Model-Based Enterprise Capabilities Matrix

2019 INCOSE International Symposium

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INCOSE
International Council on Systems Engineering

AEROSPACE

Model-Based Enterprise Capability Matrix Workshop

Agenda

10 minutes Welcome and self-Introductions, sign-in sheet

20 minutes Overview of the effort, matrix and it's user's guide

- *Matrix and Users Guide purpose, history and their development plan*

60 minutes Working session – apply the matrix against a scenario

- *Two scenarios to choose from:*
  - Gov't Satellite Acquisition
  - Commercial product added to an existing product line
- *Instructions for attendees*
- *Split into groups of 4-6*
- *Apply the matrix*
- *Record findings*

30 minutes Workshop out briefs

Gain experience on applying the Matrix and User's Guide

Model-Based Capability Matrix

Challenge Team Effort

- Co-Leads:
  - *Al Hoheb, The Aerospace Corporation/SED, albert.c.hoheb@aero.org*
  - *Joe Hale, NASA/MSFC, joe.hale@nasa.gov*
- Challenge team:
  - *Federation of those willing to assist in the development and deployment of the products; now 139 and growing*
  - *As a challenge team member you are on the mailing list to receive product updates, notices for meetings and workshops*
  - *Request feedback on products and after you apply it*
- Model-Based Capabilities Matrix (MBCM) INCOSE Challenge Team Technical Project Plan (TPP) version 2.2
  - *Approved*
- Resources:
  - *http://wiki.omg.org/MBSE/ references provide an on-line overview of the products and the Challenge team efforts*
  - *INCOSE Connect – member download area (population of products is TBD)*

Products and Status

- Model-Based Capabilities Matrix (MBCM) version 2.0b r4
  - *Two views; Role-based view, and OSD Digital Engineering Strategy goal view*
  - *Same capabilities allocated differently for the 2 views*
  - *Prints on 3 pages of 11”X17” paper*
- User’s Guide version 5.2d1 – new!
  - *Word doc instead of PPTX charts used for UG versions 1-4*
- Frequently Asked Questions (FAQs) – new!
  - *Useful for newcomers*

- Potential products
  - *Template workshop charts so you as a champion can run a workshop*
  - *Introductory video*

- What other products would be useful to you?

Overview of the Matrix and Concept of Operations

Matrix Structure

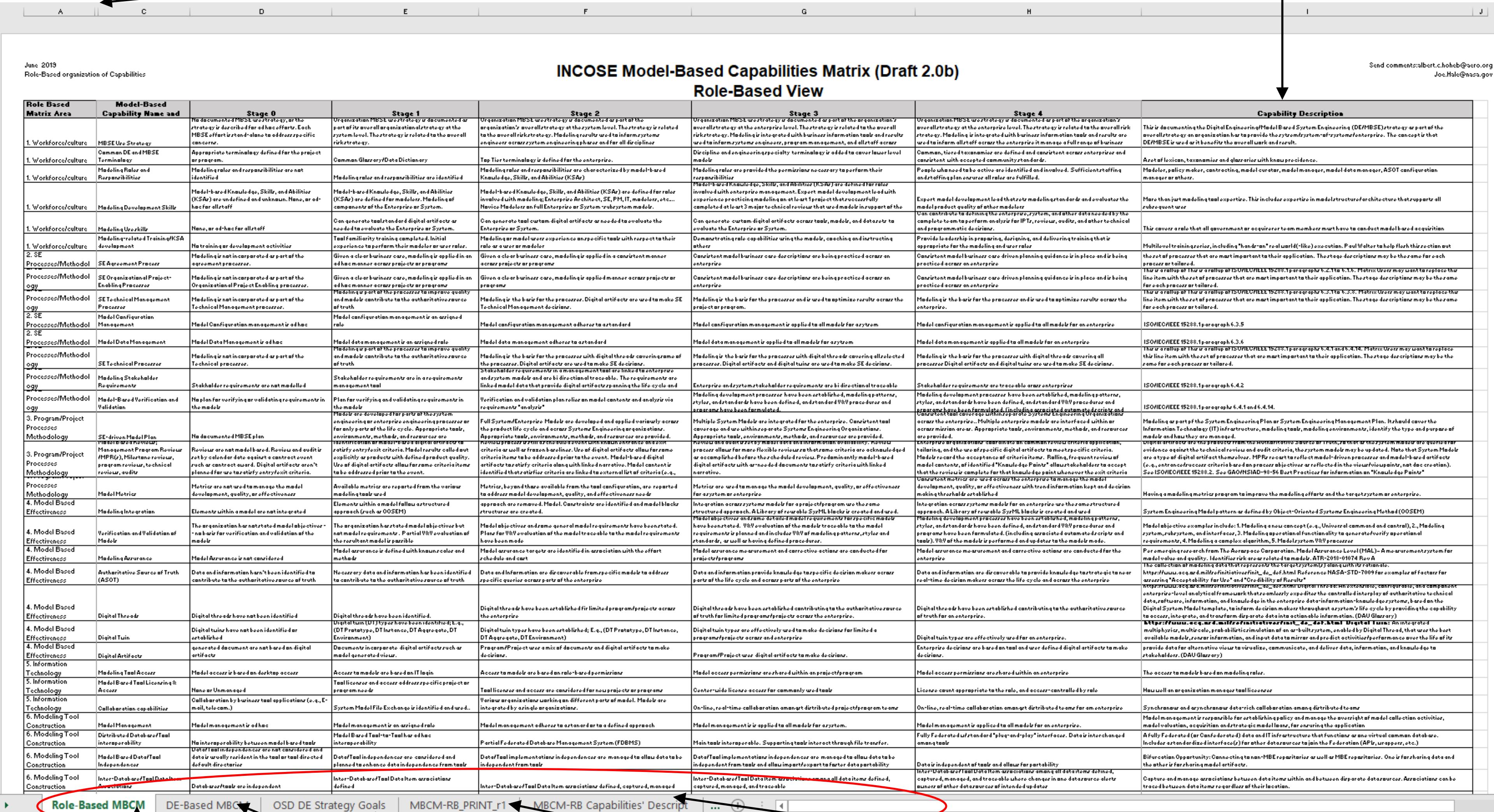
- Rows: Organization modeling capabilities for an organization
  - *Role-Based view or Digital Engineering (DE) goal view – same capabilities*
  - *Each view has the capabilities sorted by the role-based or DE goal key field*
- Columns: Increasing Stages of Capability generally defined as:
  - *Stage 0: No MBSE capability or MBSE applied ad hoc to gain experience*
  - *Stage 1: Modeling efforts are used to address specific objectives and questions*
  - *Stage 2: Modeling standards are applied; ontology, languages, tools,*
  - *Stage 3: Program/project wide capabilities; model integrated with other functional disciplines, digital threads defined and digital twin*
  - *Stage 4: Enterprise wide capabilities: contributing to the enterprise, programs/projects use enterprise defined ontologies libraries, standards*

Capabilities	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Cap 1					
Cap 2					
Cap 3					
Cap 4					

Snapshot of Matrix – Role Based View

Column B "DE Goals" is hidden

Capability Descriptions have been added



"Role-Based capabilities definition handout"

"Role-Based View"

Example "Role-Based Print Layout"

"DE Goals-Based View"

"DE Goals and Focus Areas"

Model-Based Enterprise Matrix CONOPS

Per the User's Guide

- Organization's transformation Plan
- Plan new capabilities
- Enhance processes

Identify the Enterprise, Program, or System Transformation Objectives

Use Matrix to identify the organization current and needed MBSE capabilities to meet the Transformation Objectives

Use Matrix results to plan the MBSE capabilities needed to meet the Transformation Objectives

- Pre-work to apply the matrix

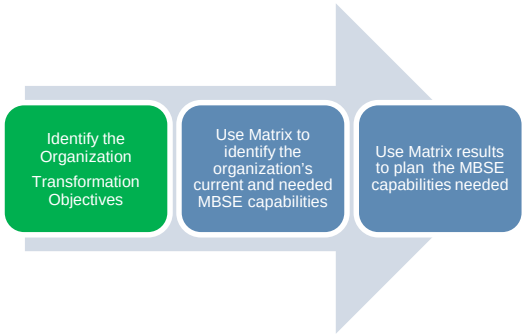
- "Half-day workshop"

- Org DE compliance Plan
- SEP/SEMP
- Multi-year roadmap
- Pre-source selection Acquisition strategy
- Qualifying sources
- MBSE roles and responsibility definition

This workshop will provide sample scenarios to apply the matrix

Sample Enterprise Transformational Objectives

Government Organization



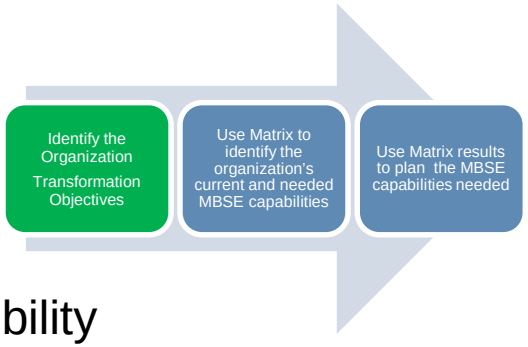
- Enhance enterprise resilience
- Enhance enterprise technical performance
  - *Technology injection*
  - *Re-allocation of existing assets*
- Enhance enterprise sustainment
- Enhance enterprise flexibility to use assets for new missions or changing mission priorities
- Move to an intelligent enterprise
  - *Reducing manpower or level of expertise*

Making more-with-less, more-with-existing, more-with-more, or preserving what is possible under stressors

Sample Enterprise/Business Unit Transformational Objectives

New!

Commercial Organization

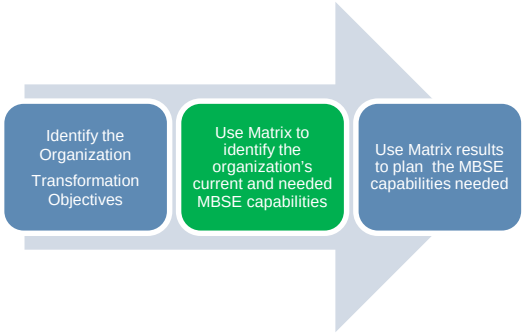


- Enhance consolidation of product lines or products
- Extend the product line or products through new features
- Extend the installed products through new features
- Examine/ensure product line backward or forward compatibility
- Enhance maintenance, service, and repair through standardization
- Minimize maintenance, service, and repair facilities, personnel, or training
- Examine if the products may be used in ways not originally intended

Transforming the organization to make better business decisions

Example of Matrix Assessment

Yellow= current state, Green is desired state

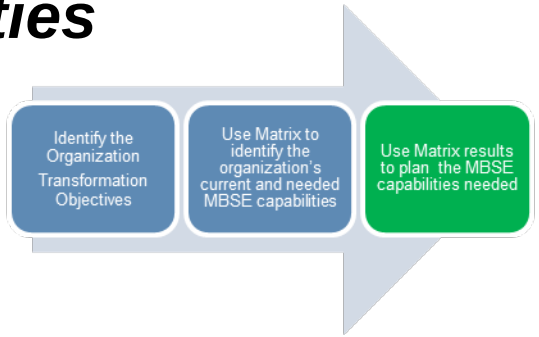


DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goal 1. Use of Models	MBSE Use Strategy	No documented MBSE use strategy, or the strategy is described for ad hoc efforts. Each MBSE effort is stand-alone to address specific concerns.	Organization MBSE use strategy is documented as part of its overall organizational strategy at the system level. The strategy is related to the overall risk strategy.	Organization MBSE use strategy is documented as part of the organization's overall strategy at the system level. The strategy is related to the overall risk strategy. Modeling results used to inform systems engineers across system engineering phases and for all disciplines	Organization MBSE use strategy is documented as part of the organization's overall strategy at the enterprise level. The strategy is related to the overall risk strategy. Modeling is integrated with business information tools and results used to inform systems engineers, program management, and all staff across the enterprise.	Organization MBSE use strategy is documented as part of the organization's overall strategy at the enterprise level. The strategy is related to the overall risk strategy. Modeling is integrated with business information tools and results are used to inform systems engineers, program management, and all staff across the enterprise it manage a full range of business concerns.
Goal 1. Use of Models	SE-driven Model Plan	No documented MBSE plan	Models are developed for parts of the system engineering or enterprise engineering processes or for only parts of the life cycle. Appropriate tools, environments, methods, and resources are provided.	Full System/Enterprise Models are developed and applied variously across the product life cycle and across Systems Engineering organizations. Appropriate tools, environments, methods, and resources are provided.	Multiple System Models are integrated for the enterprise. Consistent tool coverage and use within separate Systems Engineering Organizations. Appropriate tools, environments, methods, and resources are provided.	Consistent tool coverage within separate Systems Engineering Organizations across the enterprise.. Multiple enterprise models are interfaced within or across mission areas. Appropriate tools, environments, methods, and resources are provided.
Goal 1. Use of Models	Common DE and MBSE Terminology	Appropriate terminology defined for the project or program.	Common Glossary/Data Dictionary	Top Tier terminology is defined for the enterprise.	Discipline and engineering specialty terminology is added to cover lower level models	Common, tiered taxonomies are defined and consistent across enterprises and consistent with accepted community standards.
Goal 1. Use of Models	Model Management	Model management is ad hoc	Model management is an assigned role	Model management adheres to a standard or to a defined approach	Model management is applied to all models for a system.	Model management is applied to all models for an enterprise.
Goal 1. Use of Models	SE Agreement Process	Modeling is not incorporated as part of the agreement processes.	Given a clear business case, modeling is applied in an ad hoc manner across projects or programs	Given a clear business case, modeling is applied in a consistent manner across projects or programs	Consistent model business case descriptions are being practiced across an enterprise	Consistent model business case driven planning guidance is in place and is being practiced across an enterprise
Goal 1. Use of Models	SE Organizational Project-Enabling Processes	Modeling is not incorporated as part of the Organizational Project Enabling processes.	Given a clear business case, modeling is applied in an ad hoc manner across projects or programs	Given a clear business case, modeling is applied in a consistent manner across projects or programs	Consistent model business case descriptions are being practiced across an enterprise	Consistent model business case driven planning guidance is in place and is being practiced across an enterprise
Goal 1. Use of Models	SE Technical Management Processes	Modeling is not incorporated as part of the Technical Management processes.	Modeling is part of the processes to improve quality and models contribute to the authoritative source of truth	Modeling is the basis for the processes. Digital artifacts are used to make SE Technical Management decisions.	Modeling is the basis for the processes and is used to optimize results across the project or program.	Modeling is the basis for the processes and is used to optimize results across the enterprise.
Goal 1. Use of Models	Model Configuration Management	Model Configuration management is ad hoc	Model configuration management is an assigned role	Model configuration management adheres to a standard	Model configuration management is applied to all models for a system	Model configuration management is applied to all models for an enterprise
Goal 1. Use of Models	Model Data Management	Model Data Management is ad hoc	Model data management is an assigned role	Model data management adheres to a standard	Model data management is applied to all models for a system	Model data management is applied to all models for an enterprise
Goal 1. Use of Models	SE Technical Processes	Modeling is not incorporated as part of the Technical processes.	Modeling is part of the processes to improve quality and models contribute to the authoritative source of truth	Modeling is the basis for the processes with digital threads covering some of the processes. Digital artifacts are used to make SE decisions.	Modeling is the basis for the processes with digital threads covering all selected processes. Digital artifacts and digital twins are used to make SE decisions.	Modeling is the basis for the processes with digital threads covering all processes Digital artifacts and digital twins are used to make SE decisions.
Goal 1. Use of Models	Modeling Stakeholder Requirements	Stakeholder requirements are not modelled	Stakeholder requirements are in a requirements management tool	Stakeholder requirements in a management tool are linked to enterprise and system models and are bi directional traceable. The requirements are linked model data that provide digital artifacts spanning the life cycle and depth of design information.	Enterprise and system stakeholder requirements are bi directional traceable	Stakeholder requirements are traceable across enterprises
Goal 1. Use of Models	Model-Based Verification and Validation	No plan for verifying or validating requirements in the models	Plan for verifying and validating requirements in the models	Verification and validation plan relies on model contents and analysis via requirements "analysis"	Modeling development processes have been established, modeling patterns, styles, and standards have been defined, and standard V&V procedures and programs have been formulated.	Modeling development processes have been established, modeling patterns, styles, and standards have been defined, and standard V&V procedures and programs have been formulated. (including associated automated scripts and tools)
Goal 1. Use of Models	Model Based Reviews; Management Program Reviews /MPR(s), Milestone reviews, program reviews, technical reviews, audits	Reviews are not model based. Review and audit is set by calendar date against a contract event such as contract award. Digital artifacts aren't planned for use to satisfy entry/exit criteria.	Identification of model-based digital artifacts to satisfy entry/exit criteria. Model results called out explicitly as products with defined product quality. Use of digital artifacts allow for some criteria items to be addressed prior to the event.	Review process is still a scheduled event with known entrance and exit criteria as well as frozen baselines. Use of digital artifacts allow for some criteria items to be addressed prior to the event. Model-based digital artifacts to satisfy criteria along with linked narrative. Model content is identified that satisfies criteria are linked to external list of criteria (e.g., hyperlink to Word doc).	Review and audit is set by model data and information availability. Review process allows for more flexible reviews so that some criteria are acknowledged as accomplished before the scheduled review. Predominantly model-based digital artifacts with as-needed documents to satisfy criteria with linked narrative.	Enterprise organizations coordinate on common review criteria application, tailoring, and the use of specific digital artifacts to meet specific criteria. Models record the acceptance of criteria items. Rolling, frequent review of model contents, of identified "Knowledge Points" allow stakeholders to accept that the review is complete for that knowledge point whenever the exit criteria is met
Goal 1. Use of Models	Modeling Process quality	Modeling processes have not be identified/established	Modeling is a parallel process to engineering processes and is used to demonstrate potential modeling benefits	Modeling is the basis-of and integral-to engineering processes quality	Modeling enables processes to be re-engineered to minimize steps, increasing timeliness, while preserving product quality	Modeling processes re-engineered provides measurable improvements across the enterprise
				Metrics, beyond those available from the tool		Consistent metrics are used across the enterprise to manage the

Use any scoring method that your team agrees-to

Instead of color coding an "X" and "Check" could be used

Use Assessment Results to Plan Capabilities Improvement



- Organizational transformation strategy
- Organizational modeling capability development roadmap
  - *Community of interest roadmaps*
- Acquisition strategy – define modeling capabilities of the acquirer and the needed capabilities of the supplier
  - *Qualify potential bidders*
  - *Drive the RFP development and communication between acquirer/potential bidders*
- Product development planning
- System engineering plans (SEP), system engineering management (SEMP)plans
- Modeling and information technology roadmaps to provide the modeling environments and tools for the digital engineering enterprise
- Enhance processes with modeling capability
- Enhance workforce development to adopt and use modeling

Using the MBCM: Acceptance and Levels of Support

5 Stages of Acceptance Model

Kubler-Ross Grief and Loss Stages	MBCM Acceptance Stages*
Denial	Listen
Anger	Believe
Bargaining	Plan and accommodate
Depression	Conduct the plan
Acceptance	Assess and Plan

*From Al Hoheb, The Aerospace Corporation

5 Levels of Support Model

Level of Support	Behavior
Maximum	"I'll lead it" "Find a way to get it done"
Proactive	"I'll help and implement it" "Go the extra mile"
Moderate	"I'll look for things to support this"
Minimal	"I'll do what is necessary" "Do what I'm told"
None	"Go through the motions" "Wait and see" "Refuse"

Requires loss of "old ways" with a potential for grief with various levels of support

Matrix Effort History

Matrix Effort Pedigree and Plan

- ✓ Nov 2016 Aerospace MBSE Community Roadmap
- ✓ Oct 2017 NASA MFSC MBSE Maturity Matrix
- ✓ Nov 2017 OSD Digital Engineering Working Group – presentation and co-lead kickoff
- ✓ Jan 2018 INCOSE IW Breakout **Workshop** – presentation and workshop; – 2 half day session with over 50 participants, resulted in draft INCOSE matrix version 1.0
- ✓ Mar 2018 INCOSE Challenge Team Inputs -- comments
- ✓ May 2018 Aerospace System Engineering Forum -- presentation and **workshop**; draft INCOSE matrix version 1.1
- ✓ May 2018 USAF DE Working Group presentation – presentation, draft version 1.2
- ✓ June 2018 INCOSE Challenge Team Inputs -- draft version 1.3 in, draft users guide
- ✓ July 2018 INCOSE IS **workshop** -- draft version 1.3 in, draft users guide
- ✓ Aug 2018 version 1.4, wiki site initially populated
- ✓ Sept 2018 1.5, updated users guide
- ✓ Oct 2018 OSD Cross-check against the OSD DE Strategy – all strategy elements covered
- ✓ Oct 2018 NDIA SE Conference **workshop –** first fully populated matrix. Ver 1.5
- ✓ Nov 2018 Presentation to MIT/LL
- ✓ Dec 2018 INCOSE Challenge Team Inputs – matrix ver1.6a, TPP 2.1 (signed), User's Guide 4
- ✓ Jan 2019 INCOSE IW Outbrief and Breakout **workshop** -- matrix ver 1.7
- ✓ Feb 2019 Aerospace System Engineering Forum **workshop** – workshop program acquisition scenario
- ✓ Mar 2019 Aerospace internal and customer **workshop** -- matrix ver 2.0, organized to the OSD DE Strategy
- ✓ Jun 2019 Challenge Team meeting – matrix ver. 2.0b, additional capabilities, UG 5.2
- July 2019 INCOSE IS **workshop** -- FAQs
- Sept 2019 INCOSE Western Region - presentation
- Oct 2019 NDIA SE ME Conference presentation and **workshop**
- Jan 2020 INCOSE IW presentation and **workshop**
- TBD Draft INCOSE document approval submittal

The products have come a long way in a short time

Matrix Development Decision Points

1. Areas/categories cover the topic groups and can be allocated to Users Guide Roles
2. Row identification
    1. *Row is unique (e.g., no overlap with other rows)*
    2. *Are rows needed (unique cell information, e.g., "SE functions" or "PM functions")*
3. All cells filled in, provide a gradient from least amount of modeling application to the most desirable modeling application
4. Update for reasonableness and consistency
    1. *Terminology used consistently.*
    2. *Word and phrase clarity and agreement.*
5. First use to see if it's usable and establish candidate reports
    1. *2019 January, INCOSE IW*
    2. *2019 February, Aerospace System Engineering Forum*
6. Pilot use
    1. *Challenge Team action item and feedback*
7. General use and feedback
    1. *Enterprise, program, project, and role based use and feedback*
8. Establish candidate reports
9. Establish candidate metrics

Decision Points are identified where the available information is of sufficient quality to claim success and the development can continue

Pilot Uses

- Government Organizations that have reported applying the work
  - *MDA*
  - *GBSD*
  - *AF/SMC*
  - *AF ASE*
  - *NRO*
  - *NAVAIR*
  - *USA*
- All have tailored the matrix to suit their needs
- Getting feedback on results is desired

Positive outcomes

Workshop Activity

Choose to participate in either scenario

Workshop Scenario 1 and Instructions

Govt Team: Split into teams doing the same work

- Scenario: You are the Program/Project Manager or Lead System Engineer on an existing satellite program within a portfolio of satellite programs that is acquiring a new satellite to add to the fleet. The satellite needs to be procured quickly and needs to be of the same or greater performance.
- Instructions:
  - *Determine the driving objectives (see next page) – select, tailor, add objectives if needed*
  - *From the objectives, review the matrix rows and identify the needed stage to accomplish the objectives.*
  - *Recommend your team identify*
    - A lead moderator and a recorder
    - Scoring method (check the cell, color the cell, weight the cell, use the stage number)
    - how to capture results (e.g., bullets, chart, etc..) to outbrief
  - *Prepare for discussion*
    - What was the approach used to map Scenario Objectives-to-Capability Rows?
    - What results did you get? Where they useful?
    - What additional preparation would you have liked if you were doing this on your program?
    - What difficulties did you have? What results were surprising?

Scenario 1: Candidate Driving Objectives

A satellite program portfolio acquiring a new satellite to the fleet

1. Minimize enterprise or system configurations
2. Minimize requirement-design errors to meet cost/schedule goals and field capabilities quicker.
3. Minimize development time to get to production by replacing paper-based SE reviews and audits.
4. Ensure the enterprise or system meets strict surety, safety, security, or effectiveness requirements.
5. Minimize verification and validation effort and “test” time.
6. Create the Authoritative Source of Truth (ASOT) data, information, knowledge, wisdom needed to either re-compete work or product development.
7. Utilize standardization and common interfaces across the enterprise to enhance its open nature, enable alternate solutions, minimize development and enhance manufacturing flexibility.
8. Enhance servicing and management of fielded capabilities.
9. Assess existing fielded systems to plan service life extensions.
10. Optimize acquisition, program/project management and system engineering collaboration effectiveness

Determine those that are important and supplement with others if needed

Workshop Scenario 2 and Instructions

New!

Commercial Team:

- Scenario: You are the Program/Project Manager or Lead System Engineer on an existing product line that would like to add a new product. The product needs to be developed quickly to bring new features to market.
- Instructions:
  - *Determine the driving objectives (see next page) – select, tailor, add objectives if needed*
  - *From the objectives, review the matrix rows and identify the needed stage to accomplish the objectives.*
  - *Recommend your team identify*
    - A lead moderator and a recorder
    - Scoring method (check the cell, color the cell, weight the cell, use the stage number)
    - how to capture results (e.g., bullets, chart, etc..) to outbrief
  - *Prepare for discussion*
    - What was the approach used to map Scenario Objectives-to-Capability Rows?
    - What results did you get? Where they useful?
    - What additional preparation would you have liked if you were doing this on your program?
    - What difficulties did you have? What results were surprising?

Scenario 2 Candidate Driving Objectives

New!

New product in a product line with new features

1. Minimize product line components and configurations
2. Minimize requirement-design errors to meet time-to-market goals
3. Minimizing development time to get to production via paperless review activity and acceptance
4. Ensure the product meets strict government regulations for safety and meets trade group certifications (e.g., “Underwriters Laboratory” to be consumer safe)
5. Minimize test time to meet time-to-market goals.
6. Create the Authoritative Source of Truth (ASOT) data, information, knowledge, wisdom needed to outsource to various suppliers.
7. Enhanced standardization and common interfaces across the produce line enable alternate suppliers, minimize development and integration while enhancing the ability to manufacture the product.
8. Enhance ease of service and repair of products in-use.
9. Determine if enhancements or service life extensions by examining all the collection of associated engineering and service data
10. Optimize processes efficiencies across the product life

Determine those that are important and supplement with others if needed

Workshop Out Briefs

Workshop Participation Wrap-Up and Feedback

- Ideas for running the workshop for a sponsor
- If you'd like to be added to the Challenge Team mailing list, please let us know
- What else would you need in order to bring this to your organization, become the motivational champion, and use it?
- Send us ideas and comments!
  - *Albert.c.hoheb@aero.org*
  - *Joe.Hale@Nasa.gov*

Running the Workshop for a Sponsor

- Provide an overview brief to the sponsor and key advisors/stakeholder to
  - *Identifies what the matrix is, how it can be useful, how long it takes (4 hours), and resource commitment*
  - *Agree on the output product; an assessment used to begin planning*
  - *Identify key people; PM, SE, IT, Modeler, Contracts, Training, etc..*
- Develop a short project plan
  - *Tasks, timeline, stakeholders, and have it signed off by the sponsor*
- Identify/develop a customer scenarios (e.g., enterprise, program – new or existing) and identify their overall enterprise or program objectives
  - *Create the objectives if they aren't available*
- A-priori matrix tailoring
  - *Use customer language if needed*
  - *Emphasize the right capability rows; tailor-out or create new row*
  - *Agree on scoring method and being generous (benefit of the doubt)*
- Run the assessment in a half day
  - *Using the enterprise or program objectives as a basis, review the row and stage for current capabilities and those needed to meet customer objectives.*
  - *Group the gaps and begin development of an organizational development plan. It could be a multi-year roadmap.*

Thank You

Your participation and other participation like this has made this all possible

Sample Modeling Objectives

1. Modeling use cases for CONOPs validation
2. Modeling operational functionality to generate/verify operational requirements
3. Modeling a new concept (e.g., Universal command and control)
4. Modeling enterprise, system and subsystem performance
    1. *Ensure requirements traceability*
    2. *Assess design maturity*
    3. *Assess integration*
5. Modeling specialty engineering threads to verify performance
    1. *Reliability, security features, safety, surety, or effectiveness*
6. Modeling interfaces
7. Modeling a complex algorithm
8. Model for manufacturing
9. Model system V&V processes to verify by analysis
10. Model test and/or maintenance suite compatibility
11. Model the baseline for alternative sourcing