Introduction

CDR Vic Bindi, USN
SEA-8 Problem Statement

- **SEA-8**

  .. *design a system that denies enemy undersea forces (submarine and UUV) effective employment against friendly forces within the littorals during the 2025 timeframe.*
Systems engineering principles

Insights and conclusions:

- 1) No perfect system
- 2) Reaction time
- 3) Persistent systems
- 4) Kill-Chain Timeline (KCT) tradeoffs
- 5) Undersea Joint Engagement Zones (UJEZ)

Results qualified and quantified during brief
NO PERFECT SYSTEM

- Theater specific variables
- No generic global solution exists
- Each alternative architecture possessed strengths, weaknesses and performance gaps
- Combination of systems results in significant performance gain
REACTION TIME

- Enemy timelines are unpredictable
- SecDef 10/30/30 construct
- ASW 3/10/30/30 construct
- Quick reaction systems hedge uncertainty.
Bottom Line Up Front

PRESENCE

- Pervasive persistence is the goal
- Required in both time and space
  - Traditional methods
  - Non-traditional methods
KILL-CHAIN TIMELINE (KCT) TRADEOFFS

- Traditional methods require short KCTs
  - Minimum Trail Range (MTR)
  - Sporadic contact

- Non-traditional methods afford longer KCT
  - Closer trailing distances
  - Decreased probability of lost track
  - Affords the use of stand off weapons systems
UNDERSEA JOINT ENGAGEMENT ZONES

- Aviation uses a Joint Engagement Zone (JEZ)
- Future undersea technologies require more than waterspace management
- Future ASW will require Undersea JEZ
- Advances will be required in coordination, identification, networking
Morning Agenda

☐ Problem Definition
  ■ Needs Analysis
  ■ Objective Analysis

☐ Design and Analysis
  ■ Alternative Generation

BREAK

☐ Design and Analysis II
  ■ Modeling

☐ Decision Making
  ■ Analysis
  ■ Conclusions

BREAK

☐ Total Ships System Engineering (TSSE)
  ■ Payload and Operational Concepts
  ■ Combat Systems
  ■ Hull, Mechanical and Electrical (HM&E)
Afternoon Agenda

- 1200-1330 Lunch
- 1330-1400 SEA-8 Classified brief (Glasgow STBL)
- 1330-1600 Team Breakout Briefs – Bullard Hall
  - Modeling Lab 1
  - Prosecution Lab 2
  - Deployment Lab 2
  - Reliability Lab 2 annex
  - TSSE Lab 3
  - C4ISR Conference Room
Systems Engineering Design Process

- Problem Definition:
  - Needs Analysis
  - Objectives Analysis

- Design & Analysis:
  - Alternatives Generation
  - Modeling & Analysis

- Decision Making:
  - Alternative Scoring
  - Decision

- Implementation:
  - Planning for Action
  - Execution
  - Assessment & Control
Systems Engineering Design Process

- **Problem Definition**
  - Needs Analysis
  - Objectives Analysis

- **Design & Analysis**
  - Alternatives Generation
  - Modeling & Analysis

- **Decision Making**
  - Alternative Scoring
  - Decision

- **Implementation**
  - Planning for Action
  - Execution
  - Assessment & Control
Systems Engineering Design Process

Design & Analysis
- Alternatives Generation
- Modeling & Analysis

Problem Definition
- Needs Analysis
- Objectives Analysis

Decision Making
- Alternative Scoring
- Decision

Implementation
- Planning for Action
- Execution
- Assessment & Control
Systems Engineering Design Process

Problem Definition
- Needs Analysis
- Objectives Analysis

Design & Analysis
- Alternatives Generation
- Modeling & Analysis

Decision Making
- Alternative Scoring
- Decision

Implementation
- Planning for Action
- Execution
- Assessment & Control

Need Analysis  |  Obj Analysis  |  Alt Generation  |  Modeling  |  Analysis  |  Conclusions
Problem Definition

LT Keith Manning, USN
Problem Definition Phase

- Needs Analysis
  - Primitive Need
  - Stakeholder Acknowledgements
  - System Decomposition
  - Input-Output Modeling
  - Functional Analysis
  - Requirements Generation
  - Futures Analysis
  - Effective Need

- Objectives Analysis
  - Functional Objectives
  - Measures of Performance
  - Measures of Effectiveness
  - Performance Goals

Diagram:
- Needs Analysis
- Objectives Analysis
- Problem Definition
  - Needs Analysis
  - Objectives Analysis

Page 18
Problem Definition Phase

Understanding Littoral ASW Functions

Initial Tasking Need

Primitive Need Statement
Littoral ASW Points

☐ Anti-Submarine Warfare
  ■ Denying the effective use of enemy submarines
    *Avoidance - Deterrence - Destruction*

☐ Littoral ASW Threat
  ■ Air Independent Propulsion Submarines
  ■ Fuel Cell Technology Submarines
  ■ Nuclear Powered Submarines
  ■ Diesel Powered Submarines
  ■ Unmanned Undersea Vehicles
Littorals: Defined as waters within 100nm of any oceanic shoreline.
Initial SoS Components

- Alternative mixes of ASW systems
  - Legacy
    - Systems remaining in use in 2025
  - Programs of Record (POR)
    - Systems planned to be operational in 2025
  - SEA and TSSE
    - Alternative systems that are technologically feasible but do not exist as part of any official POR
Primitive Need Analysis

 Primitive Need Statement:  
*To develop a System of Systems architecture for the conduct of Undersea Warfare in the littorals in the 2025 time-frame...*

- Battlespace preparation and monitoring.
- Persistent detection and cueing.
- Combined arms prosecution.
- High volume search and kill rates.
- Non-traditional methods.
- Defense in-depth.
Stakeholder Acknowledgements

NUWC
NUWC
UW, APL
LLNL
BOEING
NPS
R&A
NAVSEA
FASWC
NSCT NSWG
SPAWAR
PACFLT
COMSUBBPAC

COMSUBDEVRON 12
COMSUBBLANT
GENERAL DYNAMICS
NUWC
FOSTER MILLER
NORTHROP
GRUMMAN
ONR
PEO SHIPS
PEO IWS
PEO LMW
N77
WHOI
NAVSEA
COMSUBPAC
STRATCOM
BOEING
SWDG
SPAWAR
NSWC

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Functional Analysis Products

System Decomposition

Function Decomposition Analysis

- Deploy
- Search
- Detect
- Track
- Identify/Classify
- Deter
- Attack
- Sanitize
- Communicate

Input-Output Modeling

- DDG, DD, FFG, MHC, MCM, LCS Sub-Surface
- SSN Air SH-60B, SH-60F, SH-60R, P-3C
- Combat Lateral Systems
- Surface Subsystems
- Sub-Space
- Sensors

Functional Analysis

- Force Composition
- Communication
- Networking Systems

SoS Process

Intended
- Complete Interpretation of CDR’s Intent
- Complete ASW Force Situational Awareness – C2 fusion
- Reduced C4I process time
- Adaptable and flexible C4ISR ability
- Supports ASW Force Effectiveness
- Reduced Prosecution Timeline
- ISR Enhanced Search Areas

Unintended
- Reduced C4ISR ability due to:
  - System Casualties
  - Environmental
  - Enemy Intercept ability
- Reduced C4ISR ability due to processing overload due to excessive information – resulting in untimely action

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Functional Analysis Products

Functional Flow Diagram

Command

Prepare | Incident Occurs | ID Threat and AO | Deliver

Maneuver

Search | Detect | Track | Classify | Command Decision

Assess Environment

Deter | Engage | Skip | Assess Denial | Mission Complete

Sustain

Reconstitute | Prepare

Needs Analysis | Obj Analysis | Alt Generation | Modeling | Analysis | Conclusions
SoS Requirements

Initial Tasking Requirements

Functional Analysis

Refined Stakeholder Needs

SoS Metrics

Final SoS Requirements
Futures Analysis

Noted Trends

- The US will maintain its technological advantage
- However, technology will spread and capability gaps will shrink
- These gaps will be exploited faster than can be countered
- The playing field will not be level
- Center of gravity mismatch and the importance of littoral ASW
- The Lucky Strike vs. Risk Aversion
  - Standoff
  - Distributed
  - Unmanned
    - Leveraging high-tech to achieve lower human risk
Forming an Effective Need

Design a future littoral undersea warfare system of systems that denies enemy undersea forces (submarines and UUVs) effective employment against friendly forces within the littorals during the 2025 timeframe.
Objectives Analysis Phase

- Objectives Analysis
  - Functional Objectives
  - Measures of Effectiveness
  - Measures of Performance
  - Performance Goals
Objectives Analysis Process

Functional Hierarchy

- Command
  - Communicate CDRs
  - Intent
- Deploy
  - Prepare
  - Deliver
  - Sustain
- Prosecute
  - Assess
  - Search and Detection
  - Tracking
  - Maneuver
  - Deter
  - Engage
- Deny
  - Classify

Objective Hierarchies
Forming Hierarchies

Functional Hierarchy

Objective Hierarchy

Function

Objective

MOE

MOP

Goals

Littoral ASW System of Systems

Command

Deploy

Prosecute

Deny

Communicate CDRs Intent

Network Tactical Data

Exchange ISR

Prepare

Deliver

Sustain

Assess

Search and Detection

Tracking

Classification

Manuever

Deter

Engage

Objectives

Measures of Effectiveness

Measures of Performance

Goals

Average time to establish complete coverage

Percent Area Covered

Average System P(d)

COI's CL's as COI's Detected

Prosecute Percent COI's Detected

80% RMP

24 hrs

100% coverage

P(d) ≥ 0.80

Average time to establish RMP

Percent Contacts Detected

Needs Analysis

Obj Analysis

Alt Generation

Modeling

Analysis

Conclusions
Transitional to Alternatives

- Generation of Alternatives

- Exercise in communication
- Systematic process
- Provides: Structure, Feedback, Anonymity

Alternatives

- I
- II
- III
- IV
- V

Objectives Analysis

Needs Analysis

Delphi Method

- Systematic process
- Provides: Structure, Feedback, Anonymity
Alternative Generation

LT Artie Mueller, USN
Scenario Building

- Scope and bound the project with realistic constraints
  - Timeline
  - Geography
  - Threats
  - Logistics
  - Endurance
  - Capabilities
ASW Timeline 3/10/30

- **72hrs** Begin ASW Operations
- **10 Days** Seize the Initiative
- **30 Days** Denial sustained for follow-on actions
Scenarios

Coastal

Very Constrained

Semi-Constrained
Coastal Scenario

- Defensive, Offensive applications
- All areas open to transit
- Applicable areas:
  - San Diego
  - Norfolk
  - North Korea
Very Constrained Scenario

- Choke point passage
- Confined waters
- Defined and predictable navigation routes
- Applicable areas:
  - Strait of Hormuz
  - Strait of Malacca
  - Strait of Gibraltar
Semi-Constrained Scenario

- Defense of island nation

- Applicable areas:
  - Taiwan Strait
  - Bass Strait
Scenario: Theater Logistics

- Needs Analysis
- Obj Analysis
- Alt Generation
- Modeling
- Analysis
- Conclusions

Diego Garcia
Pearl

6,000 NM

★ Guam
★ Pearl
Specific Geographic Littoral ASW Scenario

- Used for geographical scenario planning and simulation
- Bass Strait - water space between Australia and Tasmania
Littoral ASW Scenario: Area of Responsibility (AOR)

- Water depth
  - 50m
  - 60m
  - 70m
  - 80m
- Defense of island nation
- Air and maritime superiority not established
- 3 enemy port facilities
- 2 enemy AIP submarines in each
- 2 enemy AIP submarines unlocated
Littoral ASW Scenario: AOR operations in 72 hours

- Operate in the Area of Responsibility within the first 72 hours
- 100 NM² (10 x 10 NM blocks) outside enemy port facilities
Littoral ASW Scenario: Sustained Denial in the AOR

- 3 defined Areas of Responsibility
- 100 NM x 67 NM each
- 6,700 NM² each
- Total Size of Area of Responsibility
  20,000 NM²
Created distinct, unique alternatives to address our effective need for our Semi-Constrained Scenario

Each alternative combines components that are:

- Existing Systems
- Programs of Record
- Technologically feasible
- System gaps
SEA-8 Defined Alternatives

- **Littoral Action Group (LAG)**
  - DD(X), LCS, SSN, MH-60

- **Total Ship Systems Engineering (TSSE) – Sea TENTACLE**
  - Host ship, UUV, USV, UAV, Stationary Bottom Sensors

- **Tripwire**
  - UUV, Rapidly Deployable Stationary Bottom Sensors

- **War of Machines**
  - UUV, Recharging Stations

- **Floating Sensors**
Littoral Action Group (LAG)

Operational View 1 (OV-1)

Assets
1 DD(X)
3 LCS
2 SSNs
5 MH-60Rs

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Sea TENTACLE OV-1

Assets (for Three 67 x 100 NM boxes):

- 3 Sea TENTACLE Ships
- 144 Large Vehicle UUVs
- 144 UUV Sleds
- 864 Light Weight UUVs
- 2304 Man Portable Deployed UUVs
- 6 USVs
- 6 Vertical Take-off UA Vs
- 6 MH-60Rs

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Tripwire OV-1

Assets
- 150 Rapidly Deployable Netted Sensors
- 15 UUVs
- 2 B-2
- 2 B-52

Needs Analysis
- Obj Analysis
- Alt Generation
- Modeling
- Analysis
- Conclusions
Floating Sensors OV-1

Deployment
1,800 B-52 sorties
or
3,000 B-2 sorties

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Break
Modeling

LT Jeff Baker, USN
Modeling

- Used to predict or estimate system performance
- Provides insight
Primary Modeling Needs

- Sensor Performance: physics based
- Logistics/Deployment: analytical
- Reliability: discrete event
- Command & Control: analytical
- System Performance: entity based
High-level Model Development

**OVERALL SYSTEM PERFORMANCE**
- High-level Entity Based Model

- **Reliability**
  - discrete event simulation models

- **Logistics**
  - analytical models

- **C4ISR**
  - analytical models

- **Sensors**
  - physics based models

**OUTPUT DATA**

- Alternative
  - LAG
  - Tripwire
  - TSSE
  - War of Machines

**Needs Analysis**
- Obj Analysis
- Alt Generation
- Modeling
- Analysis
- Conclusions
Sensor Performance

- PCIMAT Physics Based

- Time of Year
- Historical Data
- Bottom Type
- Wind
- Shipping Level
- Figure of Merit
- Red Source Level
- Red Operating Depth
- Frequency of Concern
- Operator’s Ability

- Expected Detection Ranges
- Expected Propagation Loss
Sensor Performance

- Examples of propagation loss and detection range outputs from PCIMAT
Logistical Performance

- **Deployment Analytical Model**

  - Transit speed
  - Working payload
  - Transit distance
  - Distance to AOR
  - Logistics (refueling)
  - Admin (crew rest, maintenance)
  - Refueling thresholds
  - Sensor components
    - UUVs
    - Sea web sensors
    - Recharging stations

  - Force mix to meet
    - Delivery of 50%
    - Delivery of 80%
  - Assets required
  - Total tonnage of components
  - Transit time (hrs)
  - Refueling required
  - Reseed requirements
  - Payload off-load/on-load time
  - Asset arrival time
  - Percent capability over time
Logistical Performance

Distribution of Logistical Arrival Rate Alternative LAG

Logistical Differences and Limitations Based Upon Alternative Architecture
C4ISR

C4ISR Analytical Modeling

- Bandwidth available
- Bandwidth required
- Processing time
- Transmission time
- Bit Error rate
- Frequency
- Ambient noise
- Power (W)
- SNR

DDS Network Model

- Data latency
- Capacity
- Fusion time
- Range
C4ISR Model Products

C4ISR output examples:

Data Latency Experienced When COP Update is .12M

SNR Based on Range and Ambient Noise - 10KHz 20W
Overall System Performance

- High Level Entity Based Model
- Naval Simulation System

- Environmental
- Communications
- C4ISR
- Susceptibility to detection
- Red/Blue search/transit speed
- Red/Blue search/patrol pattern
- Red/Blue sensor capabilities
- Red/Blue endurance
- Operating Medium

- Surveillance detections
- Tracking sensor events
- Tracking sensor status
- Change time
- Total tracking time
High Level Modeling

NSS Simulation Examples:
Search & Detection

- Probability of Detection
  - Used NSS to simulate real-world scenario in the Bass Strait over a 30 day period (720 hours)
    - Simulation data shows when Blue assets begin operations in the AOR
  - After analysis, results show:
    - Pd of all Red submarines
    - Pd of any one Red submarine
    - Instantaneous Pd of any Red submarine
Alternative Modeling

LCDR Michael Kaslik, USN
Location of All 8 Red Submarines at Problem Start

- Two Red Submarines Underway
- Two Red Submarines in Each Port

Two Red Submarines Underway

Two Red Submarines in Each Port
Littoral Action Group
Assets and Timeline

- 2 SSNs
- 1 DD(X)
- 3 LCS’s
- 5 MH-60Rs
  - 2 on DD(X)
  - 1 per LCS

5th Day
SSNs

6th Day
DD(X)
LCS’s
MH-60Rs

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

All 8 Red Submarines Underway

SSN
MH-60R
DD(X)
LCS
TSSE Sea TENTACLE
Assets and Timeline

- 3 TSSE Sea TENTACLE Ships
  - 144 Large UUVs
  - 144 UUV Sleds
  - 864 Light Weight UUVs
  - 2304 Man-Portable Deployed Bottom Sensors

6th Day
3 TSSE Ships

10th Day
Sea TENTACLE Deployment Complete

All 8 Red Submarines Underway

TSSE Sensors modeled as a fixed aggregate sensor

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Tripwire
Assets and Timeline

- Stationary Bottom Netted Sensors
  - 50 deployed outside each of the 3 harbors
  - Sustainable through 30-day scenario

- UUV
  - 5 deployed outside each of the 3 harbors
  - 80 hr battery duration

24th Hour
- 150 Bottom Sensors

36th Hour
- 15 UUV’s
War of Machines
Assets and Timeline

- 51 Heavy Weight Vehicle (HWV) UUVs
  - 45 HWV UUVs air-deployed
  - 2 HWV UUVs outside each Red Harbors
- 9 Recharging stations

8 – 26 Hours
51 UUV’s

6th Day
Recharging Stations

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

All 8 Red Submarines Underway

UUV

8th Day
Recharging Stations

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Littoral Action Group
Probability of Detection

LAG
Probability of Detection

Black Line: Probability of Detecting a single Red Submarine by time step

Red Line: Probability of Detecting all Red Submarines by time step

Time Steps (Hrs)

Probability

Needs Analysis
Obj Analysis
Alt Generation
Modeling
Analysis
Conclusions
Alternative Comparison
Probability of Detection

LAG
Probability of Detection

Sea TENTACLE
Probability of Detection

War of Machines
Probability of Detection

Tripwire
Probability of Detection

Needs Analysis  Obj Analysis  Alt Generation  Modeling  Analysis  Conclusions
Littoral Action Group
Probability of Tracking

Littoral Action Group
Probability of a SINGLE Red Submarine from Tracked 6 - 54 Min.

- **Black Lines:** Probability of having tracked a single Red Submarine during the scenario
- Lines show 6 minutes to 54 minutes of tracking capability at 6 minute intervals
Littoral Action Group

Probability of EACH Red Submarine Tracked From 6 - 54 Min.

- **Red Lines:** Probability of having tracked each of the 8 Submarines at some point during the scenario.
- **Lines:** Show 6 minutes to 54 minutes of tracking capability at 6 minute intervals.

- 6 Minute Tracking Line
- 30 Minute Tracking Line

**Legend:**
- ▐

**Axes:**
- **Time Steps (Hrs):** 0 to 700
- **Probability:** 0 to 1

**Graph:**
- Graph showing probability over time for tracking submarines.
Littoral Action Group
Probability of Tracking

---

**Black Line**: Probability of having tracked a Red Submarine for 30 minutes

**Red Line**: Probability of having tracked each of the 8 Red Submarines at some point during the scenario

- **Max of 0.94 at 720 Hrs**
- **Max of 0.6 at 720 Hrs**
Alternative Comparison
Probability of Tracking

Littoral Action Group
Probability of Tracked 30 Min

Sea TENTACLE
Probability of Red Tracked 30 Min

War of Machines
Probability of Red Tracked 30 Min

Tripwire
Probability of Red Tracked 30 Min
Analysis

LT John J. Strunk, USN
Arrival Times Vary

Time of Arrival in AOR

Arrival Time (hours)

Sea TENTACLE and LAG nearly 5 days later due to platform speeds
Alternatives’ Strengths/Weaknesses

Time to INITIAL Detect of Red Submarines

LAG and Sea TENTACLE do not achieve 80% Pd until more than 230 hours.

Warning-time sensitive performance.

- War of Machines
- Tripwire
- Littoral Action Group
- Sea TENTACLE
Alternatives’ Strengths/Weaknesses

Time to Detect EACH of 8 Red Submarines

- Quick rise once Blue starts detecting Red
- Never reaches 100%

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Time to Detect EACH of 8 Red Submarines</th>
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<tbody>
<tr>
<td>War of Machines</td>
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<td>Sea TENTACLE</td>
<td></td>
</tr>
</tbody>
</table>

- Needs Analysis
- Obj Analysis
- Alt Generation
- Modeling
- Analysis
- Conclusions
Alternatives’ Strengths/Weaknesses

80% Probability of Achieving Two Critical Detection Metrics

WOM achieves FIRST and EACH Red EARLY

Once established, Sea TENTACLE achieves detection of each sub quickly

INITIAL Red

EACH of 8 Red Subs Detected

80% Probability of Achieving Two Critical Detection Metrics

Tripwire

Sea TENTACLE

War of Machines

Littoral Action Group

Strengths/Weaknesses

Tripwire and WOM achieve early detection on SOME Red subs.

Sea TENTACLE and LAG achieve initial Red detections later.

Tripwire and LAG experience long delays in detecting EACH sub.

WOM achieves FIRST and EACH Red EARLY.

Once established, Sea TENTACLE achieves detection of each sub quickly.
Tracking Ability

Sensitivity to Required Continuous Track Time within First 10 Days

- **Sea TENTACLE** is sensitive to required track time due to its immobile sensors.
- **Tripwire** is also insensitive, but lacks recharge capability.
- **War of Machines** is insensitive to required track time due to invasive mobile platforms.
- **LAG** shows a high probability of lost track due to the standoff ranges of manned platforms.

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**Tracking Ability Needs Analysis**

- **Obj Analysis**
- **Alt Generation**
- **Modeling**
- **Analysis**
- **Conclusions**
Tracking Ability

Ability to Continuously Track Each Red Submarine within First 10 Days

- WOM shows the ability to continuously track each of 8 Red subs
- Sea TENTACLE, Tripwire, and LAG show no ability to track each of 8 Red subs beyond 12 continuous minutes
SEA-8 Overall Conclusions

CDR Vic Bindi, USN
SEA-8 ASW Results, Insights and Recommendations

- Systems engineering principles
- Results and insights
  - No perfect system
  - Reaction time
  - Persistent systems
  - Kill chain timeline tradeoffs
  - Undersea Joint Engagement Zones (UJEZ)
ASW Results, Insights and Recommendations

NO PERFECT SYSTEM

- Scenario variables were the key factors
- Each alternative studied had weaknesses

RECOMMENDATIONS

- Study mix of developed ASW architectures
- Apply those ASW architectures to theater specific scenarios, via modeling
REACTON TIME
- Enemy timelines are unpredictable
- Quick reaction systems hedge uncertainty

RECOMMENDATIONS
- Use strategic air to expand the reach of tactical ASW operations
- Develop a JSOW like system to deliver sensors and UUVs close to the enemy shoreline
ASW Results, Insights and Recommendations

PRESENCE

- Pervasive persistence is the goal
- Traditional methods
- Non-traditional methods

RECOMMENDATIONS

- Develop UUV’s with autonomous search and track
- Develop rapidly deployable, netted sensing grids
- Develop systems that recharge, reseed and relief on station capabilities for non-traditional ASW assets
ASW Results, Insights and Recommendations

KILL-CHAIN TIMELINE (KCT) TRADEOFFS

- Traditional methods require short KCTs
- Non-traditional methods afford longer KCTs

RECOMMENDATIONS

- Develop autonomous UUVs that possess the ability to prosecute enemy submarines
UNDERSEA JOINT ENGAGEMENT ZONE (UJEZ)

- Cooperative mix of assets unlocks future ASW force capabilities
- Future ASW forces will require the establishment of the UJEZ

RECOMMENDATIONS

- Explore the doctrinal shift away from waterspace management and PMI techniques toward UJEZ
- Develop undersea networks required to support UJEZ
Future Studies

- Sensitivity analysis of alternatives in relation to geographic areas and threat scenarios (types and compositions)
- Improved UUV energy sources and recharging stations
- Role of the UUV in the engagement sequence
- UUV effects upon the Kill-Chain Timeline
- Application of alternative architectures in MIW
- Integration of strategic air in tactical ASW operations
Systems Engineering Analysis
Littoral Undersea Warfare in 2025