



Complexity Management: A Perspective on Large, Joint System Capabilities and Requirements Management in the Missile Defense Agency

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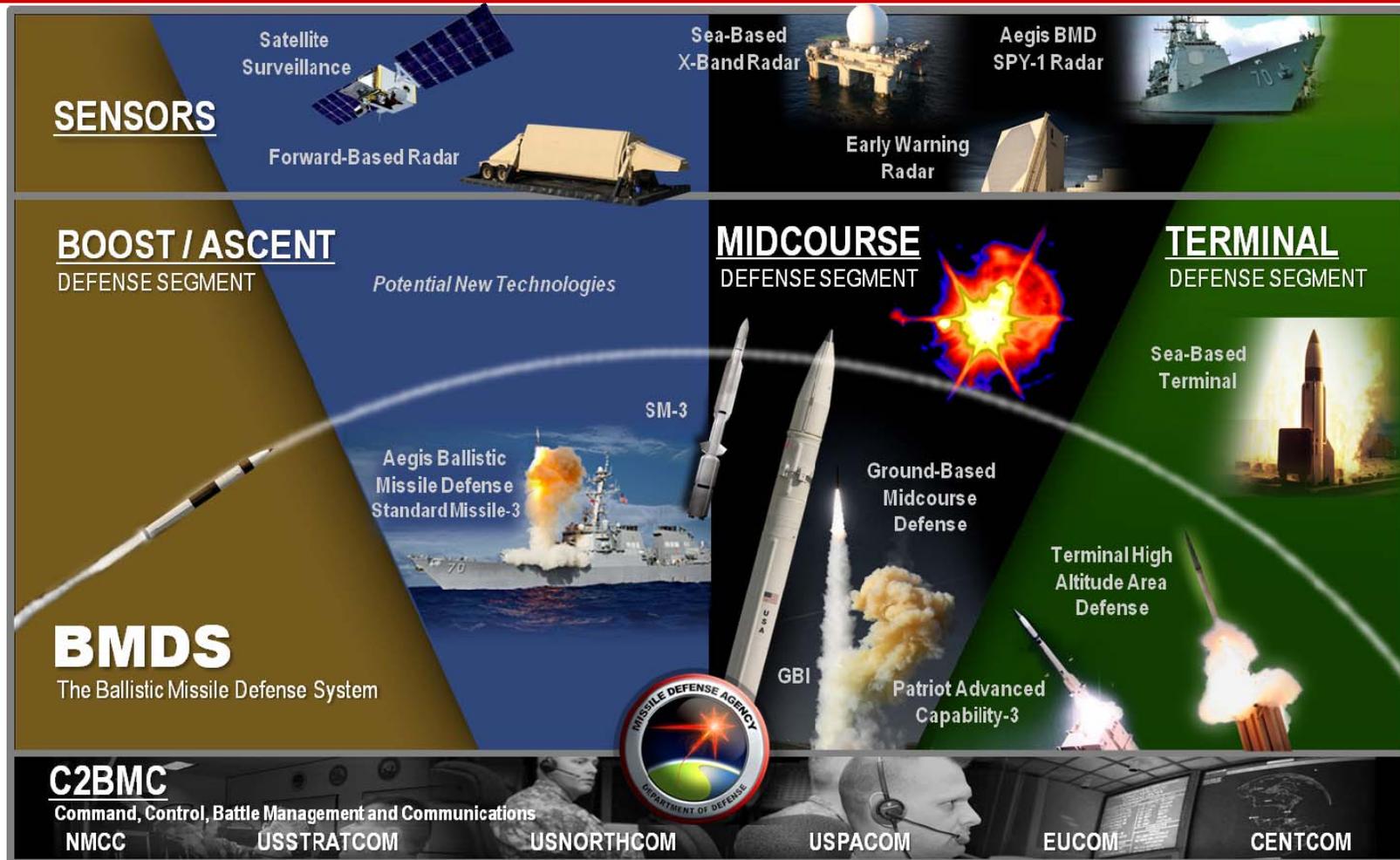


Agenda

- BMDS Overview
- Technical Management Challenges
- Translating Combatant Capabilities and Needs into BMDS-, Element-, and Interface-level Requirements
- BMDS Technical Baseline Management Approach
- Lessons Learned



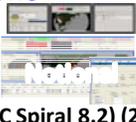
BMDS Overview



“An evolving, integrated, and interoperable System, comprising multiple Elements and components, that provides a capability to intercept ballistic missiles in all phases of their flight (i.e., boost, midcourse, and terminal) against all ranges of threats.” *

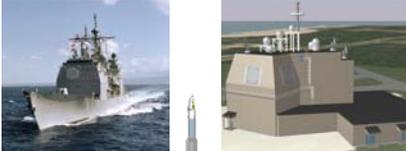


Phased Adaptive Approach To Developing And Deploying Missile Defense

Today's Capability	Additional Capability 2012 - 2018	Additional Capability By 2020
<p>Ground-based Midcourse Defense</p>    <p>Fort Greely, AK (26) VAFB, CA (4)</p>	<p>Ground-based Midcourse Defense</p>    <p>Missile Field #2 Fort Greely, AK (2012) FGA Missile Assembly Building Improved Reliability (2012) East Coast IDT (2015)</p>	 <p>FGA Missile Assembly Building Improved Reliability</p>
<p>Sensors</p>     <p>Thule Fylingdales Beale Cobra Dane</p>    <p>AN/TPY-2 (FBM) (2) Japan / Turkey Aegis SPY-1 Ships - 23 Sea-Based X-band Radar</p>	<p>Sensors</p>    <p>UEWRs (5) Clear, AK (2016) Cape Cod (2017) AN/TPY-2 (FBM) (2) Initial PTSS (2018)</p>   <p>Aegis SPY-1 Ships - 37 C2BMC Lab (Expanded Sensor Network)</p>	 <p>Aegis Ashore 5.1 / SM-3 IIB / Sea-based? (Poland) - Interceptors (2020)</p> <p>Sensors</p>   <p>Enhanced Discrimination PTSS Constellation (2020)</p>
<p>Command, Control, Battle Management & Communications</p>   <p>Fort Greely, AK Schriever AFB, CO (C2BMC Spiral 6.4) PACOM NORTHCOM STRATCOM EUCOM</p>	<p>Command, Control, Battle Management & Communications</p>   <p>(C2BMC Spiral 6.4) CENTCOM (2012) (C2BMC Spiral 8.2) (2017) PACOM NORTHCOM STRATCOM EUCOM CENTCOM</p>	<p>Command, Control, Battle Management & Communications</p>  <p>(C2BMC Spiral 8.4) (2020) PACOM NORTHCOM STRATCOM EUCOM CENTCOM</p>



European Phased Adaptive Approach To Developing and Deploying Missile Defense

Phase I: Today's Capability	Phase II: Enhanced Medium-Range Missile Defense (By 2015)	Phase III: Enhanced Intermediate-Range Missile Defense (By 2018)	Phase IV: Early Intercept of IRBMs and ICBMs (By 2020)
 <p>Aegis BMD 3.6.1</p> <p>SM-3 IA</p>	 <p>Aegis BMD 4.0.1/5.0</p> <p>Aegis Ashore 5.0 (Romania)</p>  <p>SM-3 IB</p>	 <p>Aegis BMD 5.1</p> <p>Aegis Ashore 5.1 (Poland and Romania)</p>  <p>SM-3 IIA</p>	 <p>Aegis BMD 5.1x</p> <p>Aegis Ashore 5.1x (two sites)</p>  <p>SM-3 IIB</p>
 <p>AN/TPY-2 (FBM)</p>	 <p>C2BMC Updates</p> <p>ALTBMDC Lower Tier</p>	 <p>Initial PTSS</p>  <p>C2BMC Updates</p> <p>ALTBMDC Upper Tier</p>	 <p>PTSS</p>  <p>Enhanced C2BMC</p>
 <p>C2BMC AOC Ramstein</p> <p>ALTBMDC Interim Capability</p>	<p>Potential EPAA Surge</p>  <p>THAAD</p>	<p>Potential EPAA Surge</p>  <p>THAAD Launch on Remote</p>	<p>Potential EPAA Surge</p>  <p>THAAD Full Network</p>



The BMDS Environment

- Management
 - Multiple stakeholders at different levels—System, Element, and Component
 - Differing acquisition governance and funding with each Service—Air Force, Army, Navy
- Operational
 - Operational needs vary by region and threat and regional needs may dictate competing objectives for individual system that will operate in the region vice the objectives for the overall BMDS
- Development
 - Elements and components at varying stages of acquisition lifecycle
 - Priorities and plans are constantly evolving with asynchronous schedules
 - Testing is more challenging with higher potential for unintended consequences
- Engineering Considerations
 - Balance act between BMDS performance and the Element performance
 - Understanding interfaces and facilitating maximum flexibility



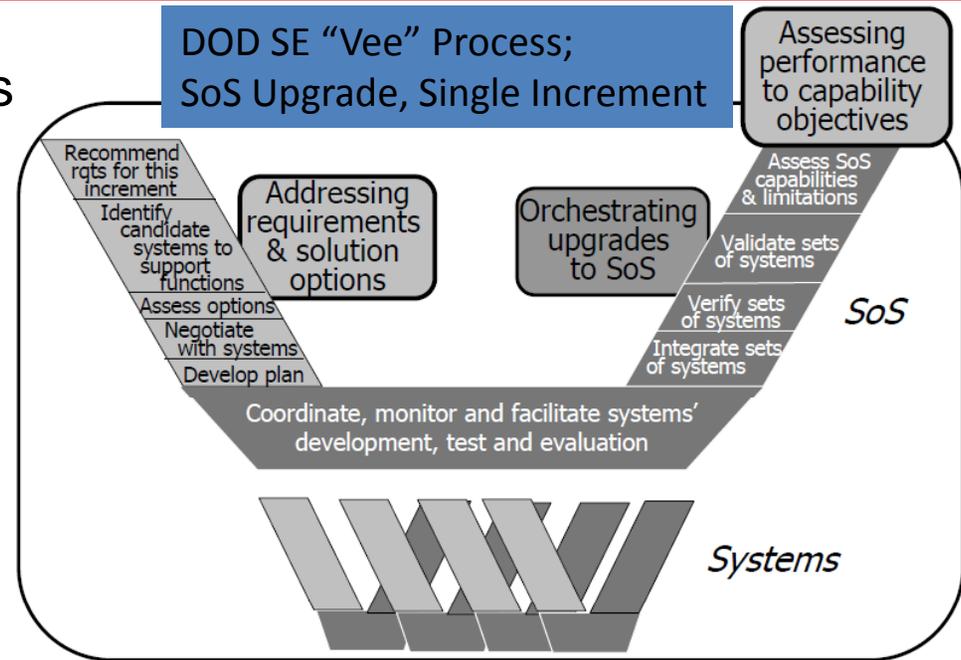
Technical Management Challenges

- Perspectives on two of the five Systems Engineering Focus Areas
 - Capabilities and Requirements Management
 - Technical Baseline Management

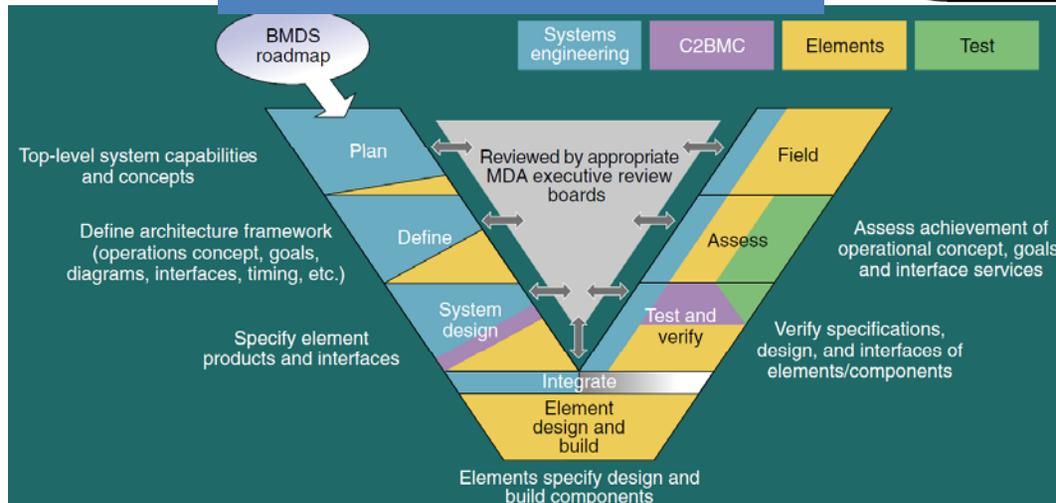


Capability & Requirement Management - DoD SoS Guide vs. MDA

- DoD SE Guide for SOS processes (Right) similar to MDA processes for capabilities-based acquisition
- MDA has authority from DoD to depart from (but be consistent with) acquisition policy



MDA SE "Vee" Process for BMDS

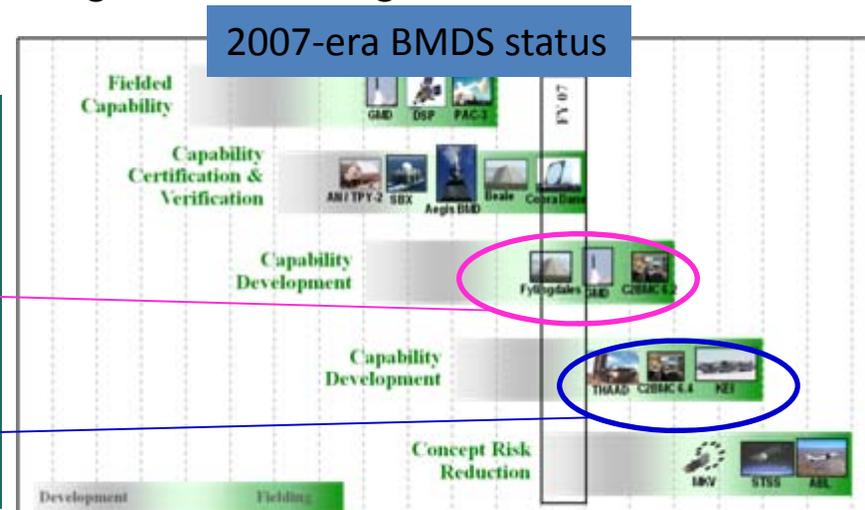
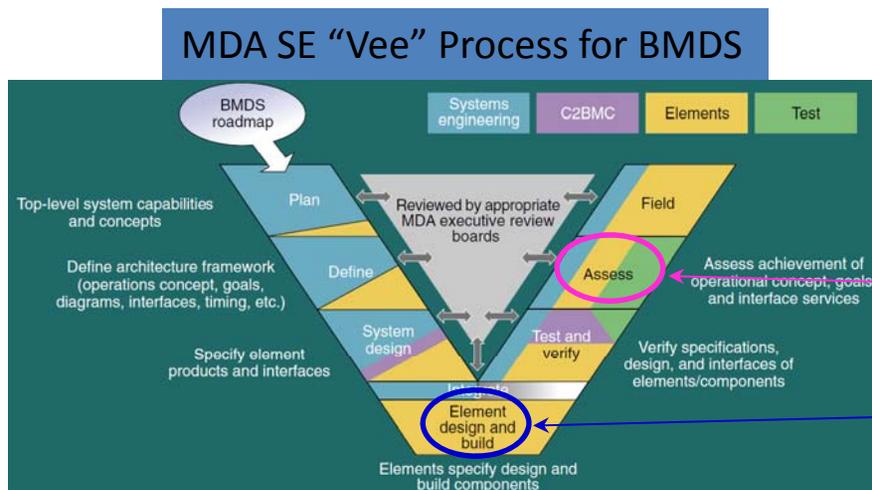


Source: Eccles, 2008, "The [MDA] Systems Engineering 'V'"



Capability & Requirement Management- MDA Manages Multiple Builds

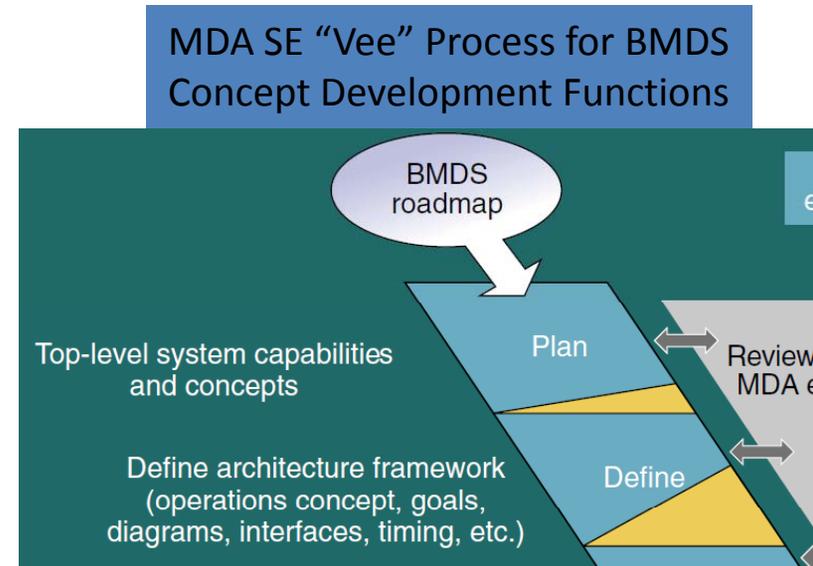
- MDA must manage the complexity of multiple “capability increments” of BMDS in development simultaneously
- Below right is a snapshot of MDA’s status of major sub-systems as of 2007 with four BMDS major capability increments in-work
- Example:
 - BMDS Subsystem of C2BMC (version 6.2) was in assessment & verification
 - C2BMC (version 6.4) was in element design & build stage





Capability & Requirement Management- Concept Development Process

- Recurring re-look of desired capabilities to insert into BMDS
- Multiple inputs—vision documents Warfighter input, others
- Capabilities assessed against technology readiness, current capabilities, evolving threat with trade studies
- MDA decides on capabilities and develops architecture in concept documents (CND's, CPS's, SDD)





Capability & Requirement Management- Concept Development- Example

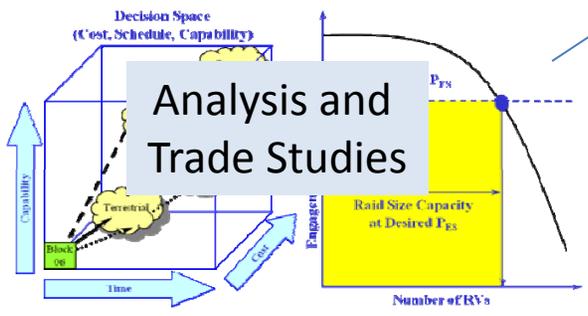
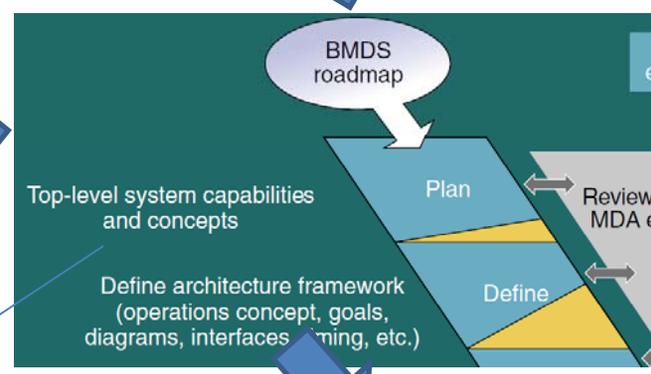
- 2007-11-era concept development
 - Inputs
 - Technology insertion candidates
 - Trades
- Major capabilities decided: C2BMC upgrades, TPY-2 radar, THAAD

MDA Director intent Prior System Baseline Design

SecDEF guidance

Warfighter input

Internal "vision" docs

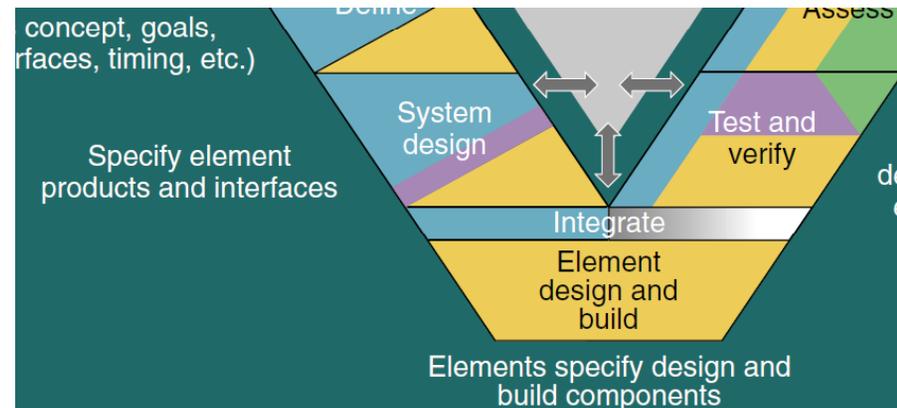




Capability & Requirement Management- System Definition & Design Process

- Further develop desired system capabilities
- Conduct more detailed engineering analysis to develop BMDS System Specification content

MDA SE “Vee” Process for BMDS System Definition & Design

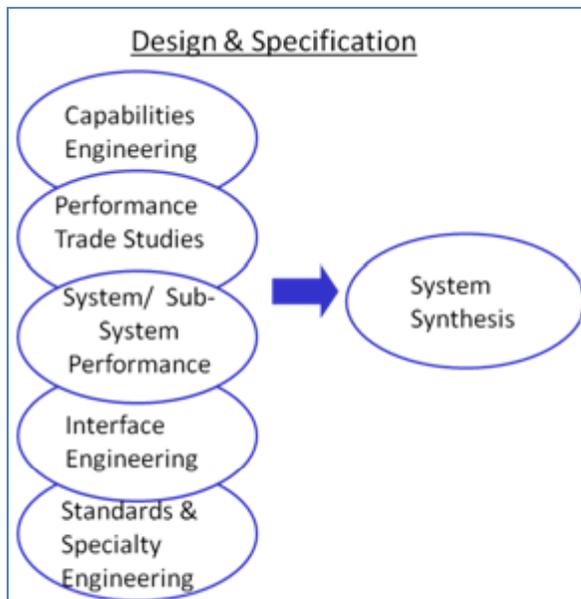
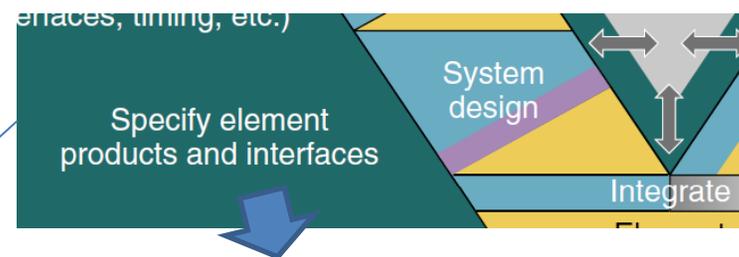


- Analyze capabilities and allocate required element/subsystem behavior to subsystems
- Goal: develop BMDS requirements sufficient to drive required BMDS system behavior and meet critical MDA acquisition needs—but allow the Element design space for Subsystem engineering



Capability & Requirement Management- System Definition & Design- Example

- Development of the 2007-era BMDS System Definition & Design of Requirements followed the framework
- System Analysis resulted in BMD allocated requirements to C2BMC to be implemented in 6.2 / 6.4



C2BMC 6.2/6.4 requirements

- Major Requirements allocated to C2BMC 6.2 and 6.4 for
- Warfighter BMD Planning
 - Network communications
 - Situational awareness for Warfighter
 - TPY-2 radar battle management
 - Track forwarding of TPY-2 Data

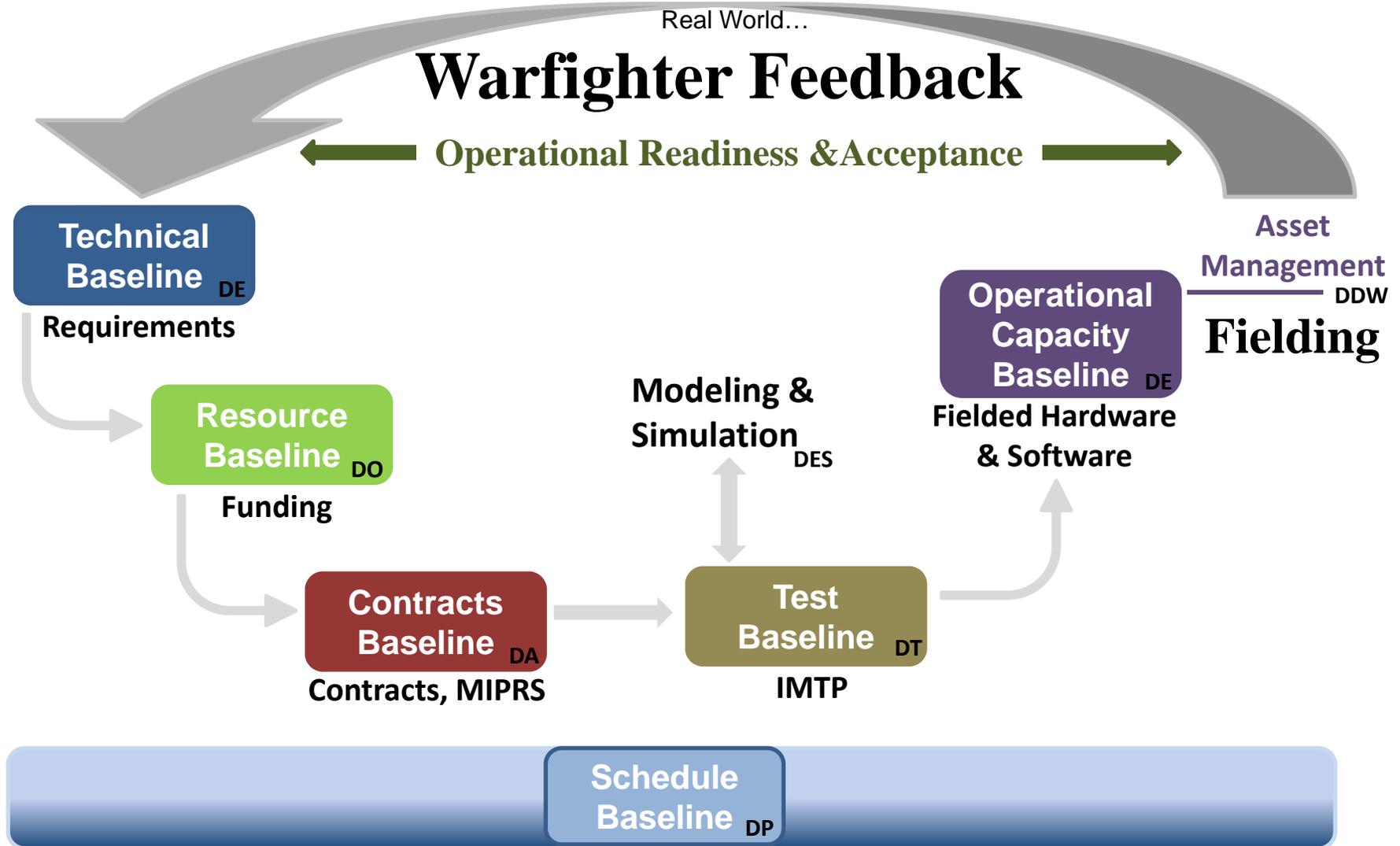


BMDS Baseline Integration Management

Functional Manager	Baseline	Function
DE (Engineering)	Technical Baseline	Configuration-controlled technical documentation that provides guidance, specifications, technical requirements, integration and planning, and system level descriptions to govern design, development, performance, systems integration, verification, and testing aspects of the BMDS.
DT (Test)	Test Baseline	A schedule of major flight and ground tests, key modeling and simulation events, and the primary goals associated with those tests and events
DE (Engineering)	Operational Capacity Baseline	A listing of PCB-approved BMD system level hardware and software available for Warfighter use
DA (Acquisition)	Contracts Baseline	a timeline for a set of MDA contracts designed to deliver integrated BMDS capabilities
DO (Operations)	Resource Baseline	The expected investment in the development and delivery of a product
DP (Programs & Integration)	Schedule Baseline	A timeline for key product development milestones and tasks, such as key decision points and product deliveries to the Warfighter

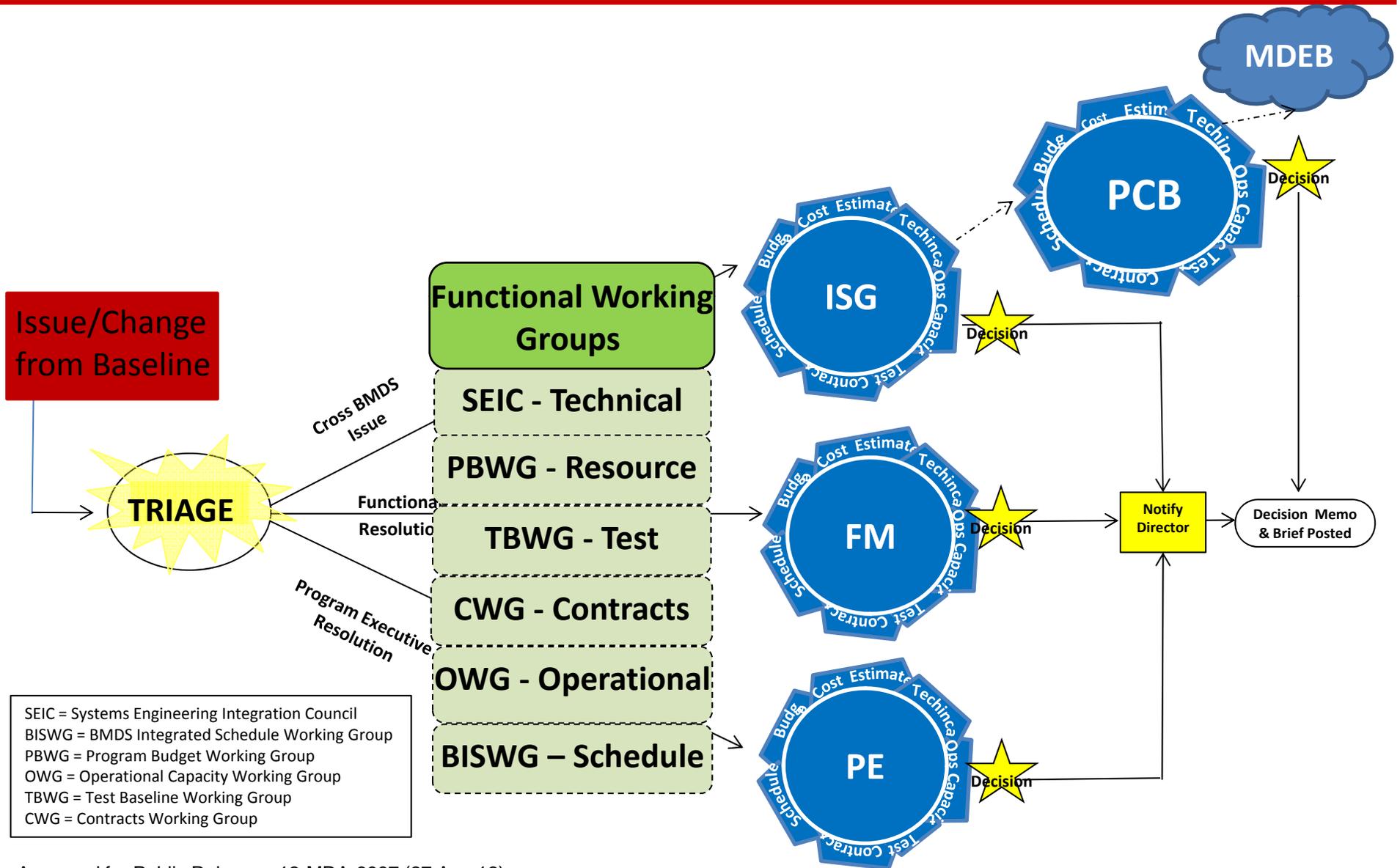


Baseline Relationships





Change Management Decision Flow





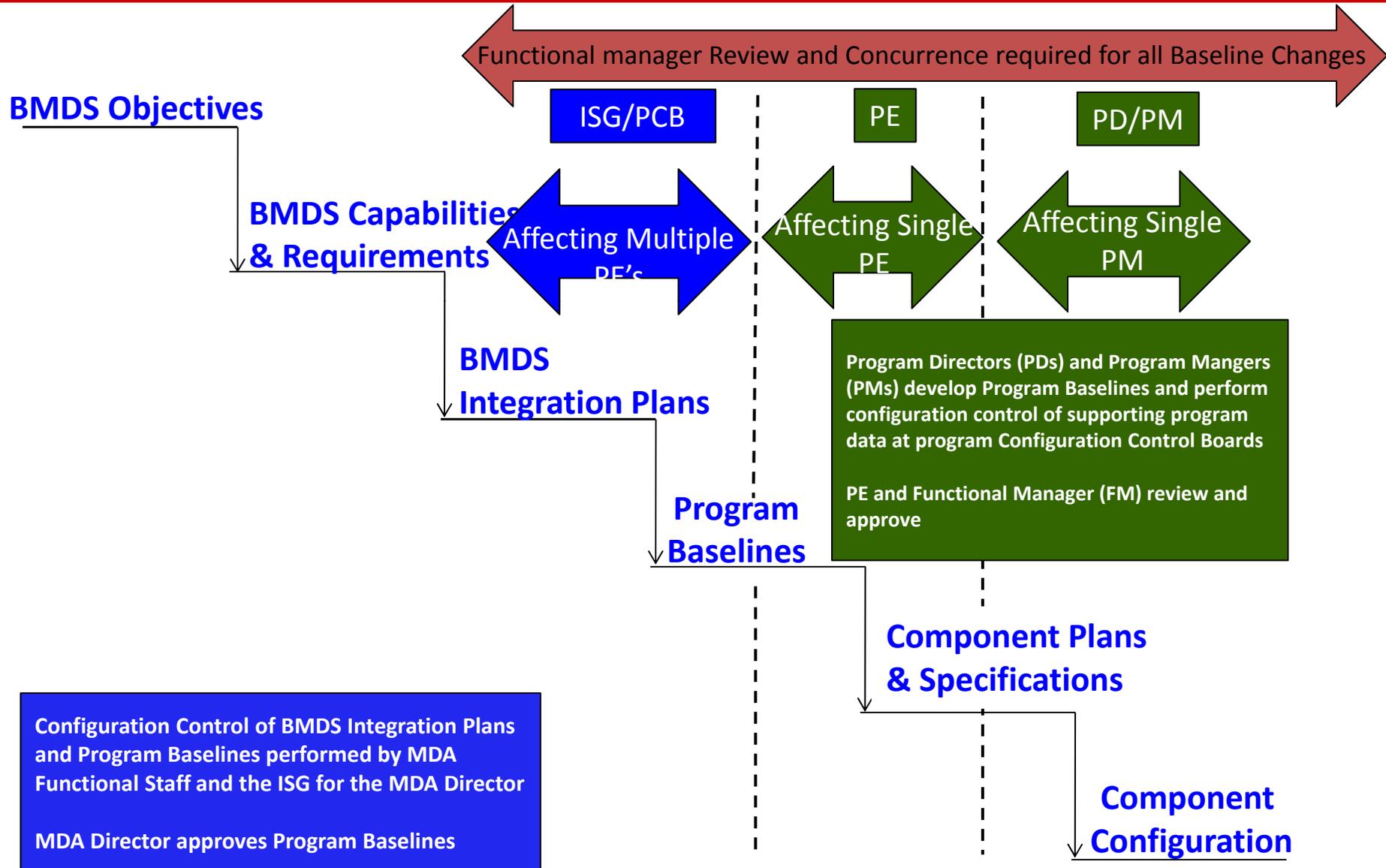
Detailed Technical Baseline Class Criteria

Functional / Level	BMDS Class I	BMDS Class II	Element Class I / II
Technical Baseline	<p>Change to planned form, fit, function, and performance of: (1) the BMDS; (2) an Element Capability Specification to include first-level specification(s) used for compliance with Element Prime Contractor(s), i.e., “On Contract;” and (3) BMD System-level interfaces between Elements and Subsystems.</p> <ul style="list-style-type: none"> • Where form and function are captured in the BMD System Description Document (SDD), BMD System Specification, Element Capability and First-level Specifications, and Communication Network Specification. • Where fit is captured in the System Interface Control Documents (SICDs) Part 1 and Part 2. 	<p>All changes not BMDS Class I with approval by Single Technical Authority. Example administrative changes include, but not limited to:</p> <ul style="list-style-type: none"> • Changes to justified orphan requirements from non-BMDS sources and not subject to above BMDS Class I definition, e.g., Army transportability requirements for THAAD. • A change in nomenclature, e.g., renaming FBX-T radars to AN/TPY-2 FBM. • Adding additional descriptive information to clarify intent, such as explanatory statements in requirement paragraphs • Moving requirements within specification sections without changing requirement text. • Reformatting tables only to clarify intent. 	<p>Changes to planned form, fit, and function, which reside within an Element, i.e., only Element products below the Element Capability and First-level Specification and SICD Part 2 (not in BMDS TBL) and not subject to above BMDS Class I / II definitions.</p>

Note 1: Regardless of Decision-level, all BMDS Class I and II changes must adhere to previously established and documented criteria and procedures for vetting change requests through SEIC, ICWG, BRWG, and other SEIC subgroups as appropriate for documentation in the BMDS TBL.



Authority Demarcation





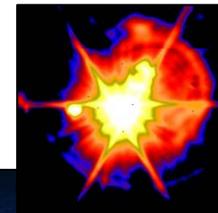
Lessons Learned

- While MDA can deviate from DoD Acquisition policy, one can see that we are consistent with DoD systems engineering policy, guidance, and best practices
 - Systems engineering “Vee”
 - Requirements management
 - Technical baseline management—the Technical and the Operational Capacity Baselines are equivalent to traditional functional, allocated, and product baselines
- MDA has an established process to garner Warfighter input as well as feedback much like the JCIDS process



Conclusion

- Successfully applying sound systems engineering process and best practices to develop, test, and field an integrated BMDS
- Delivering real capability to the Warfighter to protect the United States, our forward deployed forces, and our friends and allies from hostile ballistic missile attack





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