Industry Support to Mission Analysis and Mission Engineering

Preliminary Study Report – May 2016

NOTE: *Not an official position from these organizations, but the study was coordinated through them.*

BLUF

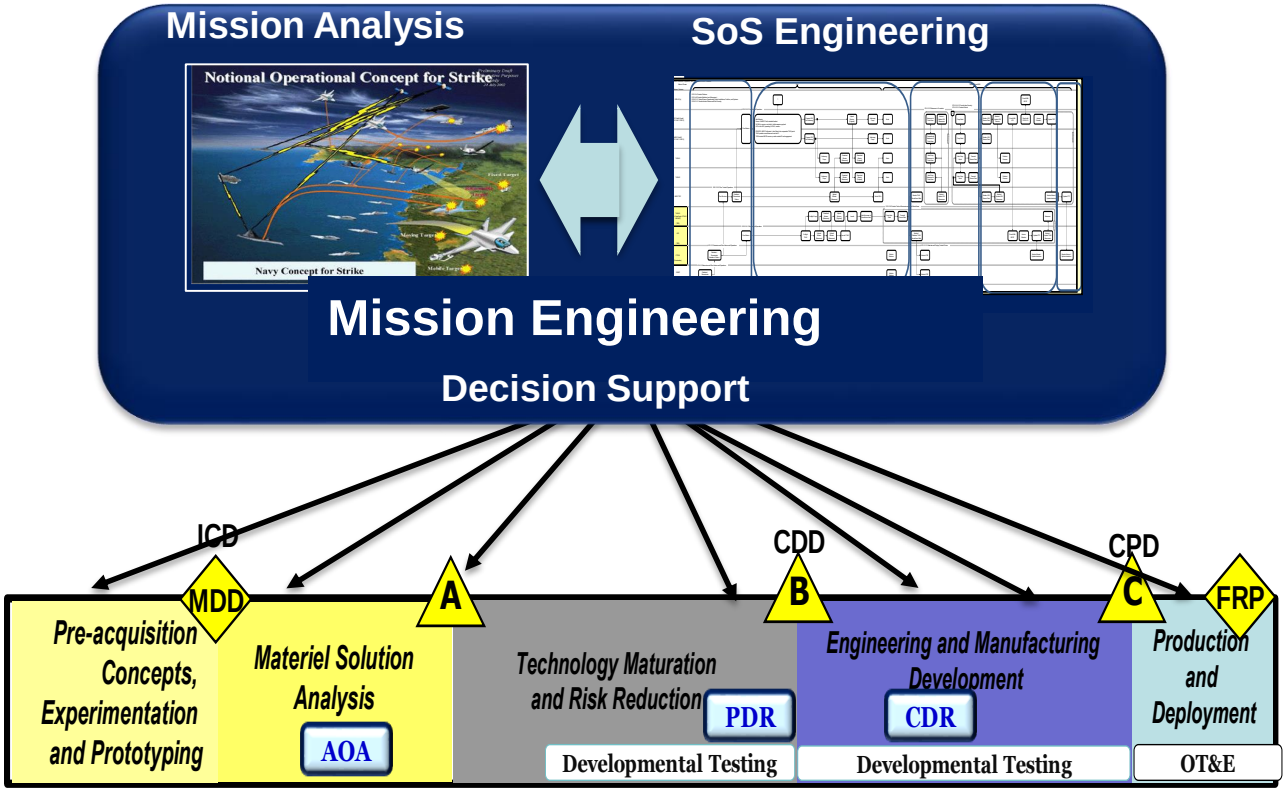
NDIA SED and INCOSE Offer to Lead Industry Task Team on Mission Engineering: (1) State of industry practice and (2) Role of industry

- Both government and industry are doing mission engineering with shared areas of interest, but:
  - Mission Engineering requires more definition,
  - There are challenges associated with Mission Engineering,
  - There is a need for the right enablers; such as practices, tools, modeling, and data, and
  - There is a need to hone Mission Analysis / Mission Engineering skills based on the items above
- Collaboration between DoD and industry can help ME effectiveness

The defense industry can be a key Mission Engineering partner to address the needs.

ME and System Acquisition

OSD(ATL)'s Mission Engineering definition: "the deliberate planning, analyzing, organizing, and integrating of current and emerging operational and system capabilities to achieve desired warfighting mission effects."



Industry Study Highlights: Mission Analysis, SoS Engineering, and Decision Support across the lifecycle support Mission Engineering.

NDIA SED and INCOSE Offer to Lead Industry Task Team

- Determine the state of practice in industry regarding Mission Analysis and Engineering.
- Determine how industry can help improve the state of the practice for Mission Engineering.
- Recommend level of industry involvement in Mission Engineering.

Study Plan

- Recruit study team with leaders of related professional societies
- Conduct weekly virtual team meetings
- Collect and evaluate relevant industry studies
- Develop survey
  - Use mission analysis as baseline to assess mission engineering
  - Use SEBoK definition of mission analysis
  - Use OSD (ATL) definition of mission engineering
  - Use professional societies and team members to deploy survey (MORS supported the survey development)
- One day meeting at AIA, Arlington, VA on 21 Apr 16
  - Review survey results and recent industry studies
  - Develop preliminary findings and conclusions

Study Team

Greg Parnell, Team lead – Univ of Arkansas, Representing MORS and INCOSE
Bill Miller, Team co-lead – IDI & Stevens Institute, Representing INCOSE and NDIA
Kirk Michealson, Survey – Tackle Solutions, Representing MORS

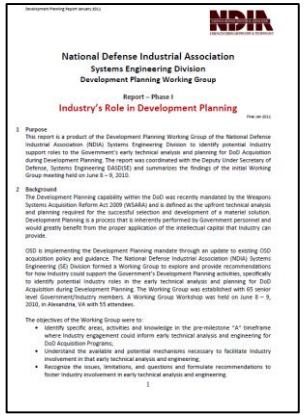
Frank Serna – Draper Lab, NDIA SED Chair– co-sponsor
Garry Roedler – Lockheed Martin, INCOSE President-Elect – co-sponsor

Judith Dahmann– MITRE, NDIA SoS Committee– DoD Liaison
Frank Salvatore – Engility, Representing INCOSE
Jon Backhaus –Lockheed Martin, Representing AIA

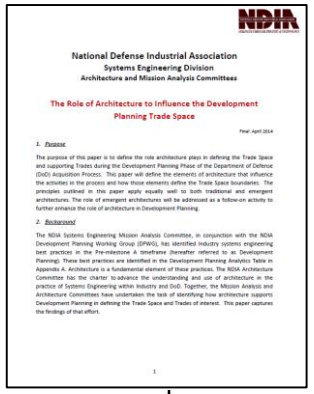
Bernie Smith, Lockheed Martin
Dan Strosnider – Boeing
Bob Scheurer – Boeing
Rich Poel – Boeing , NDIA SOS
Jeff Bergenthal – JHU/APL, NDIA
Jeff Wolske – Raytheon, NDIA SOS
Andron Creary – Northrop Grumman

Development Planning Studies / Reports

- **"Industry Support to Development Planning (DP)" [NDIA May 2013]**
  - FOCUS: Defined as the **upfront technical analysis and planning required for the successful selection and development of a materiel solution**, DP is a process that is inherently performed by Government.
  - FINDINGS:
    - **Need to consider how alternative solutions impact other systems in the SoS.**
    - The Government decision-maker can make **better and more informed decisions** on a given program if they have more pertinent critical information of the type that Industry can provide.
    - OCI & IP barriers to collaboration.
    - **SE discipline and Improved Methods of Collaboration & Communication Mechanisms are needed** – includes both one-on-one and cross-industry opportunities.
    - **All of these are needed too for Mission Engineering**.


National Defense Industrial Association
Systems Engineering Division
Development Planning Working Group
Report – Phase I
Industry's Role in Development Planning

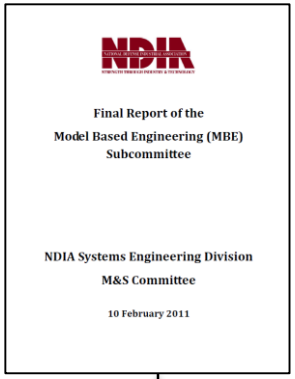
- **"The Role of Architecture to Influence the Development Planning Trade Space" [NDIA Apr 2014]**
  - FOCUS: To **define the role architecture plays in defining the Trade Space and supporting Trades during the Development Planning Phase** of the Department of Defense (DoD) Acquisition Process.
  - FINDINGS:
    - Mission Architecture focuses on the Mission and tasks to be performed, and how it needs to be done.
    - SoS Architecture focuses on the systems and how they work together for mission needs; covers how each system is used and how they are used as a set.
    - System Architecture focuses on individual systems, how they are used; covers how each system is constructed and how it performs the required tasks.
    - **Each view of architecture plays in defining the solution trade space and trades for ME**.
    - Architecture development is an iterative process throughout the life cycle.


National Defense Industrial Association
Systems Engineering Division
Architecture and Mission Analysis Committees
The Role of Architecture to Influence the Development Planning Trade Space

Model Based Engineering / Systems Engineering (MBE/MBSE) Studies / Reports

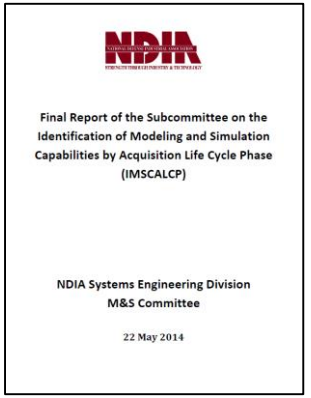
- **"Lifecycle Benefits of Collaborative MBSE Use for Early Requirements Development" [AIA May 2016]**
  - FOCUS: Document the **current maturation state and implementation recommendations for Model-Based Systems Engineering** within Aerospace & Defense.
  - FINDINGS:
    - Establish a **government-industry collaborative, secure MBSE framework** to support diverse toolsets and controlled data exchange **to develop stable, clear, affordable, non-conflicting program requirements** and facilitate the total life-cycle benefits of MBSE. This environment **supports a Mission Engineering infrastructure**.
    - Revise regulations required to provide the government appropriate data rights.

- **"Model Based Engineering (MBE)" [NDIA M&S Feb 2011]**
  - FOCUS: Assess and promote **Model Based Engineering (MBE) practices in support of the DOD capability acquisition life cycle**.
  - FINDINGS:
    - **MBE can provide a direct linkage between Mission Analysis and Mission Engineering and enhance the effectiveness and affordability of Mission Engineering**.
    - Collaboration amongst DoD, Industry, Tool Vendors, and Standards Organizations is necessary to support accessibility and reuse of data across MA and ME tools.
    - **MBE enables reuse from one program to another to support MA and ME for systems of systems**.



Modeling & Simulation (M&S) and Systems of Systems (SoS) Studies / Reports

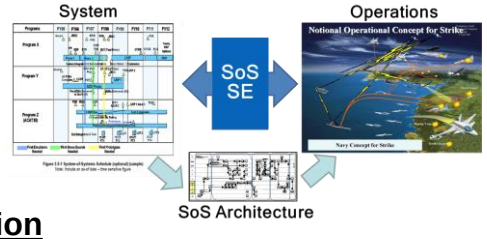
- **"Identification of Modeling and Simulation Capabilities by Acquisition Life Cycle Phase" [NDIA M&S May 2014]**
  - FOCUS: Consider the state of the art and practice of modeling and simulation (M&S) across the Defense Systems Acquisition Life Cycle.
  - FINDINGS:
    - The study identified systems engineering and acquisition functions that can be enabled by the use of M&S.
    - **Study results can aid in identifying how M&S capabilities can support Mission Analysis and Mission Engineering activities performed across the acquisition life cycle**.


Final Report of the Subcommittee on the Identification of Modeling and Simulation Capabilities by Acquisition Life Cycle Phase (IMSCALCP)

NDIA Systems Engineering Division
M&S Committee

22 May 2014

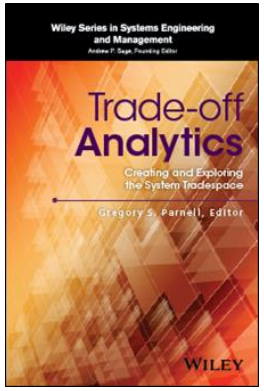
- **Review of SoSE and Mission Engineering [MITRE Apr 2016]**
  - FOCUS: Provided an overview of SoS – A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities.
  - FINDINGS:
    - **Operational Mission is a Driver for SoSE**.
    - SoSE is Bridge Between Acquisition & Operations.
    - Key element of SoSE: **Assessing impact of SoS on mission outcomes for mission engineering**.



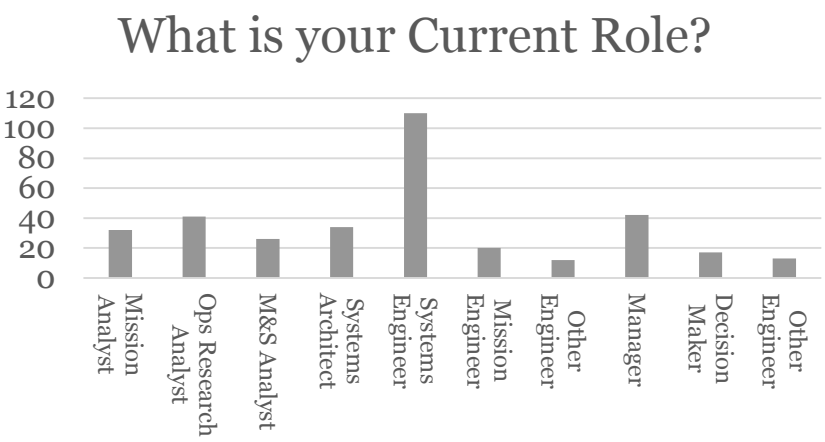
Book Reviews

- **INCOSE SE Handbook and SE Body of Knowledge**
  - FOCUS:
    - INCOSE SE Handbook: Shows what each systems engineering process activity entails in the context of designing for affordability and performance, as well as supporting ME.
    - SEBoK: Provides a compendium of the key knowledge sources and references of systems engineering organized and explained to assist a wide variety of users, including for mission engineering.
  - OVERVIEW:
    - INCOSE SE Handbook: **<u>Describes Mission Analysis</u>** purpose Same as IEEE-15288.
    - SEBoK: Provides some examples of major pitfalls of conducting mission analysis as well as some mission analysis proven practices.

- **"Trade-off Analytics: Creating and Exploring the System Tradespace" [INCOSE Project 2016]**
  - FOCUS: There are no best practices for trade-off analysis. Develop an INCOSE Decision Management Process and document best practices.
  - OVERVIEW:
    - New book has 4 sections: Foundations; Process, Principles, and Techniques; Illustrative Life Cycle Examples; and Summary and Future Opportunities.
    - Decision support model in the book **<u>captures and synthesizes outputs from individual analyses into trade-space visualizations designed to facilitate rapid and complete understanding of the trades</u>** available to stakeholders and provide drill down capability to supporting rationale that can be used in Mission Engineering.



Industry Survey Demographics

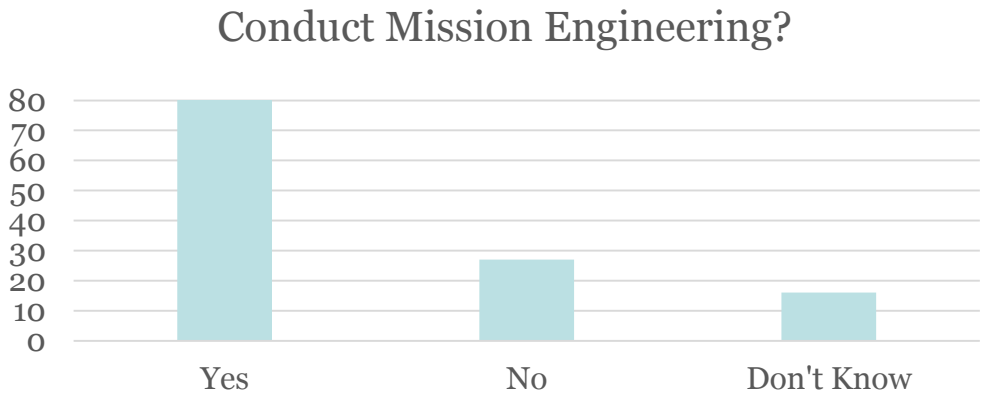


181 total respondents

Companies

- **Prime Developers / Integrators**
  - BAE Systems – 3
  - Boeing – 9
  - General Dynamics – 2
  - Lockheed Martin – 16
  - Northrop Grumman – 6
  - Raytheon – 8
- **Analysis / Support**
  - Anser – 2
  - Booz Allen Hamilton – 5
  - Engility / TASC – 8
  - SPA – 4
- **FFRDCs**
  - MITRE / IDA / SEI / Aerospace Co – 11
- **Other**: 88 additional companies with only 1 respondent each
- **Notes:**
  - Roles include Mission Engineer (20) and Mission Analyst (25)
  - Majority were Systems Engineers

Is Mission Engineering (ME) Being Conducted?

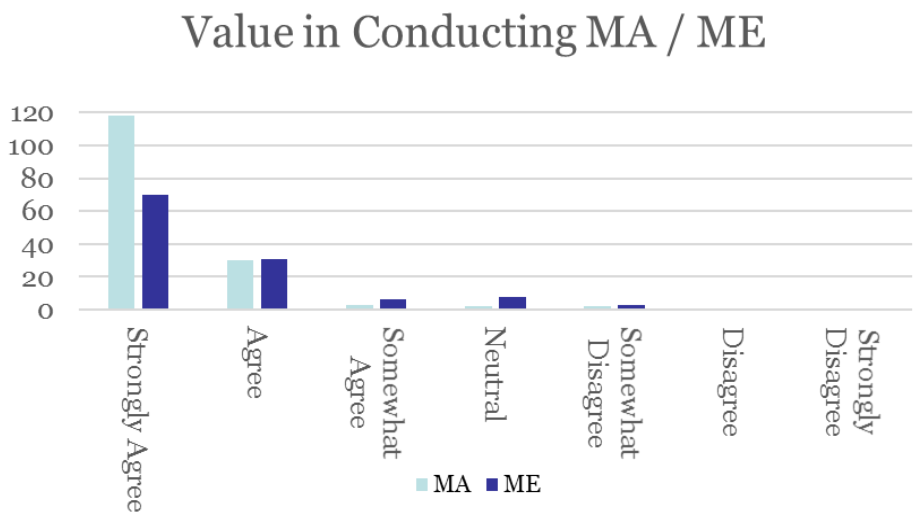


OSD(ATL) Definition Provided to Survey Respondents – Perform this or equivalent?

- *About 65% of respondents claim performing Mission Engineering*
- May not call it "mission engineering," but many organization's definition has the *same intent* as the OSD(ATL) definition
- Few organizations (<15% of the respondents) that said they didn't do ME

Large number of organizations are doing mission engineering

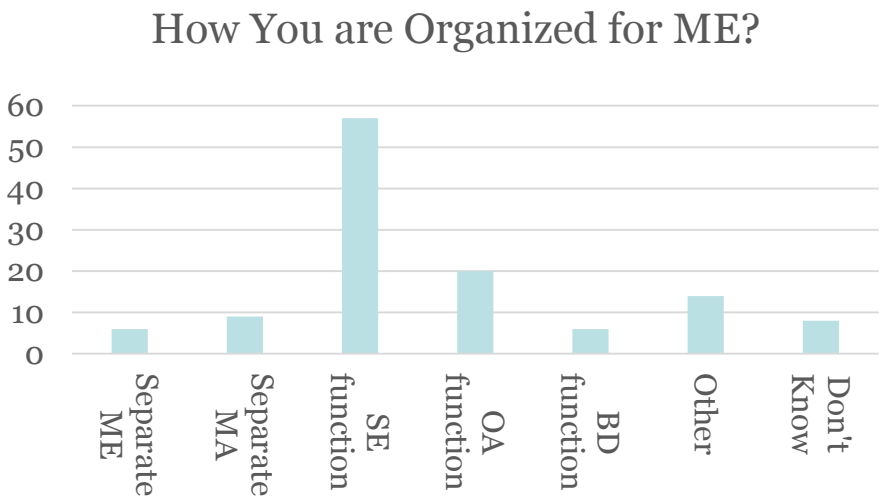
Value of Mission Analysis (MA) / Mission Engineering (ME) – Why Do It?



- **Respondents value ME / MA**
- **Why Industry Conducts ME**
  - Aid understanding the strengths and weaknesses of any military capability
  - Focus future IRAD / technology investments
  - Enable determination of affordable / best value alternatives for capabilities and upgrades
  - Improve mission effectiveness

Industry motivation for ME aligns with the DoD motivation for ME

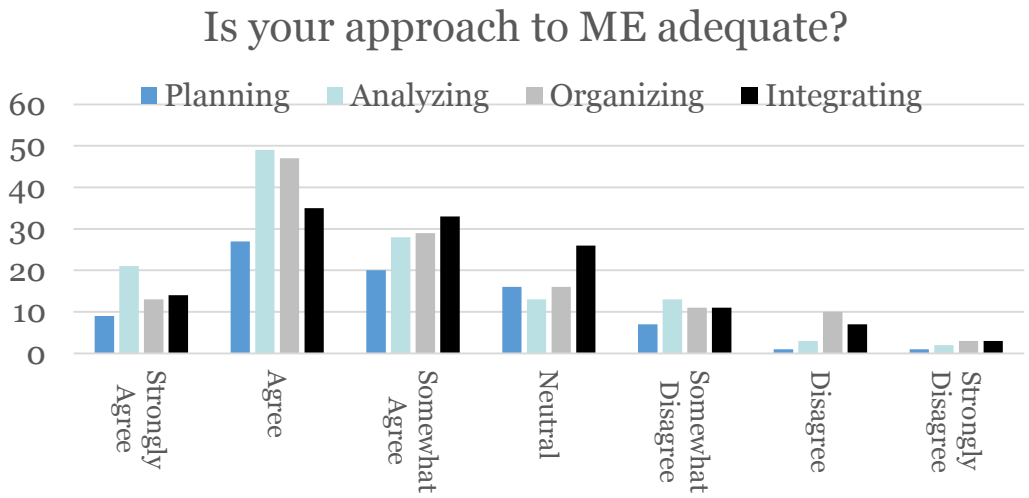
Organizing for Mission Engineering



- Mission Engineering is covered by a range of organizational functions
- Most common is ME as part of SE function
- More than half plan for ME using typical planning elements

Although some of industry is organized with specific ME/MA functions, most cover this in their SE function

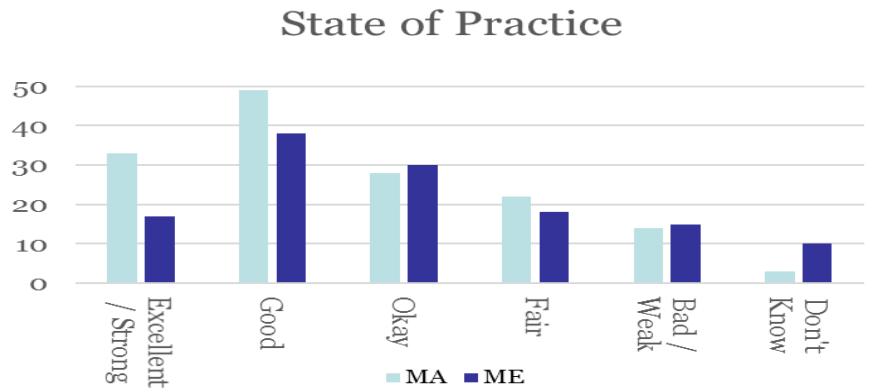
Organization's Approach for Mission Engineering

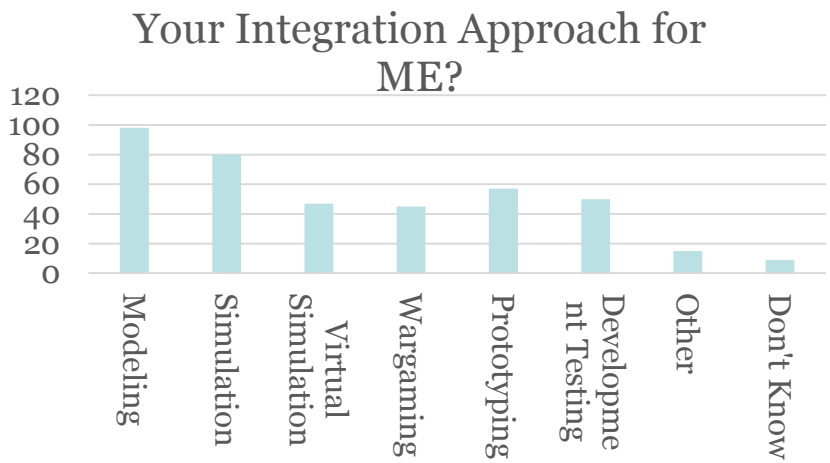


- Perception of adequacy may vary by stakeholder role
- Industry has experience in all four ME elements
- Greatest opportunities for improvement appear to be in planning and integration
  - Planning is often done on an ad hoc basis
  - Wide range of tools and analysis are applied

Industry experience in ME provide a potential base for shared experience

State of the practice based on experience



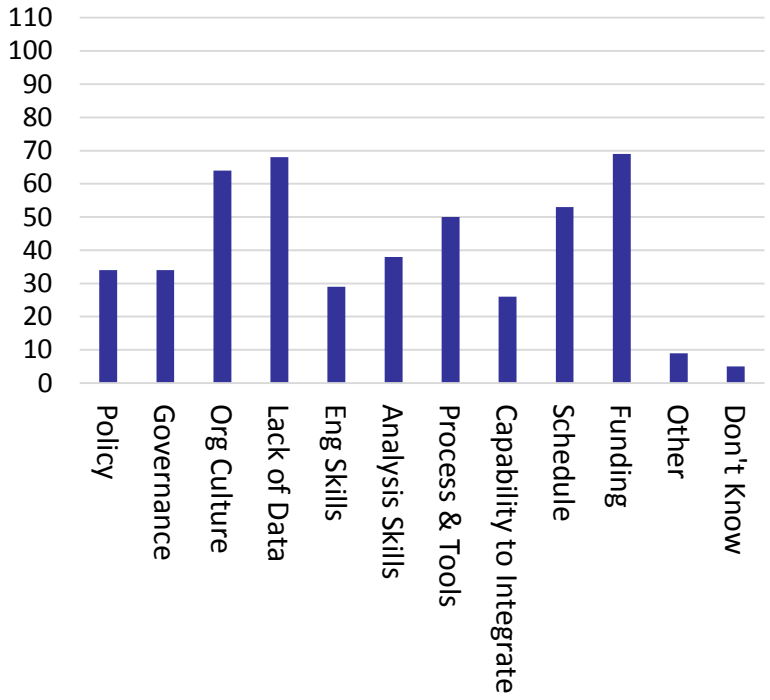


- **Predominant positive view of current state of practice**
- **Considerations**
  - ME requires a common understanding and decomposition of missions
  - ME depends on common understanding of applicable systems of systems
  - Modeling, simulation, and other analysis techniques are essential to mission impact evaluation
  - Skills and experiences are difficult to obtain
  - Value comes from solution integration

Greatest value is gained through achieving common understanding and collaborating with system data and M&S.

ME Challenges

What challenges do we face in ME?



Identified several challenges that can be addressed by collaboration

- **Non-technical challenges dominate and reflect impact of DoD on industry**
  - Policy
  - Governance
  - Organizational culture
  - Schedule and funding
- **Technical challenges cut across skills and tools**
  - Processes and tools
  - Engineering and analysis skills
  - Integration capability
- **Access to data is a large challenge**
  - Access of right data at right time
  - Access by industry to data (e.g., Proprietary, IP, OCI concerns – real and perceived)

Industry study recommendations address some ME challenges

- Recognized need and specific **recommendations for government-industry collaboration, in multiple industry group studies**, **can address many of the data challenges**
  - Collaborative foundation / framework
  - Mechanisms for sharing and protecting data
- Further implementation of **model based engineering practices can address many of the technical challenges**
  - Open standards will be required to support accessibility and reuse of data across engineering tools

Collaboration can help ensure identification of feasible alternatives and technologies.

- Final Report of the Model Based Engineering (MBE) Subcommittee, NDIA Systems Engineering Division M&S Committee, February 2011
- Life Cycle Benefits of Collaborative MBSE Use for Early Requirements Development, Aerospace Industries Association, 2016
- Industry's Role in Development Planning Phase I Report, NDIA Systems Engineering Division Development Planning Working Group, January 2011

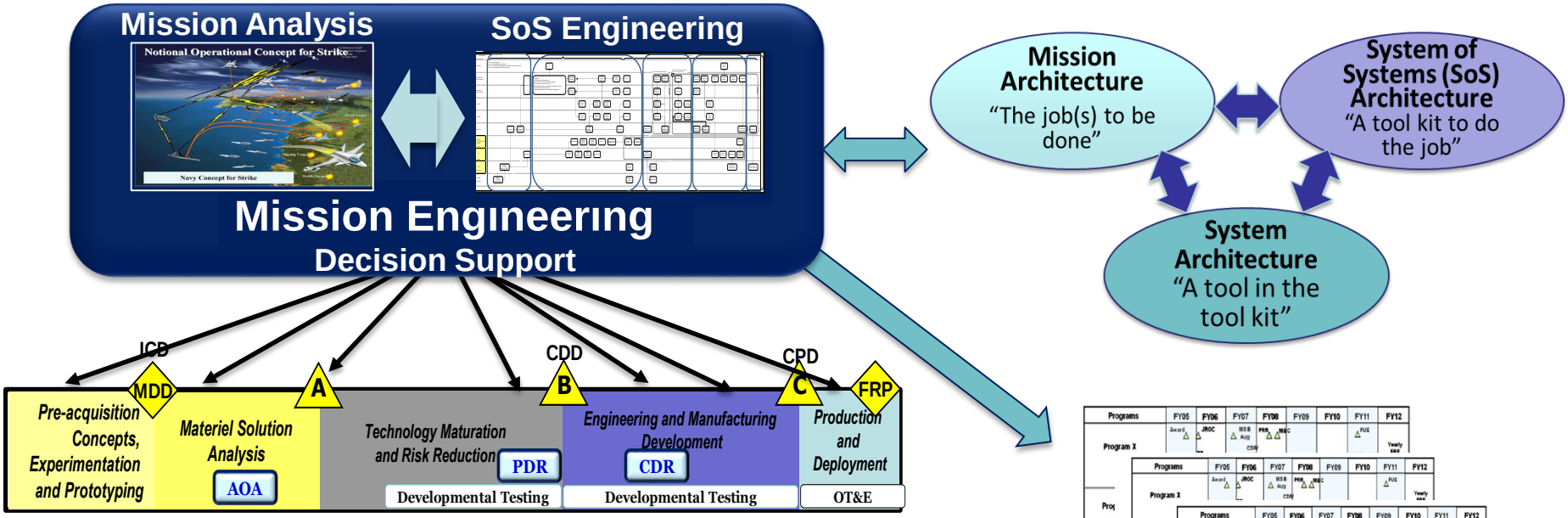
A Model Based Engineering Infrastructure May be Useful

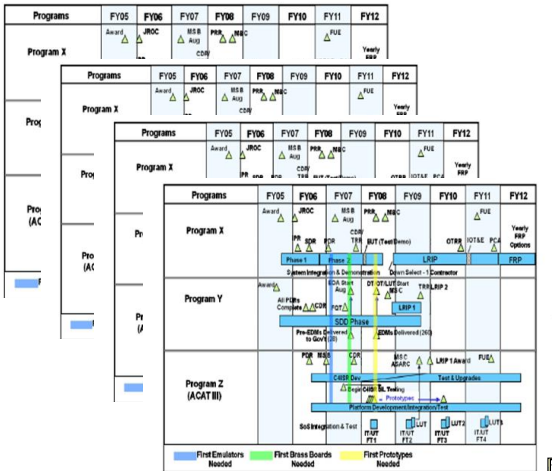
- Recommend investigation of a government industry collaborative environment where both parties can run analysis, share data, and obtain and contribute knowledge
- A model based environment would be enablers for ME
  - AIA and NDIA studies support MBE
  - M&S (tools & techniques) is used widely in the defense industry and could support Mission Engineering.
  - MBE (interoperable / cross-discipline approach) is not fully implemented in the defense industry sufficiently to support mission engineering.
- MBE allows for reuse of artifacts for collaborative analysis
- Will need to determine what is pragmatic and sustainable

MBE can provide a direct linkage between Mission Analysis & Mission Engineering

- Final Report of the Model Based Engineering (MBE) Subcommittee, NDIA Systems Engineering Division M&S Committee, February 2011
- Life Cycle Benefits of Collaborative MBSE Use for Early Requirements Development, Aerospace Industries Association, 2016

ME and System Acquisition





Mission Engineering provides an integrated view of missions and supporting capabilities

- To anchor system acquisition decisions to mission operational context
- To synchronize systems' developments to support mission capability
- To provide an integrated mission capability to warfighters

Provides engineering focus needed to ensure the solution investments provide highest value and probability of mission success

Shortages of MA / ME Skills and Experiences

- ME requires an understanding of operations, missions, systems engineering, and architectures
- Skills and experiences are difficult to get
  - There are no courses for MA & ME
  - There are no industry skill codes
- Industry has Mission Analysis and Mission Engineering capabilities that could be leveraged by the DoD.

DoD and industry can collaborate to build Mission Engineering competencies.

Conclusions

- Industry finds value in ME and MA
- Industry has much to offer
  - Large number of practitioners
  - Variety of tools and approaches
- Much more can be done if we work collaboratively to:
  - Refine and understand the definition of ME
    - Especially the relationship with Mission Analysis, SoSE, and other activities
  - Address the common challenges
    - Share best practices, tools, and models
    - Find a means to provide access to relevant data
    - Share resources for skill development
  - Explore other opportunities (e.g., additional modeling capabilities)
- Recommend establishing a joint action plan to move forward

- Backup

Defining Mission Engineering

- **Mission engineering (ME) is a recognized term by some, but not all in industry**
- **Based on the DoD provided definition, industry team took this perspective on key elements of ME**
  - Mission analysis (MA): Understanding the end-to-end operational mission, including CONOPs, mission threads, scenarios, and threats, is foundation for ME
  - Systems of systems engineering (SoSE): ME applies engineering across the set of systems supporting mission capability, including how the set of systems are employed, including both SoS analysis and architecture and integrated planning, orchestration and testing across systems for mission outcomes
  - Decision support: ME provide evidence to support crosscutting decisions about investments, individual systems, and operational employment based on the mission level SoS perspective