Advanced Undersea Warfare Systems

SEA-17B Capstone Project

Final Progress Review
25 MAY 2011

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Overview

SEA-17B has developed an Advanced Undersea Warfare System that enables control of the future Undersea Battlespace using superior weapons, sensors, AND communications.

- Flexible
- Scalable
- Tailorable

Agenda

Section 1	Section 2	Section 3	Section 4
• Tasking • Methodology	• Problem Statement • Stakeholder Analysis • CONOP • Needs Analysis	• Functional Analysis • Alternative Generation • DOE	• Design Concept Overview

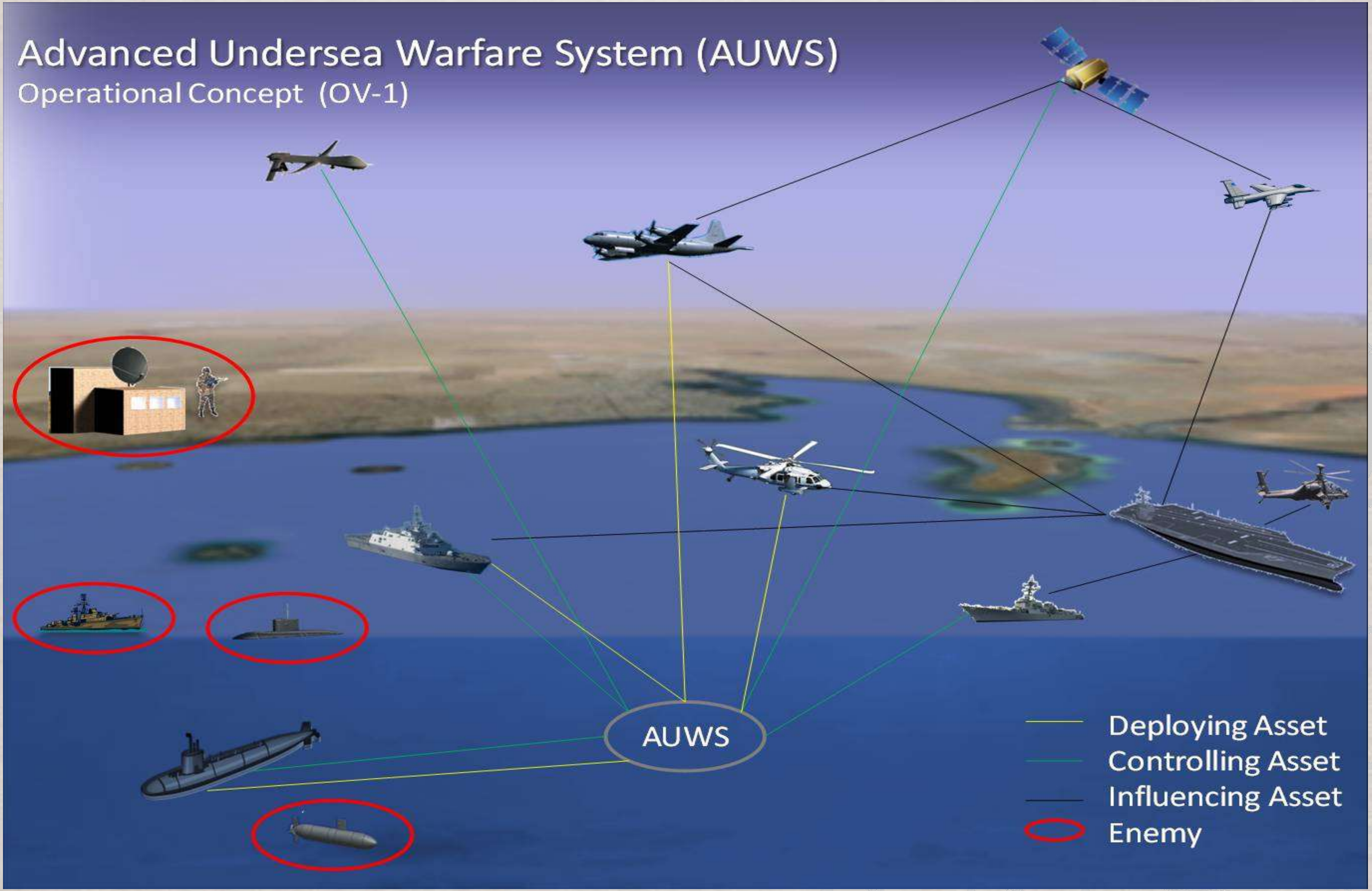
Section 5	Section 6	Section 7	Section 8

• Analysis of Alternatives
  • Performance
  • Cost
  • Risk
	• Recommend-ations
	  • Primary
	  • Secondary
	  • Hybrid
		• Project Insights
		• Project Recommend-ations
			• Conclusions

Section 1

Tasking
Methodology

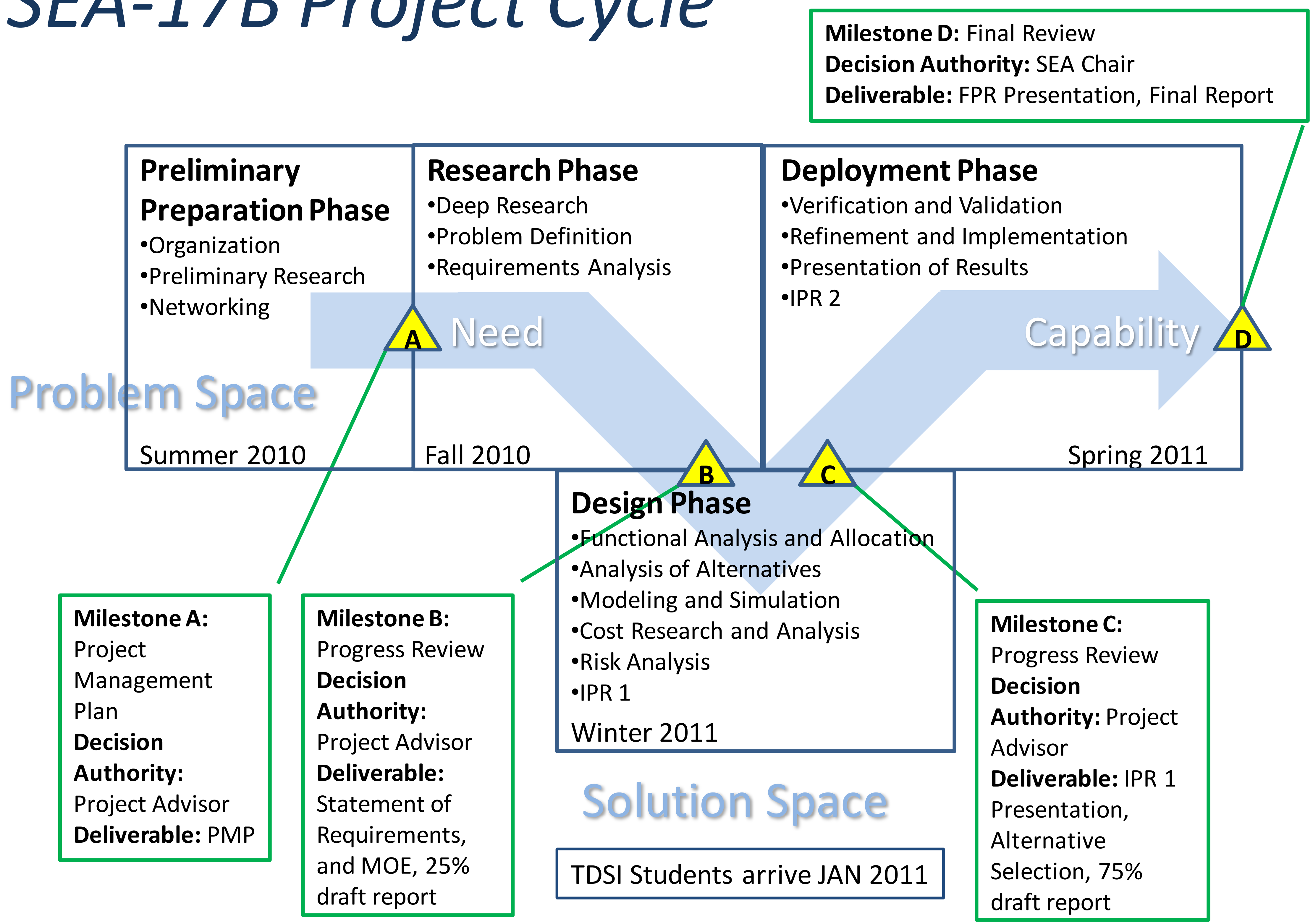
Tasking



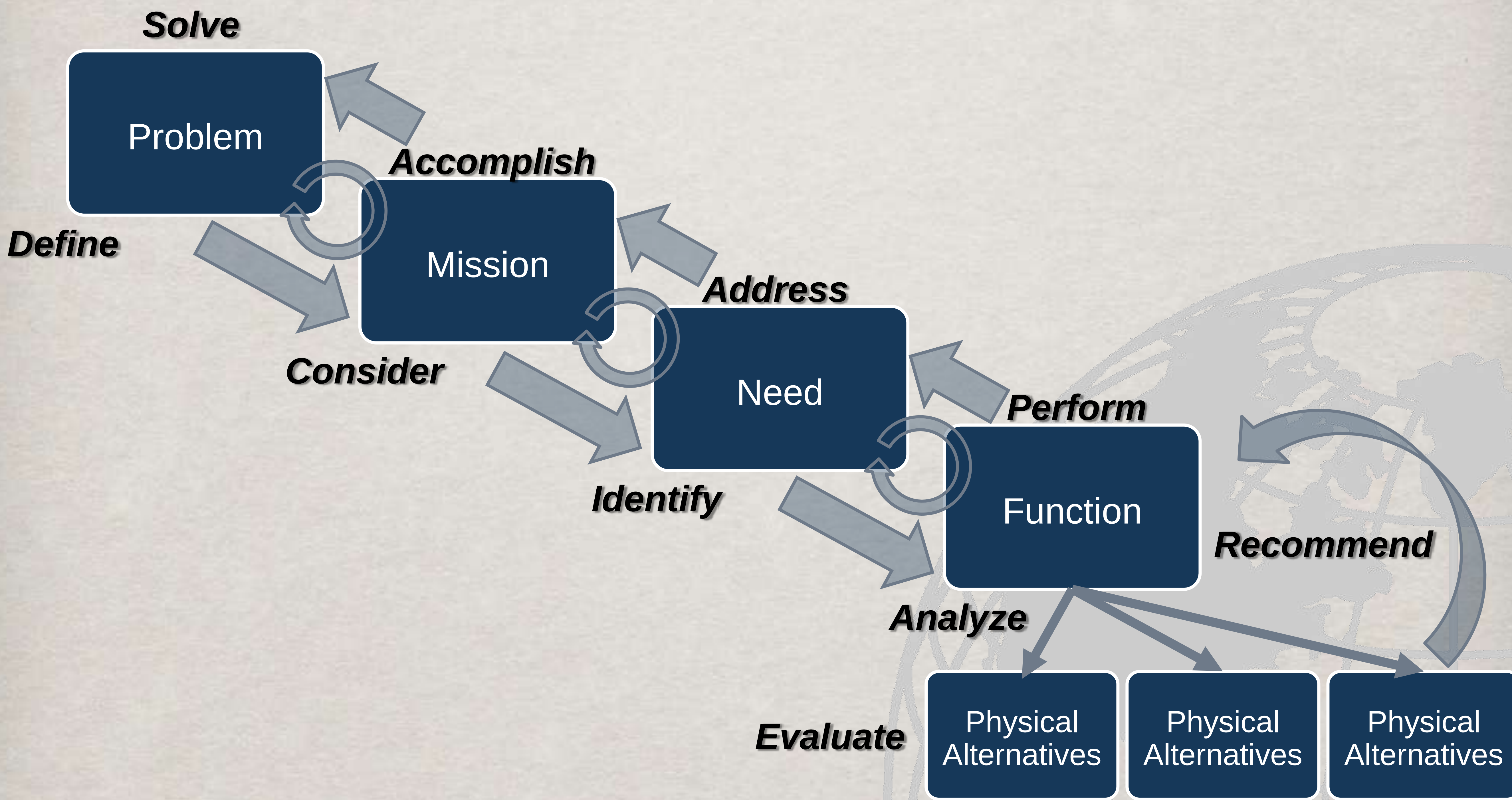
Advanced Undersea Warfare System (AUWS)
Operational Concept (OV-1)
AUWS
Deploying Asset
Controlling Asset
Influencing Asset
Enemy

Systems Engineering Plan

SEA-17B Project Cycle



Systems Engineering Process



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Section 2

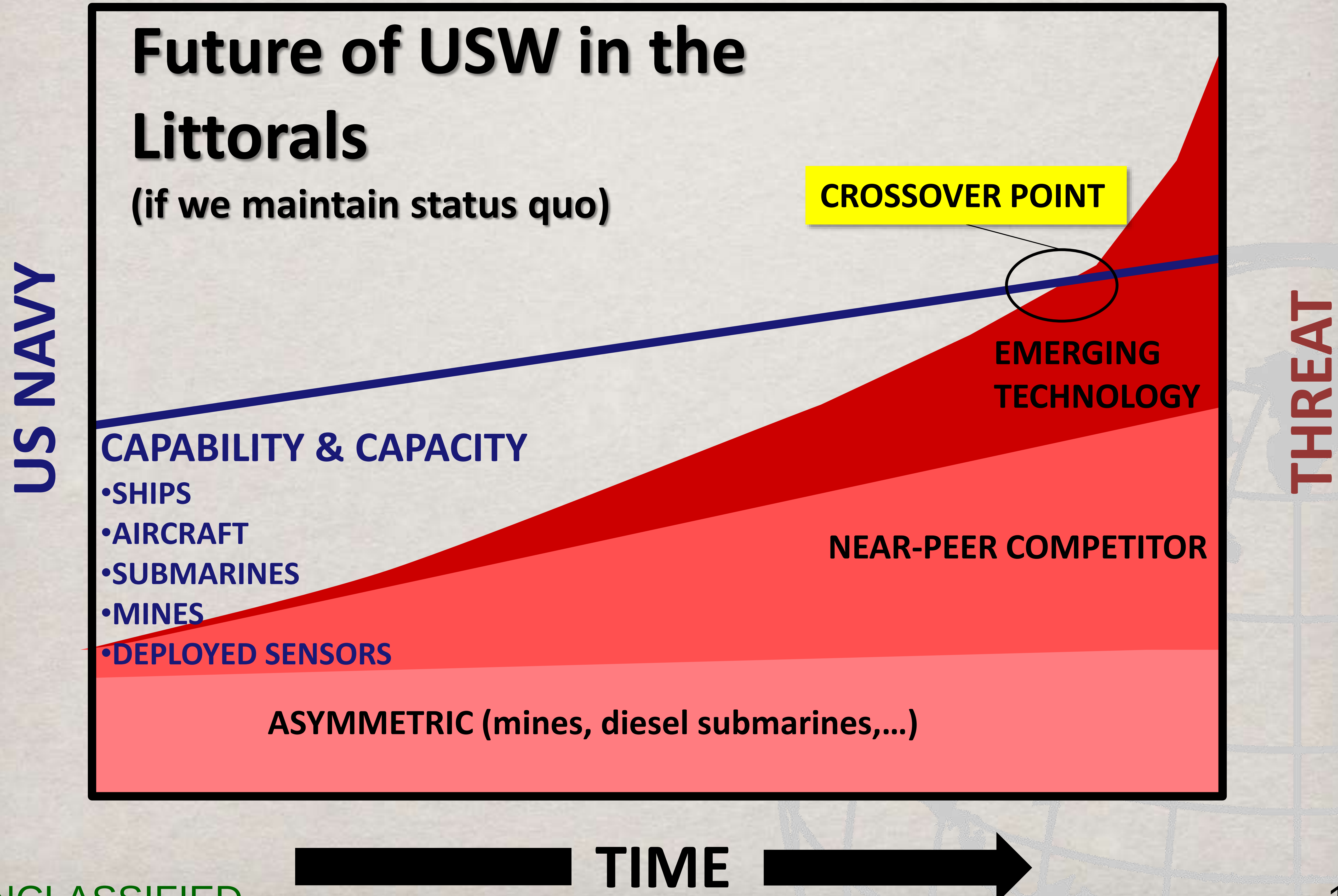
Problem Statement
Stakeholder Analysis
CONOP
Needs Analysis

Problem Statement

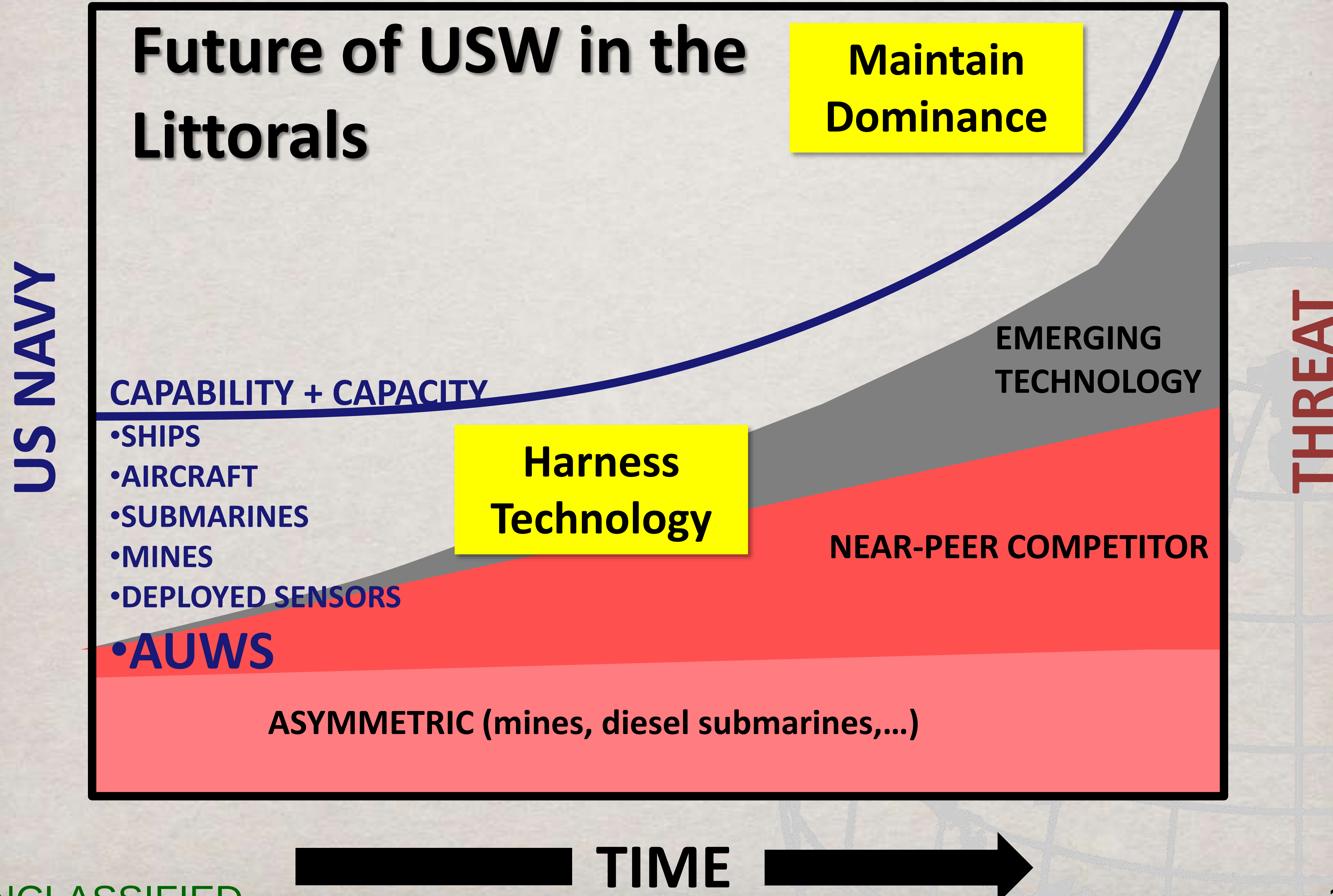
Over the next twenty years the capacity and capability of USW platforms will not meet operational demands in non-permissive areas. Furthermore, the emergence of near-peer competitor navies, the distributed nature of the asymmetric maritime threat, and the development of autonomous undersea threats present a unique challenge that current platform-centric solutions are not ideally designed to confront.

Control the undersea battlespace with weapons and sensing superiority!

A Visual Representation

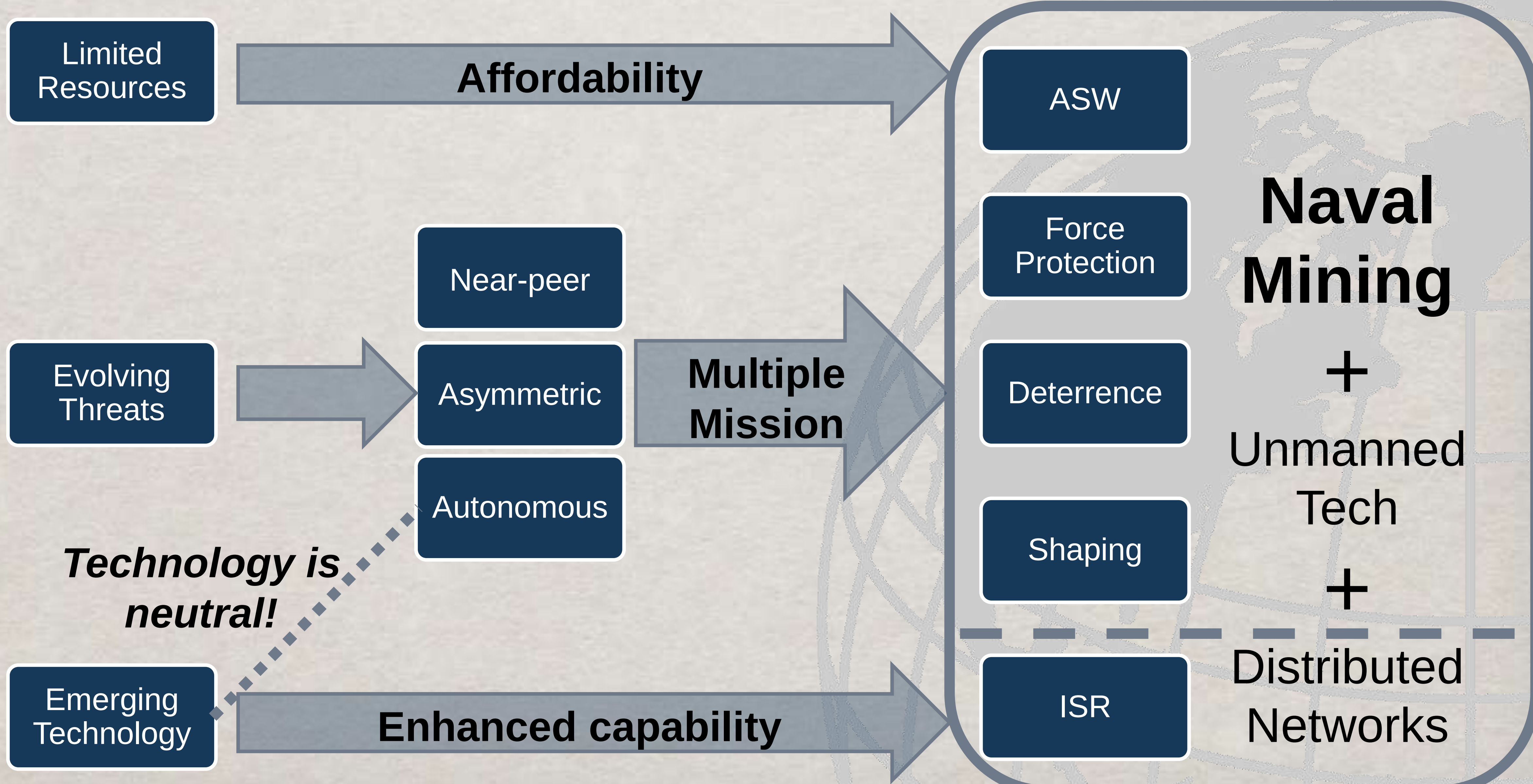


Closing the Capability Gap

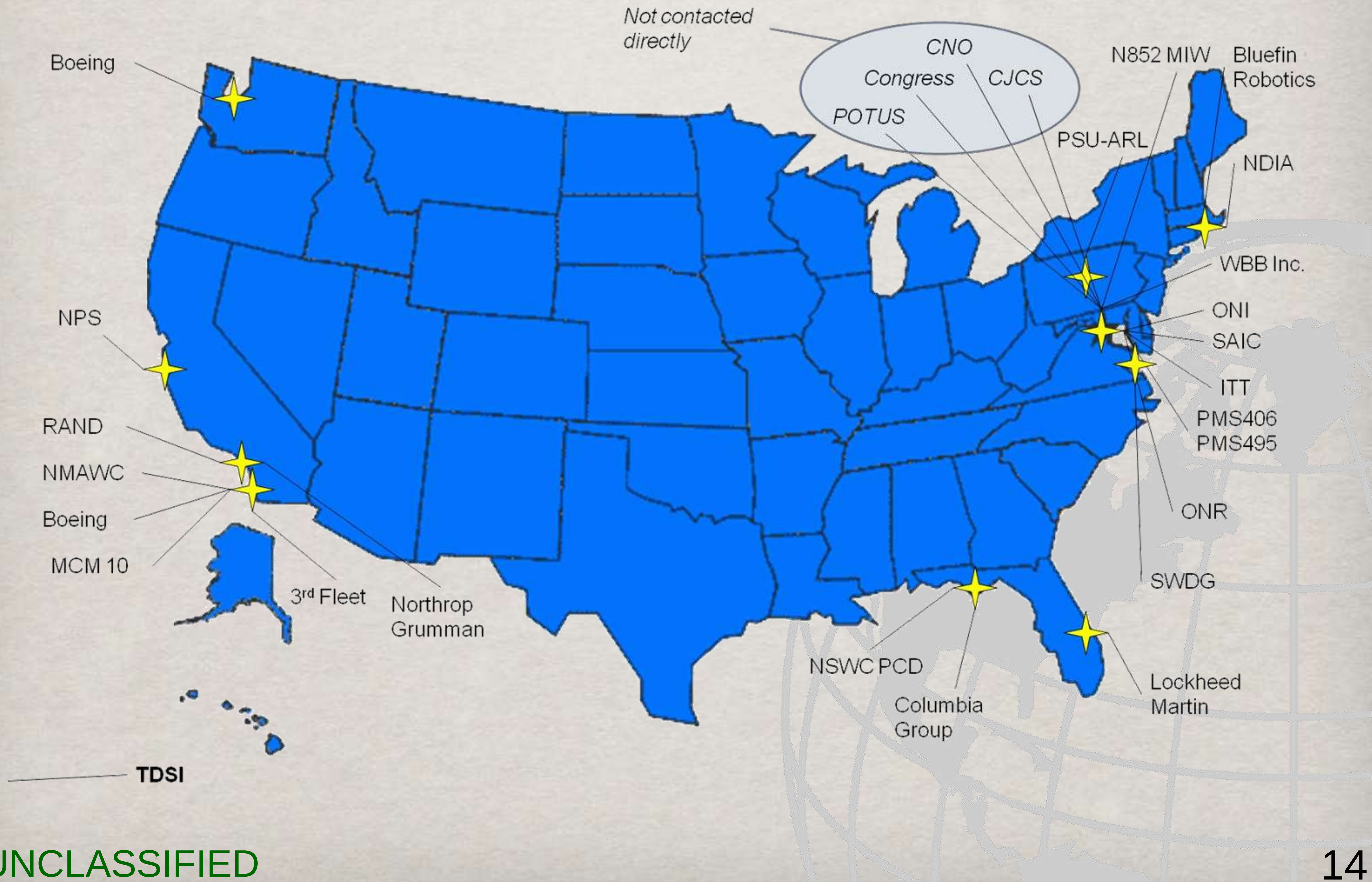


Considering Mission Areas

Limited resources, evolving threats, and emerging technologies all suggest leveraging the benefits of Mine Warfare in the undersea environment.



Stakeholder Analysis



Stakeholder Matrix

		Decision Makers	Integrators	Implementers
Internal	Operational	POTUS, SECDEF, SECNAV, CNO	COCOMs, CSG, ESG	CO, Wardroom, Crew
	Industrial	CEO	Engineers	Technicians
	Acquistions	POTUS, Congress	DOD Acq	SUPPO/SK
	RDT&E	PEO	LSE	SME
External	US	Taxpayers		
	Friendly	Concerned Global Citizens and Governments		
	Neutral	Concerned Global Citizens and Governments		
	Hostile	Affected Population and Government		

Concept of Operations

0	1	2	3	4
Shape	**Deter**	**Seize**	**Dominate**	**Stabilize**
COVERT ISR •Clandestine insertion •Battlespace preparation •ISR for Intelligence Operations	**SMART "MINE" THREAT** •Hold-at-risk •Early Warning •Show of force	**ENGAGE-MENT** •Engage hostile targets as directed	**PERSISTENT ASSET** •Area Denial •Maintain persistent presence	**FORCE MULTIPLIER** •Protect friendly assets •Monitor area to contribute to COP

Needs Analysis

Section 3

Functional Analysis
Alternative Generation
Design of Experiments

Functional Analysis – I/O

INPUTS

Controllable:
- Power Consumption
- Operator Inputs
- System Parameters
- Mission Data
- Training Methodology
- Peer System Input

Uncontrollable:
- Contact Signature
- Unknown Threat Tactics
- Weather
- Environmental

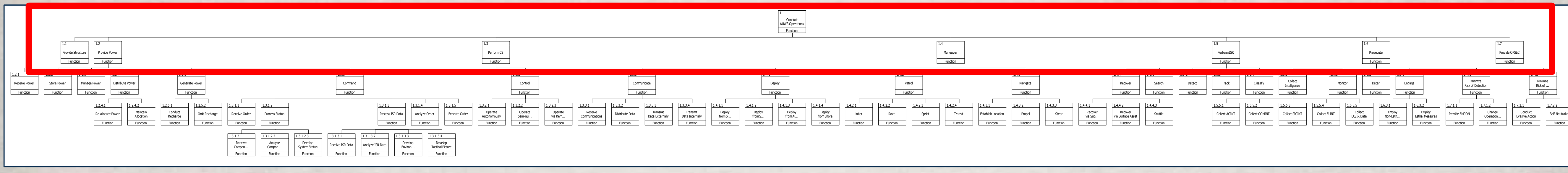
AUWS

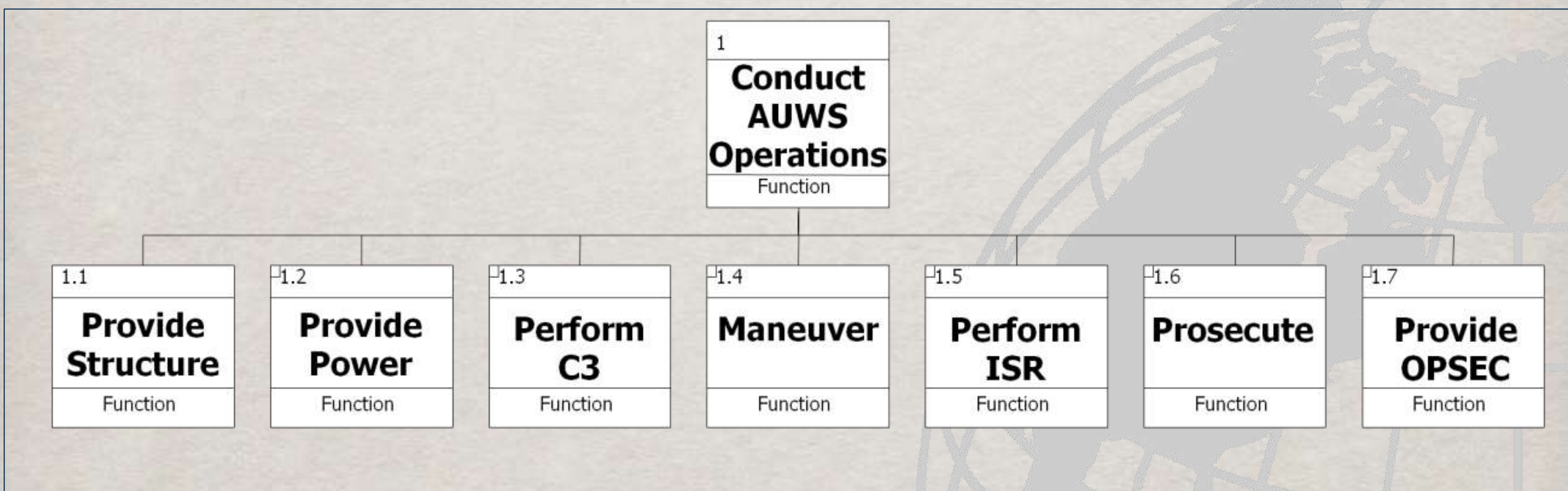
OUTPUTS

Intended:
- Threat Classification
- Threat Prioritized
- Mobilization of Kinetic Subsystem
- Automated Engagement of Threat
- Threat Elimination
- Sensor Data
- Communication with Command and Control
- BDA

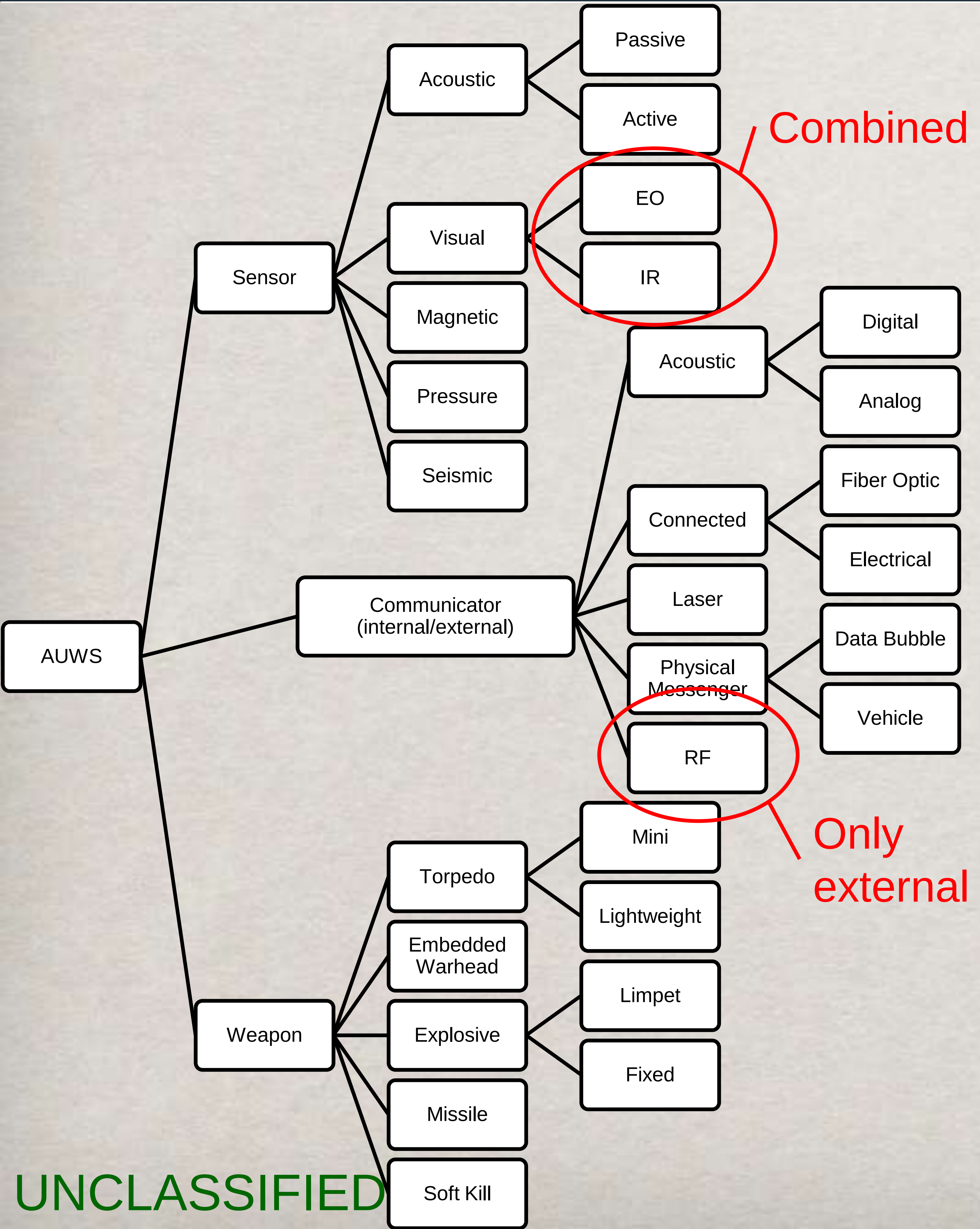
By-Products:
- Unintended Casualties
- “Stray” Signals
- Impact to Ecosystem

Functional Analysis - Decomp





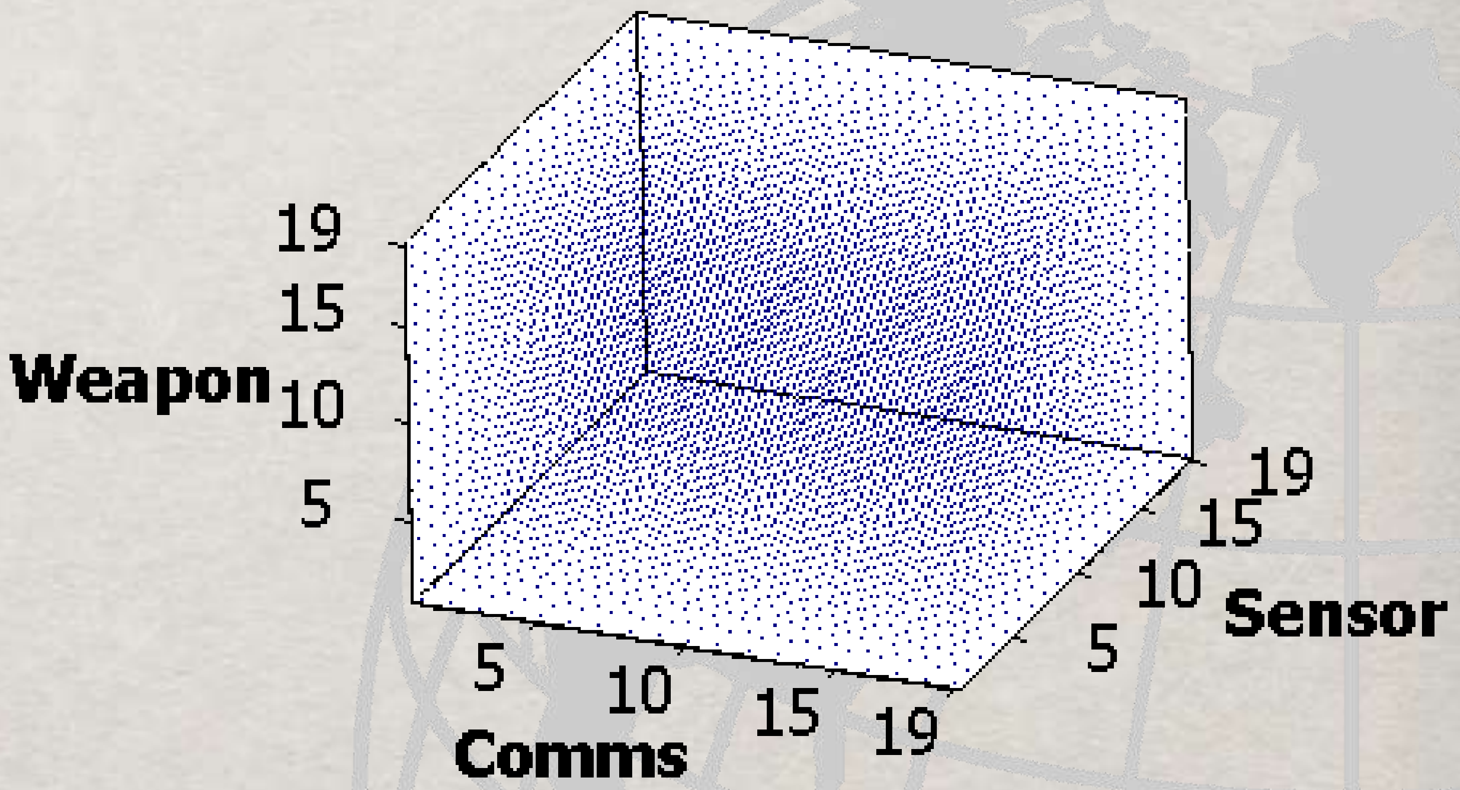
Alternative Generation



- 3 elements, 7-8 variants
  - Over 1 billion possibilities
- Eliminated infeasible, least promising variants
  - Warfare Innovation Workshop
  - 33,000 possibilities
- Made operational assumptions
  - 48 possibilities
- Work groups
  - 7 preliminary concepts
- Scoring and Screening
  - 4 concepts selected

Design of Experiments

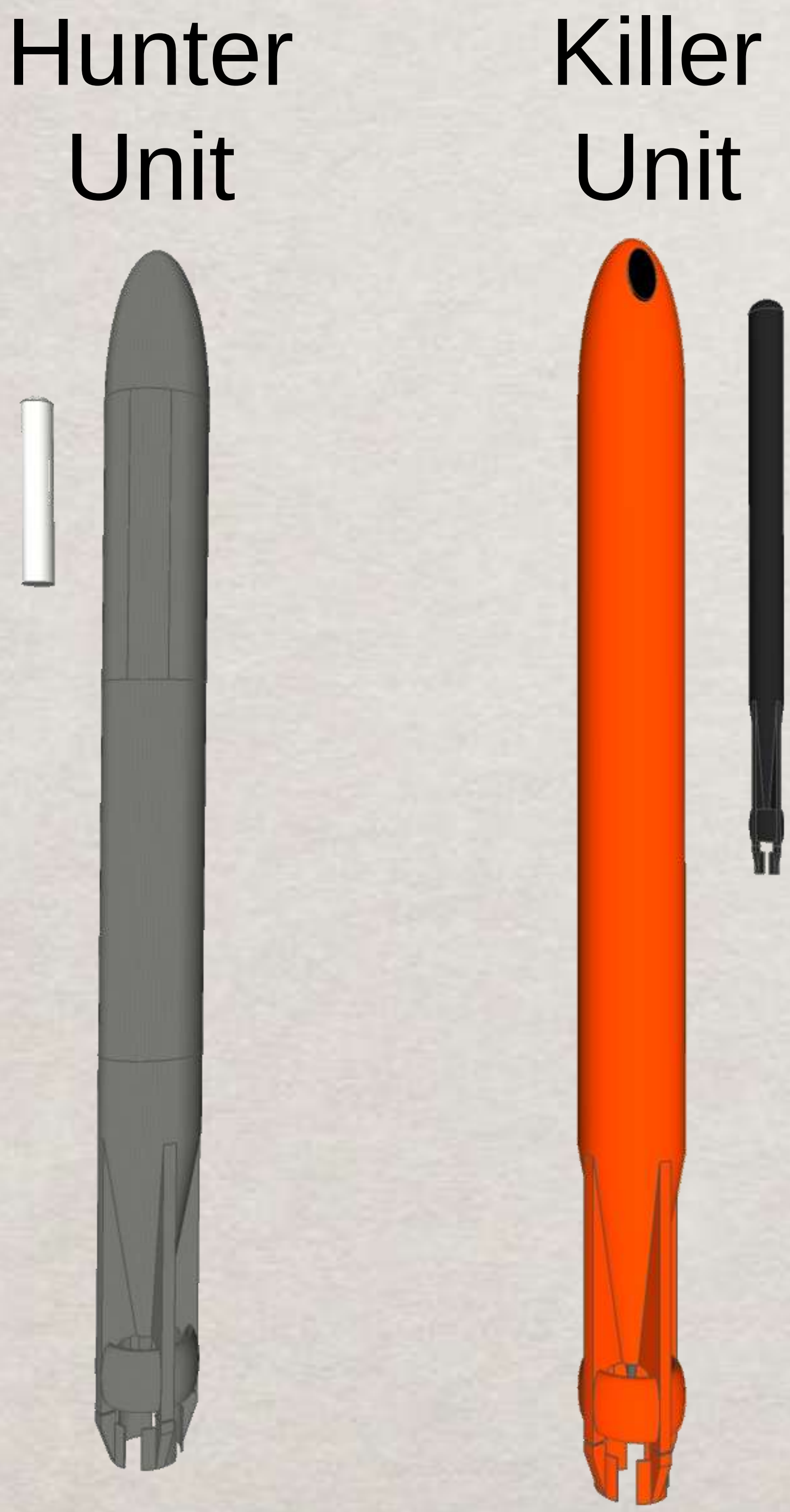
- Used as a validation tool
  - Goal: adequately cover the design space
- Critical elements (Factors)
  - Weapons, sensors, and communicators
- Levels
  - Large/small
  - Centralized/distributed
  - Smart/dumb
  - Mobile/stationary
  - Combined/separate
- *Led to a change from Swarm to LD-UUV*



Section 4

Design Concept Overview
V-CAP
LD-UUV
Glider
Squid

V-CAP Diagram



Twin torpedo-shaped autonomous UUVs

Power
High-capacity Battery supplemented with wave-motion recharge unit

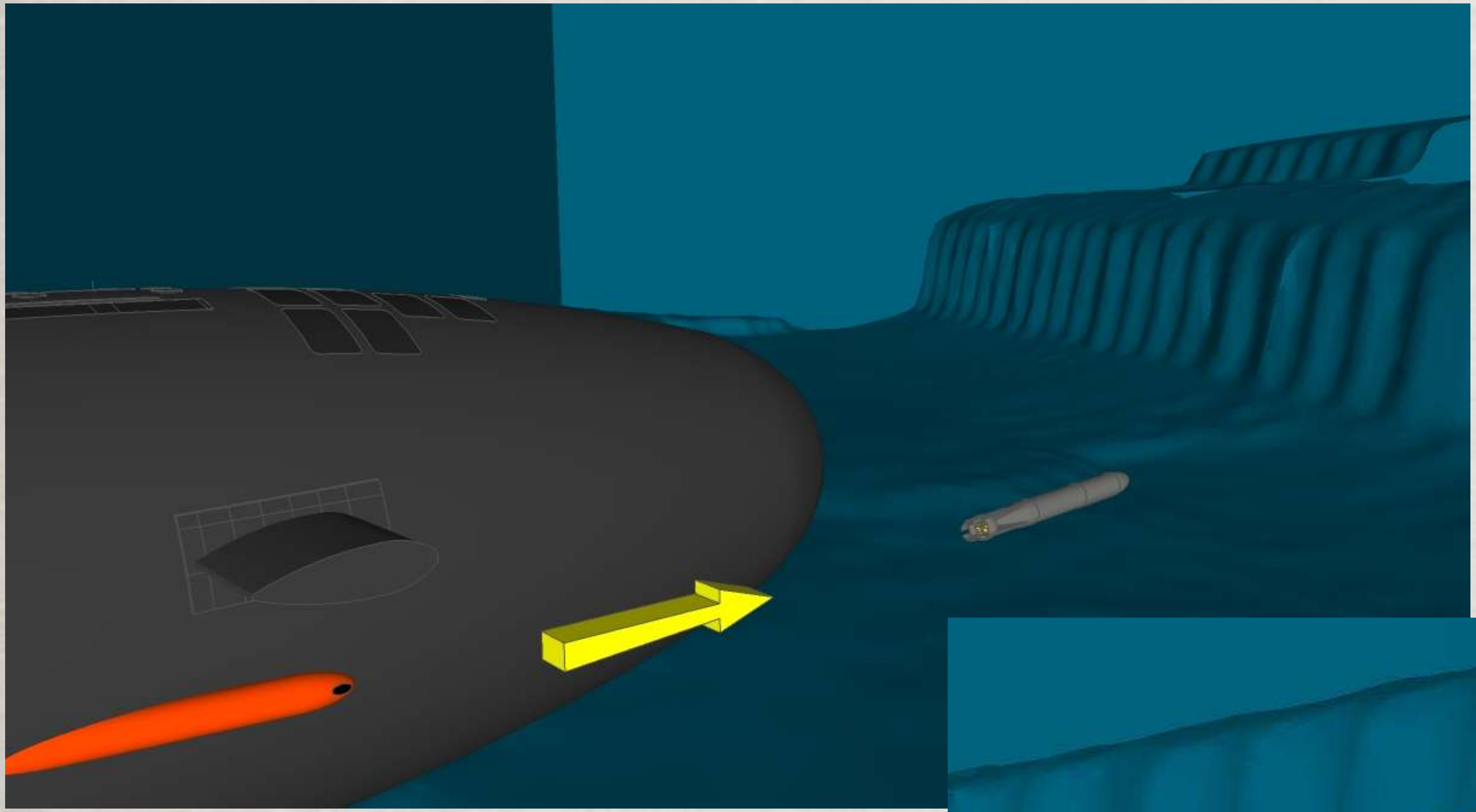
Mobility
Hybrid Electric/OTTO fuel propulsor

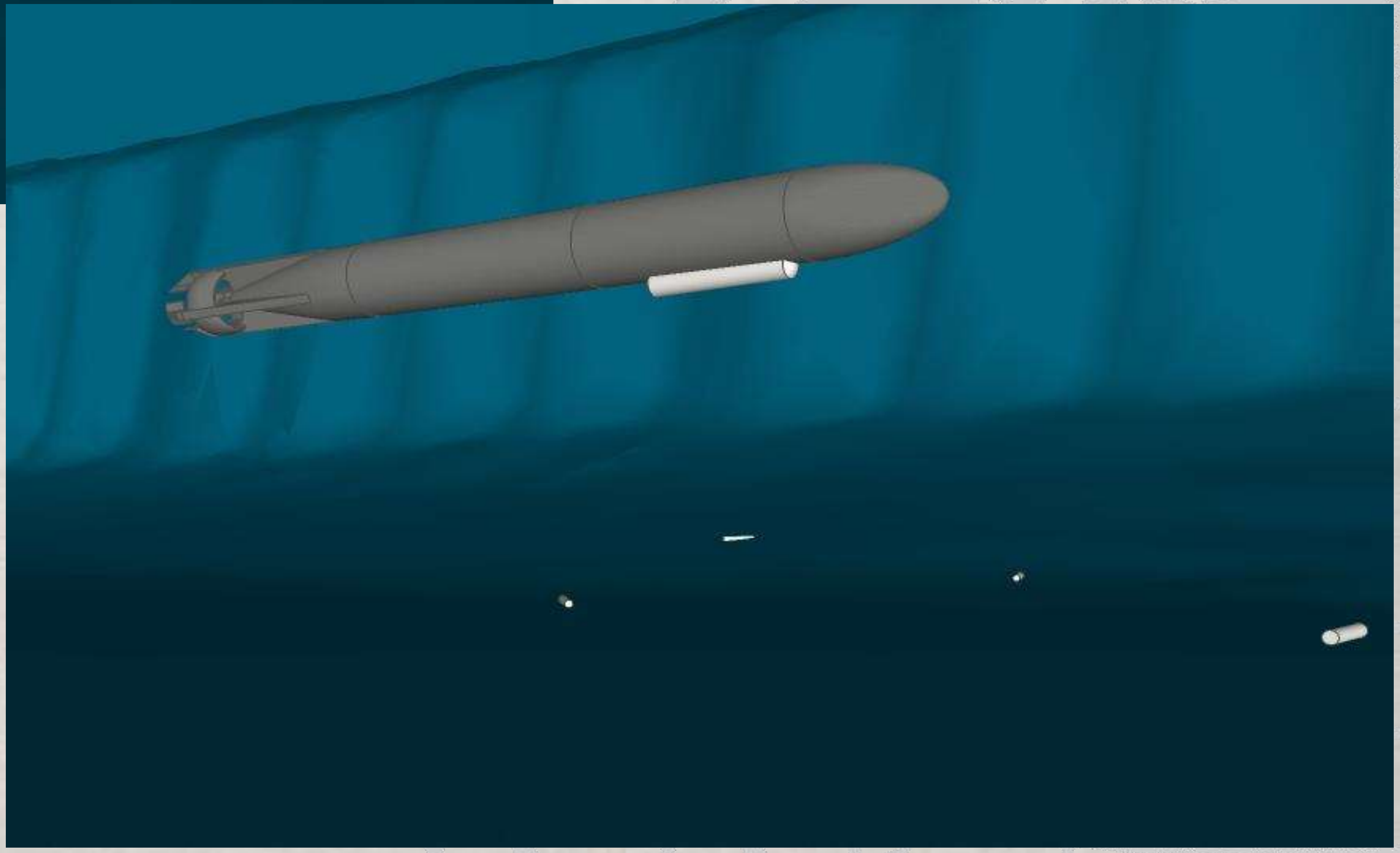
Communications
LOS RF, Iridium, and Acoustic modem (internal)

Sensors
Acoustic and EO sensors
Deployable distributed sensor nodes

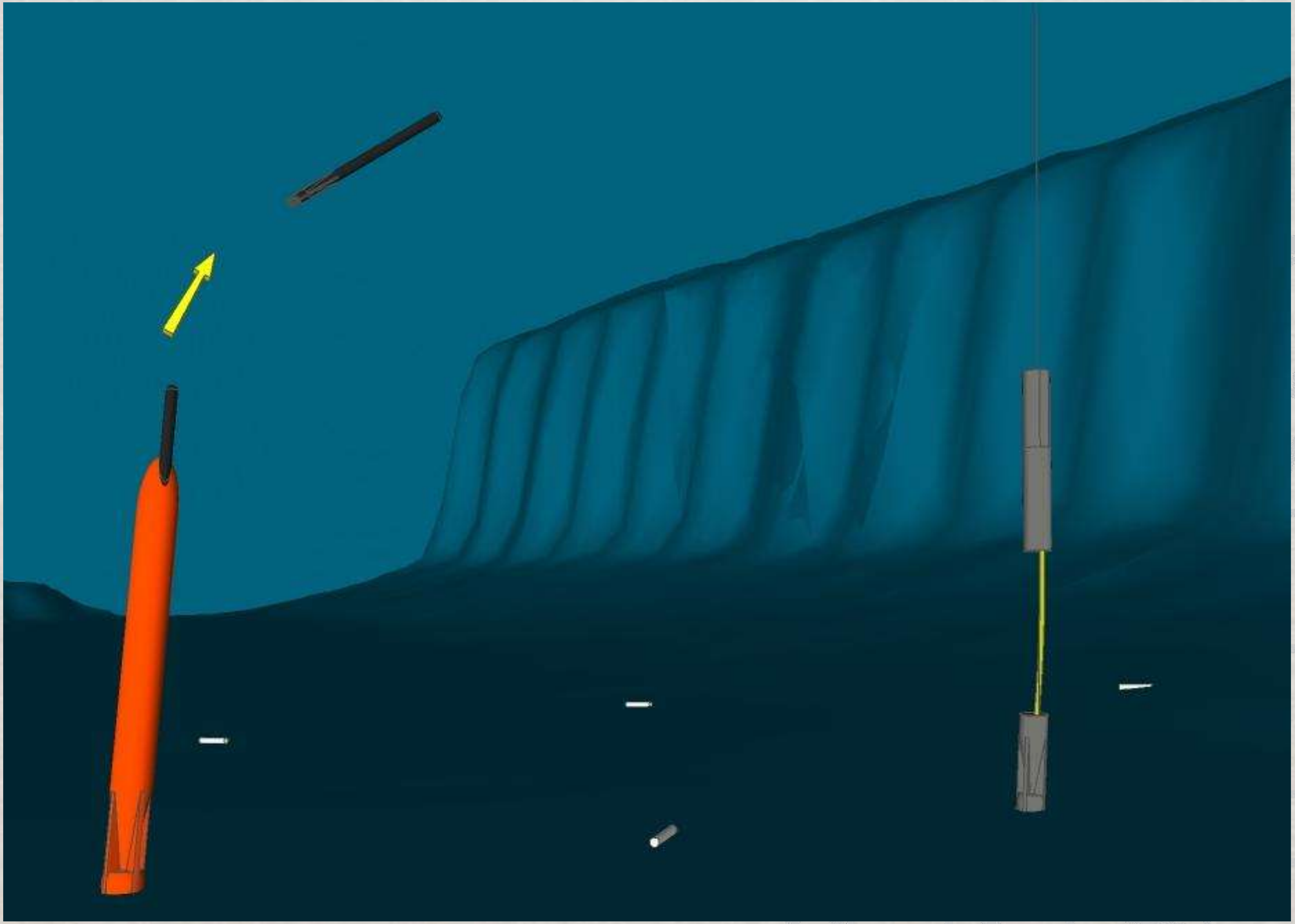
Armament
2x mini-torpedoes per Killer unit

V-CAP Deployment

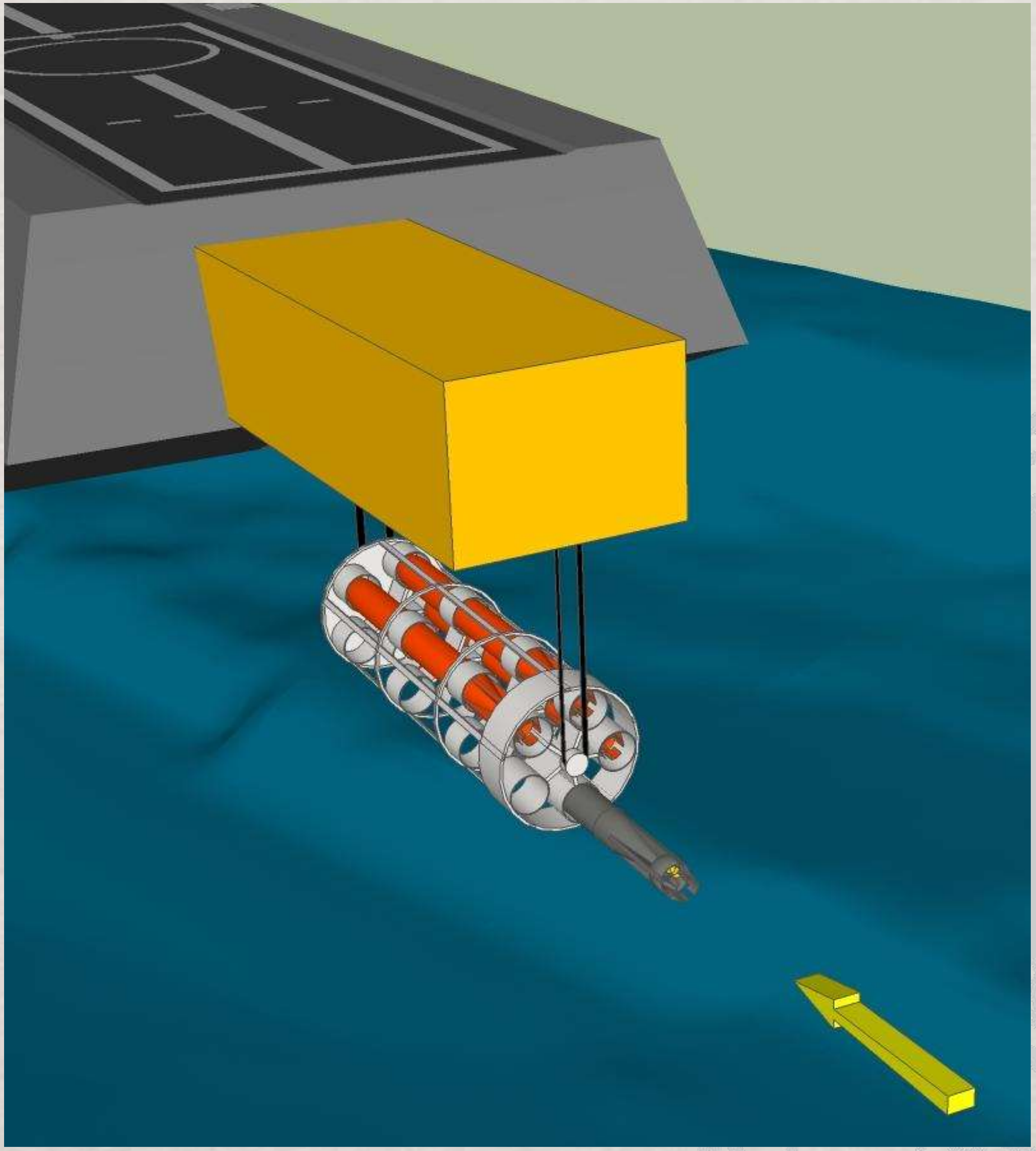




V-CAP Employment



V-CAP Recovery

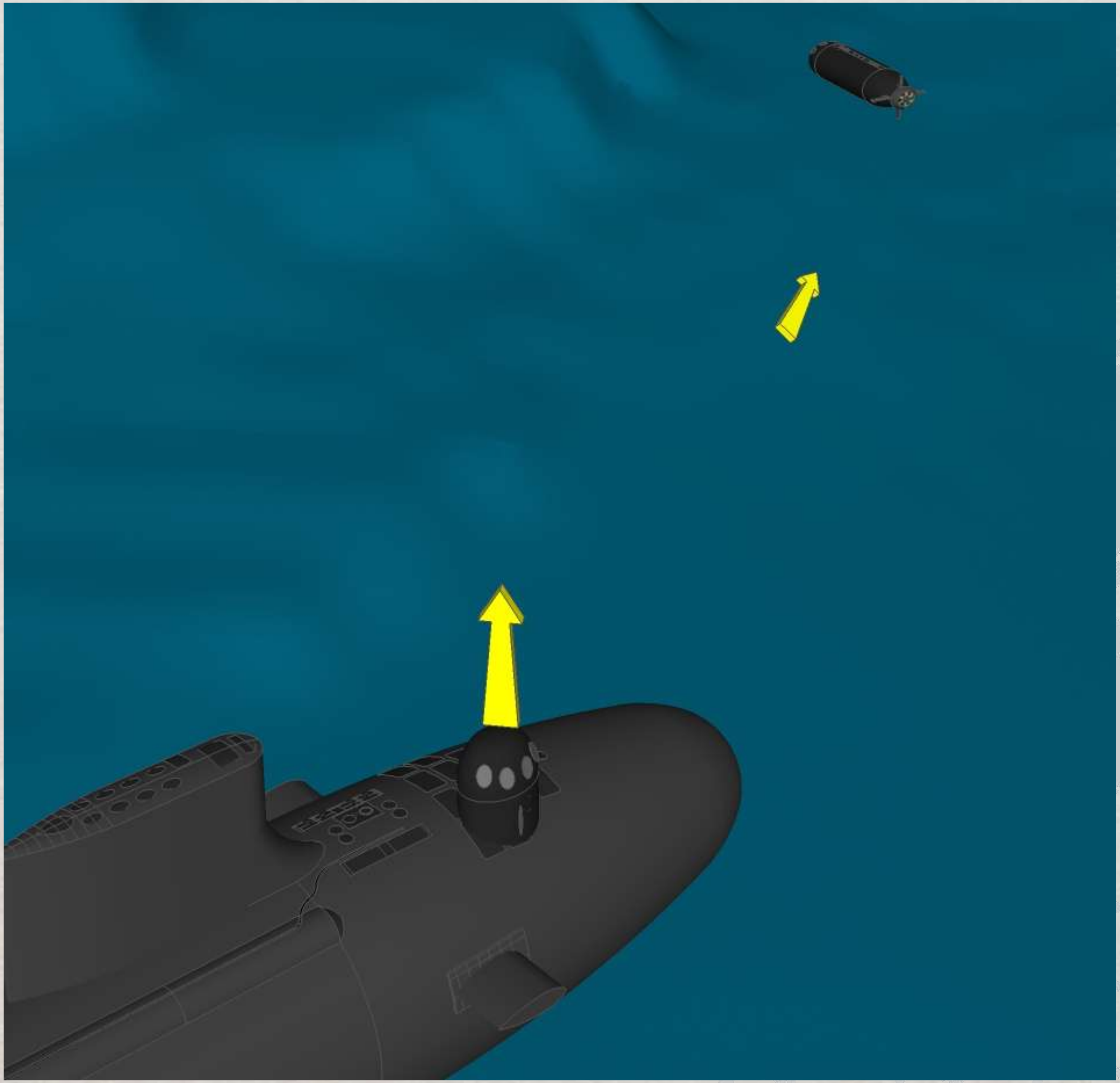


Large Diameter UUV Diagram

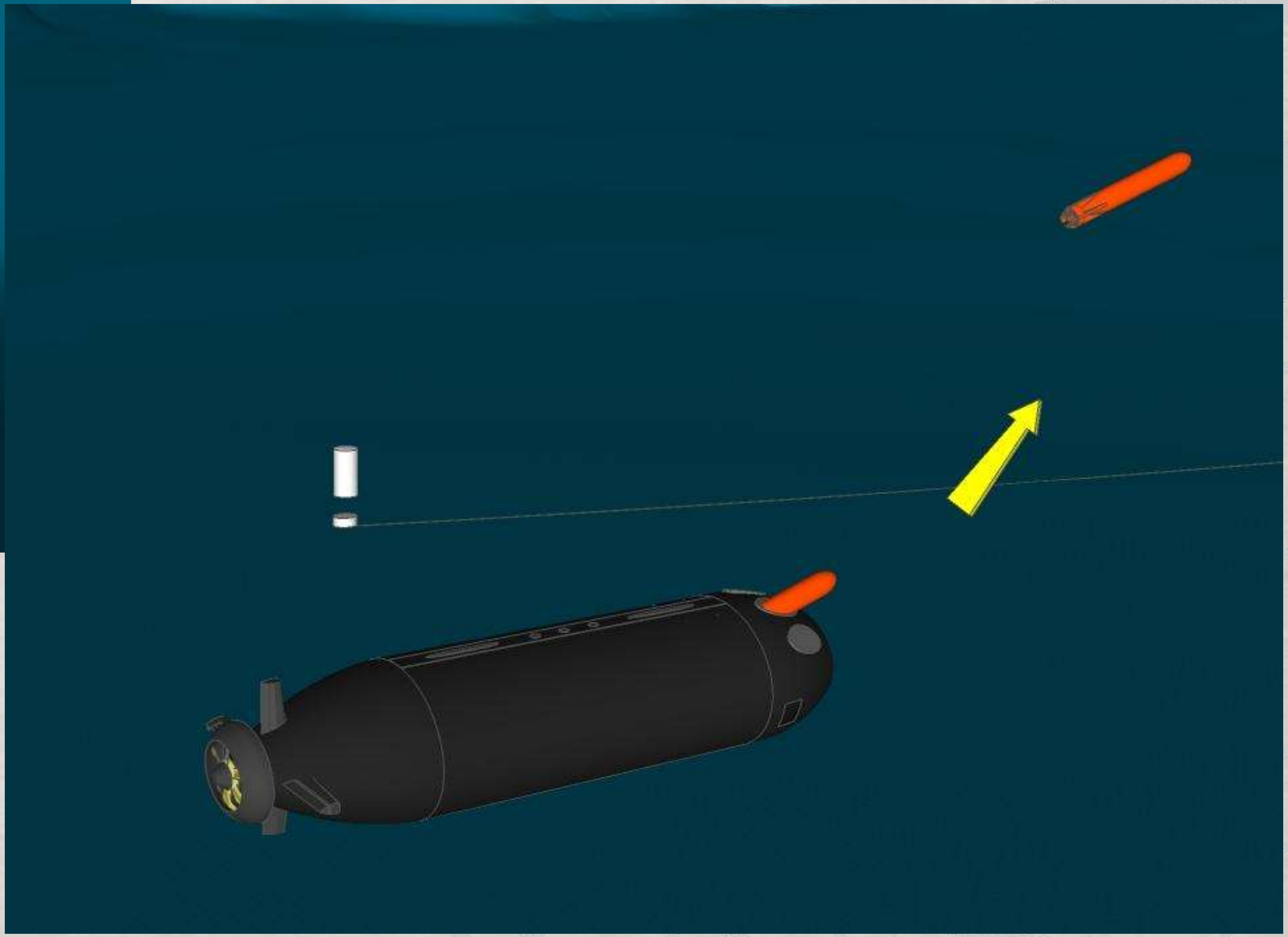
Large Diameter autonomous undersea payload delivery and engagement UUV

Power
High-capacity Battery
Mobility
Electric-drive propulsor
Communications
LOS RF, Iridium, and Acoustic modem (internal)
Sensors
Acoustic and EO sensors
Deployable distributed paired sensor nodes
Armament
4x lightweight torpedoes

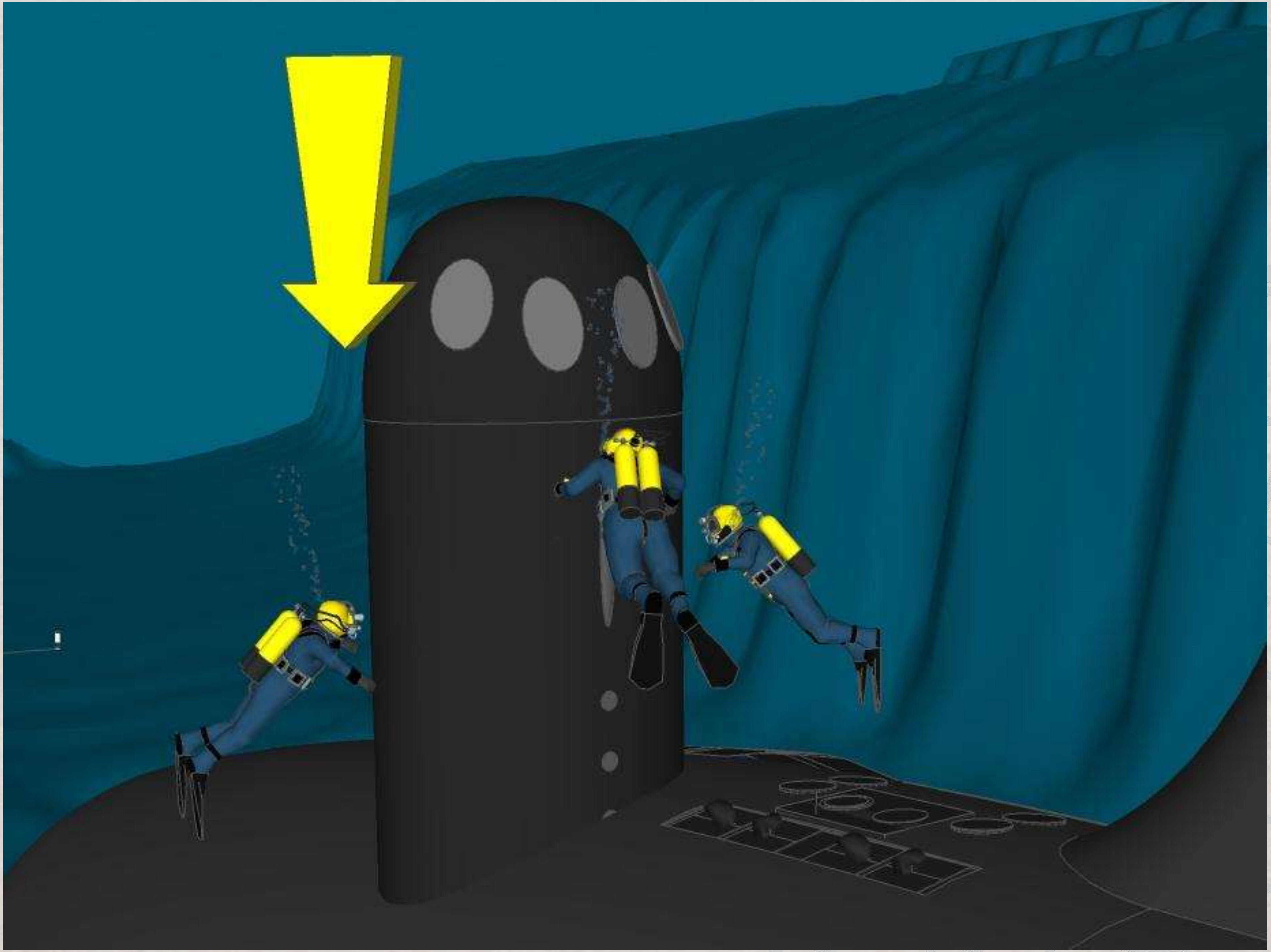
LD-UUV Deployment



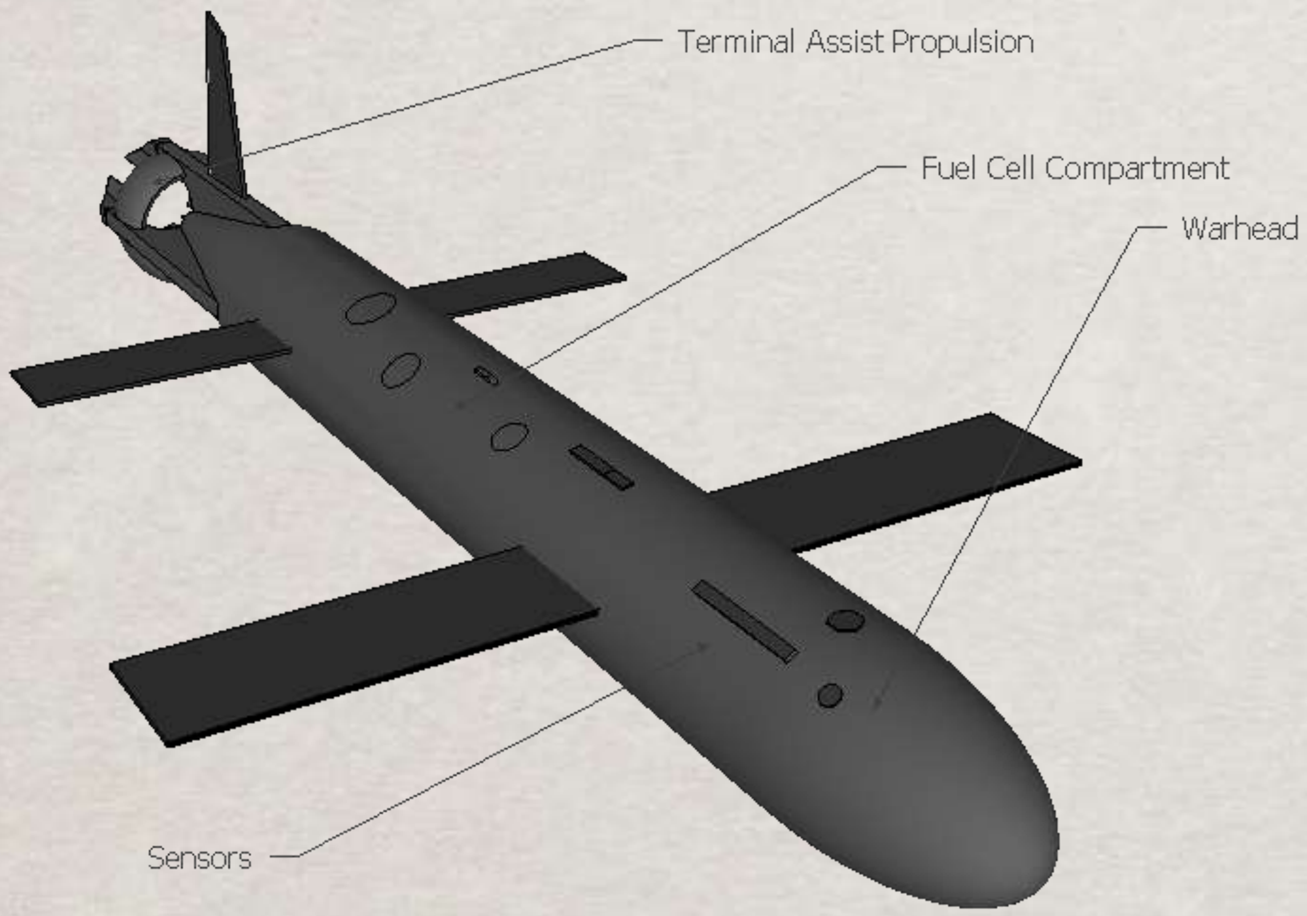
LD-UUV Employment



LD-UUV Recovery



Glider Diagram



Networked Autonomous high-endurance UUVs

Power
Fuel cell with supplemental solar cell recharge

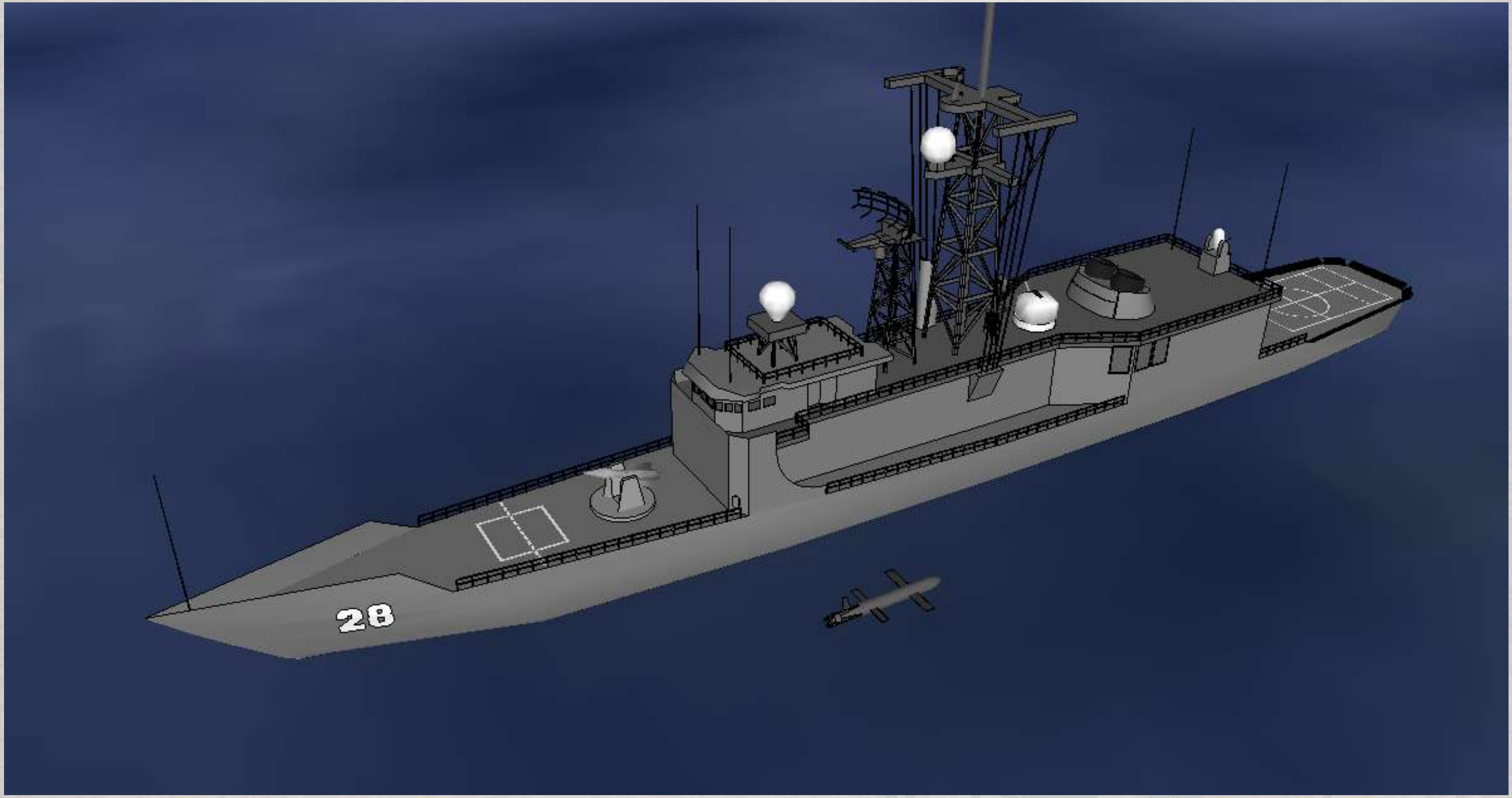
Mobility
Adjustable ballast and control surfaces with OTTO-fueled terminal homing propulsor drive

Communications
LOS RF, Iridium, and acoustic modem (internal)

Sensors
Passive sonar

Armament
10 kg HE shaped charge

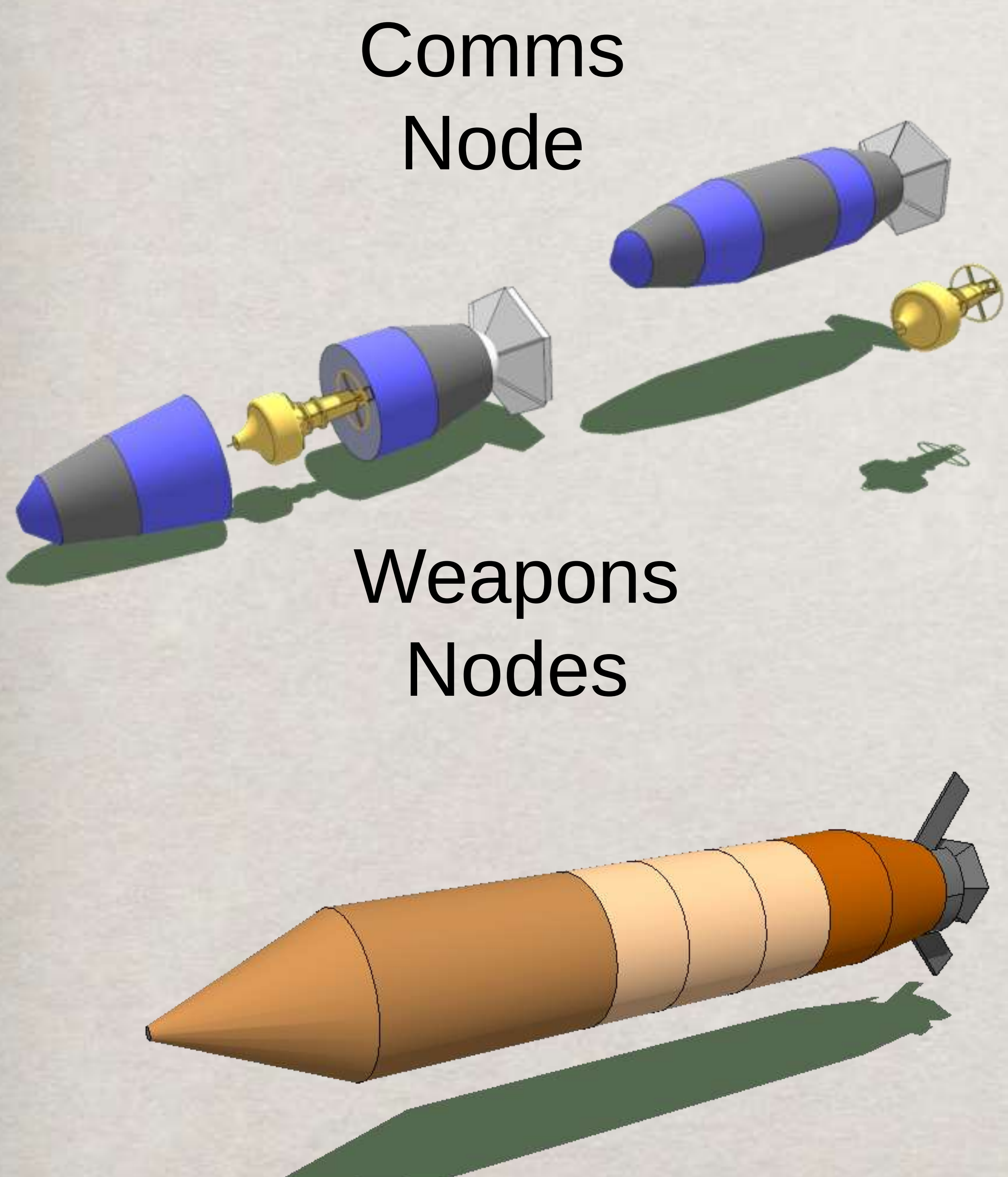
Glider Deployment



Glider Employment

Glider Recovery

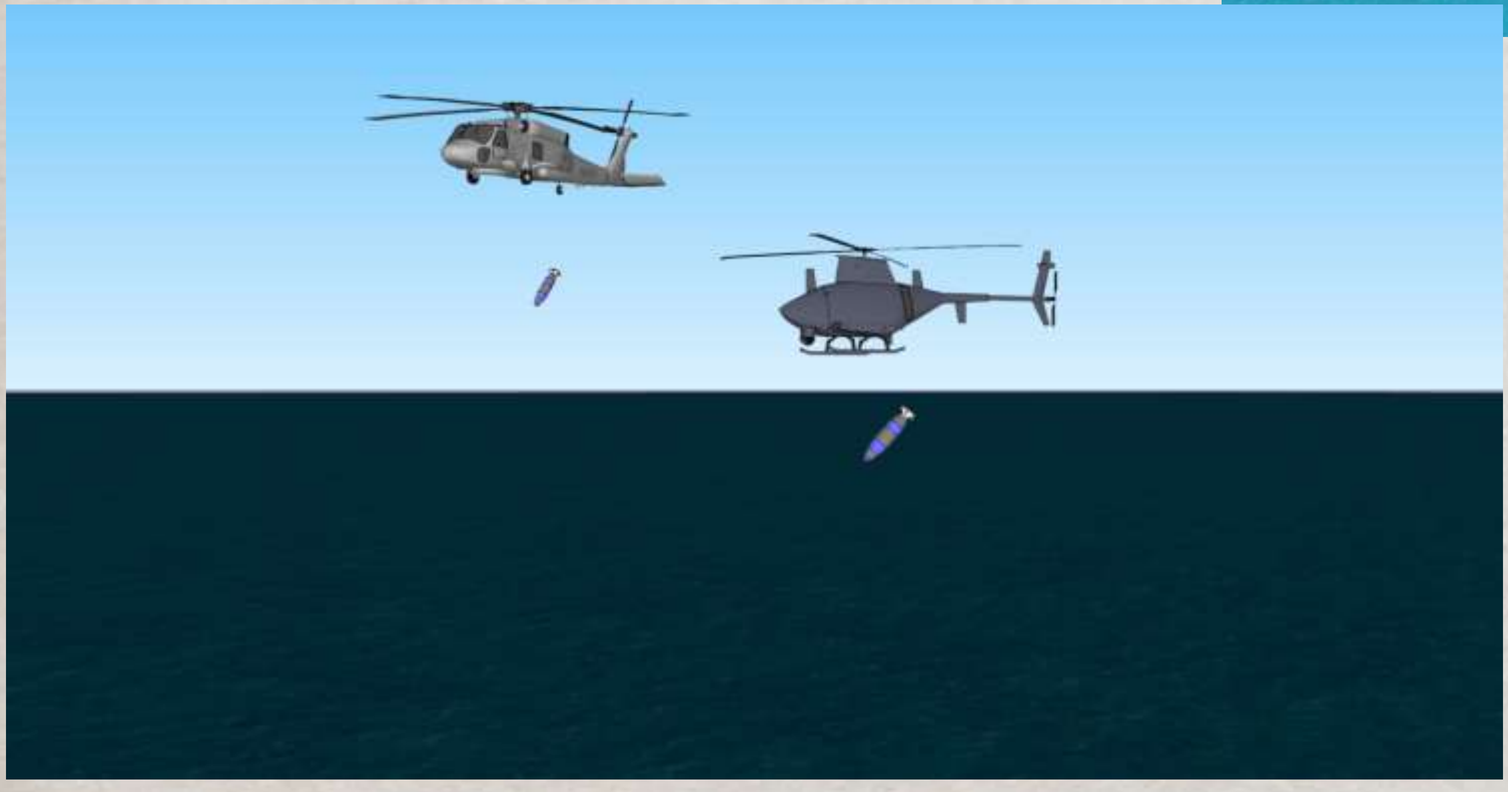
Squid Diagram



Distributed network of stationary weapons and comms nodes, each with onboard sensors

Power
Non-rechargeable batteries
Mobility
N/A
Communications
LOS RF and Iridium (external) and acoustic modem (internal)
Sensors
Passive sonar mounted to Weapons and Comms nodes
Armament
Multiple 1 kg HE sub-munitions

Squid Deployment



Squid Employment

Squid Recovery

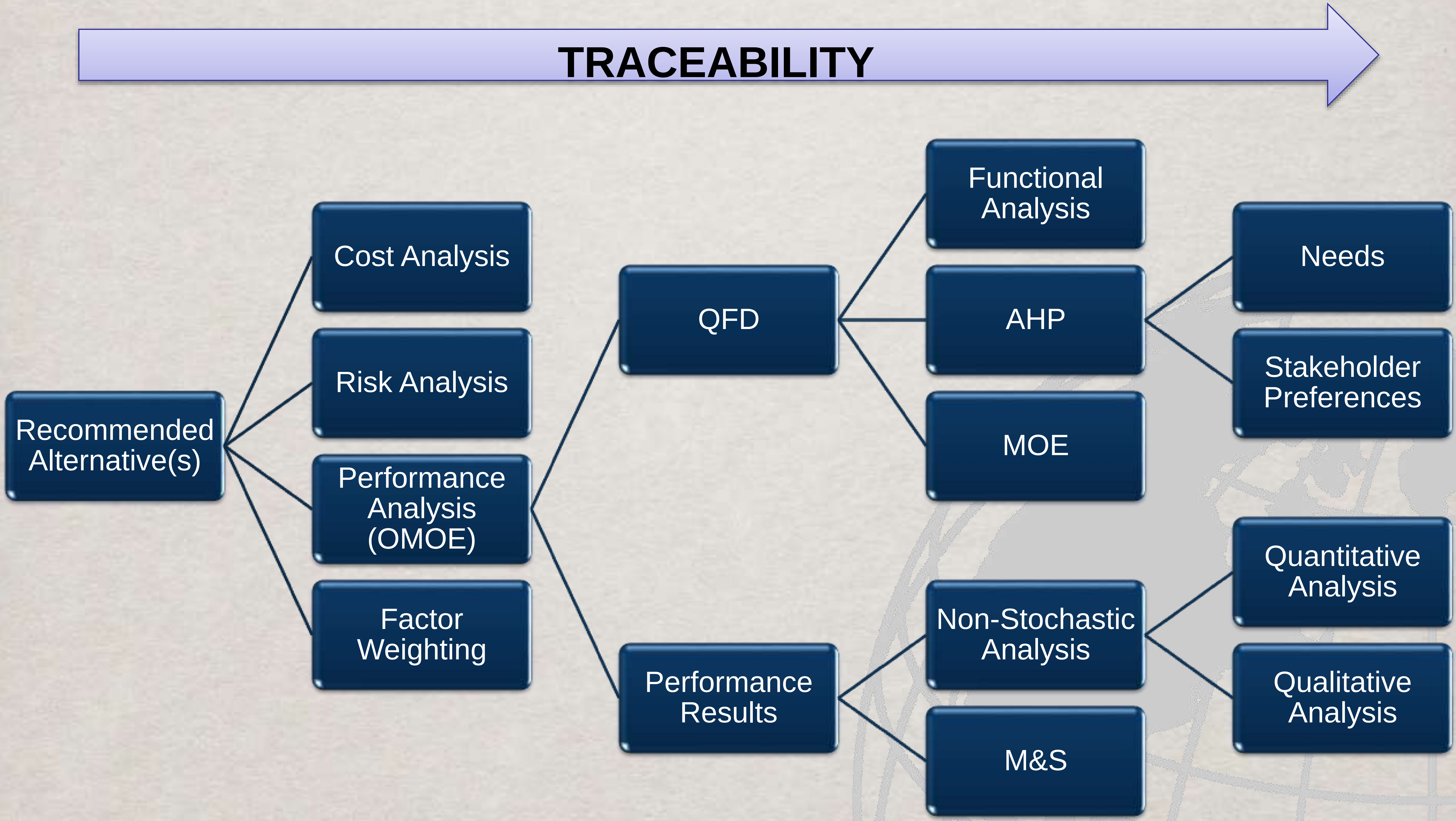
High Volume of Units + No Internal Propulsion = Recovery not Feasible

- Expendable design
- Disarm and Self-neutralize on command or via timer

Section 5

Analysis of Alternatives
Performance
Cost
Risk

AoA Methodology



Non-Stochastic Analyses

- MOE: Capability to Operate for a Minimum of 30 Days

Concept	Endurance in Days
V-CAP	123
LD-UUV	126
GLIDER	**987**
SQUID	16

- MOE: Capability for Deployment from Current and Future Platforms

Concept	Capability Score (1-3)
V-CAP	**2.5**
LD-UUV	1.5
GLIDER	1.0
SQUID	1.0

- MOE: Capability for Recovery by Current and Future Platforms

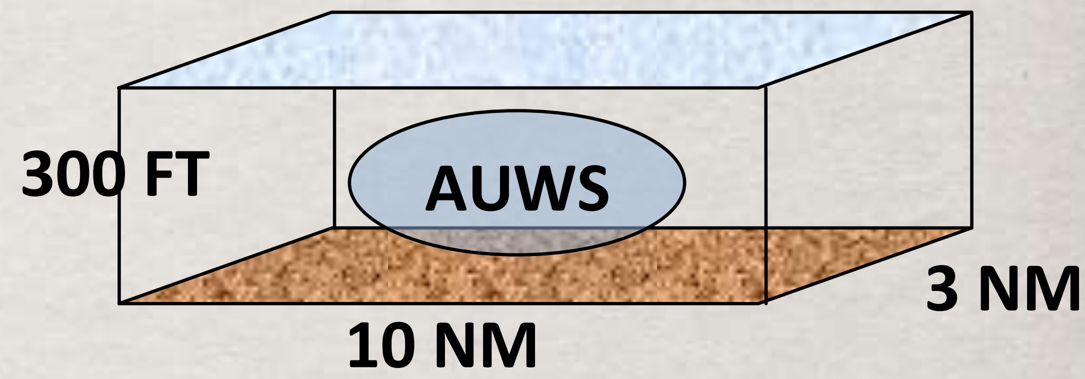
Concept	Capability Score (0-3)
V-CAP	**3.0**
LD-UUV	1.5
GLIDER	2.0
SQUID	0.0

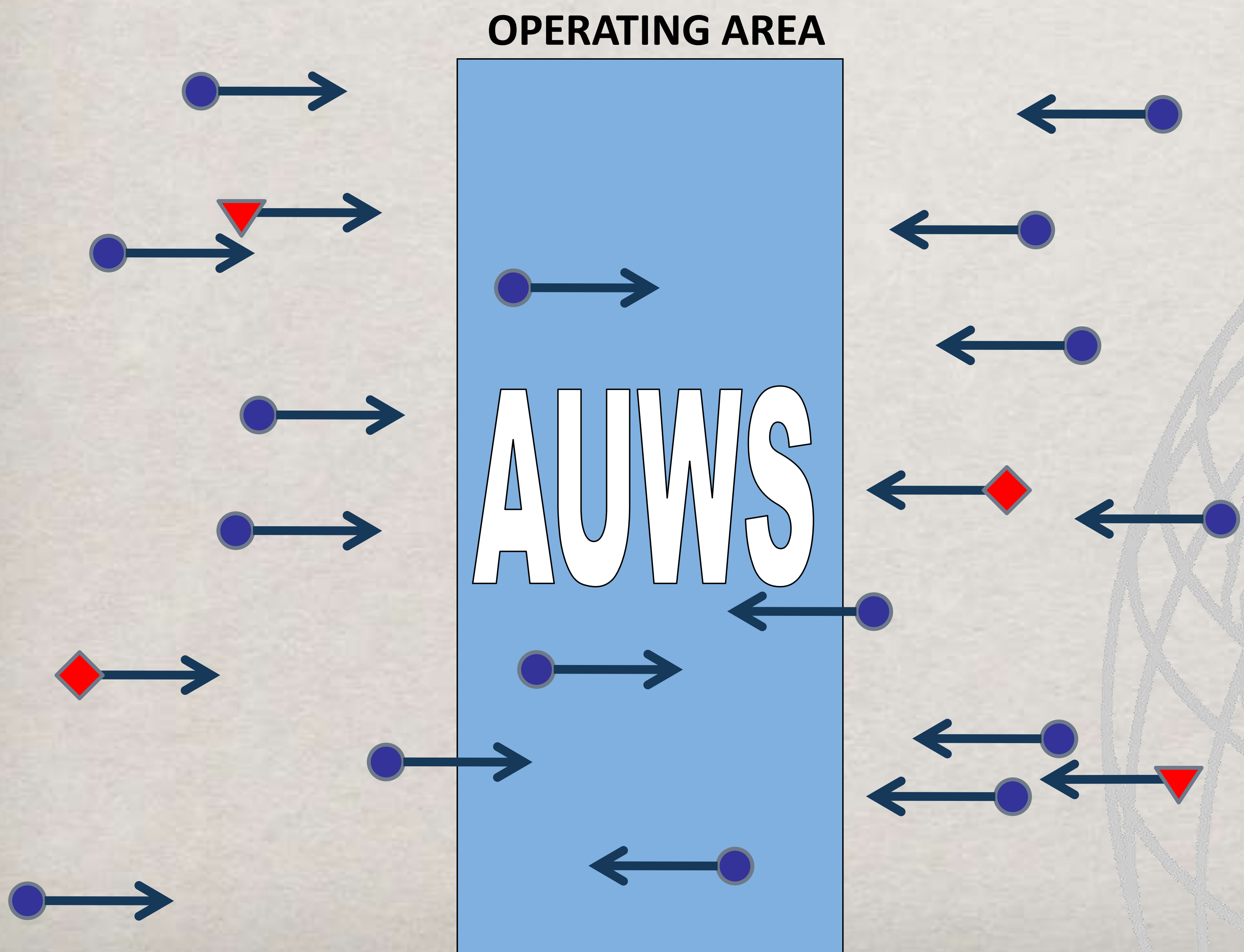
- MOE: Capability to Avoid Detection

Concept	Capability Score (0-1)
V-CAP	**1.0**
LD-UUV	**1.0**
GLIDER	0.25
SQUID	0.5

Model Scenario

- Neutral/Friendly Surface Vessel
- Threat Surface Vessel
- Enemy Submarine





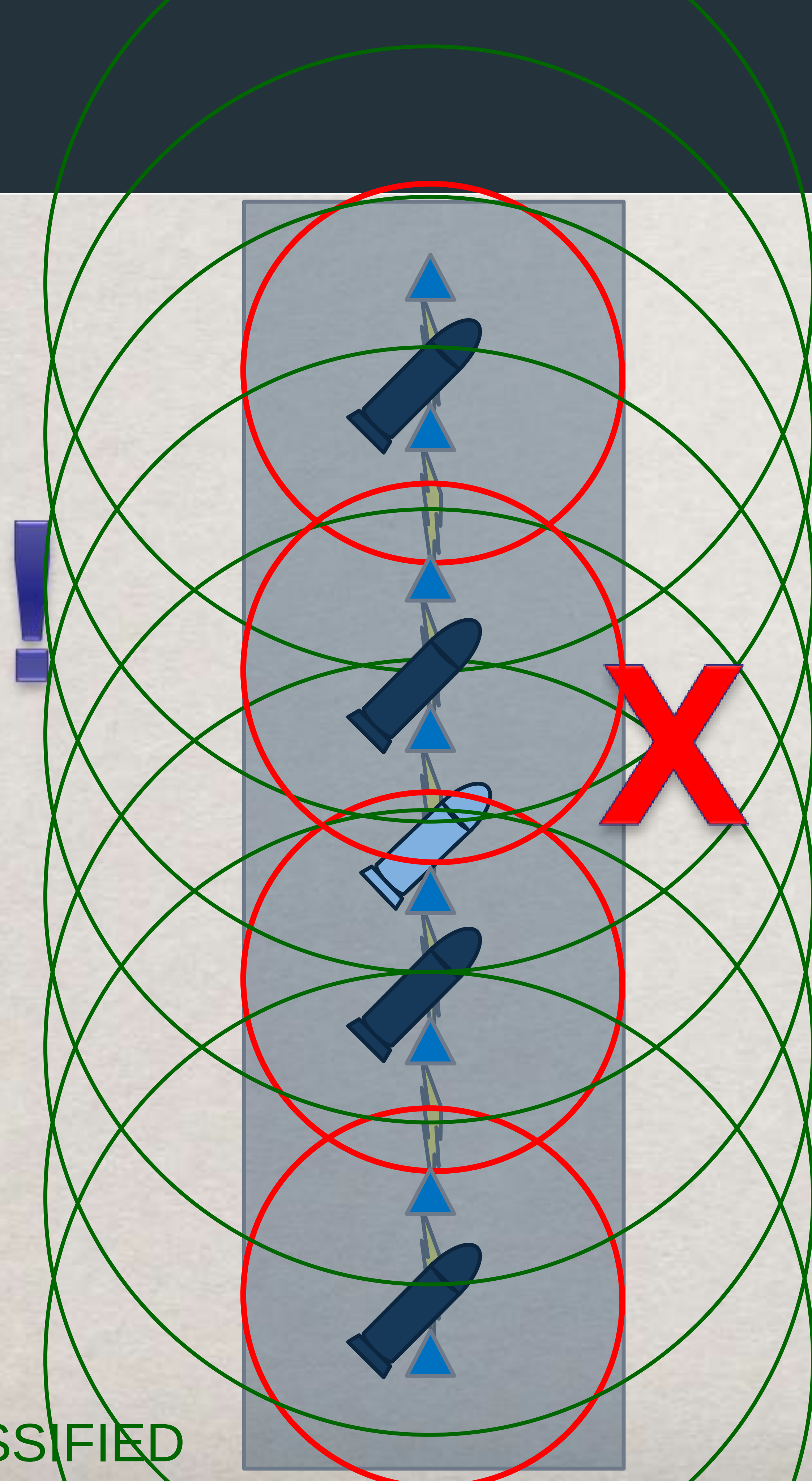
Environmental Characteristics

Sea State: 2-3
Winds: <30kts
Currents: <5kts
Depth: 300 ft
Bottom Type: Mud, Sand

Traffic Characteristics

Vessel Type: Various (merchants, tugs, fishing boats, small and large naval ships, and submarines)
Average Speed: 15 kts
Arrival Rate: 7 ships/hr
Threat Frequency: 5%
Position: Uniformly Distributed on Long Axis
Ambient Noise: Heavy Traffic in Shallow Water

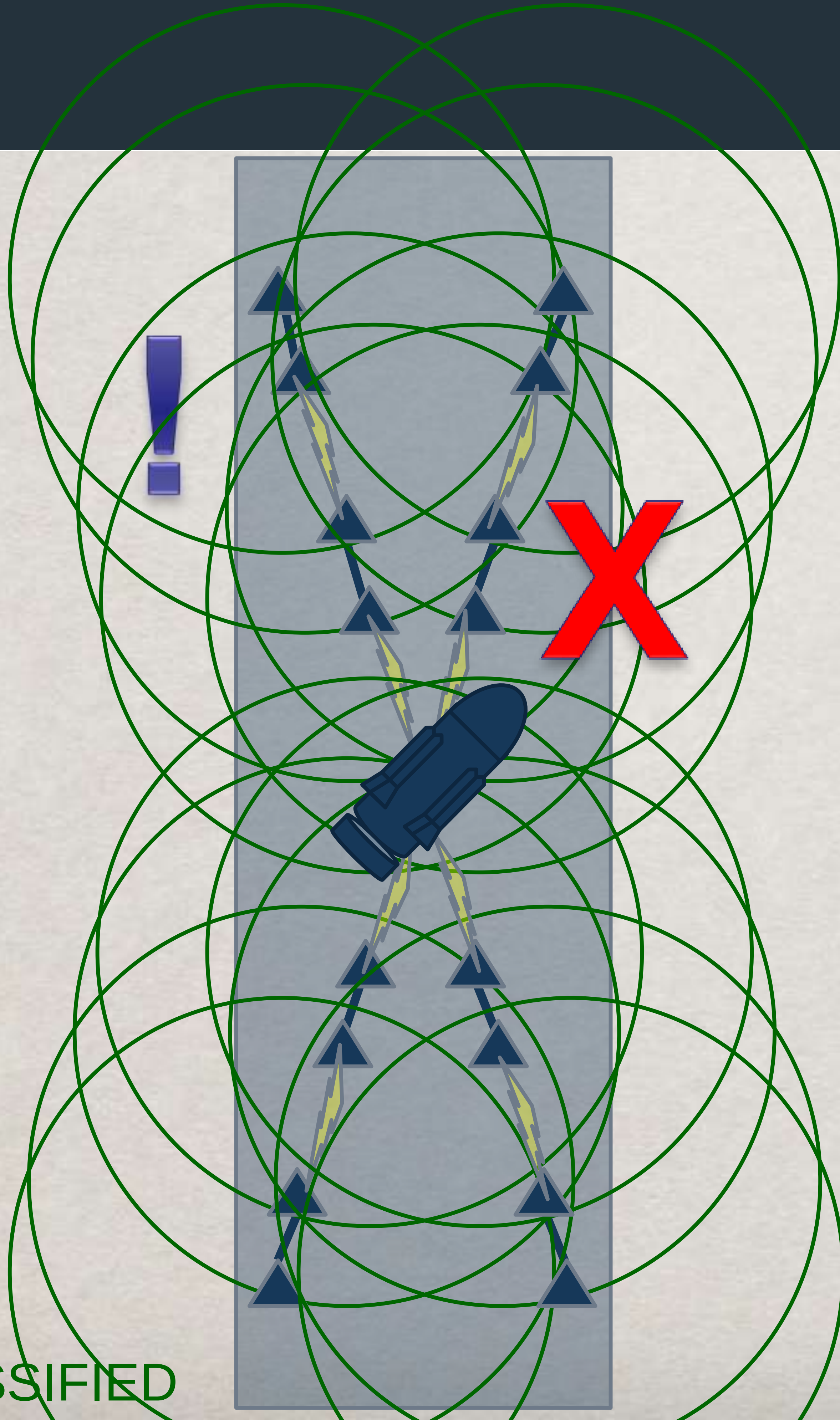
V-CAP Model



<u>4 Killers with 2 CRAW torpedoes each, 1 Hunter with 8 sensor nodes</u>

- Sensor Range: 2.7 nm
- Comms Range: 1.6 nm
- Kill Range: 3000 yds
- Hunter serves as gateway
- Sensor Nodes report all contacts and relay all messages

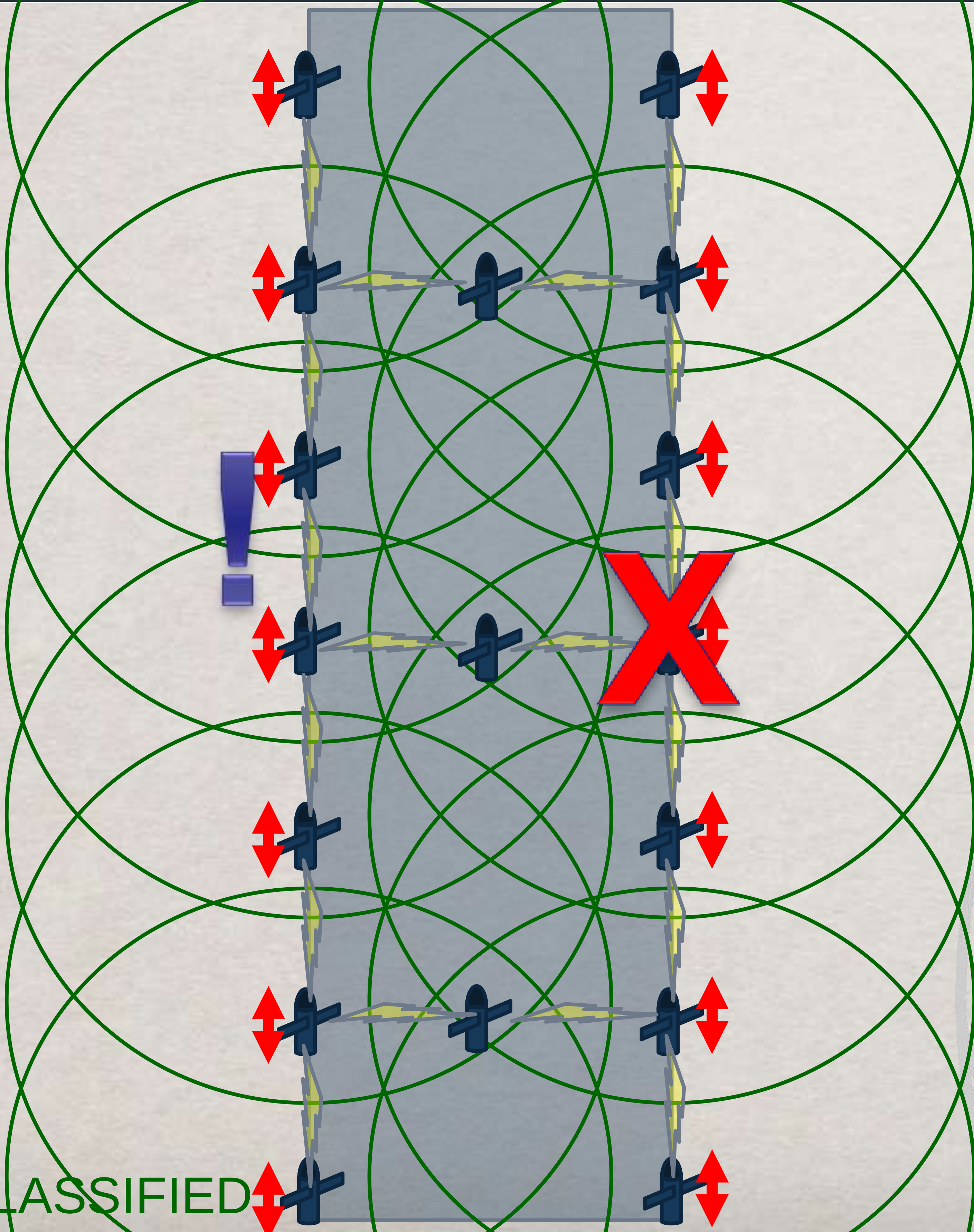
LD-UUV Model



<u>1 LD-UUV, 16 sensor nodes, 4 Mk-50 torpedoes</u>

- Sensor Range: 2.0 nm
- Comms Range: 1.2 nm
- Kill Range: > 10 nm
- Cable: 1000 yds (8 pairs)
- At least 2 nodes required for classification
- Nodes “decide” which contacts to report (group based)
- UUV serves as gateway

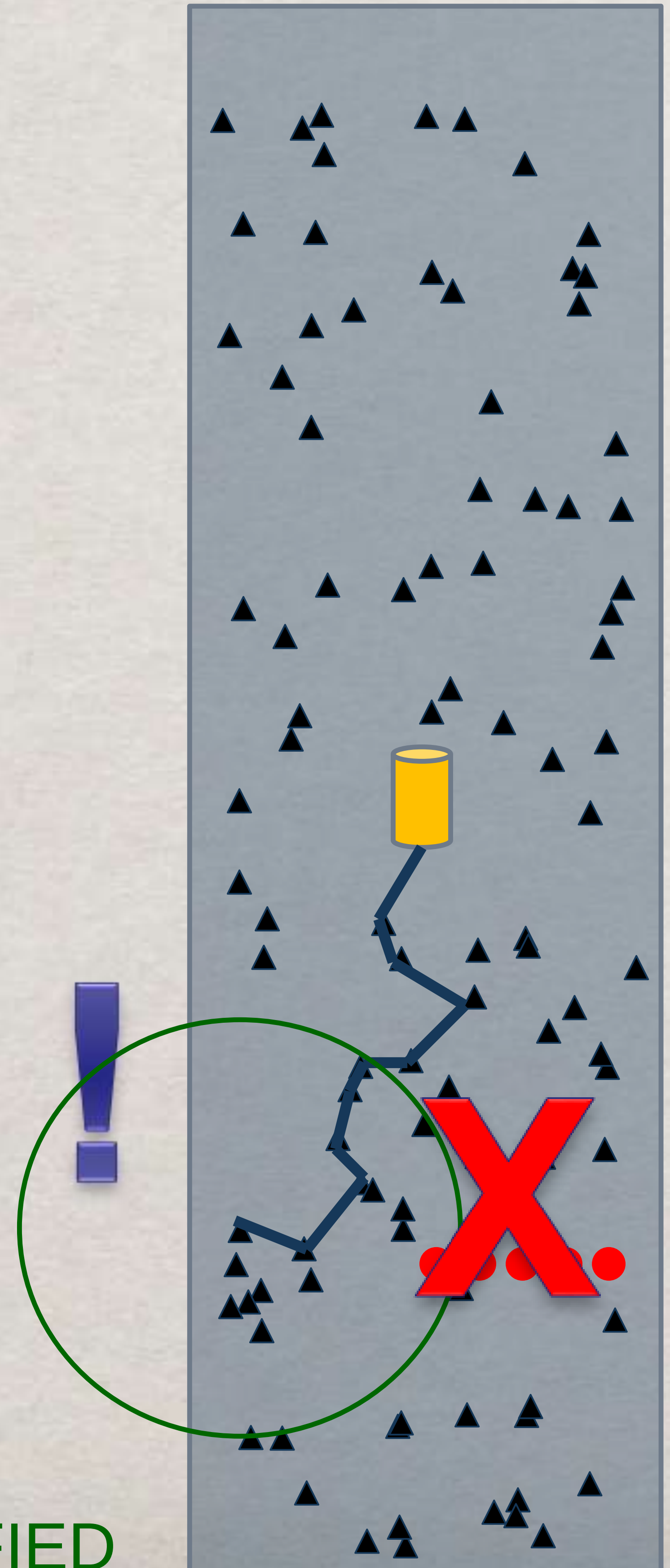
Glider Model



17 Gliders

- Sensor Range: 2.7 nm
- Comms Range: 1.6 nm
- Speed: 2 kts
- Lateral Intercept Range: 0.55 nm (from Approaching Target Model)
- Coordinated Barrier Search (1.43 nm segments)
- Middle Gliders primarily for comms relay
- Gliders “decide” which contacts to report
- Gliders surface for external communications

SQUID Model

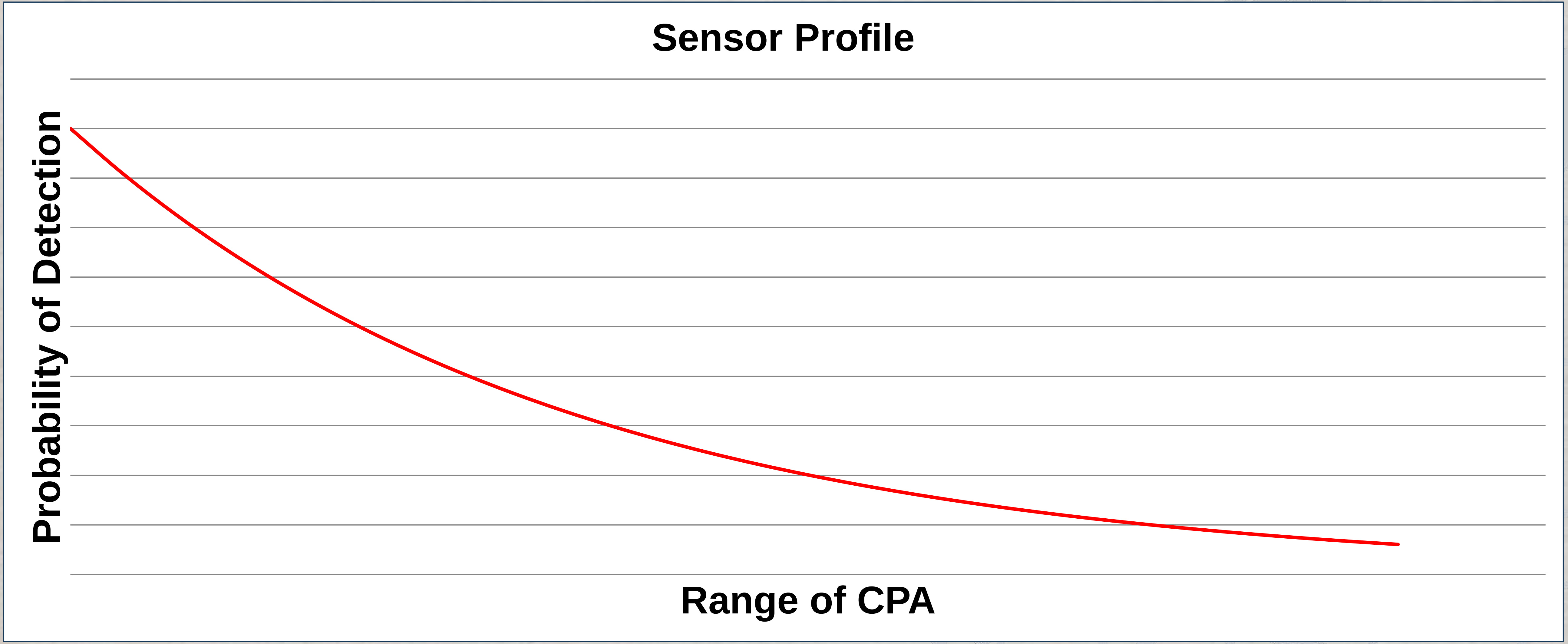


130 sensor/weapon nodes, 1 communications gateway

- Sensor Range: 1.35 nm
- Comms Range: 0.8 nm
- Kill Range: 50 yds
- Squid nodes randomly placed (e.g. artillery, air drop)
- Nodes must have path to gateway to be “in network”
- Must be in network to report contacts and engage threats
- 126 nodes in network on avg.
- Each node determines shortest path to Gateway
- Nodes report all contacts and relay all messages

M&S Results

	Avg TTC (min)	P_d	P_k
Glider	13.3-15.0	0.74-0.75	0.16-0.22
LD-UUV	2.9-3.1	0.80-0.81	0.33-0.43
Squid	3.5-3.7	0.97-0.99	0.07-0.09
V-CAP	4.5-4.7	0.80-0.82	0.54-0.65



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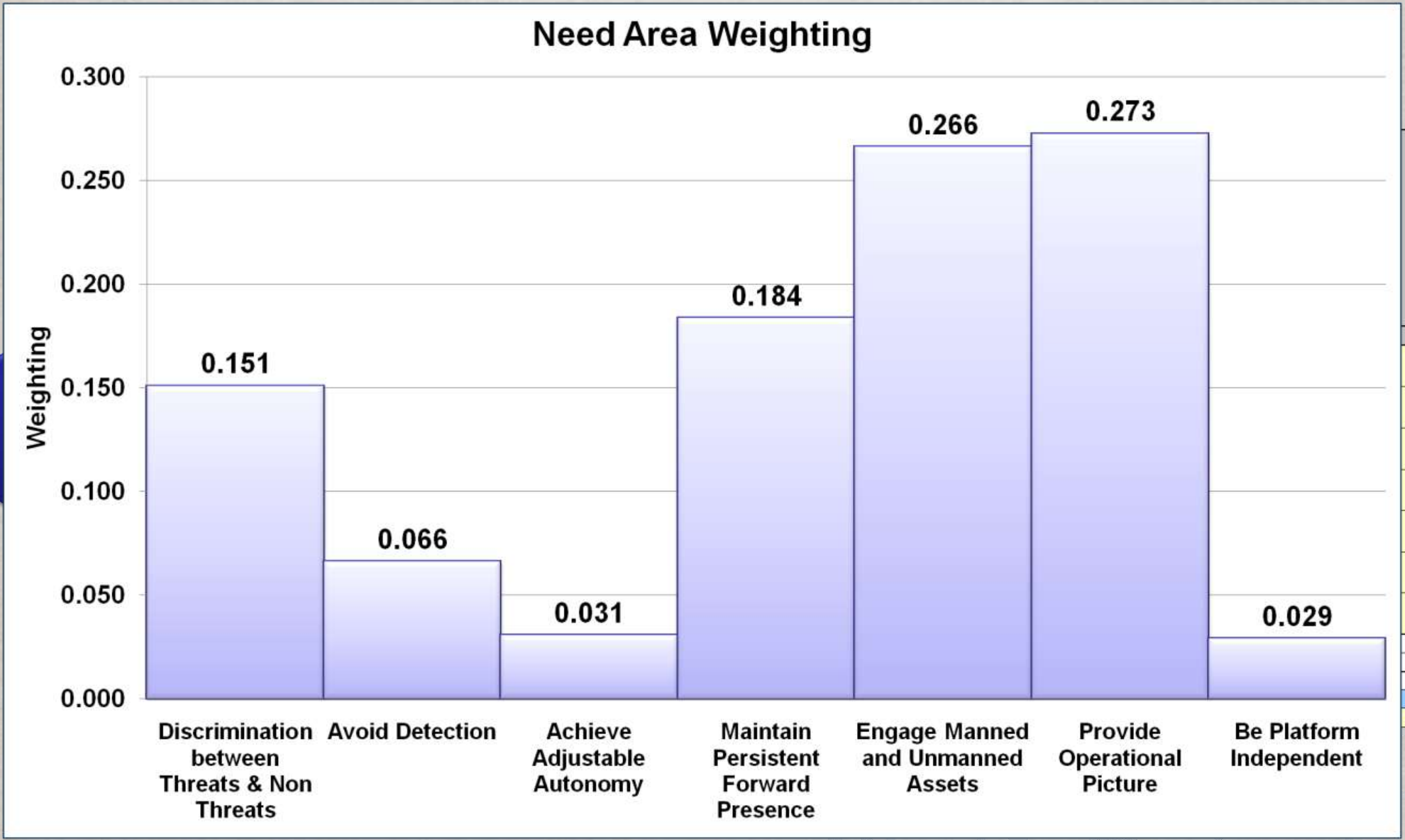
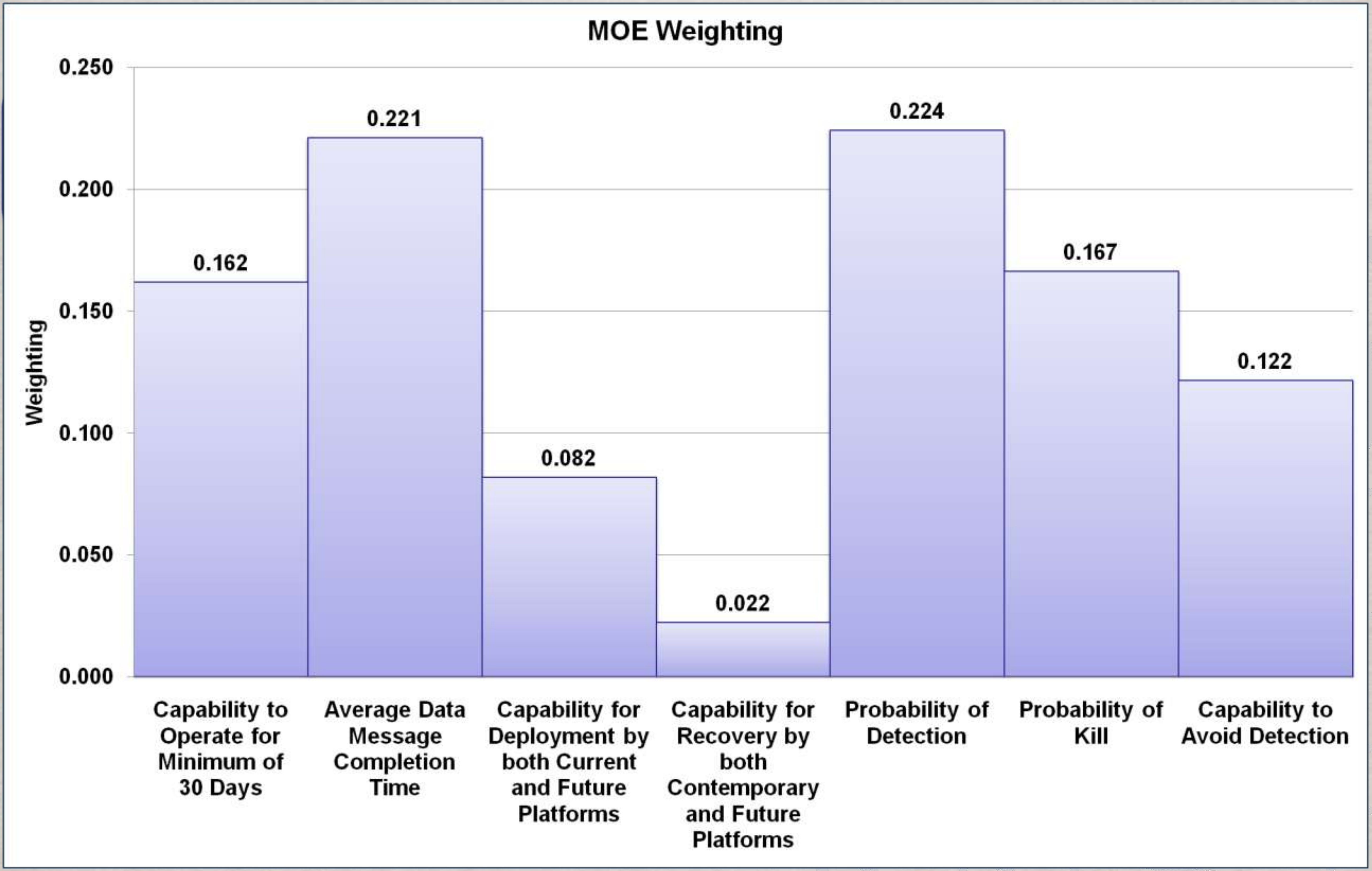
Analytic Hierarchy Process



Quality Functional Deployment

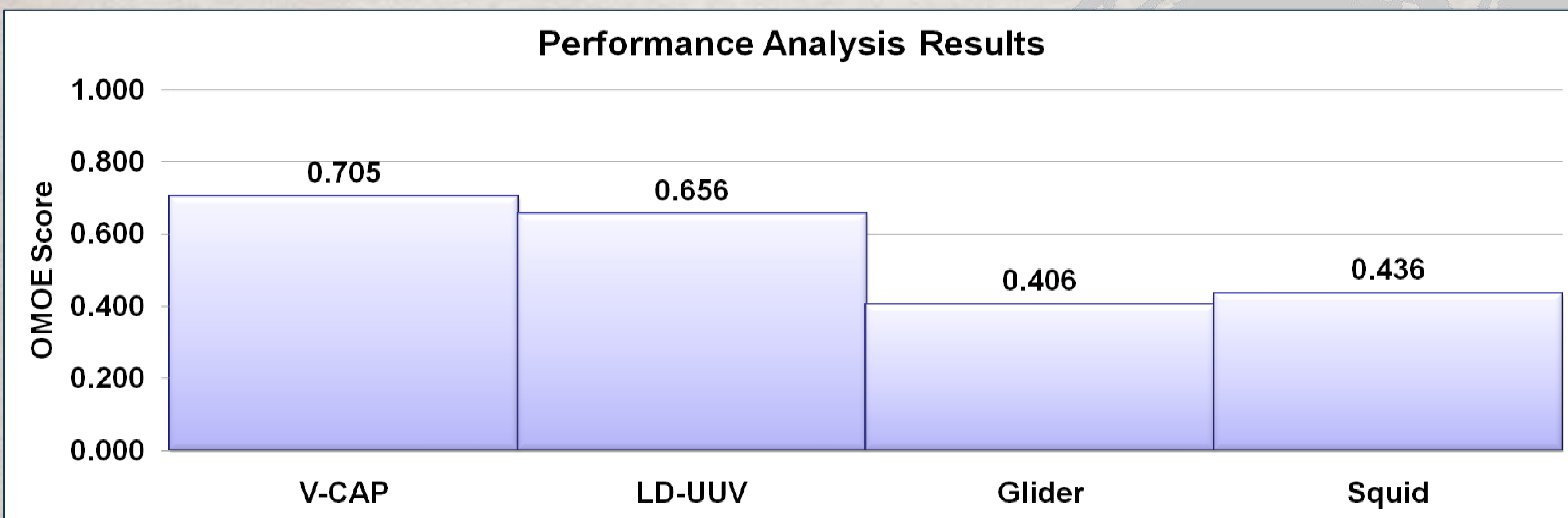


Performance Analysis Results

Non-Stochastic Analysis

QFD MOE Weighting

M&S



Cost Analysis Results

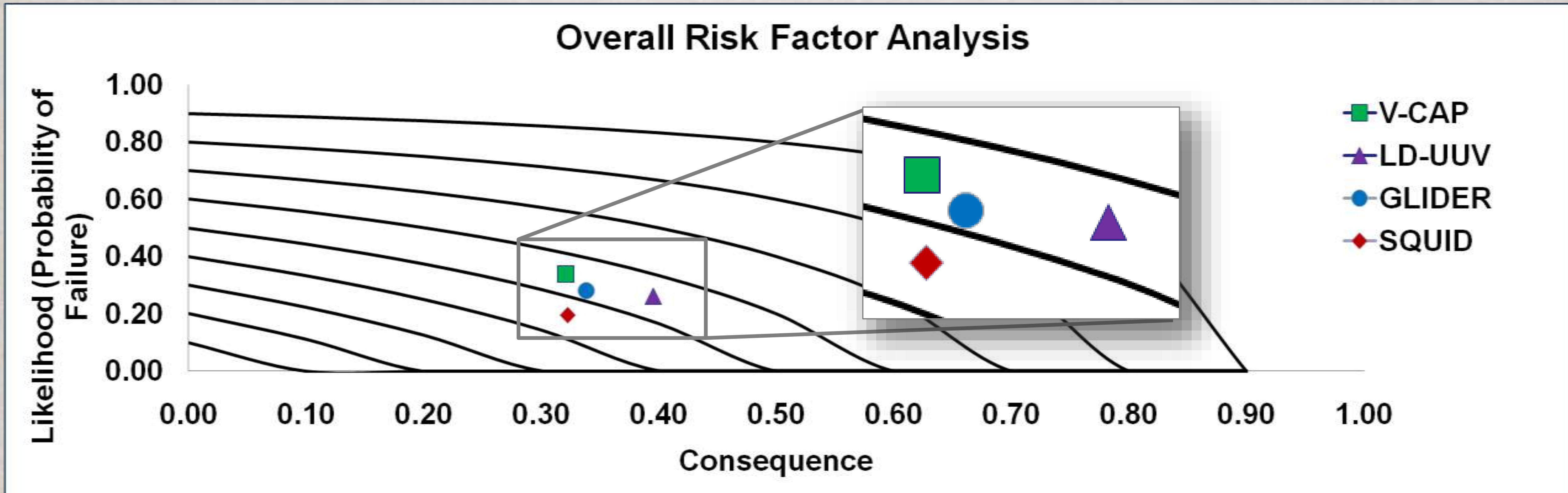
20-yr Rough Cost Estimate

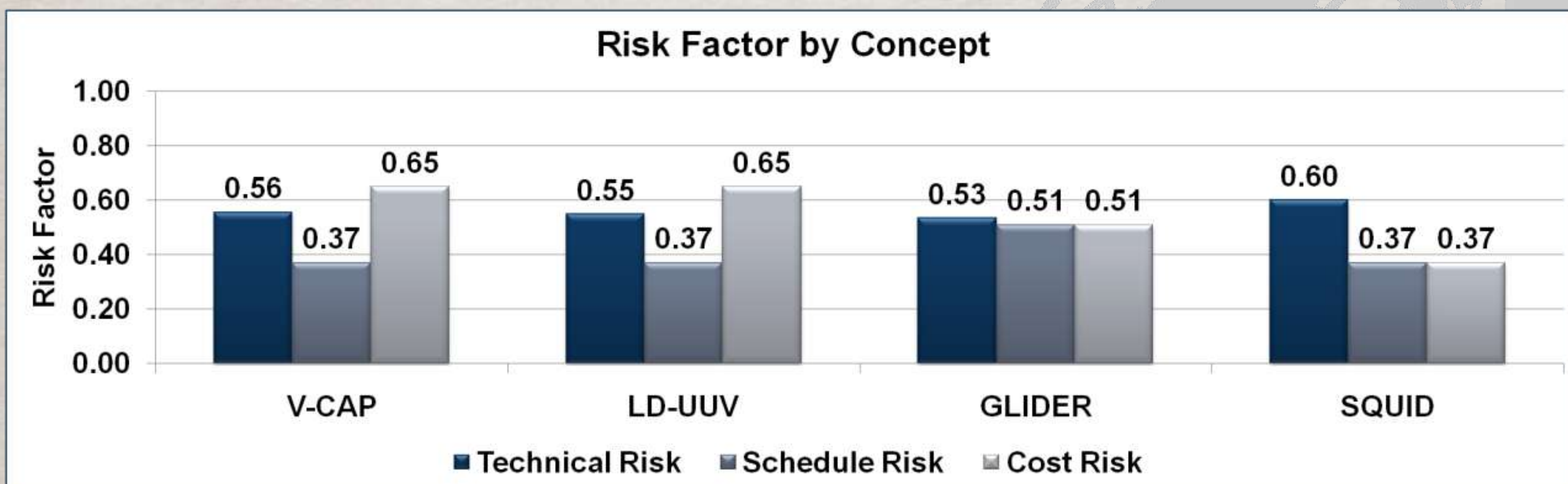
- **RDT&E Costs** - excluded
- **Production Costs**
  - Based on Component Costs
- **O&S Costs**
  - Consumables – Fuel, Warheads, Replacements
  - Personnel (excluded)
- **Disposal Costs** - excluded

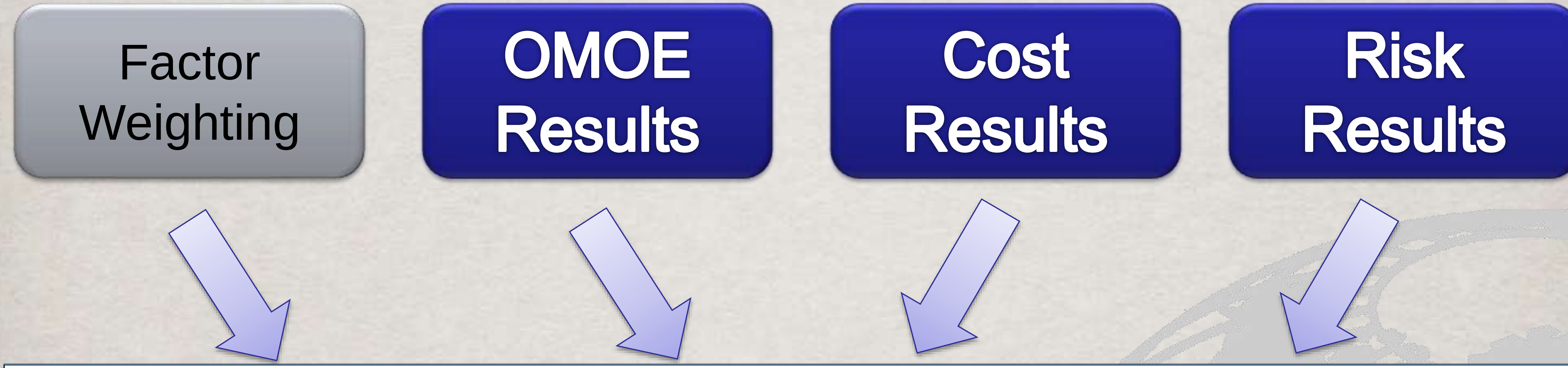
Alternative	Cost (FY2011$M)
V-CAP	**359**
LD-UUV	**690**
GLIDER	***75***
SQUID	**2418**

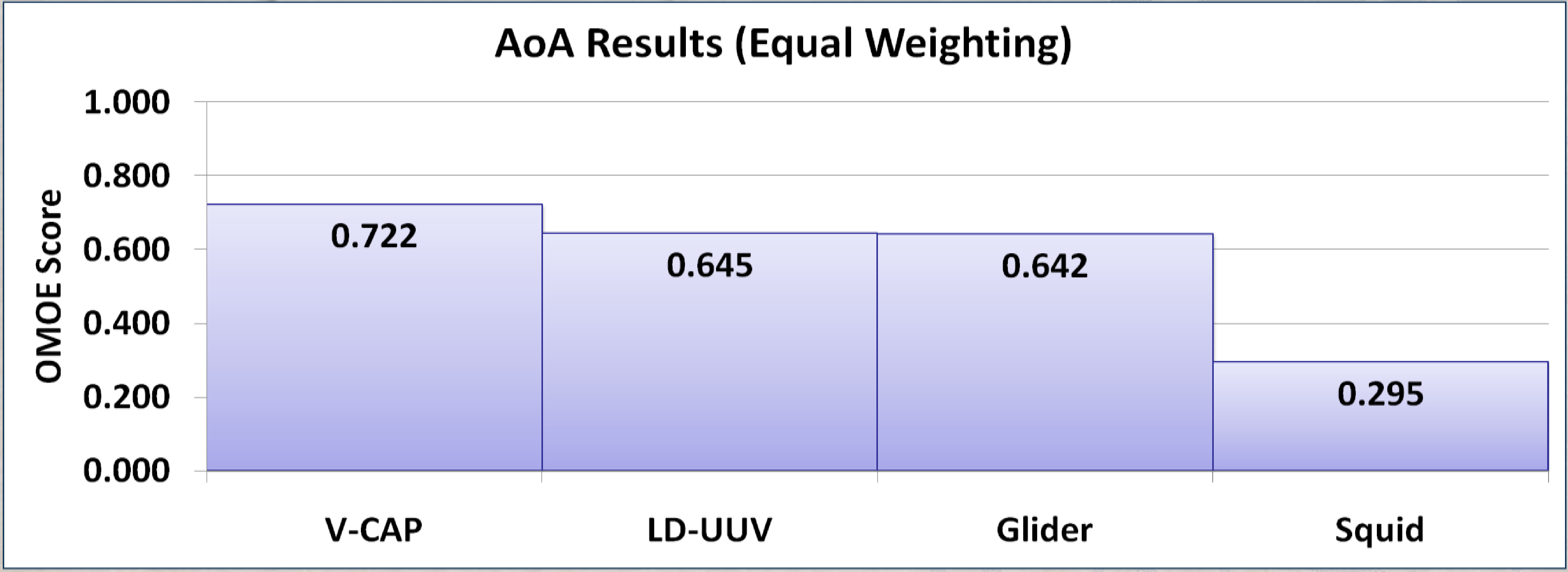
V-CAP: Good balance
LD-UUV: High per-unit cost
GLIDER: Low procurement & consumable cost
SQUID: High cost due to large number of expendables

Risk Analysis Results

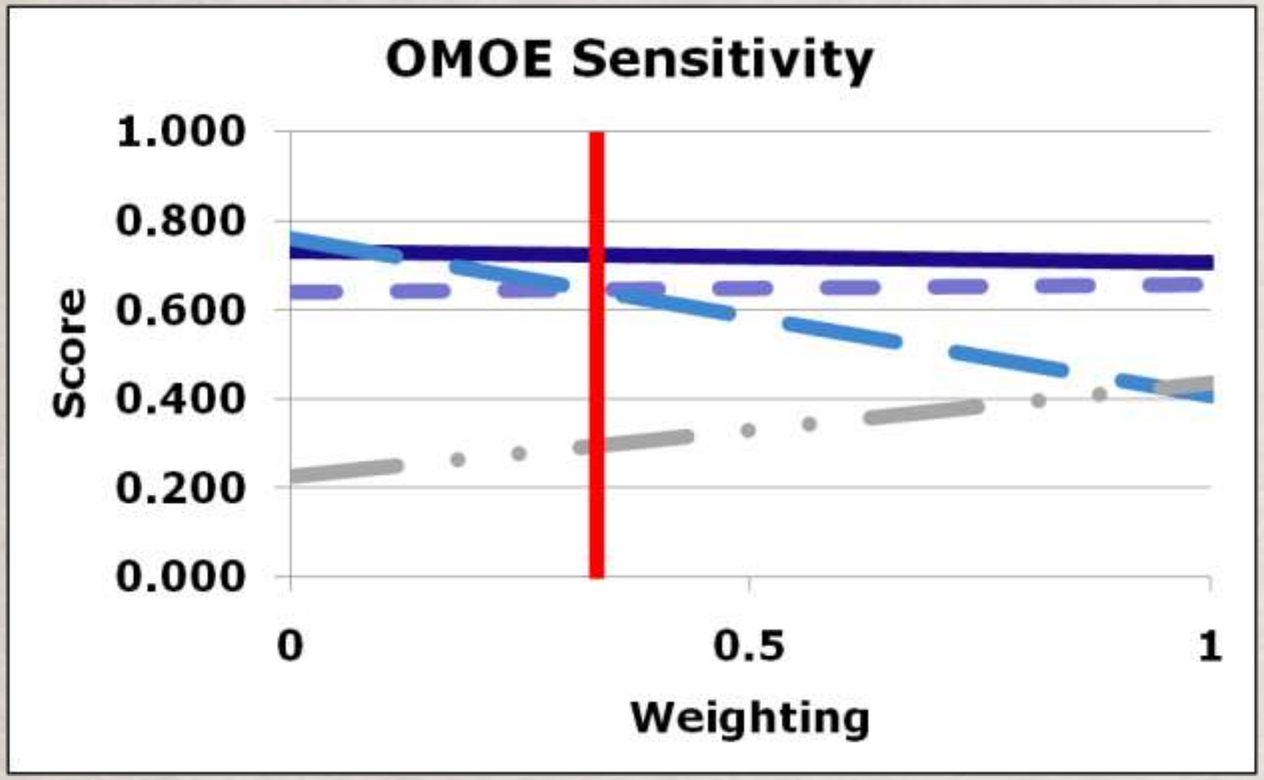


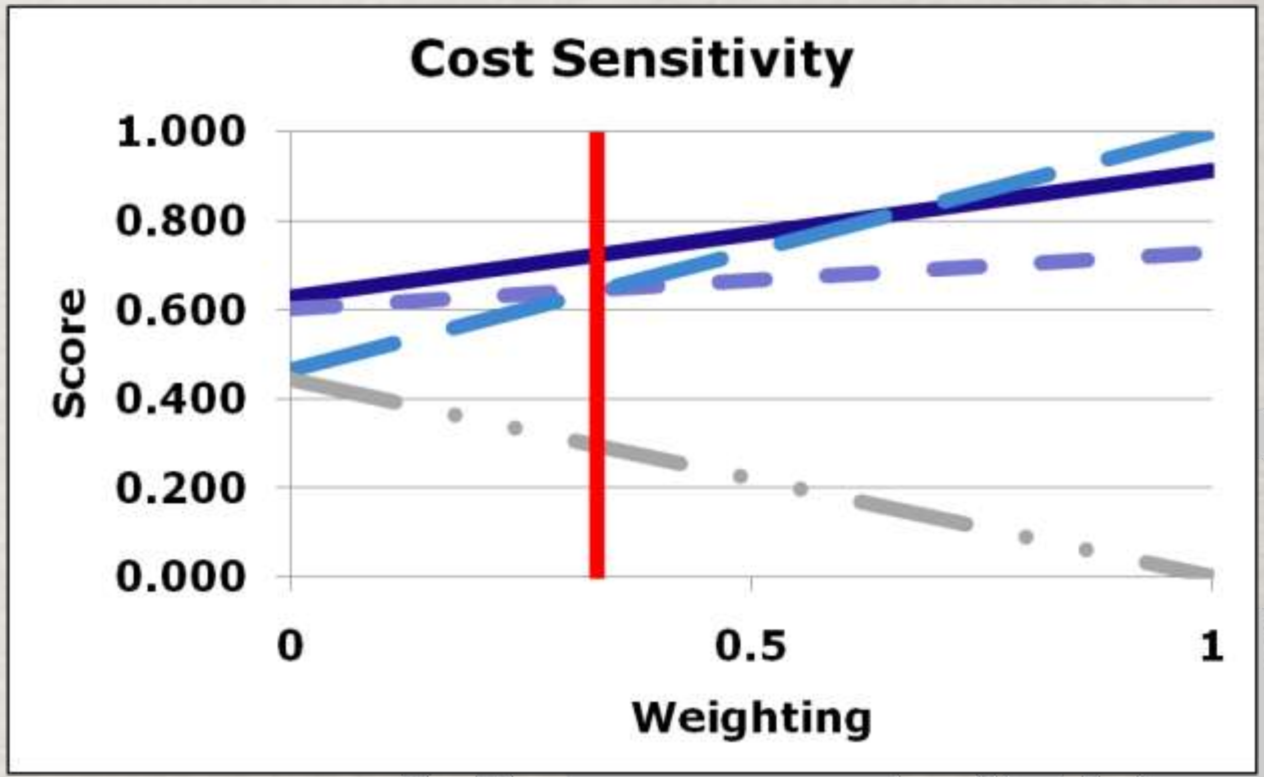


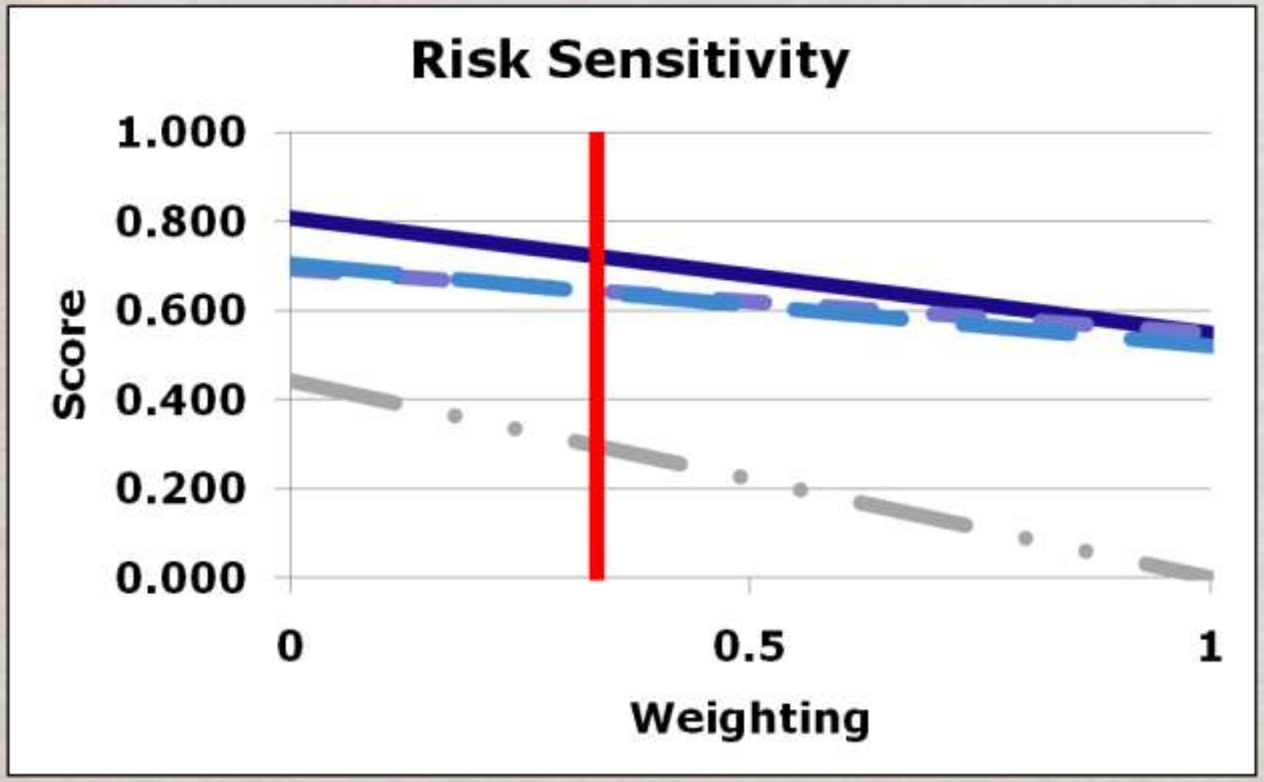

Factor Weighting
OMOE Results
Cost Results
Risk Results


AoA Results (Equal Weighting)
OMOE Score
1.000
0.800
0.600
0.400
0.200
0.000
0.722
0.645
0.642
0.295
V-CAP
LD-UUV
Glider
Squid

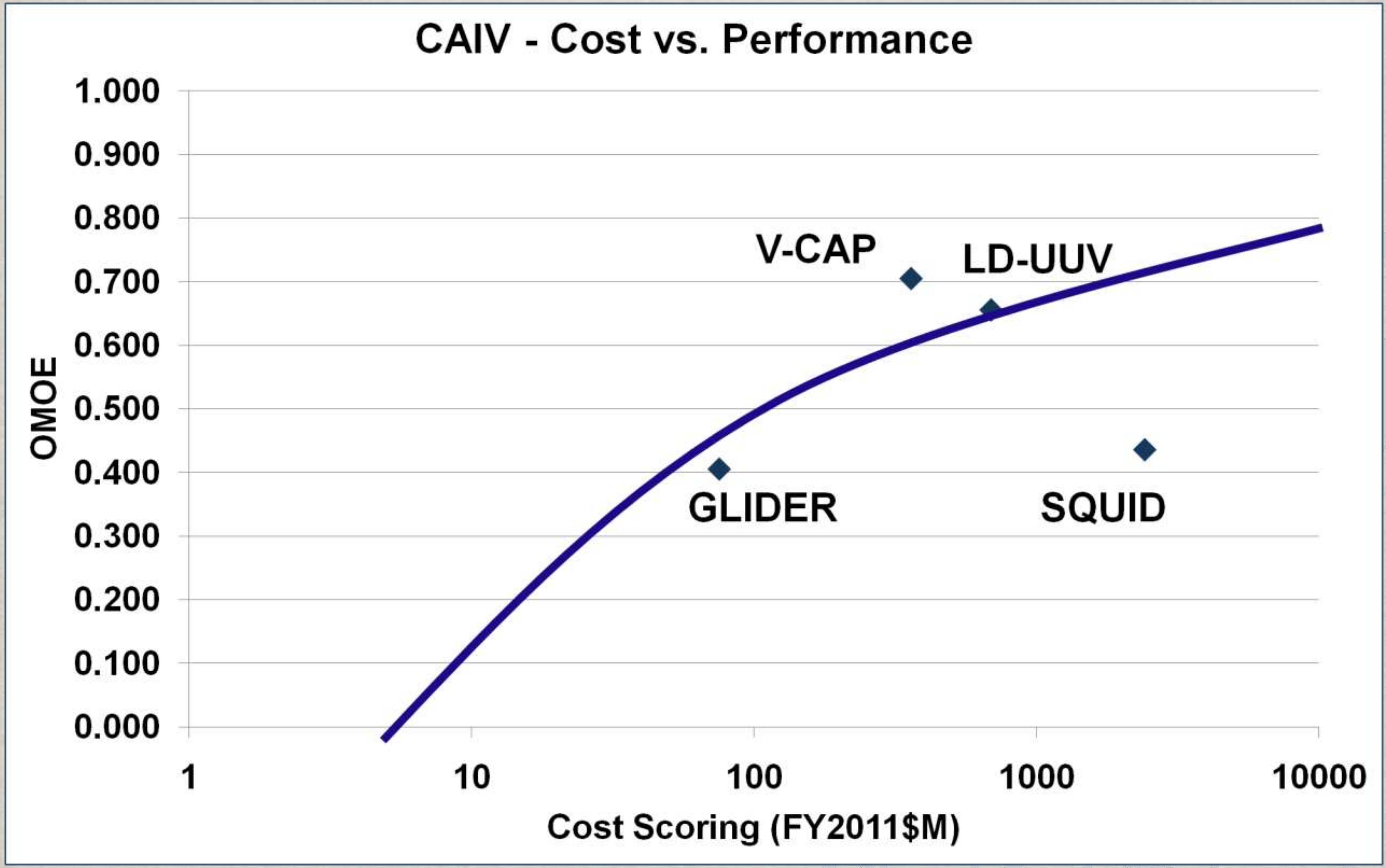
AoA Sensitivity







AoA CAIV



CAIV - Cost vs. Performance
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
OMOE
V-CAP
LD-UUV
GLIDER
SQUID
1
10
100
1000
10000
Cost Scoring (FY2011$M)

Status Quo Alternative

- Options for the given scenario
  - ~~Mines~~
  - ~~Surface Combatants~~
  - Submarines
- Superior performance
- Cost is debatable
  - Assume AUWS provides no LCC savings!
- Operational risk is unacceptable
  - $2B strategic asset and hundreds of lives at risk
  - Even one SSN is “overkill”
- AUWS can be scaled to balance risk with performance


Courtesy of www.navy.mil

Section 6

Concept Recommendations
Primary: V-CAP
Secondary: LD-UUV
Hybrid

Primary Concept: V-CAP

Pros:

- Best P_k
- Good P_d
- Ease of Deployment & Recovery
- Follow-on Salvo
- Cost

Cons:

- Slower Comms
- Shorter Endurance

Secondary Concept: LD-UUV

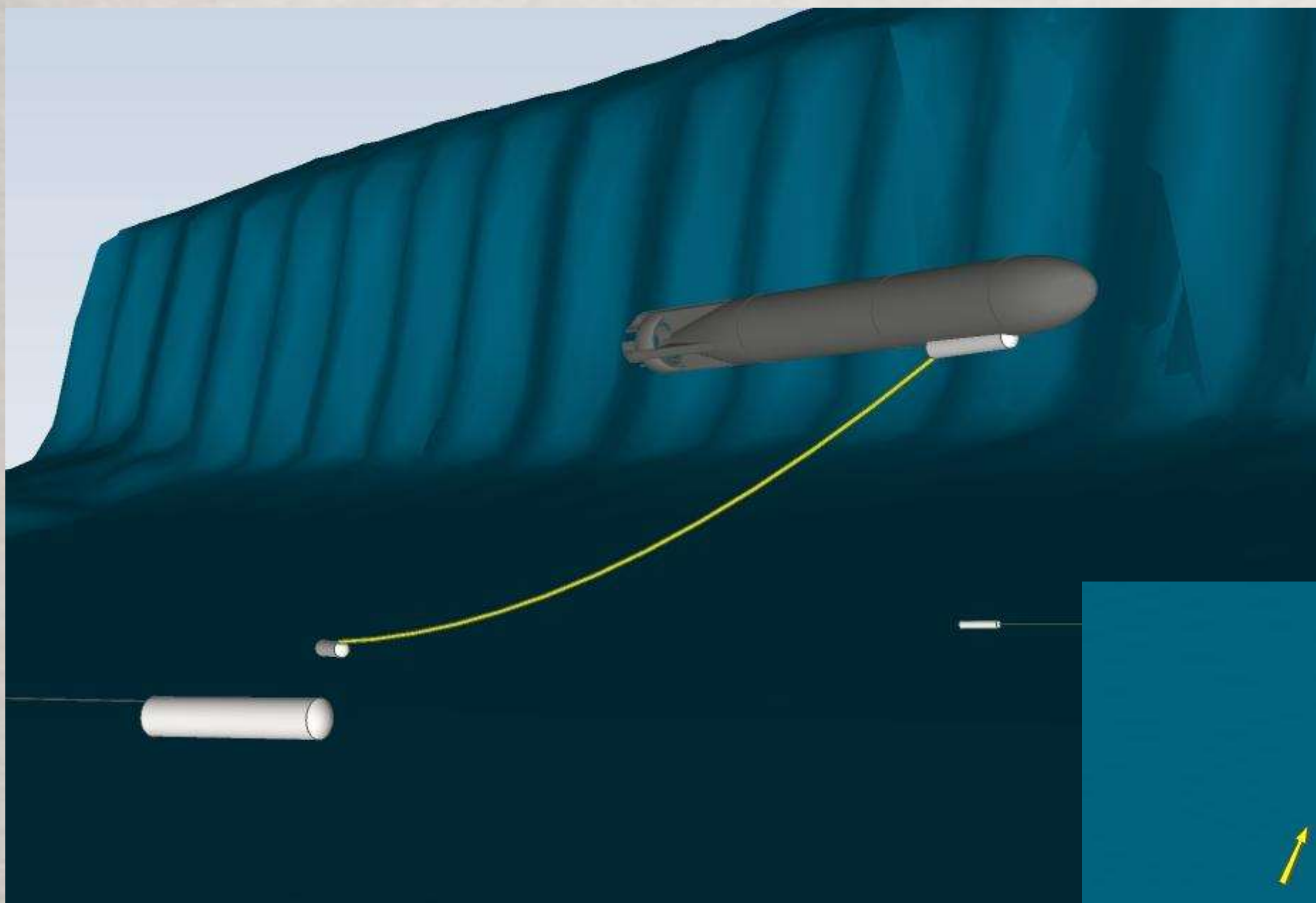
Pros:

- Rapid Comms
- Better Endurance

Cons:

- Limited Deployability
- Limited Recoverability
- Limited Salvo
- Cost

Hybrid Recommendation



- Double Deployment
  - Improved P_d, P_k
- LD-UUV Paired Nodes
  - Improved Comms

Section 7

Project Insights
Project Recommendations

Insights

Flexibility

- Network Integration
- Platform Integration
- Command & Contr

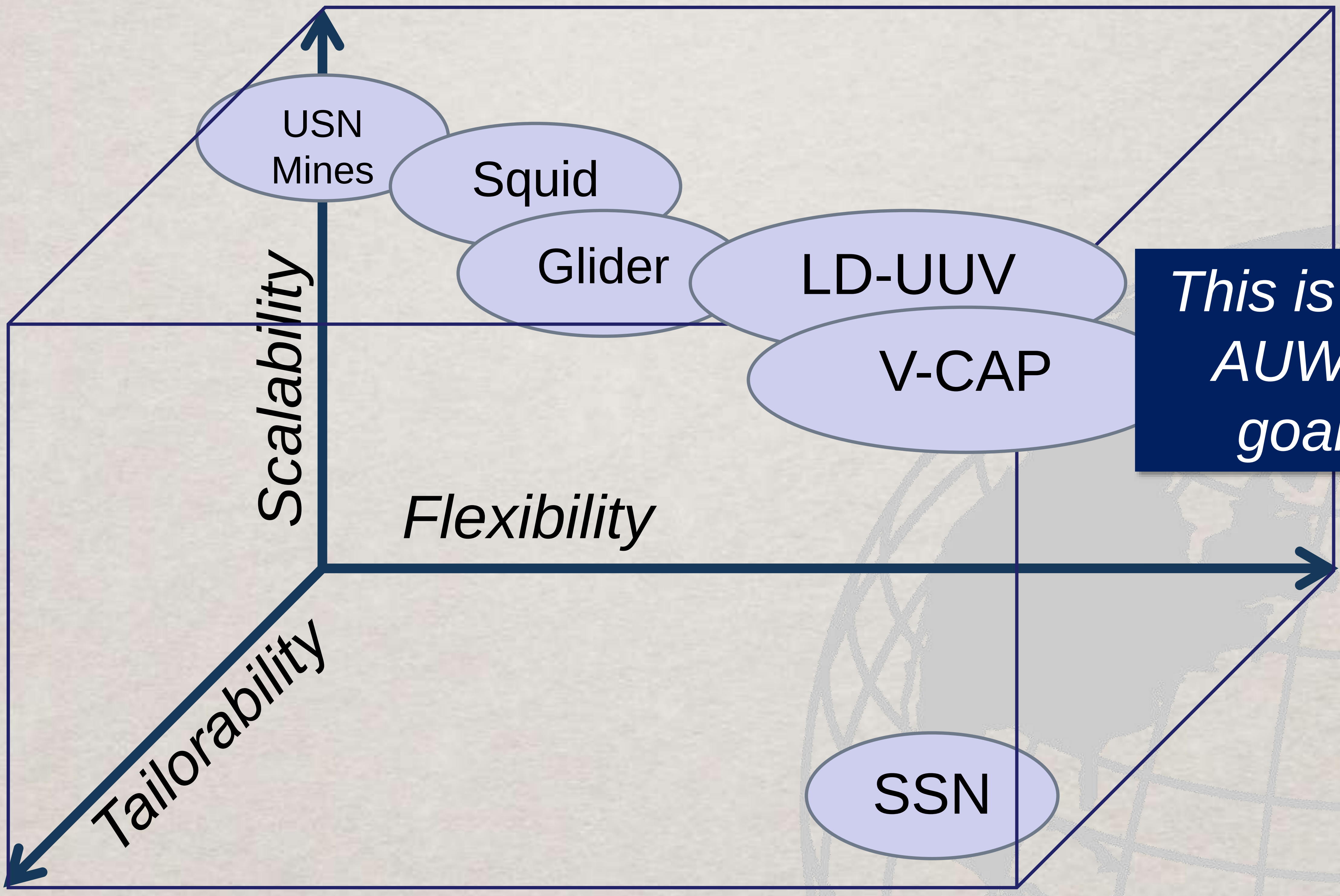
Scalability

- Balance required w/ Cost & Performance
- Trade-off w/ Flexibi
size of units)
- Unlike Current Sy

Tailorability

- Mission-reconfigurable modular design
- Optimal redundancy (heterogeneous vs. homogenous)
- Separation & distribution yield tactical advantage

AUWS Tradespace



This is the AUWS goal!

Recommendations

- Near Term (FYDP 2012-2016)
  - Continue detailed analysis of superior AUWS concepts
  - Review and update doctrine (ROE, tactics, training, etc.)
  - Use this analysis to help ONR define Science and Technology Gap
  - ONR assigns Future Naval Capabilities Manager for AUWS concepts R&D
  - Get prototypes *(of any kind)* in the hands of sailors!
- Mid Term (FYDP 2016-2020)
  - Develop Initial Capability Document based on this analysis
  - Initiate AUWS Program of Record based on current best assessment of capability gap
  - Do not wait for technology to advance to optimal levels
- Far Term (FYDP 2020 →)
  - Maintain a goal of achieving AUWS full operational capability by 2030

Section 8

Closing Remarks

Closing Remarks

The undersea battlespace of the future is a complex, dynamic environment that cannot be divided neatly along platform or community lines.

Advanced Undersea Warfare Systems are just one element of a comprehensive, unified approach to maintaining and enhancing USW dominance in the future.

Questions