



Ballistic Missile Defense Analysis with International Partners: Approach and Lessons-Learned

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Briefing Purpose

- **Provide an overview of how BMD Analyses with International Partners can be conducted to ensure:**
 - **Technically accurate analyses that provide both countries with confidence in the conclusions**
 - **A common understanding of BMD system capabilities and challenges**
 - **We'll refer to this cooperative BMD analysis as “Joint Analysis”**



Joint Analysis Objectives

- **Conduct Joint Analysis to Evaluate Future Ballistic Missile Defense Options for the Defense of the U.S. and it's International Partners**
- **Analyze Range of BMD Weapon System and Engagement Sequence Options Including:**
 - **Existing U.S. BMD systems, i.e. PATRIOT PAC-3, THAAD, ABL, Aegis BMD, KEI, and GMD**
 - **Improvements to existing systems**
 - **New or additional sensors**
 - **Command and Control, Battle Management and Communications (C2BMC) Alternatives**
 - **Single Country and Joint Operations**
 - **Support to Deployed U.S. and Joint Forces**
 - **Other Emerging Technologies**
 - **Future Cooperative Development Opportunities**
- **Recommend Development Option(s) for Ballistic Missile Defense Capability that Include Cost, Schedule and Risk**



Joint Analysis Approach

Identify BMD System Needs and Objectives



- BMD Roles and Missions
- BMD Performance Requirements



Define Scenario Parameters

Adversary Missile Characterization



Operational Constraints



System Component Capabilities

- Technology Options
- Schedule
- Programmatic Constraints

MISSILE COMPONENT

AEGIS BMD SYSTEM ELEMENT

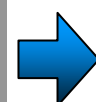
REMOTE SENSORS COMPONENT

C2BMC COMPONENT



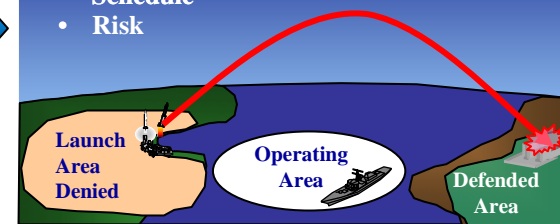
Develop System Concepts

- System Architecture
- Functional Allocations
- Performance Allocations



Evaluate System Concepts

- Capability
- Cost
- Schedule
- Risk

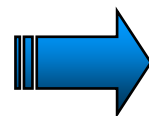


Recommend Development Option(s)

Radar
C2BMC
Aegis
SM-3
⋮

Capability Improvement
Schedule & Cost

08 10 12 14 16



Development and/or Procurement





Joint Analysis Major Steps

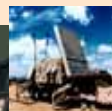
BMD SYSTEM COMPONENTS



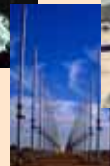
Existing Systems



Missiles



C2BMC



External Sensors

Joint BMD Analysis

GOAL: Evaluation of Future Missile Defense Options to Enhance the Security of the Two Countries

Step 1	Step 2	Step 3	Step 4	Step 5
Analysis Management	Analysis Assumptions	System Concept Exploration and Guideline Development	System Concept(s) Evaluation	Development Options
Defines responsibilities for maintenance of the Integrated Master Schedule, the reporting of Study progress, and final preparation of Joint Analysis products	Identify component options, develop performance characterizations, operational performance measures, adversary characterizations, concept evaluation measures	Establish the System Component Guidelines and system concept option(s)	Evaluate the capability of each system concept identified	Develop implementation schedule options and evaluate the associated costs, risks, and performance

Management Plan Established

Joint Analysis Final Products

Analysis Baseline Review (ABR)

Alternative Systems Review (ASR)

Development Options Review (DOR)



EXAMPLE : Step 2 Major Tasks

Identify and Model Component Options

Identify Component Options



Identify Programmatic Constraints

Component	Calendar Year														
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4
Weapon	SM-3														
	PAC-3														
	THAAD														
	KEI														
Sensor	SPY-1														
	TPY-2														
	GMD Sensors														
	Other														
C2BMC	U.S. C2BMC														
	Partner System														
	Other														

Identify Initial System Configuration Options

Element	Option 1	Option 2	Option 3
Aegis w/ SM-3	X		
PATRIOT w/ PAC-3	X	X	
THAAD		X	X
KEI			X
Sensors	TPY-2	TPY-2	TPY-2
C2BMC	X	X	X

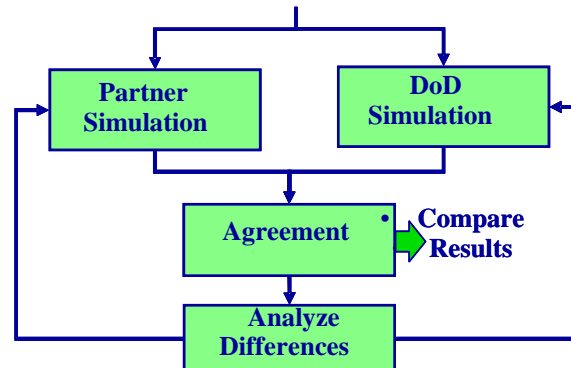
Develop Component Models

System Component	Performance Guideline	Value
System Component	Midcourse Lateral Gy	m/s
	Midcourse Lateral Acc	m/s ²
Missile	Min. Closing Velocity	km/s
	Search Sector (msec)	deg
	Search Time (msec)	sec
	Radar Detection Ref. Range (msec)	km
	Radar Detection Ref. Range (msec)	km
	Radar Track Ref. Range	km
	Detection Ref. RCS	dBsm
	Radar Discrimination Ref. Range	km
	Discrimination Ref. RCS	dBsm
	Discrimination Observation Time	sec
	Track Accuracy (position)	m
	Track Accuracy (velocity)	m/s
	Time to First Track	sec
	Accuracy of Coordinate Frames	mrad
	Cou Delay	sec
C2BMC	Processing Time	sec
	Communications Delay	sec

Example Cases

Benchmark Simulations

Benchmark Scenarios





EXAMPLE: Step 3/4 Major Tasks

System Concept Exploration, Guideline Development, and Performance Evaluation

Develop Candidate System Descriptions

- Components
- Functional allocations
- C2BMC connectivity

Components and Functions

Develop System Component Performance Allocations

Performance Trade Studies

System Component	Performance Guideline	Value
Sensor		
Search Sector (msec)	deg	
Search Time (msec)	sec	
Radar Detection Ref. Range (msec)	km	
Radar Detection Ref. Range (msec)	km	
Radar Track Ref. Range	km	
Detection Ref. RCS	dBsm	
Radar Discrimination Ref. Range	km	
Discrimination Ref. RCS	dBsm	
Discrimination Observation Time	sec	
Track Accuracy (position)	m	
Track Accuracy (velocity)	m/sec	
Time to First Track	sec	
Accuracy of Coordinate Frames	deg	
Cue Delay	sec	
C2BMC		
Processing Time	sec	
Communications Delay	sec	

System Concepts

Evaluate System Concept Performance

Evaluation Criteria:

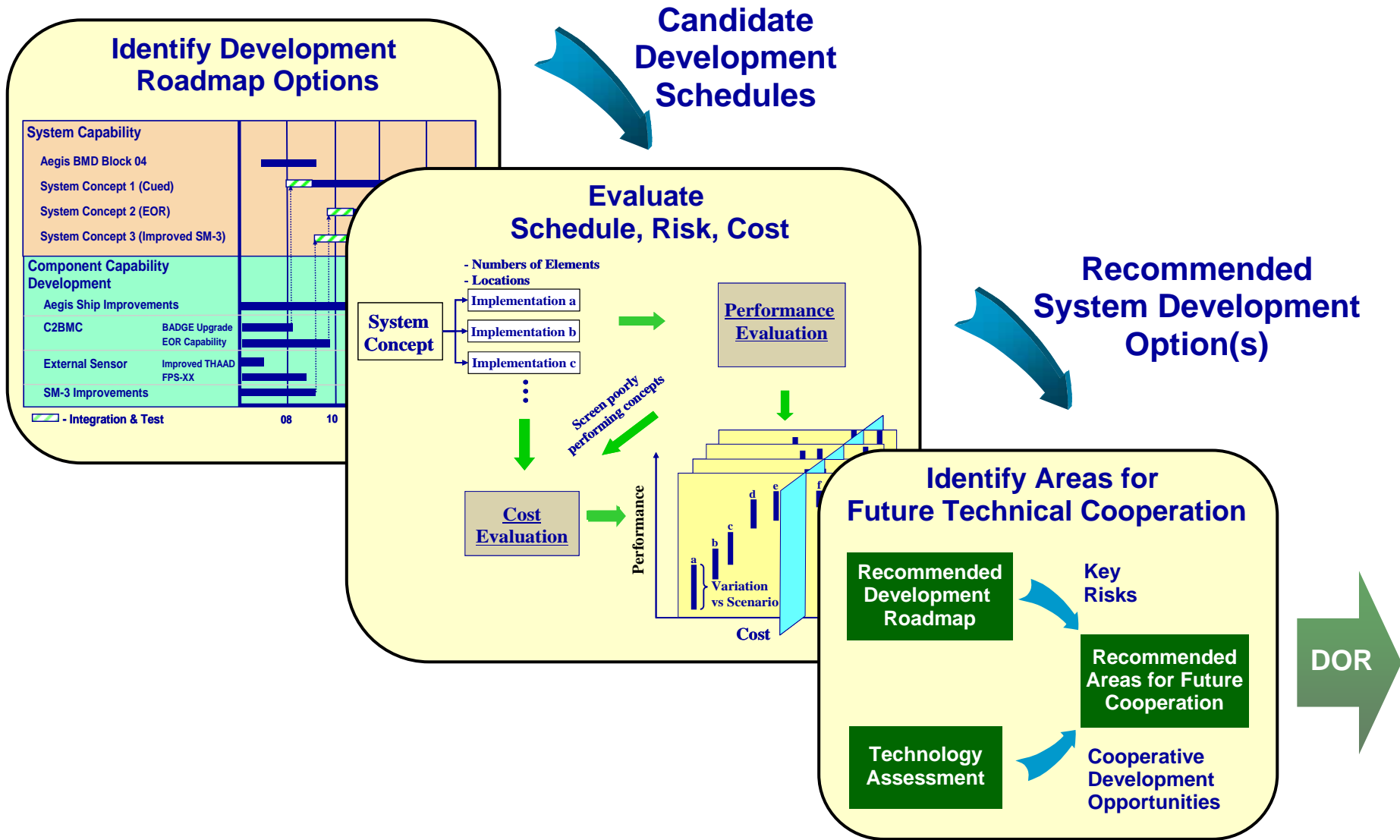
- Performance vs MOEs
- Cost
- Schedule
- Risk

Step 5



EXAMPLE: Step 5 Major Tasks

Identify Development Options





Key Milestones

- **Analysis Baseline Review (ABR)**
 - Candidate system configuration options
 - Component performance assumptions
 - Operational parameters and constraints
 - Adversary characterizations
 - System concept evaluation measures

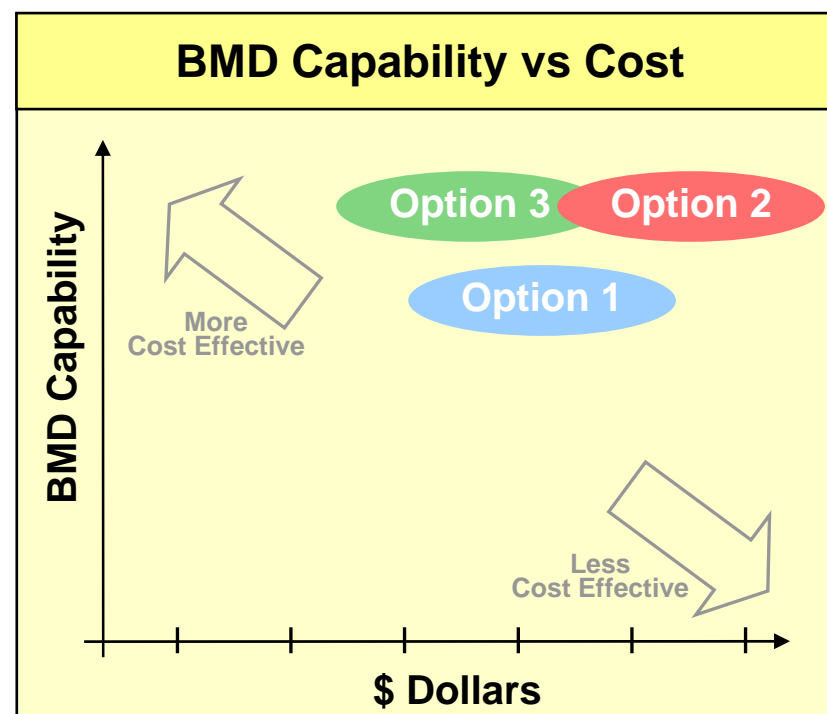
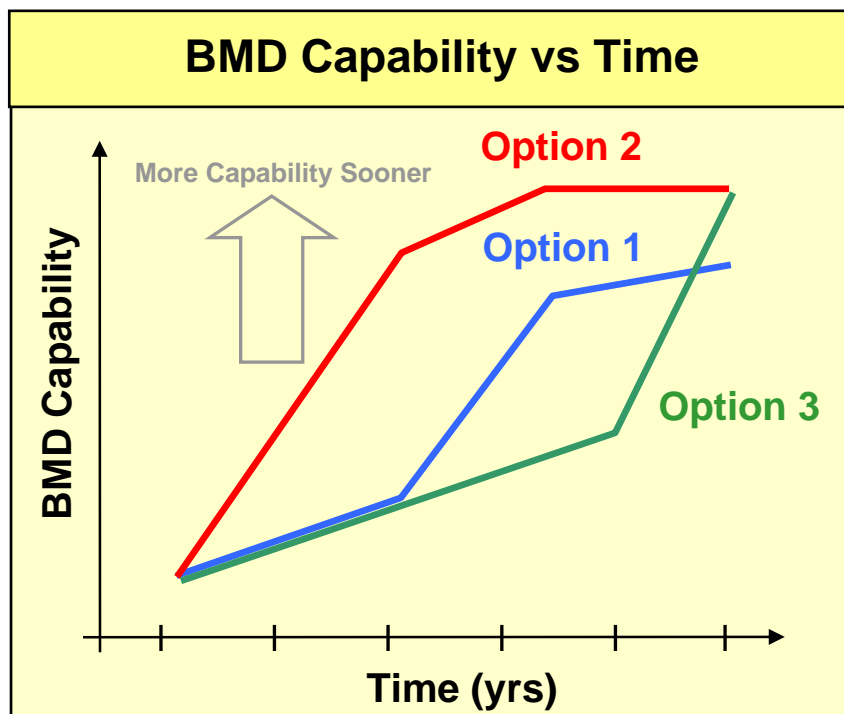
- **Alternative Systems Review (ASR)**
 - System concept options
 - Sensors, Missiles, C2BMC structures
 - Component Performance Guidelines
 - Performance evaluation of candidate system concepts

- **Development/Procurement Options Review (DOR)**
 - Cost, risk, and schedule evaluation of candidate system concepts
 - Recommended development/procurement roadmap options
 - Identify technical areas for future cooperation



Joint Analysis Products: Capability vs Cost and Schedule

Example of Joint Analysis Development/Procurement Options Comparison





Lessons-Learned

- **Early definition of goals and objectives is key to success**
 - **ABR is the time to finalize the goals and assumptions of the analysis**
 - **Each country must have confidence that the analysis process will result in meaningful conclusions**
- **True Joint Analysis is time-consuming, but the process fosters trust and a common understanding of BMD capabilities and challenges**
 - **Requires a willingness to disclose each country's knowledge of the threat and key aspects of BMD system performance**
 - **Benchmarking of country's independent simulations builds confidence in the results**
 - **“One-way analysis” is not sufficient to obtain buy-in with International Partners**
- **Following the conclusion of Joint Analysis, both parties must maintain momentum to ensure meaningful follow-on activities**