Developing a Mission Solution: From Mission Gap Analysis to Preferred System Concept

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- Development in the Acquisition Cycle
- Affordable Weapon System Study (AWS)
- Implementing JCIDS at RMS
- Mission Capability Analysis
- Solution Capability Analysis
- First Principles Analysis
- Quality Functional Deployment / Preferred System Concept
- Summary

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Introduction

- Mission analysis studies conducted per the Joint Capabilities Integration & Development System (JCIDS) process identified gaps in the Navy's ability to provide accurate, responsive "Fire Support from the Sea"
  - Marine and Army forces operating ashore throughout conflict spectrum
  - Gaps defined in the Marines' Joint Fires Initial Capabilities Document (ICD)
  - Included impact from use of MV-22 Osprey, which provides Marines ability to conduct vertical envelopment ops far beyond naval gunfire range
- Navy interested in developing a refined system concept for an Affordable Weapon System (AWS) as a ship- and/or air-launched material solution " for the 2016 timeframe
- AWS Team employed RMS Mission System Engineering (MSE) Process
  - Mission Capability Analysis (MCA) used to identify relevant Mission Areas and Missions, and then determine the 2016 timeframe capability shortfalls
  - Solution Capability Analysis (SCA) used to identify, rank and rate solution options, and map options against defense strategies and mission shortfalls.

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Development in the Acquisition Cycle: JCIDS and DoDI 5000.02

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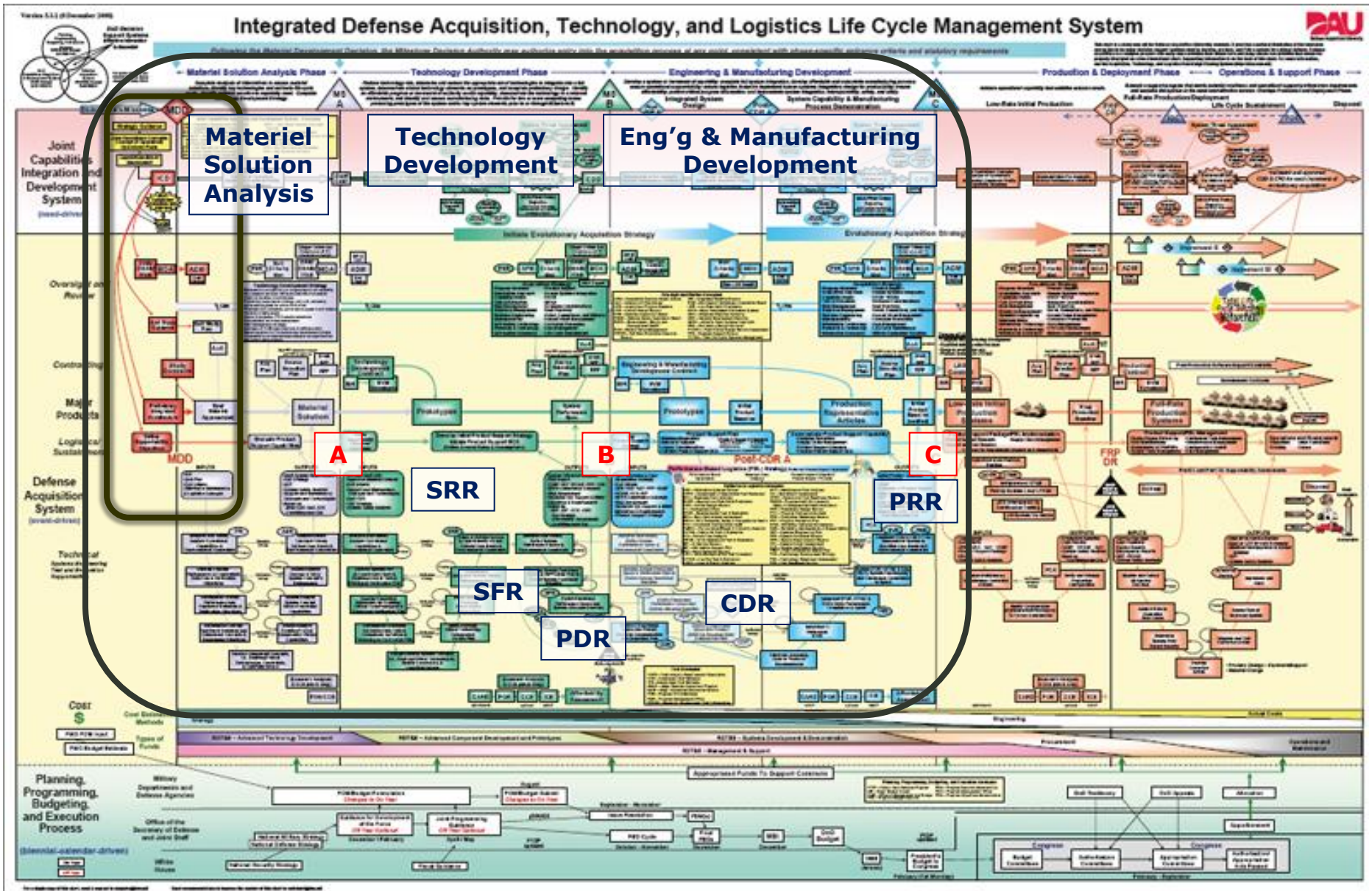

Affordable Weapon System Study: Mission Capability Analysis Process

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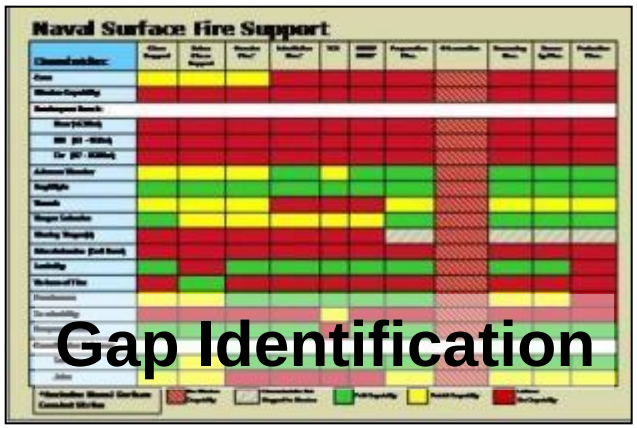
One aspect of the AWS study was to determine the capabilities and associated tasks, conditions and standards required for Naval Surface Fire Support (NSFS) missions performed at standoff ranges.

MCA Identifies:

- Appropriate Mission Areas and Missions
- Scope of Mission Area / Military Problem
- 2016 timeframe capability shortfalls

MCA Maps:

- Capabilities to Defense Strategies
- Relevant objectives to capability gaps
- Example Scenarios to mission areas



Focus on Identifying the Gaps

Affordable Weapon System Study: Solution Architecture & Design Development

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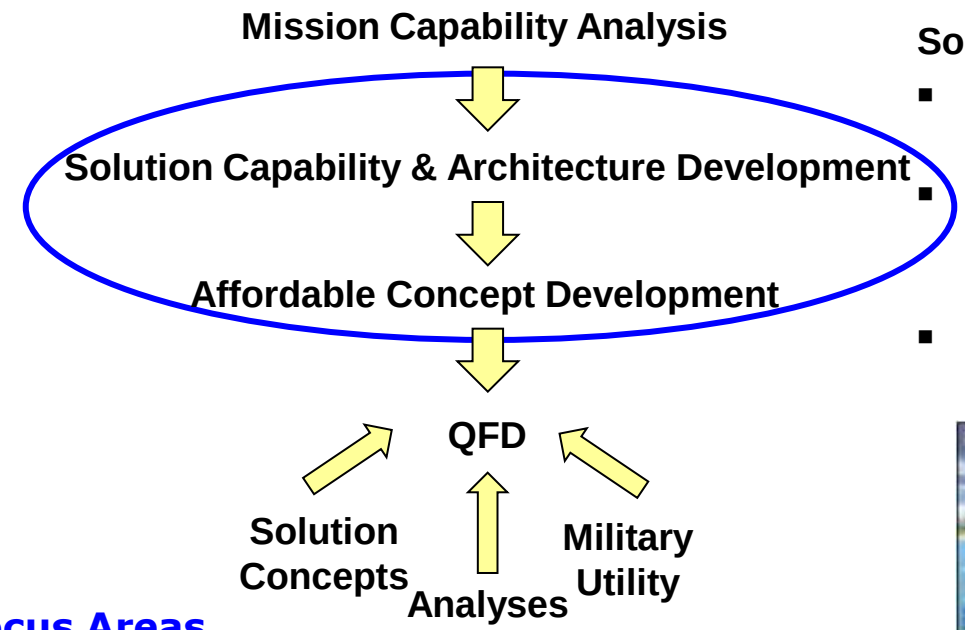
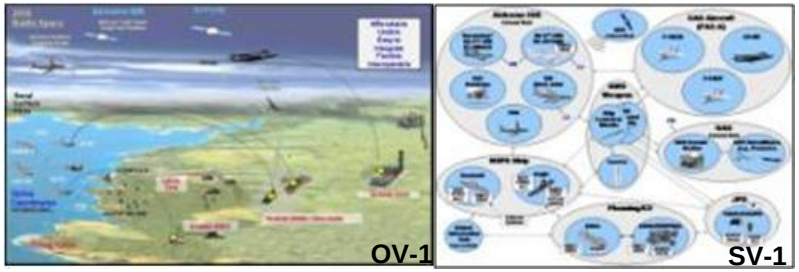
- MOEs → System Capabilities → System Requirements
- Use of Existing Navy Surface Fires Infrastructure
- Detailed Architecture Definition beyond M/S A levels
  - DoDAF AV-1, AV-2, OV-1 thru OV-7 SV-1 thru SV-9)



Solution Architecture includes:

- Operational Architecture
  - Kill Chain & Operational Model
- System Architecture & Solution Capabilities
  - Networks, Data Links, Systems, Functions, Interfaces, Function to Activity Mapping
- Weapon System (WCS & Missile)
  - Functionality, Timelines, End Game



Focus Areas

Architecture Flexibility wrt Preferred System Concept
System of Systems Interoperability & Functionality
Priority on Affordable & Useful → Achievable SoS Design → Exceptional Value to the Warfighter

Focus on Development of Solution Architecture & Concepts

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Affordable Weapon System (AWS) Operational Concept OV– 1

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Implementing JCIDS at RMS: Mission System Engineering (MSE)

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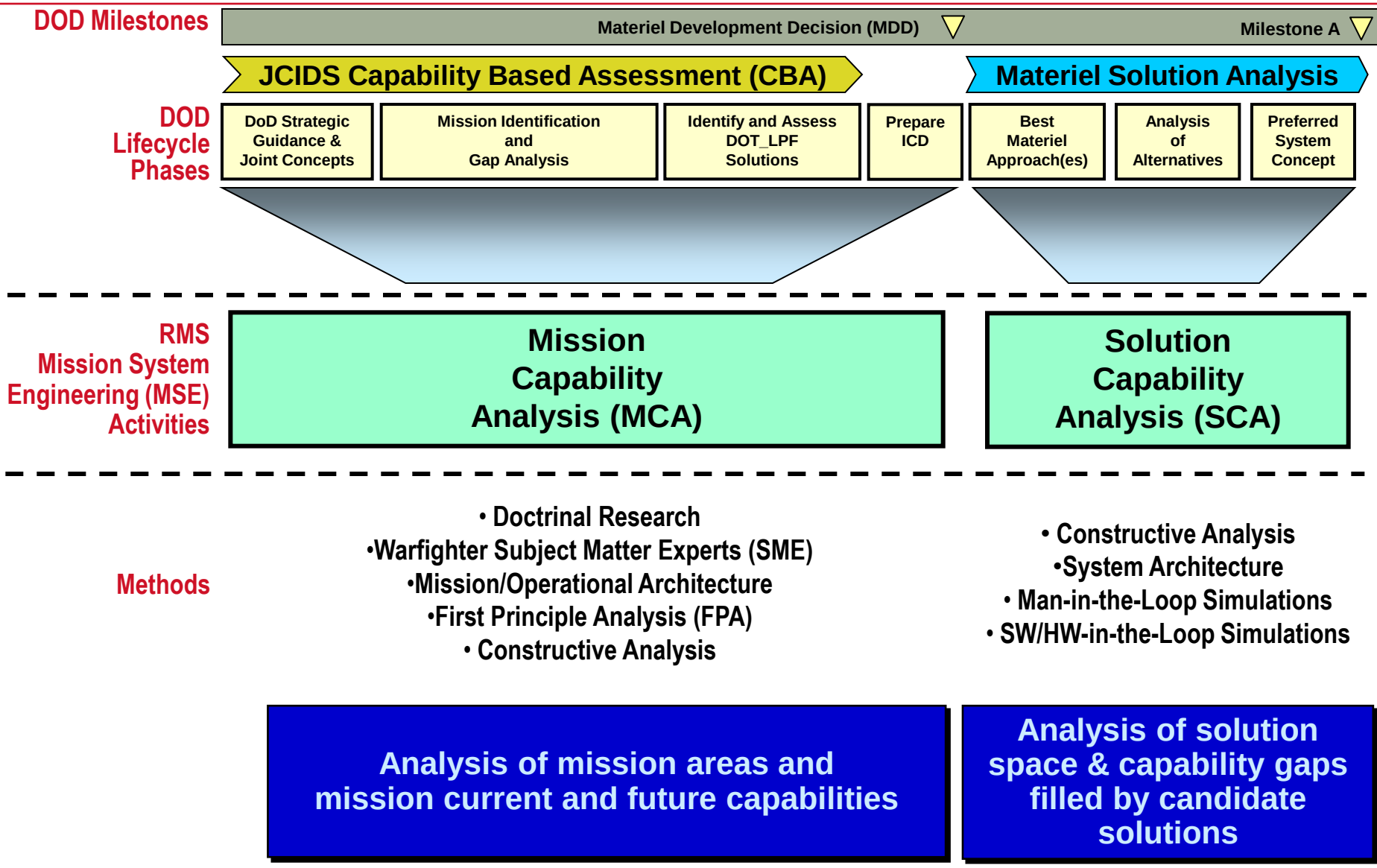

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Implementing JCIDS at RMS: MSE Components

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Mission Capabilities Analysis (MCA)

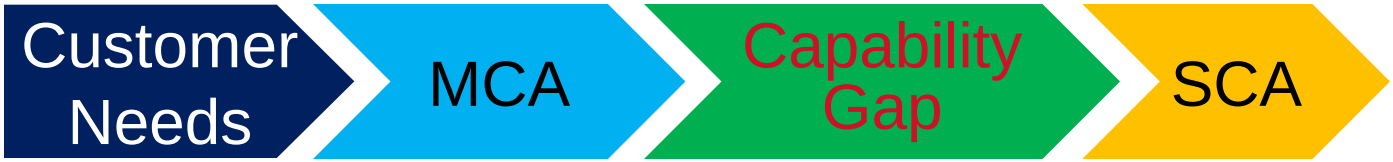
Analysis of mission areas and mission current and future capabilities

- Identifies
  - Mission Areas and Missions
  - Scope Problem
  - Relevant Timeframe
  - Capability Gaps
- Maps
  - Capabilities to Defense Strategies
  - Relevant Objectives to Capability Gaps
  - Example Scenarios to Mission Areas
- Includes
  - Mission Analysis
  - Capability Analysis
  - Gap Analysis

Solution Capability Analysis (SCA)

Analysis of solution space and capability gaps filled by candidate solutions

- Identifies
  - Solutions Ranked & Rated
  - Engagement Cost
- Maps
  - Options to Strategies
  - Solutions to Capability Gaps
  - Capability Gaps to Filled Gaps
  - Mission Weakness to Areas Fulfilled
- Includes
  - Tailored Analysis



Implementing JCIDS at RMS: Mission to Solution Relationship

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MISSION CAPABILITIES ANALYSIS (MCA)

SOLUTION CAPABILITY ANALYSIS (SCA)

Mission Areas

Missions & Scenarios

Capability Attributes

Includes time frame and scope

Always keeping in Context of the Employment

Consider "ilities" – feasibility, operational suitability, affordability

Current Capability Assessment ☆

Mission Architecting Begins

Gap Identification ☆

Gap Descriptions and Weighting

DOT_LPF Analysis

Solution Space Analysis ☆

Solution Concepts ☆

Concept Capability Assessment ☆

How do the concept capabilities fill the gaps?

Concept Gap Analysis

What gaps still exist with the concept in place?

Rating/Ranking of Viable Concepts

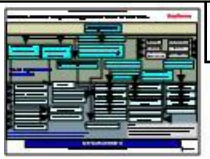
☆ Architecture

MSE is tailored to project status and growth needs

MCA Approach

MISSION CAPABILITIES ANALYSIS (MCA)

Mission Areas



Missions & Scenarios

Includes time frame and scope

Always keeping in Context of the Employment

Capability Attributes

Consider "ilities" – feasibility, operational suitability, affordability

Current Capability Assessment ☆

Mission Architecting Begins

Gap Identification ☆

Gap Descriptions and Weighting

- Perform Literature and Doctrinal Research
- **Review with Subject Matter Experts**
- Conduct Mission Analysis
- Summarize Findings
- Identify Capability Gaps
- Identify AWS Concept Trade Space

☆ **Architecture**

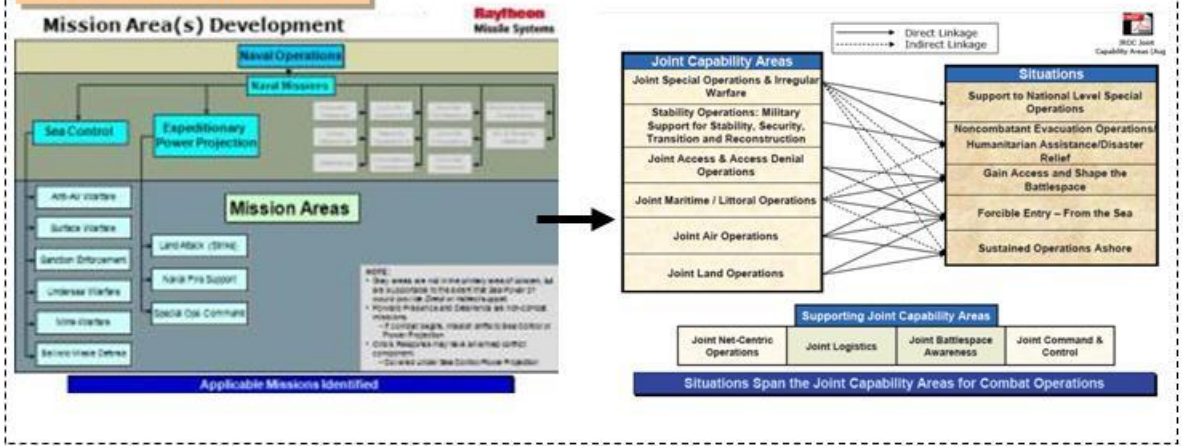
Review's Purpose:

- **Capture mission breakdown for Naval Strike and Fire Support from Warfighter perspective.**
- **Focus on Mission Operations, Capabilities, and Mission Execution Cost**
- **Utilize Warfighter Subject Matter Experts with broad spectrum of user perspectives. Subject**

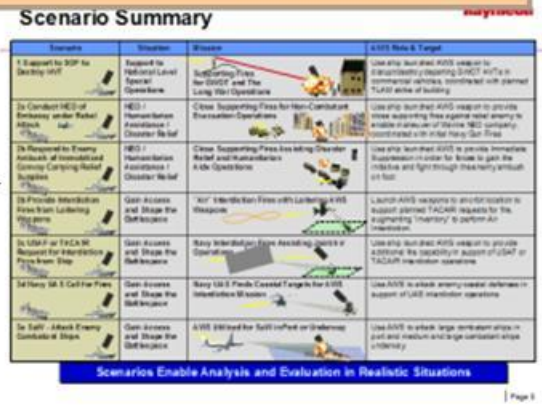
Subject Matter Experts Provide Key Input for Analysis

MCA Example

Missions Identified



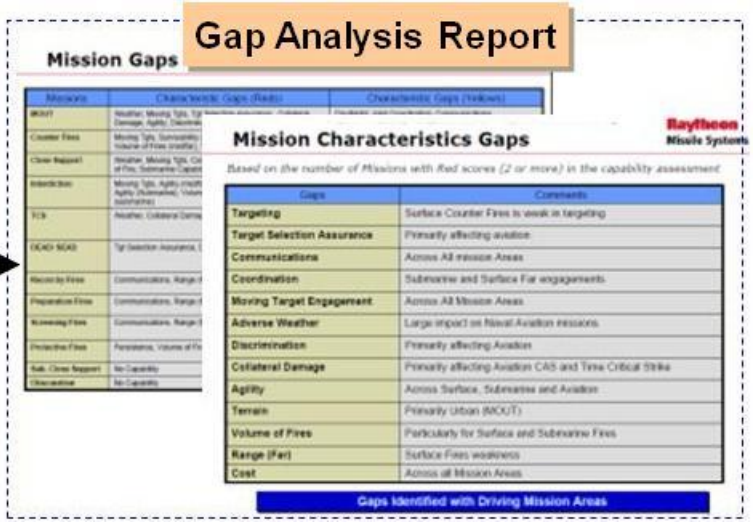
Reference Scenarios Identified and Used to Assess Missions



Assessed Capabilities Using Reference Scenarios

Identified Gaps

Gap Analysis Report



Mission and Mission Characteristics Gaps drive System Level Concept Development and Analysis

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SCA Approach

- Rank Options
- Rate Options vs Gaps uncovered in MCA
- Cost Engagements
- **Map Options, Capability Gaps and Mission Areas**
- Includes tailored analysis to cover Identified Gaps

Mapping Purpose:
- **Options: determine extent to which Options are in line with Defense Strategies**
- **Capability Gaps: determine which Capability Gaps are fulfilled by other systems**
- **Mission Areas: determine extent to which Mission Area weaknesses are fulfilled**

SOLUTION CAPABILITY ANALYSIS (SCA)

Solution Space Analysis

Solution Concepts

Concept Capability Assessment

How do the concept capabilities fill the gaps?

Concept Gap Analysis

What gaps still exist with the concept in place?

Gap Descriptions and Weighting

DOT_LPF Analysis

Rating/Ranking of Viable Concepts

☆ **Architecture**

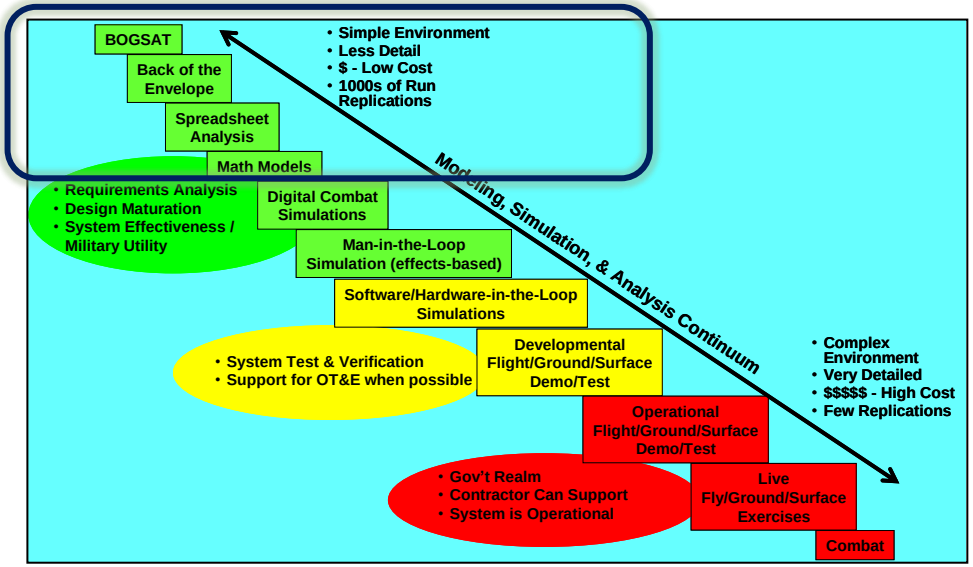
What Kind of Item Meets the Warfighter's Need?

First Principle Analysis

- **Purpose**
  - Support decision making
  - Begin design space bounding
  - Begin analysis plan development
- **Based on Top Level Understanding**
  - Operating Concepts
  - System Components
  - Interactions
- **What is it used for?**
  - Quick response and understanding at early stages of system development
  - Qualitative input to early business decision points
  - Sanity check comparison with higher order models
  - Design space development
  - Military utility analysis
  - Requirements development, balancing, influence
  - Op Con Validation
- **What it is not**
  - High Fidelity Level Models
  - Detailed Analysis
  - The Final Answer

- **How is it done?**
  - Understand the problem/question and level of fidelity
  - Identify components
  - Describe the interactions/effects in a computationally efficient manner
    - Mathematically
    - Model the system

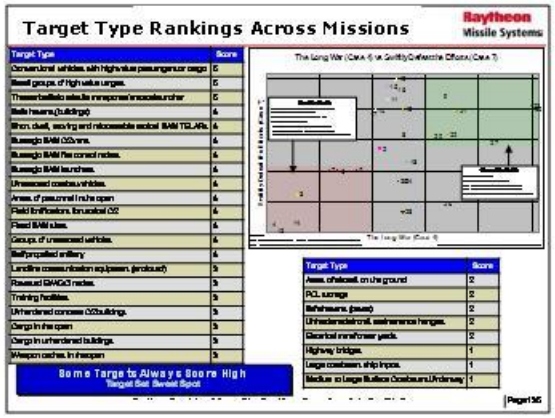
    ❖ Tools: Excel, Matlab, Pencil And Paper
  - Design experiments
  - Conduct experiments
  - Analyze results
  - Iterate

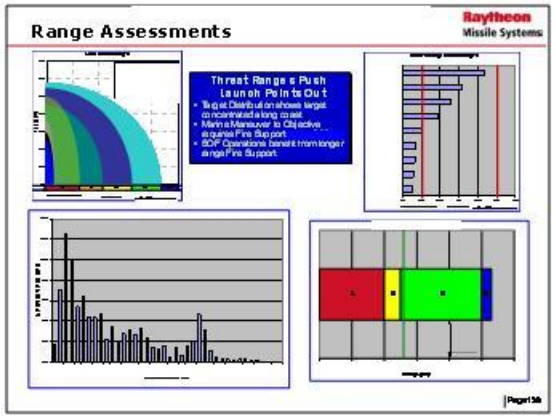


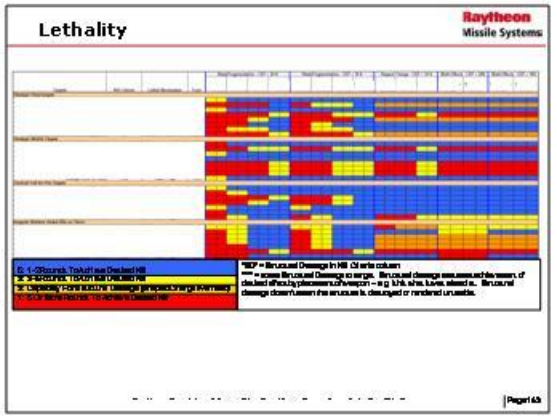
Just Enough Fidelity to Provide Early Insight

SCA Example

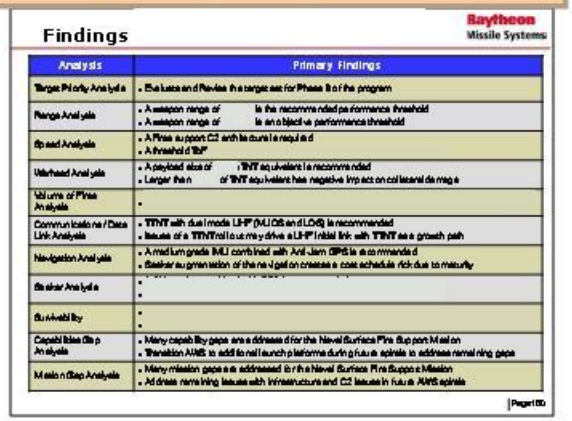
Solution Space Identified



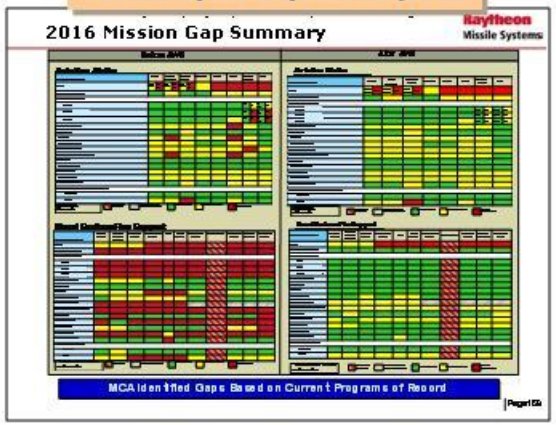




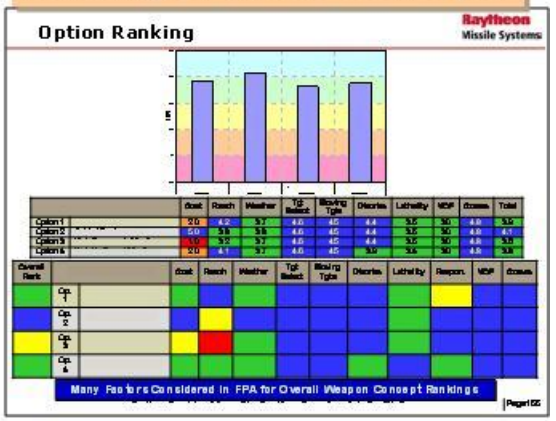
Concept Capability Assessment



Concept Gap Analysis



Ranking of Viable Concepts



The Solution Concepts are Assessed for Ability to Fill Capability Gaps

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Quality Function Deployment / Preferred System Concept Methodology

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Step 1 Airframe Options

Criteria

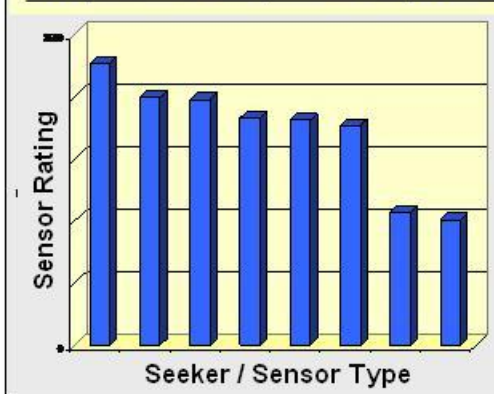
- Affordability
- Gap Coverage
- FPA
- Interoperability Complexity
- Risk

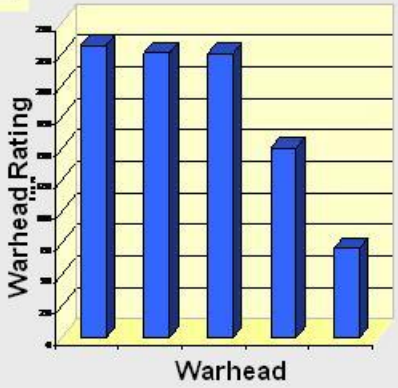
CRITERIA	WEIGHT
Highest Importance	5
Medium -High	4
Medium Importance	3
Medium -Low Importance	2
Low Importance	1

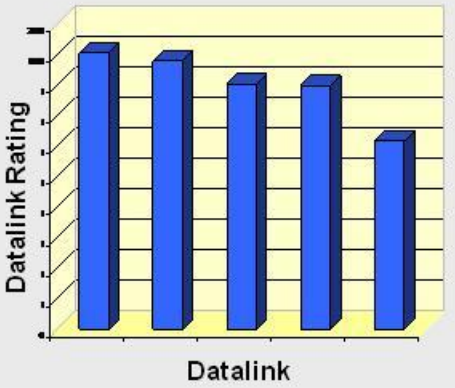
CATEGORY	DEFINITION	WEIGHT
Cost	Flyaway, NRE, or TOC cost relationship	20%
Gap Coverage	Ability to closes an MCA Gap	15%
Operational Effectiveness	Effect on the defined target set or scenario	10%
System Impacts	Impact to the infrastructure	10%
Weapon Performance	Key elements of the weapon performance	10%
Risk	Riskiness of development & manufacture	10%
Programmatic	Impacts to the notional SDD effort	10%
Strategic	Strategic position provided to all parties	15%

QFD SCORING	SCORE
A strong fulfilling relationship between the criteria and the Solution Approach	9
A moderate fulfilling relationship between the criteria and the Solution Approach	3
A weak fulfilling relationship between the criteria and the Solution Approach	1
No relationship between the criteria and the Solution Approach	0

Step 2 Subsystem Options







Option Preferred Due to Ability to Affordably Fill Mission Characteristic Gaps

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Summary

- Raytheon uses Mission Analysis to Focus Selection of the Preferred System Concept on the Ability to Cover Gaps
  - Mission Capability Analysis
  - Solution Capability Analysis
- Mission Capability Analysis identifies Missions, Mission Gaps and Mission Characteristic Gaps
- Solution Capability Analysis bounds the Solution Space and assesses the Solutions Concepts for ability to fill the Capability Gap
- Results of the Affordable Weapon System Mission Analyses were key input to the QFD study and selection of the AWS Preferred System Concept – Airframe and Subsystems

Mission Analysis Enables Raytheon to Work Solutions Focused on Warfighter Need

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Biographies

- **Elizabeth M. (Liz) O'Keefe** is a Senior Principal Systems Engineer and Certified Architect at Raytheon Missile Systems, and has been with Raytheon and its legacy companies for 29 years. She has a BS degree from Clarkson University in Electrical Engineering (EE) - Communications and a MS degree in EE - Systems from California State University at Fullerton. Liz has worked in Radar Analysis, Systems Integration, Simulation, Engineering Processes, and Strategic Planning. She was Systems IPT lead for SM-3 Block I and then Chief Architect and Chief Engineer for SM-3 Strategic Architecture & Analysis (SA&A) and related Navy BMD programs, as well as Program Manager for the SM-3 SA&A and Low Cost Kill Vehicle programs. Liz was recently Chief Architect for the Affordable Weapon System and Net-Ready Key Performance Parameter Architecture Evaluator (NetRAE) Tool programs.

- **James G. (Jim) Sierchio** is a Senior Principal Systems Engineer and Certified Architect at Raytheon Missile Systems. He has been with Raytheon for 11 years, developing mission architectures and CONOPS for such BMD-related programs as Exo-Atmospheric Kill Vehicle, Multiple Kill Vehicle, and Sea-Based Terminal, the latter as Chief Architect. Jim is a retired Air Force Lieutenant Colonel, with a career spent in directed energy, space systems and BMD R&D, and technical intelligence. Jim has a BSE degree from Princeton University in Aerospace & Mechanical Sciences, a MS degree in Aerospace Engineering from the University of Dayton, an Engineer degree in Aeronautics & Astronautics from New York University, a MBA degree from Averett University, and a DBA from California Coast University.

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BACKUP

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