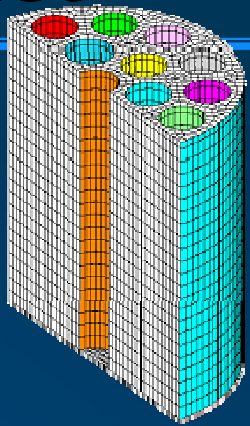


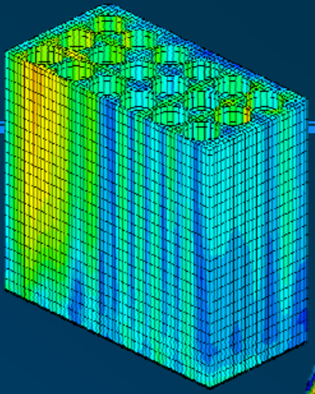
The Flexible Payload Module is moving from Concept Exploration through Risk Reduction

Phase 0	Phase 1	Phase 2	Phase 3
Concept Exploration	Program Definition & Risk Reduction	Engineering & Manufacturing Development	Production, Fielding, & Operational Support
System Analysis Reqts. Definition Conceptual Design Technology & Risk Assessment Prelim. Cost, Sched. & Perf. Concept	Concept Design Update Sub-system Tradeoffs Preliminary Design Prototype Testing Manufacturing & Supportability Considerations	Detail Design Development Risk Management Development Test & Evaluation System Integration, Test & Evaluation Manufacturing Process Verification	Production Rate Verification Operational Test & Evaluation Deployment Operational Support & Upgrade Retirement Replacement Planning

The Composite Construction Proved to be Simple and Robust

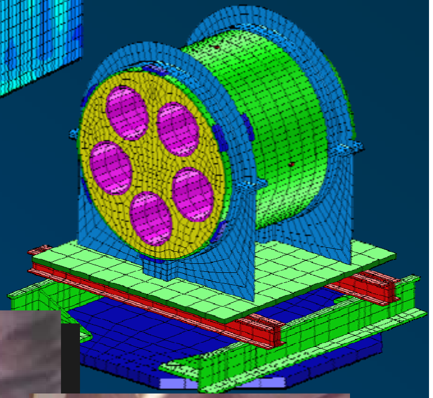
- Analyzed for Pressure and Shock Loads
  - Robust structure in any configuration
  - Shock testing validated the analysis
- Built at Quonset Point
  - Completed in 23 days
  - Exothermic reaction easily accommodated





Parametric Studies

Shock Test Article



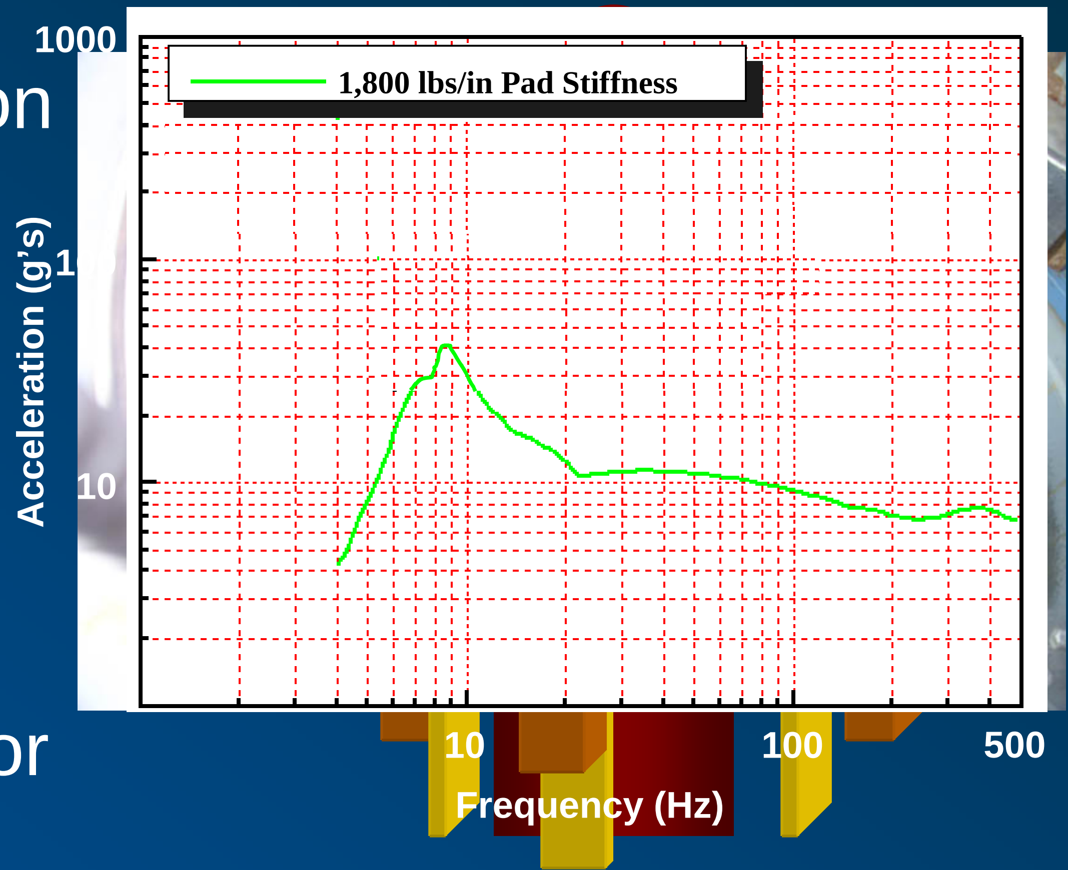
Syntactic Pour in FPM

Compact Expendable Hatch Supports High Payload Density

- Combination of Steel Shell and Syntactic Buoyancy Element
- Eliminates Hinges and Actuators to Open and Close
- Hatch Release Actuator Designed to Maximize Packing Factor
- Floodable Air Volume Allows Hatch to Scuttle at Desired Time

Shock Mitigation Pads/Launch Rails Accommodate Joint Forces Payloads

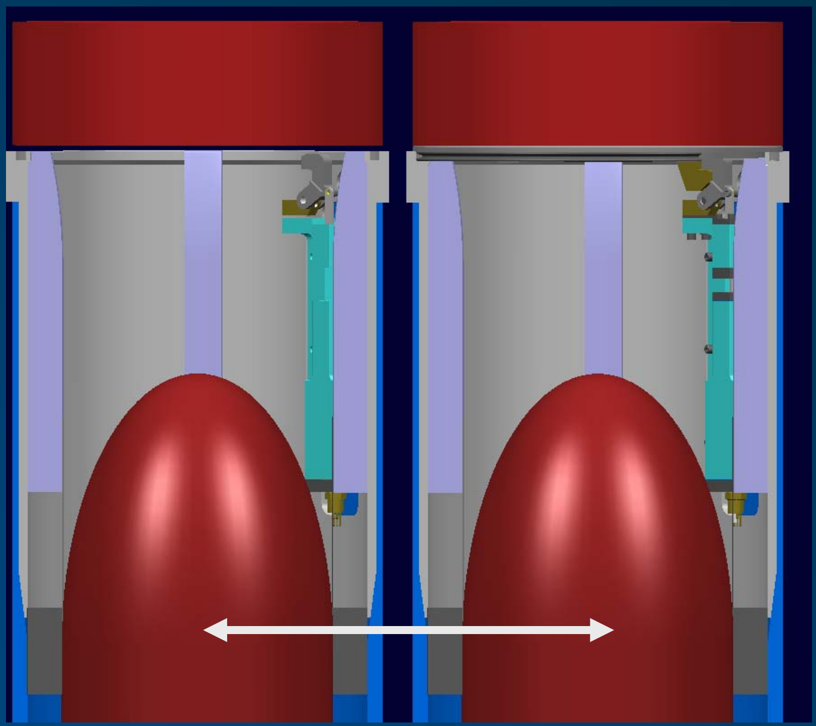
- Closed cell foam provides the mitigation for lighter payloads
  - Compresses under pressure to release capsule for launch
  - Reduces capsule accelerations to 10 - 30 g's
- Easily reconfigured for the next payload



Many of the Key Technologies Serve to Increase Payload Density

- Expendable hatch minimizes mechanical systems
- Foam filled structure allows closely packed tubes
- Shock mitigation pads reduce the accelerations and maximize packing factor

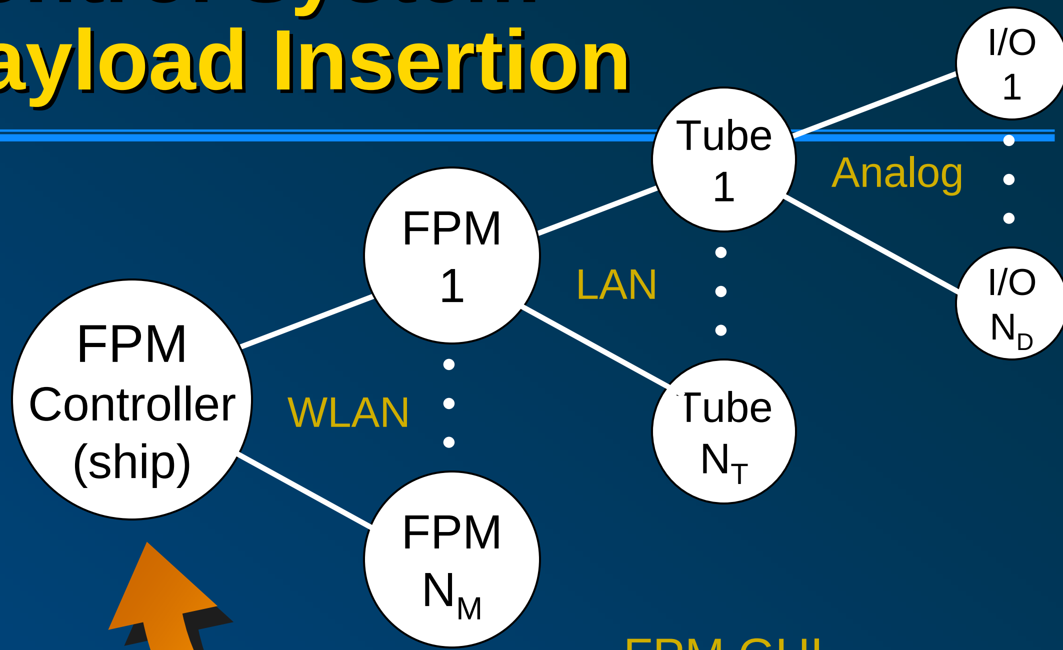
Section View of FPM



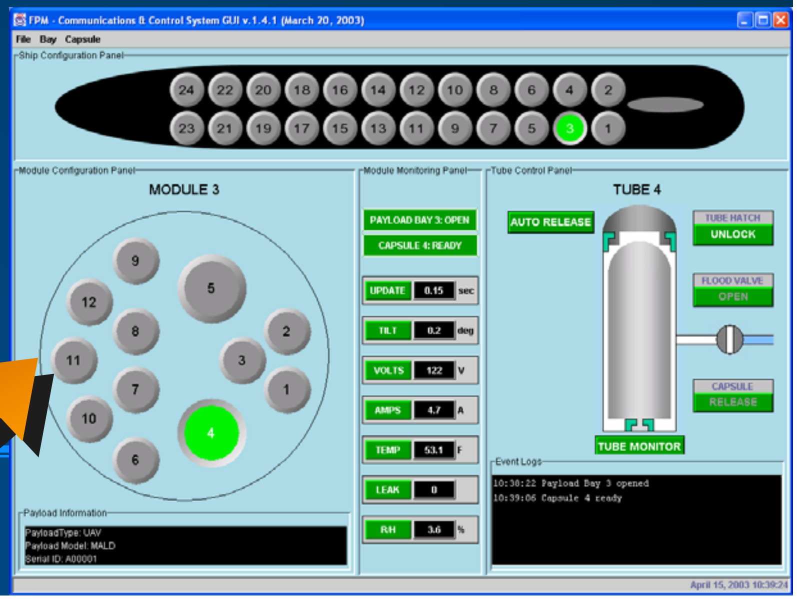
16.2" Centers Between
11" OD Capsules

Network-Based Control System Supports Rapid Payload Insertion

- Scalable, Flexible Architecture
- Built upon COTS Technology
- Provide intelligence onboard FPM platform
  - Enables "plug and fight"
- Shipboard User Interface uploads FPM configuration



FPM GUI



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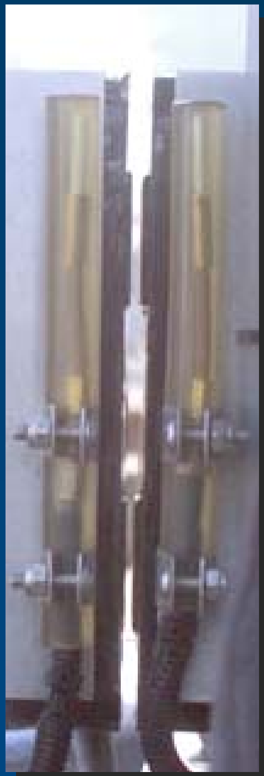
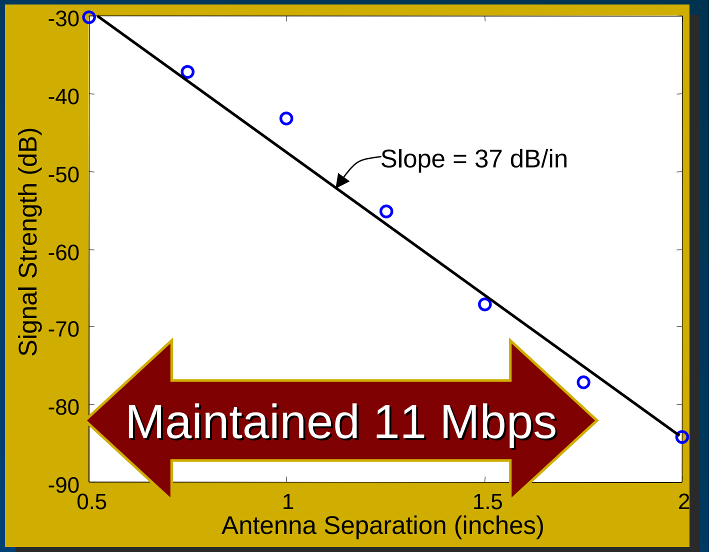
Commercial Wireless Networking Employed for the Ship/FPM Interface

- Leverages Network Based Architecture
- Commercial Standard IEEE 802.11b WLAN
- Capable of maintaining 11 Mbps over small seawater gap

Attenuation of 2.4GHz RF in Seawater

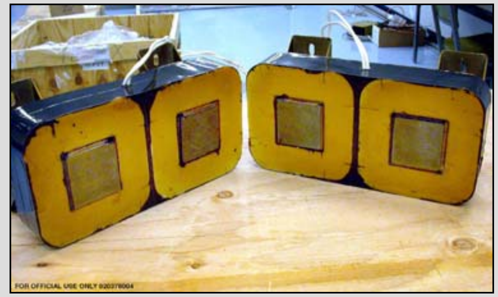


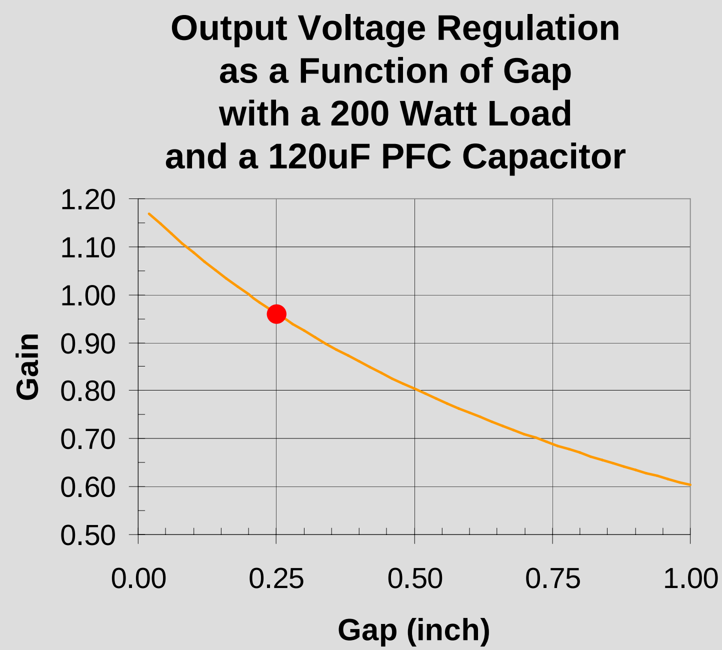


Waterproof Dipole Antennas

Inductive Power Transfer was Demonstrated Using a Split Core Transformer

- Demonstrated transfer of power from ship to FPM
  - 20 kW ultimate rating
  - 2 kW for demo FPM
- Environmentally sealed
- FPM-to-Capsule inductive coupler is under development

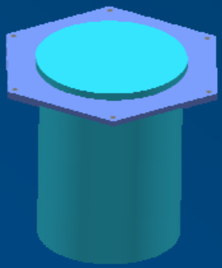




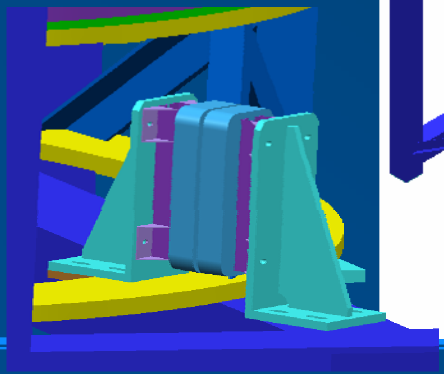
These Technologies Were Integrated Into a Demonstration FPM

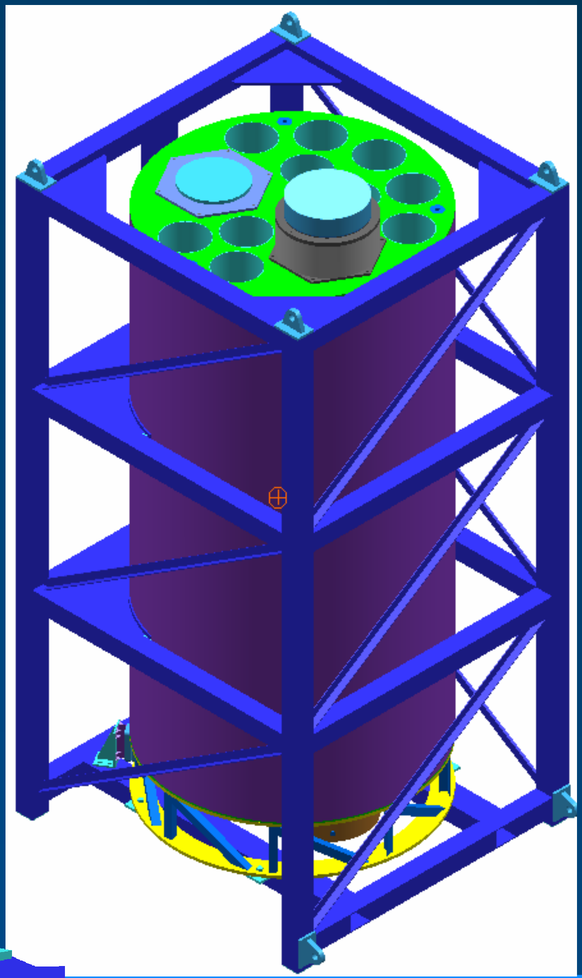
Shipboard GUI

Onboard Electronics

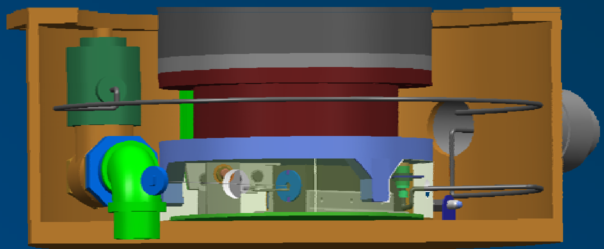


Wireless Connectivity & Inductive Coupler





Upper Housing



Lower Housing

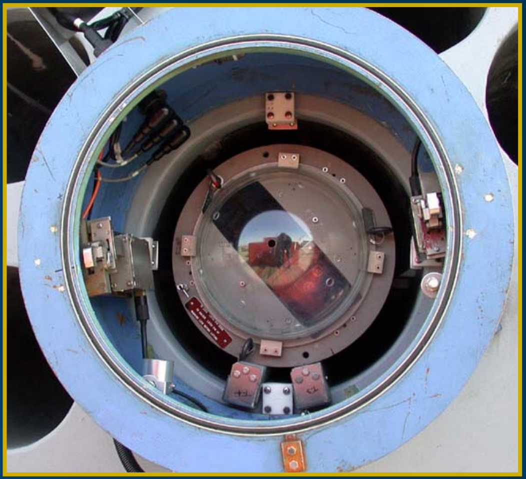
These Technologies Were Integrated Into a Demonstration FPM

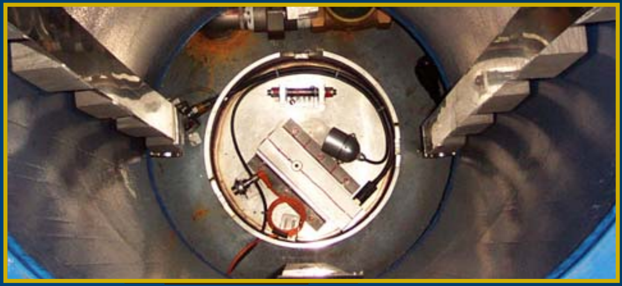
Shipboard GUI

Onboard Electronics

Wireless Connectivity & Inductive Coupler

Upper Housing

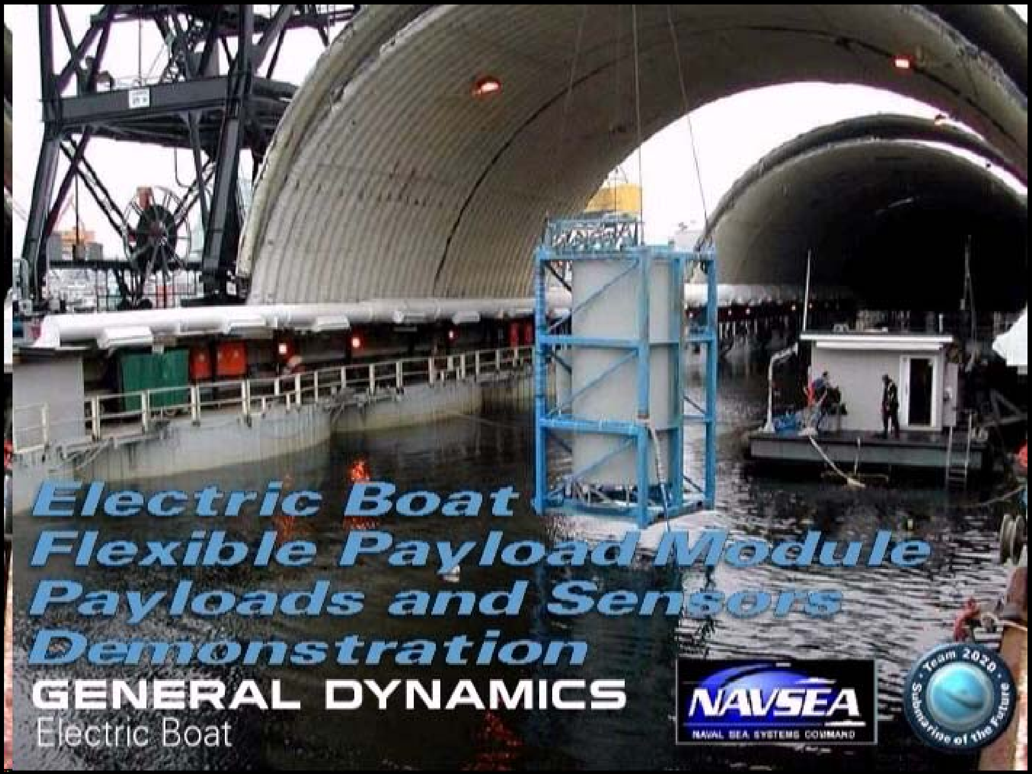




Lower Housing

The Full Size FPM Was Successfully Demonstrated at Electric Boat

- Employed all key technologies
- Demonstrated full system functionality
- Executed an automatic launch sequence
- Test-fit into a D5-sized missile tube



A Second Generation Flexible Payload Module Was Built For the 2004 Navy Silent Hammer Experiment

FPM Concept Refinement

- Full Scale Production Methods
- Network Based Control
- Wireless Technology
- Buoyant Capsule Integration

Flexible Payload Module (FPM)
Under Construction in Shipping Cradle

FPM integrated into a missile tube on USS Georgia

The Flexible Payload Module Provides an Open Architecture - System Level Solution To Meet Future Mission Needs

- Reduced cycle time to field new mission capability by minimizing payload specific ship modifications
- Decoupled payload development cycle from the ship development cycle
- Maintains critical warfighting performance
- Risk reduction on critical technologies has been accomplished

Electric Boat Is Moving Forward With The Payload Module Concept For The VIRGINIA Class Submarine