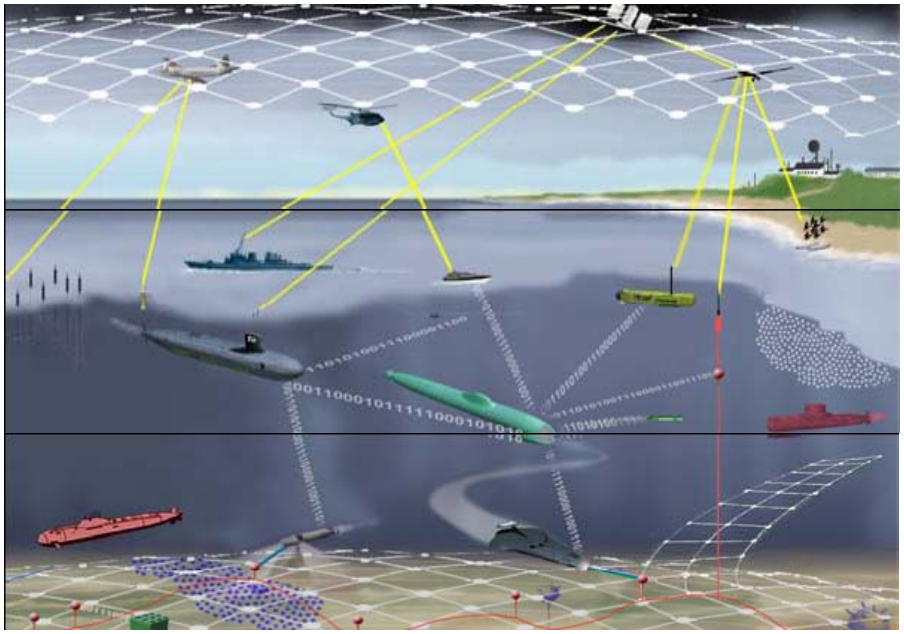

C4I Architecture Supporting Conduct of Defensive and Offensive Joint ASW

Presented By:
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Bill Traganza
Matthew Letourneau
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28 Oct 2009
(based on report # NPS-00-001)

Team Members

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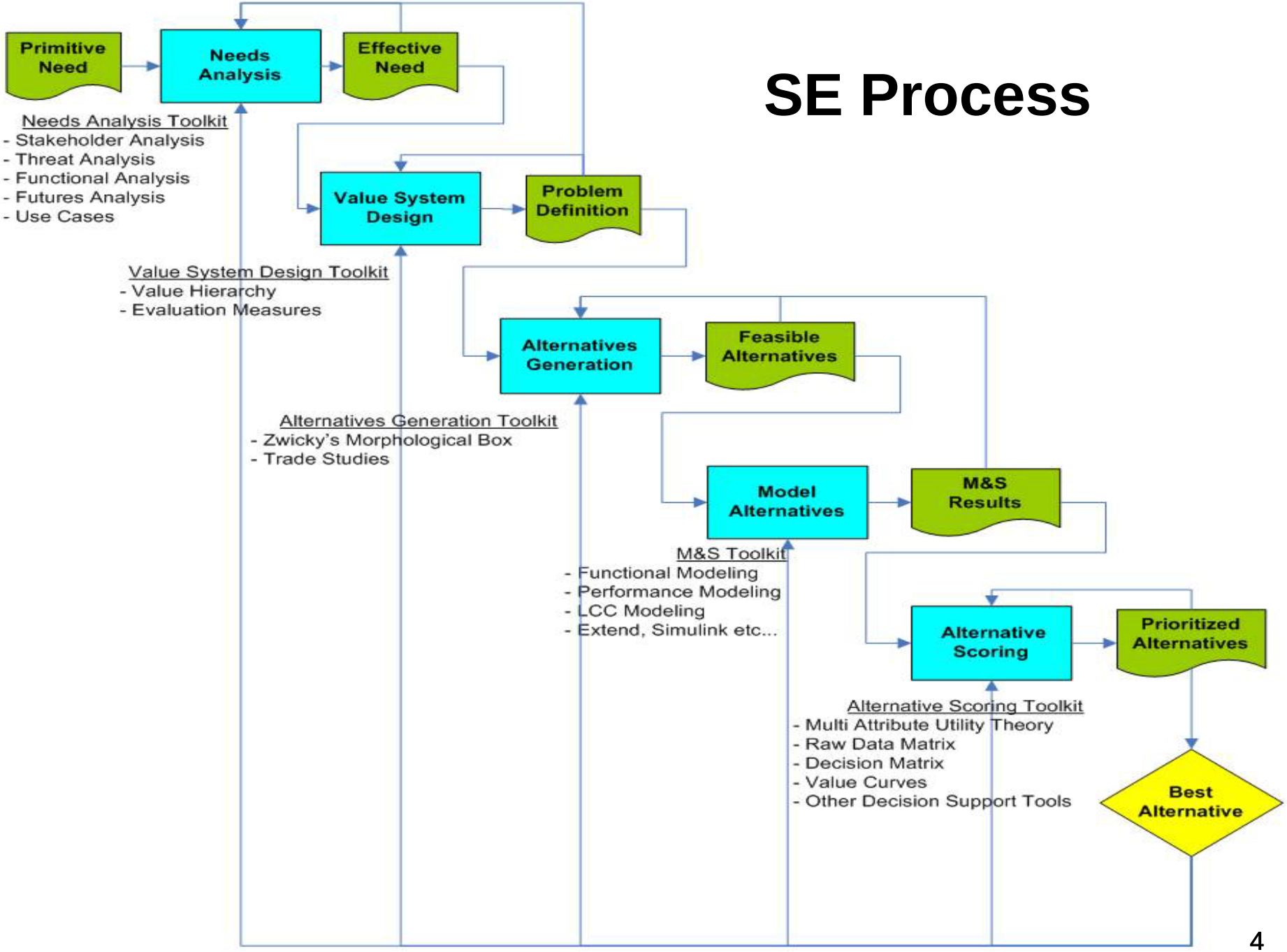
- Commands represented by team
  - Space and Naval Warfare Systems Command -- Systems Center San Diego and Charleston
  - Naval Surface Warfare Center – Corona Division
  - Program Executive Office Littoral and Mine Warfare – Maritime Surveillance Systems Program Office
  - Program Executive Office C4I
  - Joint Tactical Radio System – Joint Program Executive Office
  - East Coast Electronic Warfare Systems
  - Communications-Electronics Research Development and Engineering Center
- Project advisors: Gregory A. Miller & John M. Green

Project Purpose

- Create a new standardized joint ASW-specific C4I architecture
  - To enhance the commander's ability to execute the joint ASW mission in support of a combatant commander's campaign objectives [NCOE JIC, 2005].
  - To meet key ASW stakeholder requirements, addressing current capability gaps and responding to changing threats
  - To guide development, force composition, and acquisition decisions
- Constrained to:
  - Target time frame: 2020
  - Needs to use
    - Open standards
    - Common waveforms
    - Common data schema
  - Interoperable with existing & evolving systems
  - Vertically integrated with other DoD C4I systems

SE Process

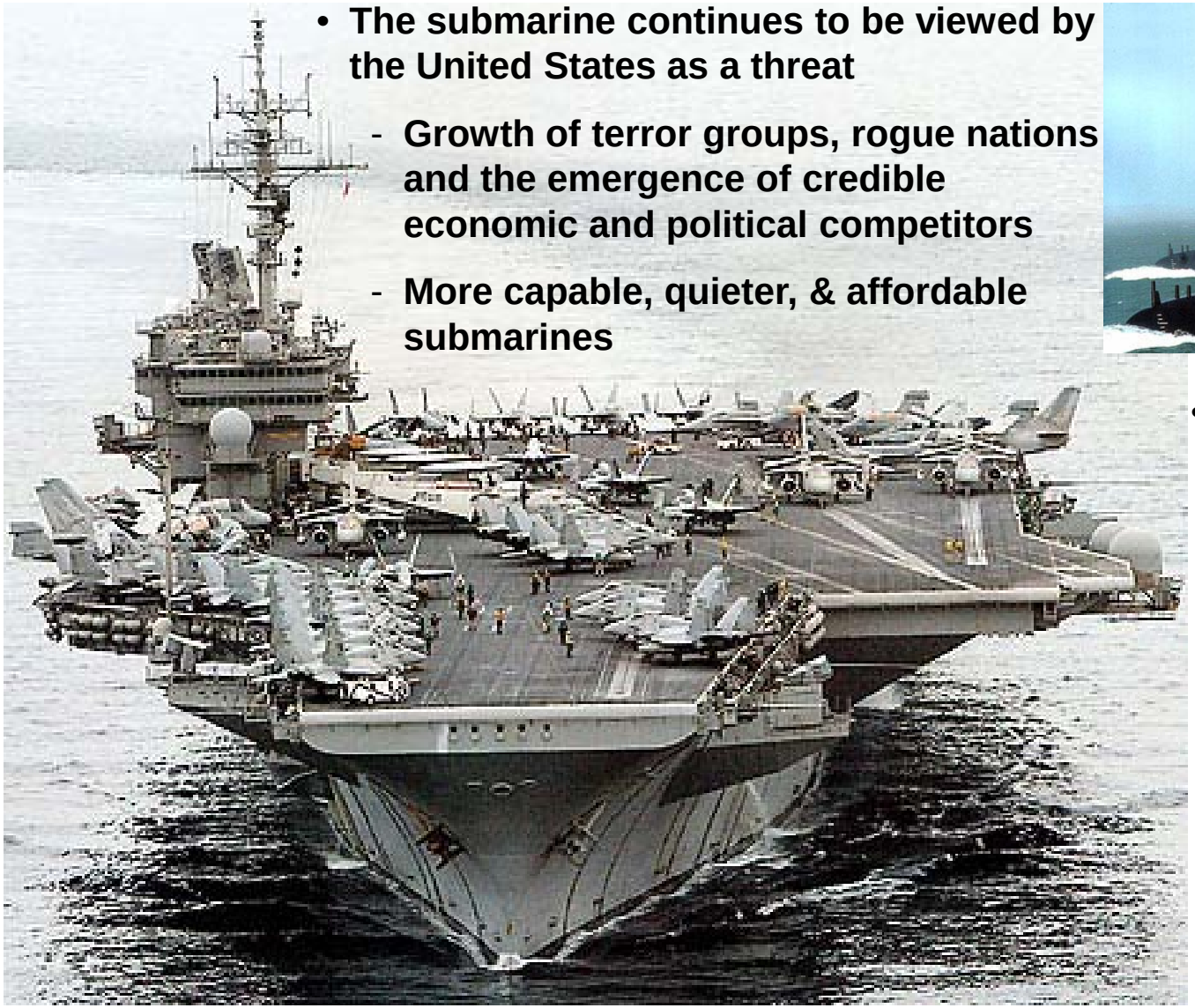

Primitive Need
Needs Analysis
Effective Need
Needs Analysis Toolkit
- Stakeholder Analysis
- Threat Analysis
- Functional Analysis
- Futures Analysis
- Use Cases
Value System Design
Problem Definition
Value System Design Toolkit
- Value Hierarchy
- Evaluation Measures
Alternatives Generation
Feasible Alternatives
Alternatives Generation Toolkit
- Zwicky's Morphological Box
- Trade Studies
Model Alternatives
M&S Results
M&S Toolkit
- Functional Modeling
- Performance Modeling
- LCC Modeling
- Extend, Simulink etc...
Alternative Scoring
Prioritized Alternatives
Alternative Scoring Toolkit
- Multi Attribute Utility Theory
- Raw Data Matrix
- Decision Matrix
- Value Curves
- Other Decision Support Tools
Best Alternative

Needs Analysis

- Capability Gaps Analysis (Situation Today)
- Stakeholders Analysis
- Future Analysis
- Functional Analysis

Situation Today

- **The submarine continues to be viewed by the United States as a threat**
  - **Growth of terror groups, rogue nations and the emergence of credible economic and political competitors**
  - **More capable, quieter, & affordable submarines**

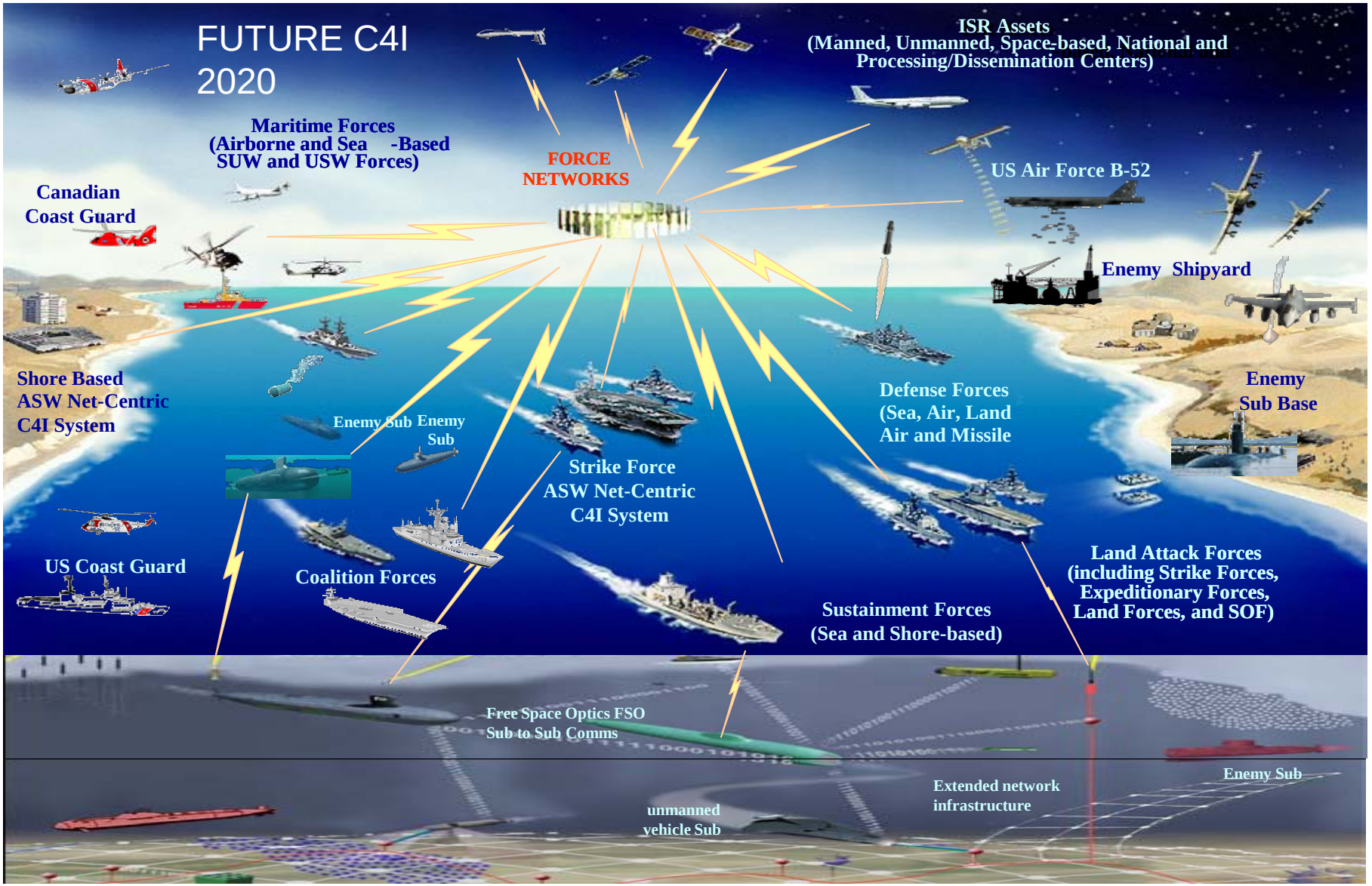


- **Platform-centric ASW C4I systems are not used in a networked fashion to share data**
  - **Limited situational awareness**
  - **Limited mission effectiveness**

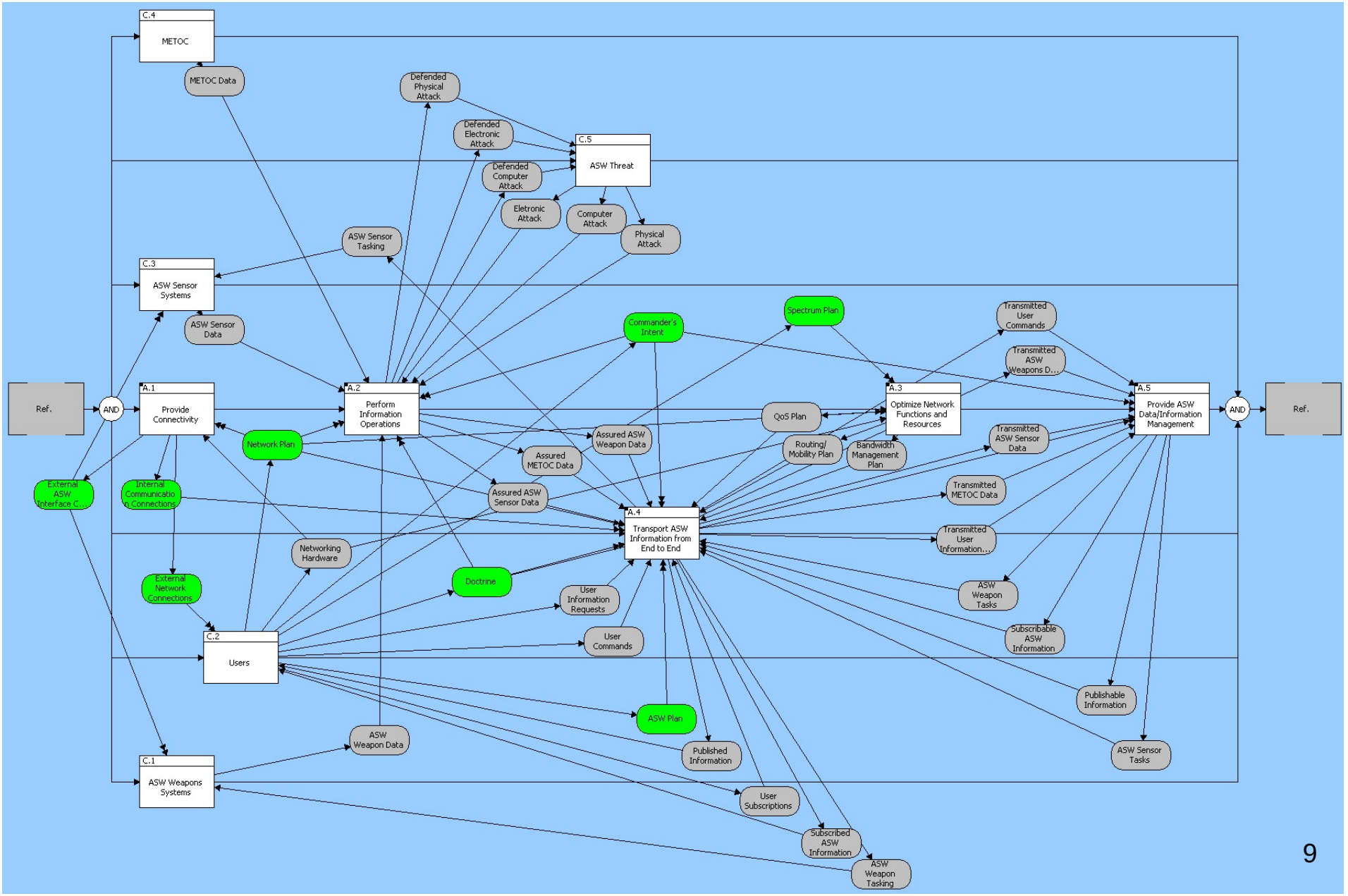
Summary of Stakeholder Input

- Legacy & Evolved Systems
  - Platform-centric C4I systems
  - Platform-centric sensors
  - Platform-centric weapons
  - Limited interoperability
- Future Systems
  - Networking to connect sensors & platforms
  - Information sharing
  - Improved information quality
  - Viewing through a COTP – fused, appropriate data
  - Conducting ASW as a Team

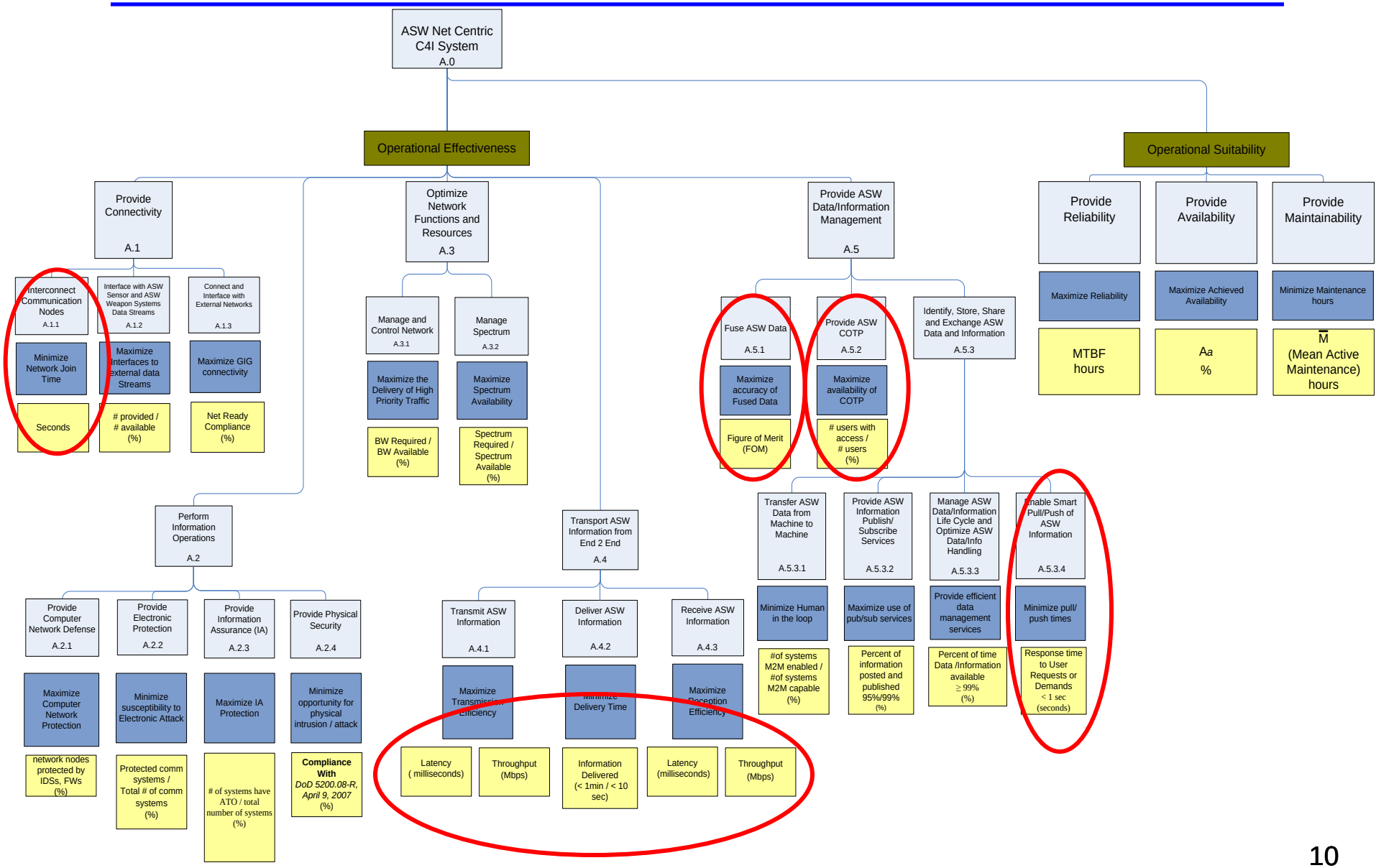
Draft Futures OV-1



C2 System Functional Analysis



Value System



Top Six Evaluation Measures

- # Users w/ access to COTP
- Time Required to Push/Pull
- Time Required to Fuse Data
- Time to Interconnect Nodes
- Transmit Latency
- Transmit Throughput

Alternatives Generation

- **Baseline Architecture**
- **Feasible Alternatives**

Programs of Record & C4I Functionality

DoD Teleport

SINGLE INTEGRATION POINT FOR DISN (TERRESTRIAL & TACSAT COMMS);
TELECOM COLLECTION & DISTRIBUTION POINT;
MULTI-BAND, MULTIMEDIA, & WORLDWIDE REACH-BACK;
STANDARDIZED TACTICAL ENTRY POINT EXTENTION;
MULTIPLE MILCOMM & COMMSAT SYSTEMS;
SEAMLESS DISN INTERFACE;
INTER & INTRA-THEATER COMMUNICATIONS;
INCREASED DISN ACCESS

Transformational Satellite System

GLOBAL NET-CENTRIC OPERATIONS;
ORBIT-TO-GROUND LASER & RF COMMS;
HI DATA RATE MILSAT COMMS & INTERNET-LIKE SVCS;
IMPROVED CONNECTIVITY/DATA TRANSFER;
IMPROVED SATCOMMS

Net-Centric Enterprise Services

UBIQUITOUS ACCESS; RELIABILITY;
DECISION QUALITY INFORMATION;
EMPOWER "EDGE" USER;
TASK, POST, PROCESS, USE, & STORE, MANAGE & PROTECT INFORMATION RESOURCES ON DEMAND

Next Generation Enterprise Network

OPEN ARCHITECTURE
SERVICE-ORIENTED ARCHITECTURE

Global Information Grid

COLLECTING, PROCESSING, STORING, DISSEMINATING, & MANAGING INFO ON DEMAND;
OWNED & LEASED COMMS

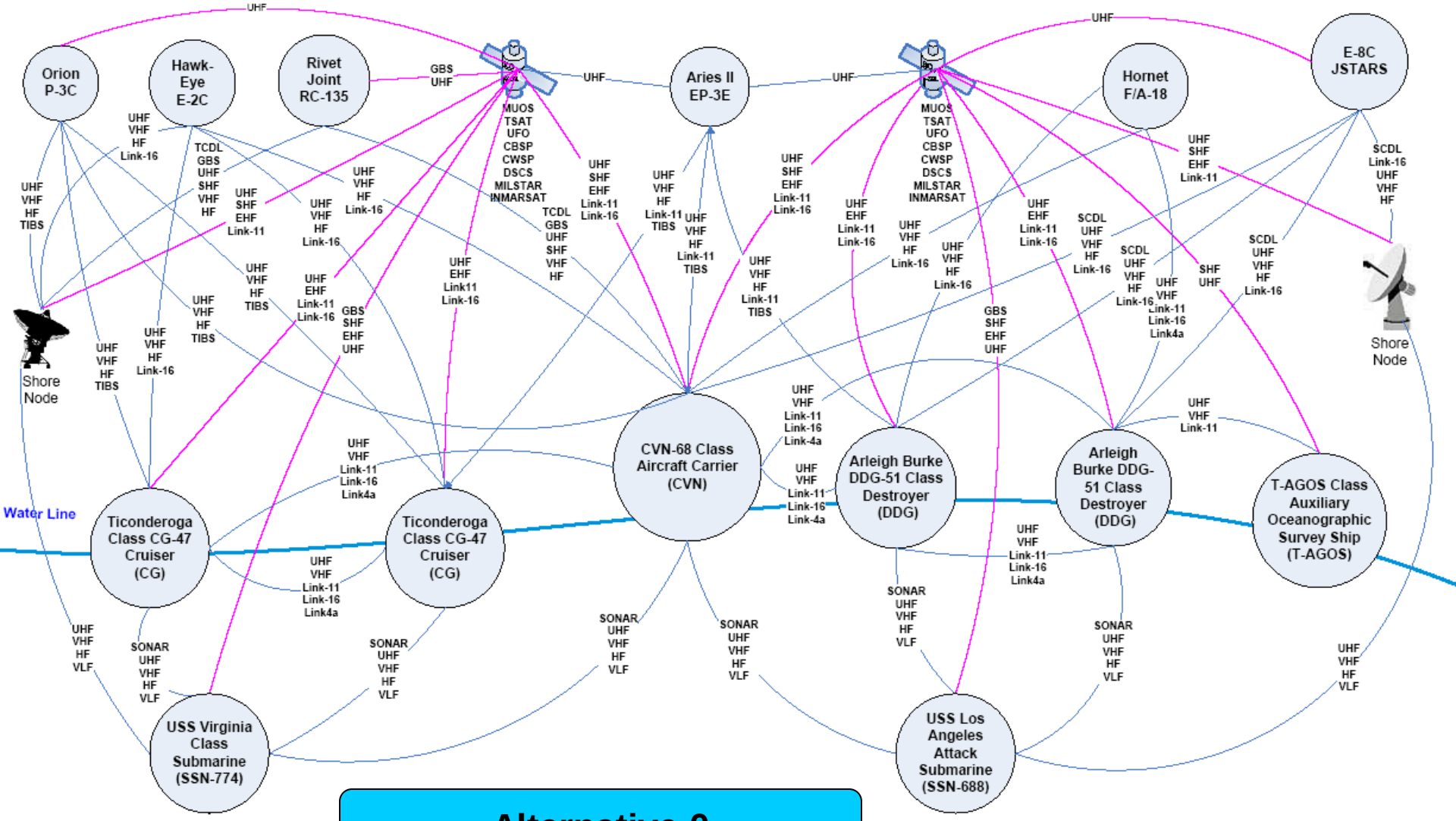
Joint Tactical Radio System

LOS / BLOS; MULTI-BAND, MULTI-MODE, MULTI-CHANNEL; NARROWBAND & WIDEBAND WAVEFORMS; VOICE, VIDEO AND HIGH-SPEED DATA

Net-enabled Command Capability

JOINT COMMAND AND CONTROL

FY2020 Baseline ASW C4I Architecture



Alternative 0

Alternative Solutions

Alternative 0 – FY2020 ASW C4I Baseline Architecture

- **Joint Surveillance and Target Attack Radar System (JSTARS)**
- **Satellite communications link (SATCOM)**
- **Surveillance and control datalink (SCDL)**
- **Joint Tactical Radio System (JTRS)**
- **RC-135: The Tactical Common Data Link (TCDL)**
- **Interface to the Tactical Control System (TCS)**
- **Link-16**

Alternative 1

FY2020 ASW C4I Baseline Architecture **plus:**

- **JTRS improvements**
- **NECC improvements**
- **CANES improvements**

Alternative 2

FY2020 ASW C4I Baseline Architecture **plus:**

- **JTRS improvements +**
- **CANES improvements**
- **Joint Track Manager**

Alternative 3

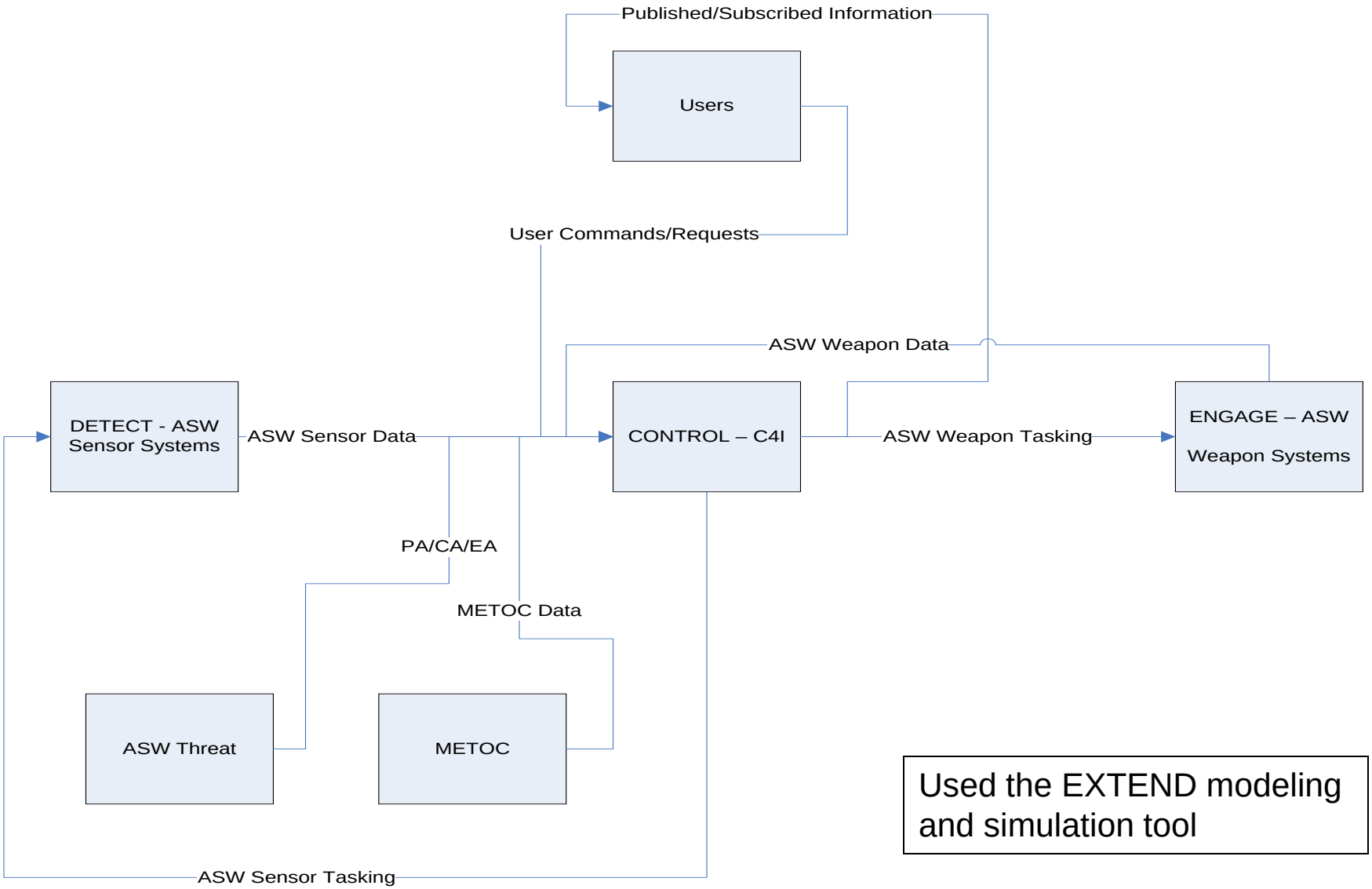
FY2020 ASW C4I Baseline Architecture **plus:**

- **Modulated X-ray source communications system**
- **Autonomous C4ISR UUVs**
- **Military High Altitude Airship (HAA)**
- **Tropospheric or space-based distribution & COTP fusion**
- **Wireless info push/pull directly to satellite or HAA based network.**

Modeling and Simulation Results

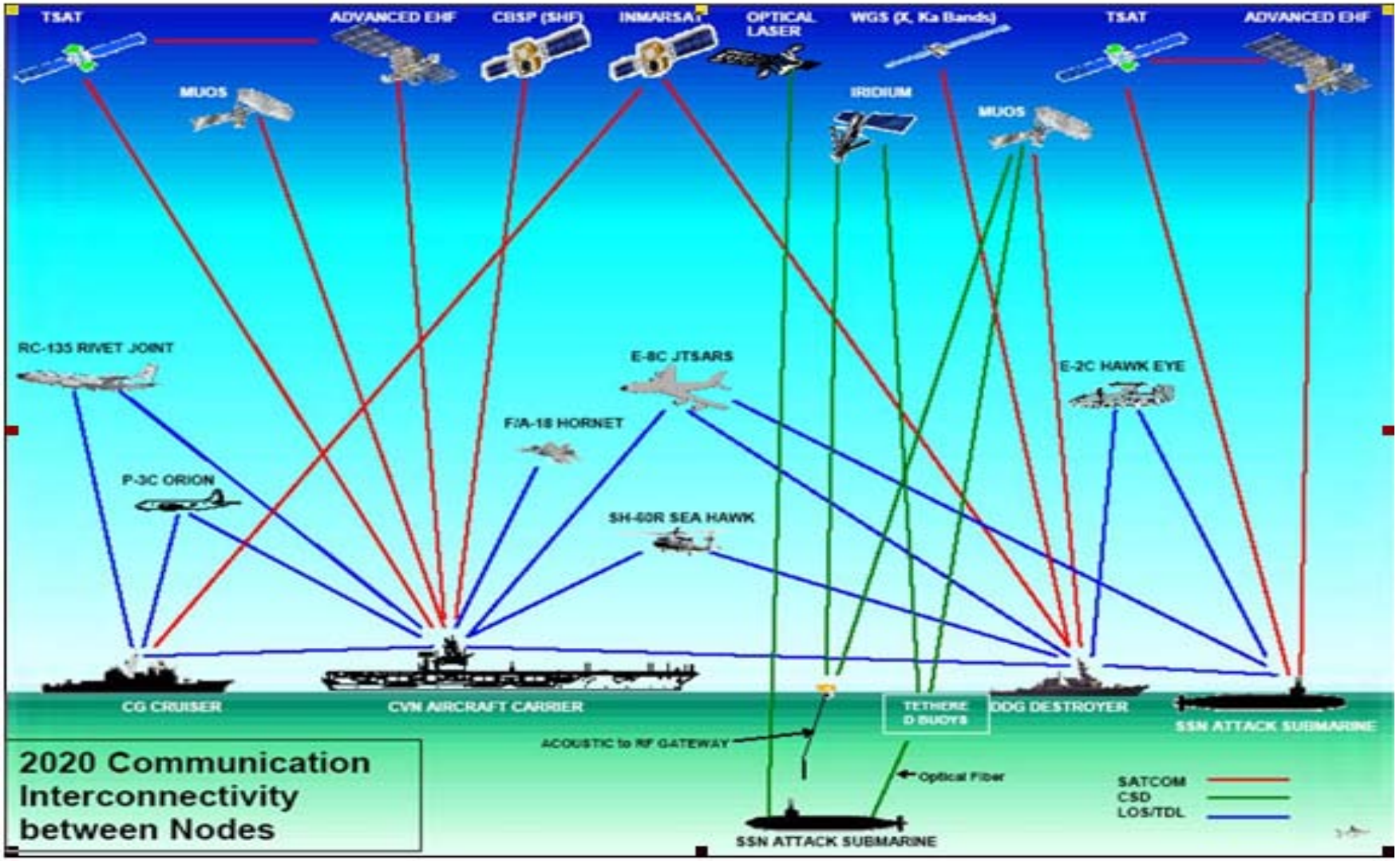
- **Model Overview**
- **Data Inputs**
- **Comparison of Alternatives**

Model Overview



Used the EXTEND modeling and simulation tool

Communication Between Platforms



Graphical Representation of the Systems Expected to Perform the Interconnect Communication Nodes Function for Alternatives 0, 1, and 2

Comparison of Alternatives

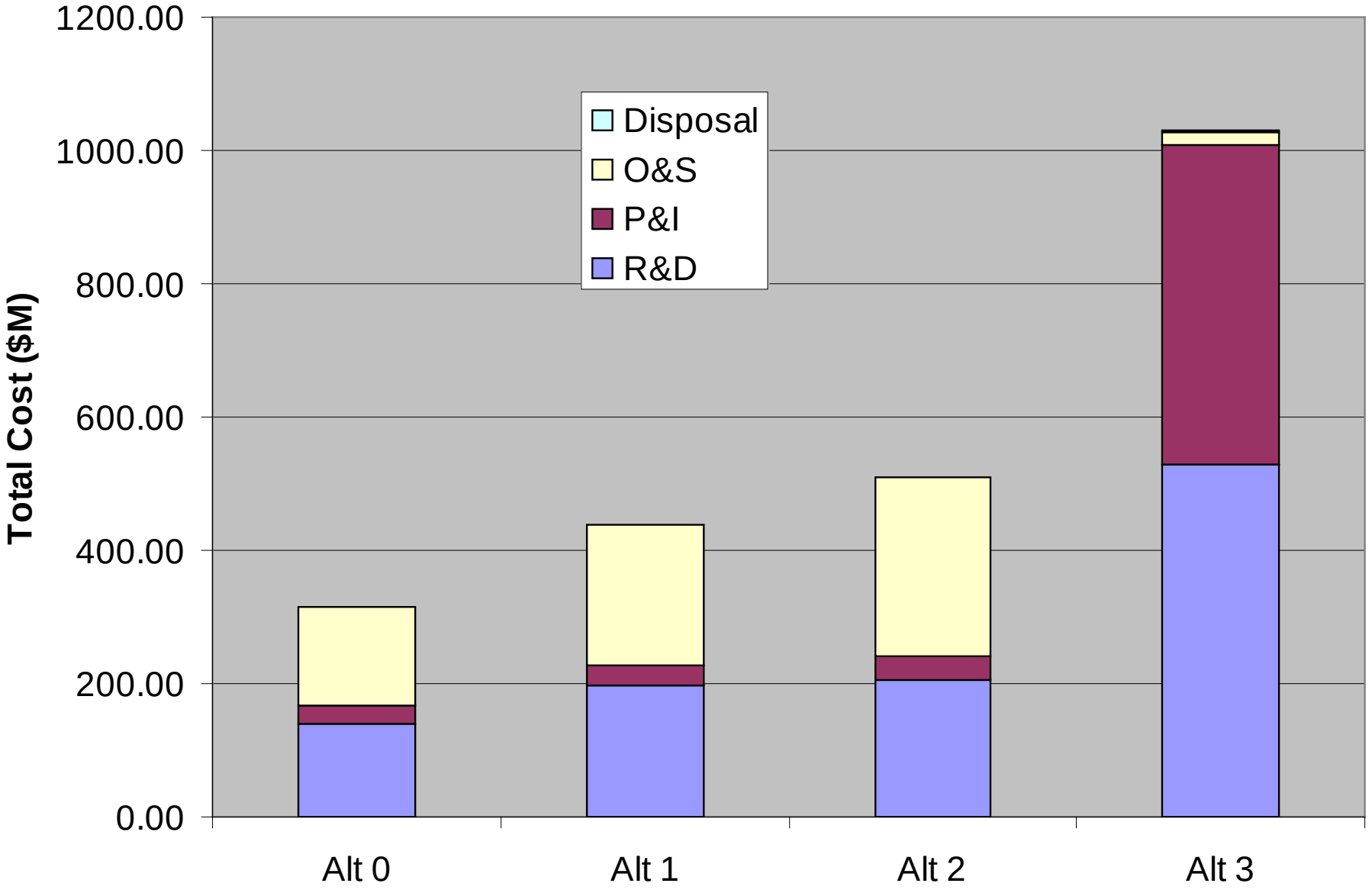
Measurement	Alt 0	Alt 1	Alt 2	Alt 3
Data Fusion Processing Time (ms)	702.39	540.13	299.82	299.72
Interconnect Communication Nodes (s)	5	4.5	2.5	2.5
Latency (ms)	1334.1	1205.0	685.56	680.16
Throughput (kbps)	51.29	53.93	58.85	58.15

Life Cycle Cost Estimate (LCCE)

LCCE

- Purpose: Basis for an informed decision when selecting an alternative
  - Assess affordability
  - Analyze alternatives
  - Cost verses performance tradeoffs
  - Establish program cost goals
- Scope: Simplified Cost Break Down Structure (CBS)
  - Research and Development (R&D)
  - Procurement and Installation (P&I)
  - Operation and Maintenance (O&M)
  - Disposal
- Assumption: A “Notional” U.S. Navy Ship
  - Common Computing, Network, Communication Infrastructure
  - C4I centric
  - Program office provided data
  - Three increments

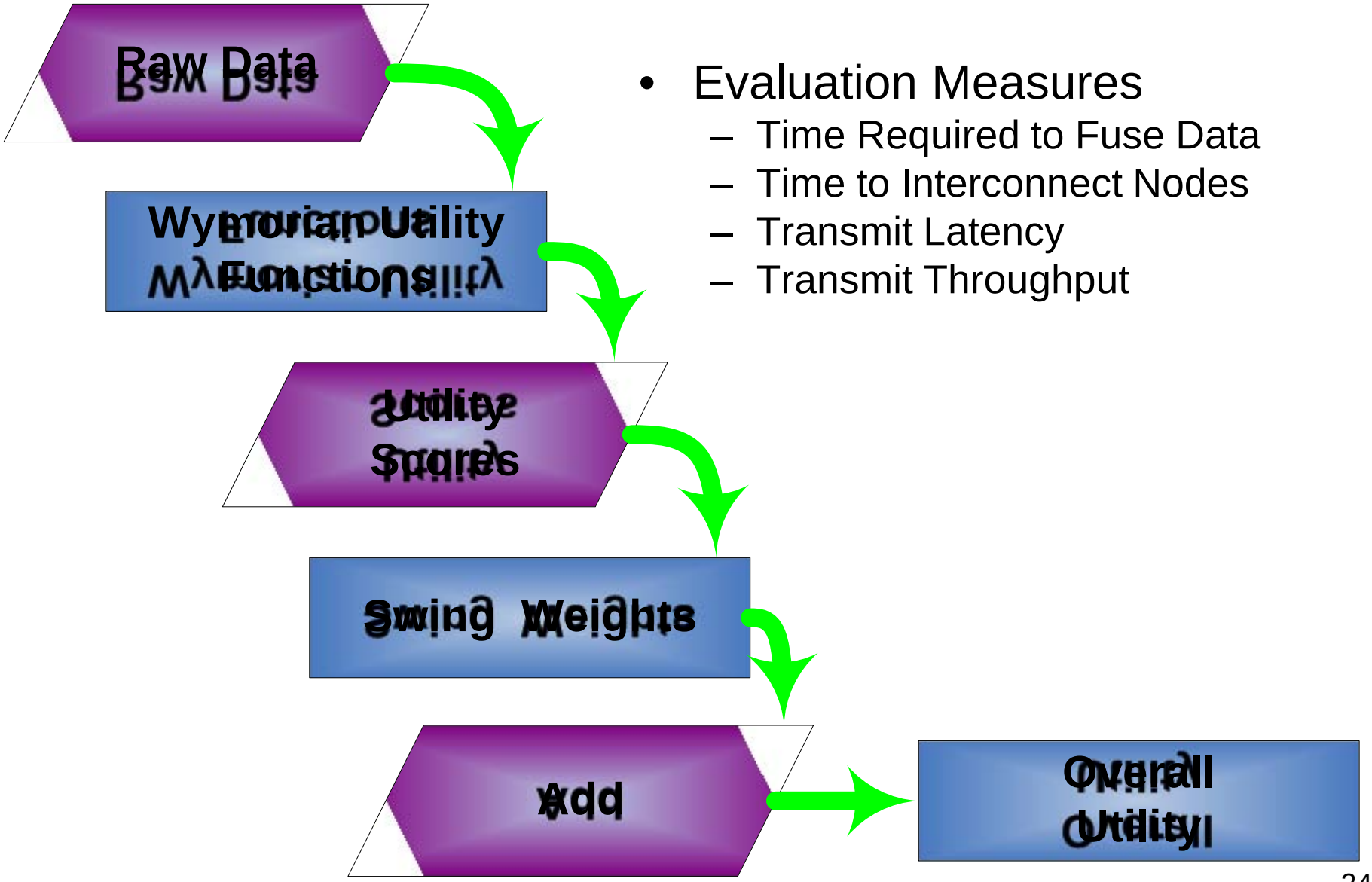
Total Cost for Each Alternative



Analysis of Alternatives

- Multi Attribute Utility Theory (MAUT)
- Raw Data Values
- Utility Scores
- Swing Weights
- Decision Matrix
- Utility Score vs. LCCE

Multi Attribute Utility Theory (MAUT)



- Evaluation Measures
  - Time Required to Fuse Data
  - Time to Interconnect Nodes
  - Transmit Latency
  - Transmit Throughput

Raw Data Values

Function (Evaluation Measure)	Alternatives			
	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Fuse ASW Data (Time Required to Fuse Data)	702.395 ms	540.139 ms	299.823 ms	299.720 ms
Interconnect Communication Nodes (Time to Interconnect)	5 s	4.5 s	2.5 s	2.5 s
Transmit ASW Information (Transmit Latency)	1334.161 ms	1205.027 ms	685.560 ms	680.160 ms
Transmit ASW Information (Transmit Throughput)	51.292 Kbps	53.930 Kbps	58.855 Kbps	58.155 Kbps

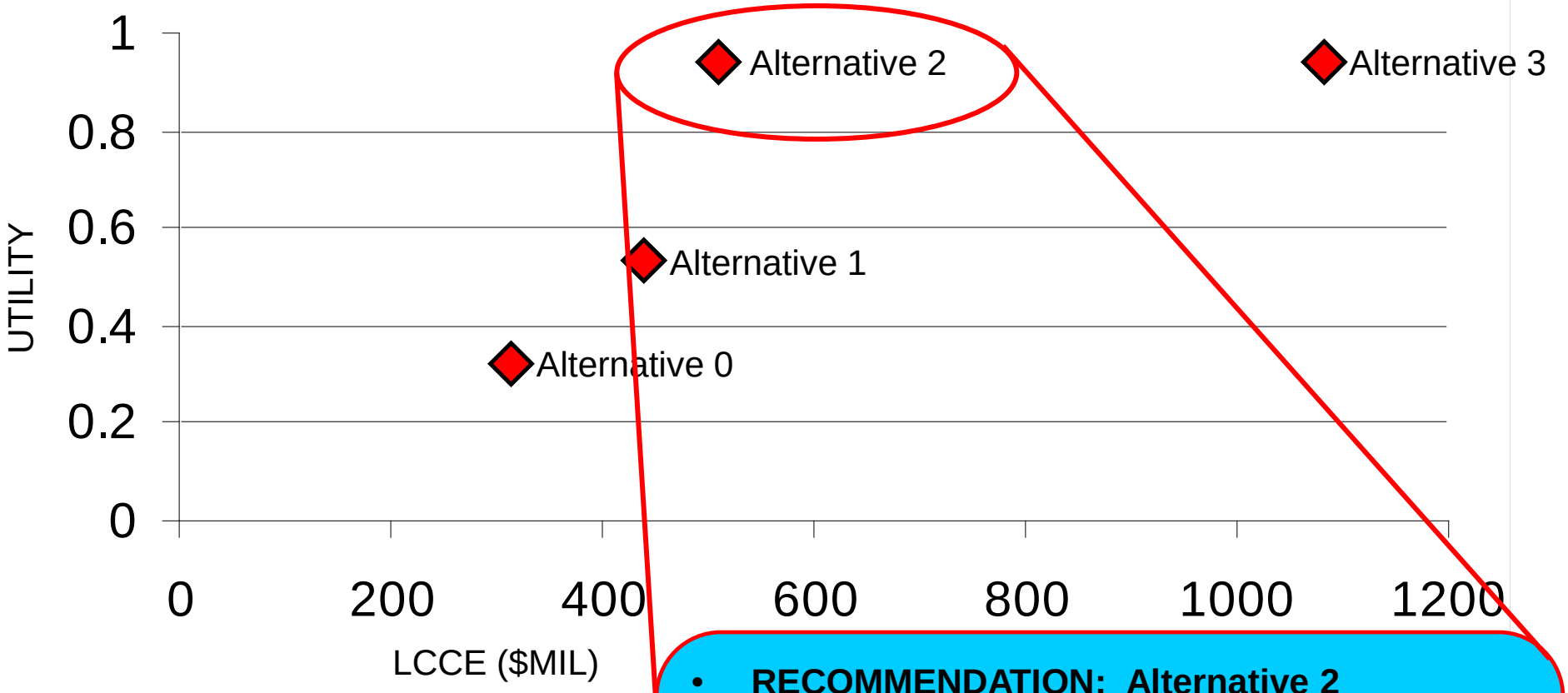
From the Extend model and scenarios

"Number of users with COTP access" and "Time required to push/pull" were identical for the four alternatives, so were not considered discriminators for decision-making.

Decision Matrix

Function (Evaluation Measure)	Weight	Alternatives			
		Alternative 0	Alternative 1	Alternative 2	Alternative 3
Fuse ASW Data (Time Required to Fuse Data)	**0.370**	0.06	0.36	0.93	0.93
Interconnect Communication Nodes (Time to Interconnect)	**0.185**	0.5	0.65	0.96	0.96
Transmit ASW Information (Transmit Latency)	**0.278**	0.37	0.49	0.9	0.9
Transmit ASW Information (Transmit Throughput)	**0.167**	0.63	0.83	0.99	0.98
Total Score (0-1)		**0.32**	**0.53**	**0.94**	**0.94**
LCCE ($Mil)		**313.90**	**439.60**	**508.65**	**1080.46**

Utility Score vs. LCCE



- **RECOMMENDATION: Alternative 2**
  - JSTARS
  - SATCOM
  - SCDL
  - Link-16
  - Joint Track Manager
  - RC-135: TCDL
  - Interface to the TCS
  - JTRS with latency & throughput improvements
  - CANES improvements

Conclusions

- There are initiatives to solve most ASW stakeholder concerns
- A system of systems (SoS) architect is needed
  - Conduct SoS M&S
  - Address projects at a SoS level
  - Enable cross-program manager collaboration
- Revise the modeling
  - Reflect current planned attributes for 2020 (changes since mid-2008)
  - M&S with all 24 functional evaluation measures
  - Include classified data sets
- Functional C4I characteristics *not* unique to ASW community
- Future C4I capabilities dependent upon cross-leveling of future DoD funding levels
- ASW operational C4I standards are needed in FY2020

Areas For Further Consideration

Operational Users and Acquisition Community

- Consider accuracy improvements provoked by data fusion and data sharing techniques during development of sensors and weapons
- ASW is a team sport [Morgan, 2008]. Need to improve ASW operational integration. Who's on the team?
  - Interagency (e.g., Coast Guard) and Joint?
  - Coalition and Allied?
    - If yes, security restraints and policies preventing IP base communications need to be addressed
- …..and many more in the report

Questions