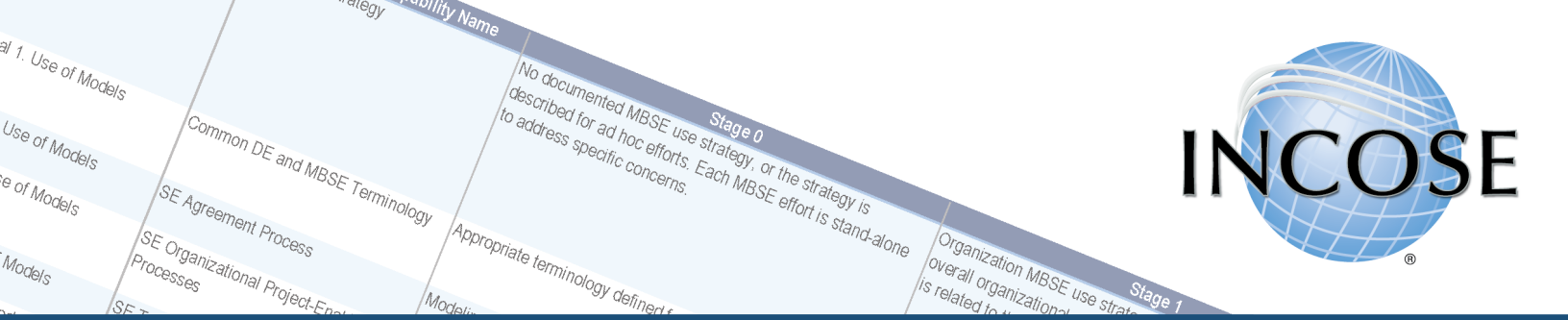

INCOSE Model-Based Capabilities Matrix and User's Guide

Version 1.0, January 2020

Joe Hale,
NASA/MSFC, retired
givem@comcast.net

Al Hoheb,
The Aerospace Corporation,
albert.c.hoheb@aero.org

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INCOSE MODEL-BASED CAPABILITIES MATRIX AND USER'S GUIDE

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Prepared by:

- Joe Hale, NASA/Marshall Space Flight Center, retired
  givem@comcast.net
- Al Hoheb, The Aerospace Corporation
  albert.c.hoheb@aero.org

REVISION HISTORY

Revision	Revision Date	Change Description and Rationale
1	01 Jan 2020	Original Publication

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LIST OF EXHIBITS

FOREWORD

The authors are grateful for the interest and passion of the Matrix users, INCOSE Challenge Team members, and workshop participants and welcome comments. The workshops provided participants the context and practice applying the matrix to different organization scenarios. The instruction, practice, and inspired confidence on potential matrix tailoring and application. This User's Guide is not a substitute for a workshop but has captured many of the ideas brought from those workshops.

1 OVERVIEW

The INCOSE Model-Based Capabilities Matrix is a tool to help organizations that have already decided to implement digital engineering or Model-Based capabilities assess, and then plan the development of these capabilities in a comprehensive and coherent manner. It is a tool for; organizational transformation and development, providing a set of capabilities and organizational implementation stages that are used for the conversation, and planning and resulting assessment of capabilities. This document uses the terms digital engineering (DE) and model-based systems engineering (MBSE).

While the pedigree of the matrix is from the US government and commercial space organizations, the intent of the matrix is to apply to non-space related organizations both in the government and commercial sectors. The authors urge users to become familiar with the terms used, but to also tailor the matrix to use terms familiar to the target organization.

The scope of the organization under regard may be the entire enterprise/business unit, program/product line, project/product, or some other level of organization. The Models being discussed may be descriptive models or analytical models. The role-based view of the Model-Based capabilities may be suitable for specific roles to take-action; enterprise manager, system engineer, program manager, Modelers, information technology representative, training, and even human resources. The other matrix view of capabilities is the allocation of capabilities to the five goals listed in the United States Office of the Secretary of Defense (OSD) Digital Engineering (DE) Strategy document. U.S. Government organizations familiar with the OSD DE Strategy may want to use this matrix capability view to maintain or demonstrate traceability among their organization's capabilities, the OSD DE Strategy, and transformation plans.

The Matrix is intended to serve as a starting point for the various organizational use cases. In most instances, the wording and level of detail will be tailored for specific applications and organizations. A section on tailoring is provided.

The purpose of this Guide is to provide approaches on how to use the Matrix for the following purposes:

- Organizational self-assessment
- Enterprise-wide assessment of a portfolio of projects/program organizations
- Role-based capabilities assessment for stakeholders in the organizational development
- DE Strategy Goals view to maintain or demonstrate traceability among their organization's capabilities, the OSD DE Strategy, and transformation plans.
- Providing the strategic basis for qualifying bidders and/or planning for the acquirer's pre-award process leading to a source selection and contract award.

Matrix assessment results typically identify the current Model-Based capability an organization has and the targeted capability stage. This "need," or "gap" provides the starting point to create plans to transform the organizations involved. The assessment grading approach and report formats are left to the matrix user to define.

The authors intend that the assessment itself be a quick half-day activity where the goal is a "good enough" assessment to begin planning the organizational transformation. Pre-work is recommended to ensure the right assessors, the matrix is tailored to the needs, and the enterprise/department purpose is defined, the organizational transformational objectives are

considered, and Modeling objectives are initially established. Sample enterprise and department purposes are provided as an appendix as are a set of Modeling objectives.

The authors intention is the matrix grading be generous when applied, meaning if in doubt allow the capability assessment to be a higher stage. The goal for matrix application is serving as a starting point for organizational transformation and development to the stage the organization has determined it would like to be competent in.

The Guide begins with an abbreviated developmental history and an explanation of the Matrix structure.

2 DEVELOPMENTAL HISTORY (ABBREVIATED)

The matrix begins with two independent efforts to provide a reference for enterprise and program/project organizations to assess their current and desired implementation of Modeling:

- The Aerospace Corporation MBSE Community Roadmap
- NASA MSFC MBSE Maturity Matrix

Following a presentation of both at the Office of the Secretary of Defense (OSD) Digital Engineering Working Group in 2017, it was decided to combine these efforts to bring the work to the January 2018 INCOSE International Workshop to determine if there was a valid community need and to design a matrix combining elements of both efforts and supplementing them to address the IEEE 15288.1 and 15288.2 as well as the emerging OSD Digital Engineering Strategy, June 2018[1]. Two four-hour workshops with 67 participants ratified the need and developed the framework for the INCOSE Model-Based Capability Matrix. INCOSE then raised the bar by commissioning a Challenge Team to continue development.

Early drafts of the Matrix were created and refined over a series of workshops at various System Engineering fora and online INCOSE Challenge Team meetings:

- INCOSE International Workshop (Jan 2018) where an INCOSE Challenge Team was formed to produce a candidate INCOSE product
- Aerospace System Engineering Forum (May 2018)
- INCOSE International Symposium (July 2018)
- NDIA SE Conference Workshop (October 2018)
- INCOSE International Workshop (Jan 2019)
- Aerospace System Engineering Forum (February 2019)
- INCOSE International Symposium (July 2019)
- NDIA Systems and Mission Engineering Workshop (October 2019)

About the Challenge Team: The Challenge Team was commissioned by Mark Sampson and Troy Peterson, INCOSE leads for the System Engineering Transformation/MBSE Initiative efforts.

Challenge Team. Co-led by

- Al Hoheb—The Aerospace Corporation
- Joe Hale—NASA/Marshall Space Flight Center

INCOSE Challenge Team. Reps from numerous Government, Industry, and Academic organizations and continues to grow make up this team. Challenge team members are volunteers

[1] https://www.acq.osd.mil/se/docs/2018-DES.pdf

that would like to be informed of the efforts, contribute as they can to develop the products, and as they are able, promote and use the products providing feedback.

INCOSE Challenge Team Resources.

- OMG Wiki: http://www.omgwiki.org/MBSE/ The OMG wiki entry discusses the effort.
- http://www.omgwiki.org/MBSE/doku.php?id=mbse:mbecm
- INCOSE Connect, workgroups, Model-Based Capabilities Matrix (INCOSE Members only). This is the INCOSE member download area for the Matrix and User's Guide.

3 Model-Based Capability Matrix Structure

The Model-Based Capabilities Matrix ("Matrix") helps organization address the problems of:

- What model-based capabilities does my organization need?
- What capabilities do my enterprise team members need?
- How do we ensure we have thought of everything?
- How can we characterize the capabilities needed and their evolution?
- What capabilities should my Project Management (PM), Systems Engineering (SE), Information Technology (IT), Modelers, and contracts staff need?
- How can my organization show traceability between the capabilities and the DoD Digital Engineering Strategy?

3.1 Capability Rows

The matrix is arranged as a table with rows identifying Model-Based capabilities for an organization and columns identifying the stage of that capability. *See Exhibit 1. Matrix Structure.* The capabilities are meant to be unique and necessary for an organization to have a Model-Based approach.

Capability Statements. Each capability is tersely noted as a capability statement. A capability statement is a statement about the organization and its capabilities and skills that defines what it can do by employing model-based effort.

- A capability:
- Produces an outcome
- Is activated by resources
- Has both an input and output
- Changes over the life cycle

Exhibit 1. Matrix Structure

Capabilities/Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Capability 1					
Capability 2					
Capability 3					
Capability N					

3.2 Stage Columns

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 address specific objectives and questions
- Stage 2: Modeling standards 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, and standards

An example of one capability is in *Exhibit 2. Model Management.* The capability description provides context and the organizational point of contact (POC) would identify the current stage and desired stage. This gap is used to plan the evolution of the capability.

Exhibit 2. Model Management

Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
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.

Capability Description
Model management establishes policy to manage model development, model configuration management, model collection activities, model valuation, acquisition and strategic model loans, and for ensuring the proper application

4 MBCM VIEWS

The Matrix has tabs that allow the capabilities to display in either of two basic views: the Role-Based View of Model-Based capabilities, and the United States Office of the Secretary of Defense (OSD) Digital Engineering (DE) Strategy document. Each view has the same capabilities however, they have been sorted differently depending on user preference.

The virtue of the Role-Based view is it conforms with the matrix versions 1.0–1.7a. It supplies a straight-forward mapping to roles performed in an organization. It is the basis for the "Model-Based Stakeholder Roles Assessment" to allocate capability transformations to specific roles (and thus specific people) in an organization.

The role-based areas are:

1. Workforce/Culture
2. System Engineering Processes/Methodology
3. Project/Program Process/Methodology
4. Model Based Effectiveness
5. Modeling Tool Construction
6. Information Technology Infrastructure
7. Policy

The virtue of the OSD DE Strategy view is organizations familiar with the OSD DE Strategy may want to use this matrix capability view to maintain or demonstrate traceability among their organization's capabilities, the OSD DE Strategy, and transformation plans.

The United States Office of the Secretary of Defense (OSD) Digital Engineering (DE) Strategy document view sorts the capabilities into the strategies' five goals. The virtue of assessing organizational capabilities against these goals is the order of goals provides a more logical flow; an example being the capabilities under "User of Models" need to be established before the capabilities allocated to the "Authoritative Source of Truth." Assessors may find it easier to use this allocation than the Role-Based allocation because it leaves workforce and culture assessments to the end after the precursor capability needs have been assessed. U.S. Government organizations familiar with the OSD DE Strategy may also want to use this matrix capability view to maintain or demonstrate traceability among their organization's capabilities, the OSD DE Strategy, and transformation plans.

1. Use of Models
2. Authoritative Source of Truth (ASOT)
3. Innovation
4. Establish Environments
5. Workforce Transformation

5 OTHER MODEL-BASED ASSESSMENT MATRICES

There are other Model-Based assessment matrices available. The Aerospace Corporation and NASA/MSFC center started this effort with their own until they collaborated. Major corporations such as Siemens, Lockheed Martin, and Boeing have at various times shown elements of their corporate defined matrices at INCOSE events. Similarly, the NIST/ASME manufacturing matrix has been in use to focus on Modeling for manufacturing. This INCOSE Challenge team effort has benefitted from presentations and been enriched by those efforts as they joined and strengthened the over 160 INCOSE Challenge Team members.

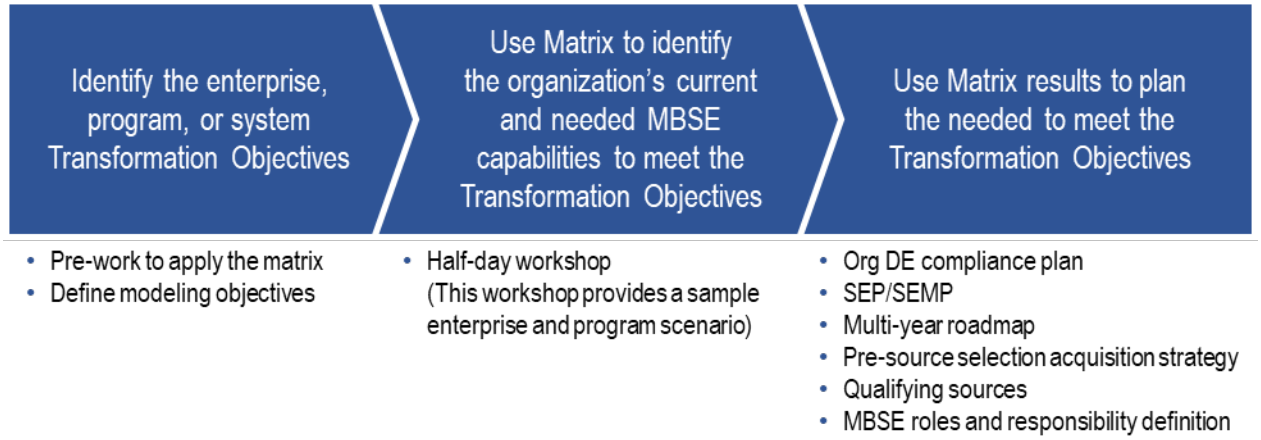
The INCOSE MBCM has been used in many INCOSE, NDIA, and corporately sponsored workshops, during which proposed concepts along with a breadth of ideas were culled and incorporated. Not all ideas can be incorporated: some ideas contradict, some are beyond the state of the current Modeling practice, some will come as users apply the matrix (such as standard scoring and reports), others are currently beyond the reach of efforts the leads and team members can achieve as volunteers.

If users discover a move valuable matrix—use it! It may fit a specific need such as Modeling for manufacturing or a matrix of Model-Based personal competencies needed to satisfy Model-related leadership or staff roles.

6 MATRIX CONCEPTS OF OPERATIONS (CONOPS)

The purpose of the matrix is to provide organizations an assessment of the capabilities needed to transform to improved and purposeful model use. *Exhibit 3. Model-Based Capabilities Matrix (MBCM) CONOPs* illustrates how an organization applies the matrix by first doing necessary pre-work. Necessary pre-work includes defining organizational transformation objectives, defining the organization's enterprise or program objectives, and tailoring the matrix. This is the step that includes organizing the assessment team, understanding how the assessment results will be characterized, and how the assessment results will be used.

Exhibit 3. Model-Based Capabilities Matrix (MBCM) CONOPs



The last step, illustrated by the right-most box of *Exhibit 3,* provides a list of products that an organization may develop and the matrix assessment results may contribute to. For example, a DoD organization may want to see what capabilities it has and what additional capabilities need to be developed if they are concerned with complying with the DoD Digital Engineering Strategy document. An organization may want to write/update their System Engineering Plan (SEP) or System Engineering Management Plan (SEMP) to more fully utilize modeling as part of their system engineering approach and the capabilities assessment results could contribute to that understanding and plan. Organizations may want to use the assessment as part of their acquisition strategy to characterize what capabilities the acquirer and suppliers may need to ensure successful modeling efforts. Lastly, the organization may want to review key roles and assess what modeling capabilities the key roles must satisfy or lead. There may be other applications for the results of the INCOSE Model Based Capabilities Matrix assessment and Exhibit 3 may not capture those.

The middle block of Exhibit 3 covered the activity of using the matrix to assess organizational capabilities. A "Half Day" workshop is noted because workshops have been run in as little as 2 hours, run for 4 hours, or run as a full day workshop. This depends on the quality of the pre-work, the size of the assessment group, and workshop leadership's direction and workshop management. A key concept to consider is that moving quickly, without a lot of debate on the assessment, may speed results, help to assess those capabilities that are most important, and yield a quick starting point for the organizational planning. The Challenge Team leaders for the development of the matrix have envisioned it quickly assessing an organization's capability and urge generous scoring because it is really not the scoring that is the result but rather the plans that result from the scoring.

Here are some recommended actions to run the Matrix Assessment:

- Provide an overview brief to the sponsor and key advisors/stakeholder to
  - Identify 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; Enterprise manager (EM), Project/program Manager (PM), System Engineer (SE), Information Technology (IT), Modeler, Contracts, Training, etc.
- Develop a short project plan and have it signed off by the sponsor
  - Tasks, timeline, stakeholders
- Identify/develop 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.

7 TAILORING

Organizations should choose which view of the capabilities it would like to use. Matrix version 2.0b and beyond provide either a role-based view (legacy version refined between matrix versions 1.0–1.7a) or a Digital Engineering view aligned to the United States, Office of the Secretary of Defense (OSD)' Digital Engineering (DE) Strategy document found at: https://www.acq.osd.mil/se/docs/2018-DES.pdf

The DE view may be important to any organization that would like to show traceability of their capabilities and plans against the DE Strategy goals and focus areas. It is arranged in a logical fashion where the earlier goals enable the completion of the later goals. Hence the associated capabilities may enable the later capabilities in the Matrix.

Tailoring of the matrix by organization is not only allowable but encouraged. Organizational language should be used to enhance the organization's understanding and use. The capabilities are not of equal value and users may want to eliminate rows, combine rows, or add rows to tailor the matrix to their needs. Tailoring may reduce direct benchmarking with other users but may be an appropriate approach based on need. Use language that is important to the organization—tailor before use:

- e.g., government organizations may use the term "center" while commercial organizations may use terms such as "business unit" or "profit center"
- e.g., NASA uses "project," DoD uses "Program"
- "Enterprise," "system-of-system," and even "system" may have specific organization definitions to be used.
- Commercial entities may want to use "Business Unit" instead of "Enterprise," "Product Line" instead of "program" and "Product" instead of "project" to describe their organization.

Identification of SE areas and individual processes to be addressed are critical to successful matrix-based assessment and the following capability planning step. Choosing the right level of SE areas/processes is a bit of an art; too many will complicate and bog down the assessment, too few may omit key concepts that are essential to success. The Matrix has gone through many debates and iterations. While it was at first desirable to have each system engineering process and subprocess as a unique row and capability it was found that some SE areas/processes were necessary to Model-Based applications. For those such as configuration management, data management, Model management, Model metrics were retained as their own capability rows. Patterns emerged from looking at the SE areas/processes candidate stage descriptions and the INCOSE Challenge Team leads made the editorial decision to not repeat those patterns.

Addition/deletion of capability rows to focus on organization perspective or to focus stakeholder roles: If the organization is more concerned about architecting or system engineering across the life cycle then the matrix may be used as is. If the organization is concerned about manufacturing readiness, then additional rows may be added to cover this and/or adoption of the NIST/NDIA/ASME Model Based Enterprise matrix for manufacturing readiness would apply. Similarly, some organizations have a focus on workforce development and would like to use elements of the INCOSE matrix to assess organization development capabilities and enhance those.

Establishing capability relative weighting: The INCOSE Matrix doesn't provide capability weighting although some users would like to add it. In the spirit of making the matrix suitable for the SE community and to promote user acceptance, users may want to add their own weighting.

8 MATRIX USES

8.1 Overview

This User's Guide has identified specific use-cases:

- Organizational self-assessment
  - DoD org DE implementation plan, SEP/SEMP, Acquisition strategy and pre-request for proposal (RFP)/source selection, Bidder qualification
  - Commercial investment plans to build organizational capability
- Enterprise-wide assessment of a portfolio of projects/program organizations
- Model-Based Stakeholder Roles Assessment to ensure that each stakeholder knows the capabilities they are responsible for and performance on that capability
- Qualifying bidders and/or planning for the acquirer's pre-award process

8.2 Organizational Self-Assessment

Organizations may want to define the capabilities and stages they would like to demonstrate once their goals are fully realized or to define roadmaps to achieve that goal. To apply the matrix, organizations may want to:

- Determine the stakeholders involved with the assessment and ensure they identify and accept the responsibilities for matrix tailoring, matrix capabilities assessment, assemble the resulting transformational plan to improve the organization's capabilities, and then be responsible for the organizational developmental activities and organizational performance.
- Determine the assessment approach. It can be done in one workshop or it can be split into separate, but related, tasks. Determine the assessment scoring approach.
- Tailor the matrix via stakeholders.
- Define the enterprise or department engineering goals for the deployment of Model-Based capabilities
- From the enterprise or department goals identify Modeling objectives.
- Use the tailored matrix to perform the capabilities assessment. Establish the scoring approach first. Will scoring identify current and desired stages for each capability? Weight the capabilities? Other approaches?
- Discuss the results and create the transformation plan(s)

Identification of the organizational Model-Based capabilities may start with identification of the enterprise or SE goals to address a need. Common needs may be:

- Minimize enterprise or system configurations where applied Model-Based can be used to achieve this for fielded and planned capabilities.
- Minimize requirement-design errors to meet cost/schedule goals and field capabilities quicker than with non-Model-Based development.
- Minimize development time to get to production via paperless review activity and acceptance—e.g. replacing paper-based SE reviews and audits.
- Ensure the enterprise or system meets strict surety, safety, security, or effectiveness requirements.
- Minimize test time using model-based engineering (MBE)/MBSE.

- Create the Authoritative Source of Truth (ASOT) data, information, knowledge, and wisdom needed to either re-compete work or product development.
- Enhance standardization and common interfaces across the enterprise or system to enhance its open nature, enable alternate solutions, minimize development and enhance manufacturing flexibility.
- Model-Based capabilities to enhance logistics and maintenance of fielded capabilities.
- Capturing existing fielded system ASOT for service life extensions.
- Optimize acquisition, program/project management, and system engineering processes by using MBSE.

Once the organizational Model-Based needs are established they may then review the capability rows and identify the needed capabilities and the needed stage to address their needs (initial matrix tailoring may be required at this point). This will result in the strategic vision.

After the strategic vision is established the organization may put together the stakeholder team to perform the assessment (tailoring may be required) of the current state of the organization's capability. Once the current state and desired state (strategic vision) are identified, the gap between the two forms the basis of capability transformational need.

The organization may want to review all the transformational capability needs together to start the organizational transformation development strategy and plan. The strategy may include incremental transformation over several years/fiscal years, include pathfinder project efforts to inform others, or adopt other strategies. The organizational transformation development strategy may use a yardstick approach where the available time or investment money for enhancing capabilities are fixed and then the set of capability enhancements would be aggregated to fit within the schedule or dollar constraint.

Defining a roadmap. If the capability gap is more than one cell (e.g., stage 2 ->stage 5) then the organization may want to define a roadmap and tie the incremental capability improvements to developmental activities.

See Appendix A.2 for examples of Matrix Uses:

- A.2.1 Strategic Vision
- A.2.2 Roadmap
- A.2.3 Yardstick
- A.2.4 Tactical Planning

Note: *To jump to the examples hold control and click on the titles, to return to this position hold control and click on the Return box.*

8.3 Enterprise-wide Assessment of a Portfolio of Projects/Program Organizations

An organization that manages a collection of programs, projects, or systems may want to characterize each part of its portfolio to identify those organizations with higher capabilities to leverage and learn from and characterize those organizations lagging and perhaps needing resources. A suggested approach to conducting an enterprise assessment includes:

- Establishing POCs for the enterprise components included in the assessment
- Tailoring the matrix for the enterprise (capabilities, language, etc.) that can be done by the enterprise manager and/or with the component POCs
- Having the components do a component self-assessment (with the enterprise manager as context or help is needed)
- Visualizing results as an enterprise to see where there are the lowest/highest stage ratings for a capability and assess widest, most occurring, gaps.

Creating an enterprise transformation development plan would follow the same general approach as the self-assessment.

8.4 Model-Based Stakeholder Roles Assessment

It may be worthwhile to put together a team of transformation stakeholders—those that would affect the change in Model-Based capabilities. The role assessment would be to define what capabilities each of the stakeholder roles will transform/develop. This team may include the Enterprise Manager, Project/Program Manager(s), System Engineer(s), IT lead, Enterprise and System level Modelers, Model managers, and perhaps even representatives from human resources, training, or other departments. A suggested approach to conducting a Model-Based Stakeholder Role assessment includes:

- Identifying the role POCs and having them commit to the assessment and potential transformation
- Having the role POCs take responsibility for specific capabilities listed in the matrix. This could be a self-allocation or a coordinated allocation. See *Exhibit 4. POC's Responsibilities*).

Exhibit 4. POC's Responsibilities

User Roles	Workforce and Culture	SE Process Methodology	PM Process Methodology	Tools and IT Infrastructure	Model Based Effectiveness	Project Use	Policy
Enterprise manager	■	■	■	■	■	■	■
Project/Program Manager	■		■			■	■
System Engineer	■	■			■	■	■
Tool curator		■	■		■		
IT Representative	■			■		■	■
Functional Specialist		■			■		
Human Resources (HR)	■					■	■
Training	■	■	■	■	■	■	■

- Based on the organizational goals and target capabilities, the role POCs, for their allocated capabilities would assess the current stage and compare them to the desired organizational stage that creates the transformational developmental need.
- From the transformational developmental need, the role POC would develop plans to improve the capabilities.

8.5 Qualifying Bidders and/or Planning for the Acquirer's Pre-award Process

8.5.1 Matrix Uses: Qualifying Bidders

Objective: Define how the Model Based Capabilities Matrix may be used to qualify bidders to provide proposals

General Approach: The purpose of qualifying bidders is to create an acceptable pool of sources to provide contracted services. This is to reduce acquirer effort, not waste the time of unqualified bidders and to reduce source selection risk of selecting an unqualified bidder.

One acquirer strategy to qualify bidders using the matrix is to provide the Matrix capability areas and capabilities along with the request for input from the potential bidders on how they would go about providing those capabilities. The acquirer would then "score" potential bidder responses against the matrix.

Acquirer pre-work includes (a) tailoring the matrix to focus on those critical elements and potentially those that would be discriminators (b) creating the capability definitions or a reference glossary of terms.

8.5.2 Matrix Uses: Source Selection

Objective: Define how the Model Based Enterprise Capabilities Matrix may be used to support source selection

General Approach: The purpose of source selection is to (a) ensure the acquirer has defined their Model-Based capabilities requirements and (b) select the appropriate source to meet those requirements.

To define the acquirer Model based capabilities requirements, the Matrix may be used to characterize the current state and the desired state. The desired state then is parsed and processed to form requirements for the supplier to perform to.

The desired capabilities can be communicated early in the first notices of the intent to acquire the supplier services. It next can be discussed at bidder's conferences and in communication. Then reflected in the draft request for proposal/source selection plan.

To select the appropriate source using the Matrix:

- If the Matrix is part of the RFP/source selection plan and part of the evaluation criteria, then the evaluation proceeds with assessment of offeror capabilities. Several different methods may be used to score. Use the:
  - Complete matrix and score the proposal for each capability to identify the stage
  - Matrix rows and stages that are the most important to the acquirer
  - Capabilities and maximal useful stage

- If the Matrix is not part of the RFP/source selection documents then, if allowed by the source selection team, it may be used as a reference to assign strengths to evaluation worksheets, findings, and ratings.
- If the Matrix is not part of the RFP/Source selection documents it should not be used as a basis for technical assessment (e.g. does not meet requirements), nor weaknesses for the risk rating, since it was not part of the evaluation criteria.

9 Report Generation Concepts

9.1 Heat Map

The general notion of "Heat Maps" is to color code rows and/or cells in meaningful ways to the Stakeholders and other users. Appendices A.2.3 and A.2.4, offer examples of color coding. *Exhibit 9* and *Exhibit 10* code Green for current Stage for that attribute. It codes Yellow for the Cell currently "in work." *Exhibit 11*and *Exhibit 12* uses the resultant current organization capabilities from preceding exhibits to plan for next steps in further capability development for the next budget cycle. One could, then, color code the cells another color for those cells included in the next cycle. Further, one could color code the cells, yet another color, for those cells included in the subsequent cycles.

9.2 Assessments Coding

In larger organizations, one might find various levels of capabilities among the various levels of the Organization (e.g. Departments, Divisions, etc.). Assessors might discover, for example, potential users might have access to a capability, but don't use it, or another "department" has and uses a capability that is not available to other "departments." In these cases, one can still capture and report the information for the Attributes under consideration by recording that "department's" full response. For example, *Access: Stage 3; Use Stage 1; Existing, but Unavailable Stage 4*. This approach may more completely capture the current state-of-affairs within an Organization AND suggest some easy wins through training or removing barriers.

9.3 Numerical Ratings

Some matrix users have noted that not all capabilities are equally important and different strategies can be adopted to handle this. One strategy is to first tailor the matrix by either combing capabilities or further splitting them to finer granularity. Another strategy is to weight the capabilities by adding a numerical weighting. In the spirit of user tailoring, this is encouraged for those that find the concept useful.

Another concept of numerical rating is to use the stage number of a capability as a rating and to characterize each capabilities' spread of current capability to desired capability. For most users this is a level of detail that detracts from, rather than adds to, their goals of using results to build and conduct organizational transformation plans.

9.4 Rollups Based on Numerical Ratings and Importance Weight

Some users have found that it is easiest to explain results to management by rolling up the capabilities under their area's title (that differ depending on the view; role-based view or digital engineering strategy goal view). For example, a portfolio manager of several/many programs may want to characterize both the individual program capabilities but also provide a sense of the state of all programs within the enterprise.

Several strategies to perform rollups have been discussed at workshops; one is to use a numerical rating to weight the capabilities and to characterize the stages. A numerical rating, either sums or averages, can be used to characterize the capabilities under an area. Another is to borrow from the heat map approach where colors are coded and then some user defined algorithm is defined to combine the capability ratings to provide a composite color under an area. As a note, one Matrix user created a set of Excel macros to do a summary rollup and presented it to the workshop. This provided a visual rating that would be helpful to enterprise/portfolio/program managers.

10 ORGANIZATION TRANSFORMATION PLANS

The purpose-for and results-from the INCOSE Model-Based Capabilities Matrix are to provide information that feeds directly into transformation plans. Taking the Matrix results to plans usually requires an executive champion and budget for the efforts that are described in the plan. In addition, it is usually helpful to create a communication plan that explains the effort, motivation, and plans to all stakeholders. The resultant communication is best if it uses reliable communication channels (corporate announcements, mailing lists, executive meetings, weekly/monthly reports, etc.).

Transformation plans may take many forms: organizational strategy, acquisition strategy, system engineering plans, system engineering management plans, modeling and information technology plans or roadmaps, community of interest roadmaps, etc. Identifying leads for these plans and associated projects provides them the opportunity to use the established communication channels to explain when the capabilities are ready. This also creates effort "ambassadors" that are the project leaders that can be used as leaders that can articulate the range of roadblocks, commitments, and steps necessary to accomplish the capabilities' goals.

The steps and effort necessary for an organization to move a capability to more advanced stages will vary greatly by organization and how capabilities are grouped or decomposed. As the Matrix user community grows and shares experiences, ideas for best practices may evolve.

APPENDIX A

A.1 Sample Enterprise and System Goals and Modeling Objectives

A.1.1 Sample Enterprise Transformational Objectives

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

- Enhance integrating systems into an Enterprise
- 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

A.1.2 Sample System Transformational Objectives

- Minimize enterprise or system configurations where applied Model-Based can be used to achieve this for fielded and planned capabilities.
- Minimize requirement-design errors to meet cost/schedule goals and field capabilities quicker than with non-Model-Based development.
- Minimize development time to get to production via paperless review activity and acceptance—e.g. replacing paper-based SE reviews and audits.
- Ensure the enterprise or system meets strict surety, safety, security, or effectiveness requirements.
- Minimize test time using MBE/MBSE.
- Create the Authoritative Source of Truth (ASOT) data, information, knowledge, and wisdom needed to either re-compete work or product development.
- Enhance standardization and common interfaces across the enterprise or system to enhance its open nature, enable alternate solutions, minimize development, and enhance manufacturing flexibility.
- Model-Based capabilities to enhance logistics and maintenance of fielded capabilities.
- Capturing existing fielded system ASOT for service life extensions.
- Optimize acquisition, program/project management, and system engineering processes by using MBSE

A.1.3 Sample Modeling Objectives

- Modeling use cases for CONOPs validation
- Modeling operational functionality to generate/verify operational requirements
- Modeling a new concept (e.g., Universal command and control)
- Modeling enterprise, system, and subsystem performance
- Ensure requirements traceability
- Assess design maturity

- Assess integration
- Modeling specialty engineering threads to verify performance
- Reliability, security features, safety, surety, or effectiveness
- Modeling interfaces
- Modeling a complex algorithm
- Modeling for manufacturing
- Modeling system verification and validation (V&V) processes to verify by analysis
- Modeling test and/or maintenance suite compatibility
- Modeling baseline for alternative sourcing

A.2 Examples of Matrix Uses

- A.2.1 Strategic Vision
- A.2.2 Roadmap
- A.2.3 Yardstick
- A.2.4 Tactical Planning

A.2.1 Matrix Use: Strategic Vision

- ***Objective:*** Define a future state description of one or more domains/attributes of a mature Model-Based Enterprise.
- ***General Approach:*** Derive a tailored vision based on the most relevant mature attribute descriptions in the right-most column.
- ***Example:*** Selected a subset of attributes from the Role-Based Matrix Area 5—Information Technology Infrastructure and Area 6—Modeling Tool Construction, see *Exhibit 5. Role Based Matrix Area Example for Strategic Vision* or the DoD DE Strategy Goal 1—Use of Models and Goal 4—Establish Environments, see *Exhibit 6. DoD DE Strategy Goal Example for Strategic Vision* as the relevant attributes for this example

Return

Exhibit 5. Role Based Matrix Area Example for Strategic Vision

Role Based Matrix Area	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
5. Information Technology Infrastructure	Modeling Tool Access	Model access is based on desktop access.	Access to models are based on IT login.	Access to models are based on role-based permissions.	Model access permissions are shared within a project/program.	Model access permissions are shared within an enterprise.
5. Information Technology Infrastructure	Model Based Tool Licensing & Access	None or Unmanaged.	Tool licenses and access address specific project or program needs.	Tool licenses and access are considered for new projects or programs.	Center-wide license access for commonly used tools.	License count appropriate to the role, and access-controlled by role.
5. Information Technology Infrastructure	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
6. Modeling Tool Construction	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.
6. Modeling Tool Construction	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Exhibit 6. DoD DE Strategy Goal Example for Strategic Vision

DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goal 4. Establish Environments	Modeling Tool Access	Model access is based on desktop access.	Access to models are based on IT login.	Access to models are based on role-based permissions.	Model access permissions are shared within a project/program.	Model access permissions are shared within an enterprise.
Goal 4. Establish Environments	Model Based Tool Licensing & Access	None or Unmanaged.	Tool licenses and access address specific project or program needs.	Tool licenses and access are considered for new projects or programs.	Center-wide license access for commonly used tools.	License count appropriate to the role, and access-controlled by role.
Goal 4. Establish Environments	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
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	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

The Stage 4 column gives the mature attribute descriptions for the relevant attributes

A Vision statement might be:

- We aim to provide a fully Federated IT architecture with:
  - Online, real-time collaboration amongst distributed teams
  - Standard "plug-and-play" interfaces
  - Managed data item relationships across heterogenous, disparate data sources
  - User Interfaces that enable navigation and interrogation across heterogenous, disparate data sources, and
  - On-line, real-time collaboration amongst distributed teams

- Potential Purposes/Uses for Strategic Visions [Source: National Defense University]
  - Help to describe an organization's purpose; a declaration of an organization's objectives can help guide its internal decision-making
  - Provides a picture of the future. It bridges the present and the future. The right vision takes the organization out of the present and focuses it on the future.
  - It attracts commitment and energizes people. This is one of the primary reasons for having a vision for an organization: its motivational effect.
  - Serve as foundations for a broader strategic plan.

A.2.2 Matrix Use: Roadmap

Objective: Define a Roadmap of increasing capability of one or more domains/attributes towards a mature Model-Based Enterprise.

General Approach: Derive a tailored roadmap based on one or more relevant attribute rows.

Example: Selected a subset of attributes from the Role-Based Matrix Area 5—Information Technology Infrastructure and Area 6—Modeling Tool Construction, see *Exhibit 7. Role Based Matrix Area Example for Roadmap* or the DoD DE Strategy Goal 1—Use of Models and Goal

4—Establish Environments, see Exhibit 8. DoD DE Strategy Goal Example for Roadmap as the relevant attributes for this example

Return

Exhibit 7. Role Based Matrix Area Example for Roadmap

Role Based Matrix Area	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
5. Information Technology Infrastructure	Modeling Tool Access	Model access is based on desktop access.	Access to models are based on IT login.	Access to models are based on role-based permissions.	Model access permissions are shared within a project/program.	Model access permissions are shared within an enterprise.
5. Information Technology Infrastructure	Model Based Tool Licensing & Access	None or Unmanaged.	Tool licenses and access address specific project or program needs.	Tool licenses and access are considered for new projects or programs.	Center-wide license access for commonly used tools.	License count appropriate to the role, and access-controlled by role.
5. Information Technology Infrastructure	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
6. Modeling Tool Construction	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.
6. Modeling Tool Construction	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Exhibit 8. DoD DE Strategy Goal Example for Roadmap

DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goal 4. Establish Environments	Modeling Tool Access	Model access is based on desktop access.	Access to models are based on IT login.	Access to models are based on role-based permissions.	Model access permissions are shared within a project/program.	Model access permissions are shared within an enterprise.
Goal 4. Establish Environments	Model Based Tool Licensing & Access	None or Unmanaged.	Tool licenses and access address specific project or program needs.	Tool licenses and access are considered for new projects or programs.	Center-wide license access for commonly used tools.	License count appropriate to the role, and access-controlled by role.
Goal 4. Establish Environments	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
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	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Roadmap for tool interoperability and traceability:

- Milestone 1: Some tool-to-tool integration; cross-tool data associations defined
- Milestone 2: Demonstration of selected tools in a Federated Architecture; cross-tool data associations defined, captured, managed
- Milestone 3: Main tools interoperable in a Federated Architecture; cross-tool data associations defined, captured, managed, and traceable
- Milestone 4: All tools interoperable in a fully Federated Architecture; cross-tool data associations defined, captured, managed, and traceable

Potential Uses of a Roadmap [source: Wikipedia]

- Provides a flexible planning technique to support strategic and long-range planning by matching short-term and long-term goals with specific technology solutions
- Has three major uses:
- It helps reach a consensus about a set of needs and the technologies required to satisfy those needs,
- It provides a mechanism to help forecast technology developments, and
- It provides a framework to help plan and coordinate technology developments.

A.2.3 Matrix Use: Yardstick

Objective: Define a method of characterizing the current capability of one or more domains/attributes for a Model-Based Enterprise.

General Approach: Assess the current Stage of Implementation by the Organization for one or more relevant attributes. Highlight the attained Stage of Implementation cell and all cells to the left of the attained Stage for all assessed relevant attributes.

Example: Selected a subset of attributes from the Role-Based Matrix Area 5—Information Technology Infrastructure and Area 6—Modeling Tool Construction, see *Exhibit 9. Role Based Matrix Area Example for Yardstick* or the DoD DE Strategy Goal 1—Use of Models and Goal 4—Establish Environments, see *Exhibit 10. DoD DE Strategy Goal Example for Yardstick* as the relevant attributes for this example

Return

Exhibit 9. Role Based Matrix Area Example for Yardstick

Role Based Matrix Area	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
5. Information Technology Infrastructure	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
6. Modeling Tool Construction	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.
6. Modeling Tool Construction	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Exhibit 10. DoD DE Strategy Goal Example for Yardstick

DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goal 4. Establish Environments	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
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	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Color coding can be used to provide additional status, e.g.

- Green indicates attribute capability is operational
- Yellow indicates attribute capability in active development

Potential Uses of a Yardstick

- Provides an easily understandable, graphical method to present:
  - The current Stage of Implementation across a variety of attributes
  - Using different color-coding, the state of activity to advance the Stage of Implementation of an attribute, e.g. *Planned Activities* and *Activities Underway* (may include different color-coding to reflect status of the activity with regard to schedule, budget, etc.)

A.2.4 Matrix Use: Tactical Planning

Objective: Given the current capability of one or more domains/attributes of a Model-Based Enterprise, determine which domain(s)/attribute(s) to apply effort/resources to advance in the near-term.

General Approach: Starting with the attained "Yardstick" assessment of one or more relevant attributes (see A.2.3 above), determine which attribute capabilities to be advanced in the budget cycle of interest. A factor to consider, in addition to resources constraints, might include possible dependencies between attributes. For example, allocating resources to advance Attribute A may not make sense without first advancing an enabling or precursor attribute.

Example: Selected a subset of attributes from the Role-Based Matrix Area 5—Information Technology Infrastructure and Area 6—Modeling Tool Construction, see *Exhibit 11. Role Based Matrix Area Example for Tactical Planning* or from the DoD DE Strategy Goal 1—Use of Models and Goal 4—Establish Environments, see *Exhibit 12. DoD DE Strategy Goal Example for Tactical Planning* as the relevant attributes for this example

Return

Exhibit 11. Role Based Matrix Area Example for Tactical Planning

Role Based Matrix Area	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
5. Information Technology Infrastructure	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
6. Modeling Tool Construction	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.
6. Modeling Tool Construction	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Exhibit 12. DoD DE Strategy Goal Example for Tactical Planning

DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goal 4. Establish Environments	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
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	Distributed Database/Tool interoperability	No interoperability between model-based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.

Beginning with the "Yardstick" example, one might next work on the "Partial Federated Database Management System (FDBMS)" before the "user interface (UI) draws from multiple Models/DBs," if, as in this example, one assumes that some Federation capability needs to be in place before the UI can draw from multiple databases.

Potential Uses for Tactical Planning

- Can be partitioned to allow different User Roles to focus on their relevant attribute scope and domains
- Helps support rational, practical, defensible decisions regarding where to apply (often limited) resources towards advancing the Stage of Implementation of an attribute(s), e.g.
- Further advancement of Attribute A may not be of value or even possible, until Attribute B is first advanced
- Provides the "Big Picture" to consider a balanced portfolio of advancement activities

APPENDIX B GLOSSARY

Currently there are conflicting terms defined for modeling and as they converge, they may be identified for this User's Guide.

There is no definitive source however here are the thought leaders:

Glossary of terms (sources to be integrated)

- Digital Engineering Information Exchange Working Group (DEIXWG)—NDIA, INCOSE, and OSD joint sponsorship. 31 May 2019 e-mail notification of terms http://www.omgwiki.org/MBSE/doku.php?id=mbse:topical_encyclopedia_for_digital_engineering_information_exchange_deixpedia

- Naval Air Systems Command (NAVAIR) System Engineering Transformation (SET) Model-related Lexicon per Dr. Mark Blackburn, Principal Investigator for the SET project. Excel of terms that have been sourced and assembled by a team
  Please contact Dr. Blackburn for access to the list: Mark Blackburn <mblackbu@stevens.edu>

- Office of the Secretary of Defense (OSD) Digital Engineering. OSD has issued the Digital Engineering Strategy and has an out-of-date set of definitions. https://www.acq.osd.mil/se/initiatives/init_de_def.html

APPENDIX C—INCOSE MODEL-BASED CAPABILITIES MATRIX FREQUENTLY ASKED QUESTIONS (FAQS)

What is the Model-Based Capabilities Matrix (MBCM)?

It is an assessment tool used to characterize an organization's model-based capabilities. In its simplest form, a capability statement is a statement about your organization and its capabilities and skills that defines what it is able to do by employing a model-based effort. A capability:

- Produces an outcome
- Is activated by resources
- Has an input and output
- Changes over the life cycle

What are the MBCM products?

INCOSE Connect, the INCOSE members-only site, is planned to contain the excel-based Matrix used for the assessment, the User's Guide, including this list of FAQs, and a set of candidate workshop PowerPoint slides that a champion can tailor and use to run their own workshop assessment activity.

What are the MBCM assessment results for?

The INCOSE Model-Based Capabilities Matrix assessment is used to characterize the organization's current modeling capabilities and to target the future modeling capabilities to meet organizational modeling objectives derived from their organizational transformational goals. The User's Guide identifies several use cases that explains in what situations an assessment is useful and provides concepts of both scoring and how to use the results.

Some use cases include: organizational self-assessment to improve the organization's modeling capabilities to meet their needs, conduct an enterprise-wide assessment to see the variation of the portfolio of programs/projects within the enterprise, qualifying bidders, or use in the pre-award "request for proposal" process to determine the acquirer's modeling capabilities and those it would contract-for, and also for role-based self-assessment such as determining if the system engineer, information technologist, modeler, program/project manager, and trainer are building the needed modeling capabilities.

The organization may use results: as an input to the organizational roadmap of projects needed year-over-year to build the modeling capabilities, as an input to their acquisition strategy of which capabilities are within the acquirer's organization and define those to be contracted, to update their system engineering plan (or system engineering management plan), and build organizational development plans or personal development plans to gain the needed modeling capabilities.

What are the benefits of using the MBCM?

The matrix is in use currently for several large US government organizations and is used in workshops to provide users practice in application. User feedback has been that this is a unique and useful tool that covers a breadth of modeling capabilities for an enterprise, program/project, and roles. The breadth provides users exposure to modeling concepts and staged definitions of modeling capabilities that may be new to them. It provides a sense of the teamwork and collaboration needed as the organization improves capabilities across the stages:

- 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, and standards

A benefit of the matrix is that it can be tailored to suit their organizational needs. The User's Guide provides reasons for tailoring and suggestions on how to tailor the matrix. This virtue ensures that the assessment is tuned to the user organization.

Another benefit is that the Matrix is provided in two views; a Role-Based view, and a Digital Engineering (DE) Goal view (Based on the US Government Office of the Secretary of Defense's Digital Engineering Strategy document). Both views contain the same capabilities but are sorted differently. US Government, and DoD organizations may want to use the DE Goal view so that their assessment is easily traceable to the strategy document. Non-government, non-DoD users may find this view as the easiest to use as well since the goals are loosely in temporal order. Other users may find the Role-Based view makes more sense and use that view.

Who should use the MBCM?

Anyone wanting to characterize their organization's current state of modeling capability and desired state so that the organization can plan their capability improvements. By role, these "champions" may be the enterprise/portfolio managers, program/project/product managers, system engineers, modeling managers, and others such as the information technologist, trainers, or even legal and human resources.

The champion would then make the "Matrix" and User's Guide known and advocate for its application. The champion could start with use of this FAQ document, associated INCOSE briefings, and/or the actual Matrix and User's Guide themselves.

When should the MBCM be applied?

The answer is, "it depends." It depends on when the organization or champion becomes aware of an organizational situation that would be addressed through improved modeling and modeling capabilities. It is recognizing the potential organization transformation objectives and realizing that enhanced modeling capabilities would help. This could be at the beginning of an effort or be applied once the effort is underway.

Some examples of when the matrix should be applied are addressed as the organization discovers a transformational objective such as: an organization is trying to bring systems to market quicker, extension of a product line, managing changes in product line, or an installed user base, qualifying sources, coordinating stakeholders to contribute to a system, managing a portfolio and working to standardize, etc.

How is the INCOSE MBCM assessment different from a Capability Maturity Model Integration (CMMI) assessment?

The CMMI assessment is characterized by the organization wanting a specific level of certification and then to use that for new business and to maintain its capabilities. The assessment could be self-assessment or third-party assessment.

The INCOSE Model-Based Capabilities Matrix is predominantly a self-assessment. The organization may want to target a specific stage for each attribute, and they could be different stages for each attribute. This is to provide the needed capability to meet their organizational and modeling objectives.

How long does a typical MBCM assessment take and what pre-work is typical?

The application of the matrix may be performed by modest teams of 4-6 people representing different roles within their organization. Scoring the matrix and having an initial assessment can be done in as little as 2-4 hours. It is recommended that the scoring be "gentle" where the organization is given the benefit of the doubt. This recommendation is made in the spirit that the organization is desiring to learn from the assessment and make plans to transform itself to greater capability.

Pre-work to set up the assessment event, select the team, tailor the matrix (if desired), and identifying organizational transformation needs and modeling objectives takes some time. Pre-work would also include what the assessment report would look like and how to use the results.

What people/qualifications are needed to perform a typical MBCM assessment?

Sometimes the person aware of how the matrix works becomes the Champion. The Champion will float the idea to potential sponsors, work with sponsors to identify the team, provide the vision of how results will be used, perform the pre-work to set up the assessment event, lead the assessment, and be the catalyst for results used in the organizational plans. Typically, the assessment team will include an enterprise/portfolio manager (if applicable), program/project/product manager, system engineer, modeling organization manager, modeler, information technologist, and HR/training. In workshops it was found that teams of 4-6 function well, complete the assessment quickly, and are generally in agreement.

APPENDIX D: ACRONYMS AND ABBREVIATIONS

Acronym	Definition
ASME	American Society of Mechanical Engineers
ASOT	Authoritative source of truth
CMMI	Capability maturity model integration
CONOPs	Concepts of operations
DB	Database
DE	Digital engineering
DEIXWG	Digital engineering information exchange working group
DOD	Department of Defense
EM	Enterprise manager
FAQ	Frequently asked questions
FDBMS	Federated database management system
HR	Human resources
INCOSE	International council on systems engineering
IT	Information technology
MBCM	Model-based capability matrix
MBE	Model based engineering

Acronym	Definition
MBSE	Model-based system engineering
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NDIA	National Defense Industrial Association
NIST	National Institute of Standards and Technology
OMG	Object management group
OSD	Office of the Secretary of Defense
PM	Project management
POC	Point of Contact
RFP	Request for Proposal
SE	Systems engineering
SEMP	System engineering management plan
SEP	System engineering plan
SET	System engineering transformation
UI	User interface
V&V	Verification and validation

APPENDIX E: PRINTOUTS OF MATRICES FROM EXCEL FILES

The following pages are a print of the Excel file for the Matrices. The large pages are set up to print on 11" x 17" (ledger, tabloid) paper.

The tab name is printed under the title in the top left corner of each page.

Role Based Matrix Area	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
1. Workforce/ culture	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 manages a full range of business concerns.
1. Workforce/ culture	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.
1. Workforce/ culture	Modeling Roles and Responsibilities	Modeling roles and responsibilities are not identified.	Modeling roles and responsibilities are identified.	Modeling roles and responsibilities are characterized by model-based Knowledge, Skills, and Abilities (KSAs).	Modeling roles are provided the permissions necessary to perform their responsibilities.	People who need to be active are identified and involved. Sufficient staffing and staffing plan ensures all roles are fulfilled.
1. Workforce/ culture	Modeling Development Skills	Model-based Knowledge, Skills, and Abilities (KSAs) are undefined and unknown. None, or ad hoc for all staff.	Model-based Knowledge, Skills, and Abilities (KSAs) are defined for modelers. Modeling of components of the Enterprise or System.	Model-based Knowledge, Skills, and Abilities (KSAs) are defined for roles involved with modeling; Enterprise Architect, SE, PM, IT, modelers, etc.… Novice Modelers on full Enterprise or System -subsystem models.	Model-based Knowledge, Skills, and Abilities (KSAs) are defined for roles involved with enterprise management. Expert model development lead with experience practicing modeling on at least 1 project that successfully completed at least 3 major technical reviews that used models in support of the review.	Expert model development lead that sets modeling standards and evaluates the model product quality of other modelers.
1. Workforce/ culture	Modeling Use skills	None, or ad hoc for all staff.	Can generate tool standard digital artifacts as needed to evaluate the Enterprise or System.	Can generate tool custom digital artifacts as needed to evaluate the Enterprise or System.	Can generate custom digital artifacts across tools, models, and data sets to evaluate the Enterprise or System.	Can contribute to defining the enterprise, system, and other data needed by the complete team to perform analysis for IPTs, reviews, audits, and other technical and programmatic decisions.
1. Workforce/ culture	Modeling-related Training/KSA development	No training or development activities.	Tool familiarity training completed. Initial experience to perform their modeler or user roles.	Modeling or model users experience on specific tools with respect to their role as a user or modeler.	Demonstrating role capabilities using the models, coaching, and instructing others.	Provide leadership in proposing, designing, and delivering training that is appropriate for the modeling and user roles.
2. SE Processes/ Methodology	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.
2. SE Processes/ Methodology	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.
2. SE Processes/ Methodology	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.
2. SE Processes/ Methodology	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.
2. SE Processes/ Methodology	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.
2. SE Processes/ Methodology	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.
2. SE Processes/ Methodology	Modeling Stakeholder Requirements	Stakeholder requirements are not modeled.	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.
2. SE Processes/ Methodology	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).
3. Program/ Project Processes Methodology	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.
3. Program/ Project Processes Methodology	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 and 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 reviews 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.
3. Program/ Project Processes Methodology	Model Metrics	Metrics are not used to manage the model development, quality, or effectiveness.	Available metrics are reported from the various modeling tools used.	Metrics, beyond those available from the tool configuration, are reported to address model development, quality, and effectiveness needs.	Metrics are used to manage the model development, quality, or effectiveness for a system or enterprise.	Consistent metrics are used across the enterprise to manage the model development, quality, or effectiveness with trend information kept and decision making thresholds established.
4. Model Based Effectiveness	Modeling Integration	Elements within a model are not integrated.	Elements within a model follow a structured approach (such as OOSEM).	Model elements not needed and that don't fit within the structured approach are removed. Model constraints are identified and model blocks structures are created.	Integration across systems models for a project/program use the same structured approach. A Library of reusable SysML blocks is created and used.	Integration across systems models for an enterprise use the same structured approach. A Library of reusable SysML blocks is created and used.

Role Based Matrix Area	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
4. Model Based Effectiveness	Verification and Validation of Models	The organization has not stated model objectives -- no basis for verification and validation of the models.	The organization has stated model objectives but not model requirements. Partial V&V evaluation of the resultant model is possible.	Model objectives and some general model requirements have been stated. Plans for V&V evaluation of the model traceable to the model requirements have been made.	Model objectives and some detailed model requirements for specific models have been stated. V&V evaluation of the models traceable to the model requirements is planned and includes V&V of modeling patterns, styles and standards, as well as having defined procedures.	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). V&V of the models is performed and updates to the models made.
4. Model Based Effectiveness	Modeling Assurance	Model Assurance is not considered.	Model assurance is defined with known scales and methods.	Model assurance targets are identified in association with the effort schedule and cost.	Model assurance measurement and corrective actions are conducted for projects/programs.	Model assurance measurement and corrective actions are conducted for the enterprise.
4. Model Based Effectiveness	Authoritative Source of Truth (ASOT)	Data and information hasn't been identified to contribute to the authoritative source of truth.	Necessary data and information has been identified to contribute to the authoritative source of truth.	Data and Information are discoverable from specific models to address specific queries across parts of the enterprise.	Data and information provide knowledge to specific decision makers across parts of the life cycle and across parts of the enterprise.	Data and information are discoverable to provide knowledge to strategic to near real-time decision makers across the life cycle and across the enterprise.
4. Model Based Effectiveness	Digital Threads	Digital threads have not been identified.	Digital threads have been identified.	Digital threads have been established for limited program/projects across the enterprise.	Digital threads have been established contributing to the authoritative source of truth for limited programs/projects across the enterprise.	Digital threads have been established contributing to the authoritative source of truth for an enterprise.
4. Model Based Effectiveness	Digital Twin	Digital twins have not been identified or established.	Digital twin (DT) types have been identified; E.g., (DT Prototype, DT Instance, DT Aggregate, DT Environment).	Digital twin types have been established; E.g., (DT Prototype, DT Instance, DT Aggregate, DT Environment).	Digital twin types are effectively used to make decisions for limited programs/projects across an enterprise.	Digital twin types are effectively used for an enterprise.
4. Model Based Effectiveness	Digital Artifacts	Hardcopy or business application (e.g., MS Word) generated documents are not based on digital artifacts.	Documents incorporate digital artifacts such as model generated views.	Program/Project uses a mix of documents and digital artifacts to make decisions.	Program/Project uses digital artifacts to make decisions.	Enterprise decisions are based on tool and user defined digital artifacts to make decisions.
5. Information Technology Infrastructure	Modeling Tool Access	Model access is based on desktop access.	Access to models are based on IT login.	Access to models are based on role-based permissions.	Model access permissions are shared within a project/program.	Model access permissions are shared within an enterprise.
5. Information Technology Infrastructure	Model Based Tool Licensing & Access	None or Unmanaged.	Tool licenses and access address specific project or program needs.	Tool licenses and access are considered for new projects or programs.	Center-wide license access for commonly used tools.	License count appropriate to the role, and access-controlled by role.
5. Information Technology Infrastructure	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
6. Modeling Tool Construction	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.
6. Modeling Tool Construction	Distributed Database/Tool interoperability	No interoperability between model based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.
6. Modeling Tool Construction	Model Based Data/Tool Independences	Data/Tool independences are not considered and data is usually resident in the tool or tool directed default directories.	Data/Tool independences are considered and planned to enhance data independence from tools.	Data/Tool implementations independences are managed to allow data to be independent from tools.	Data/Tool implementations independences are managed to allow data to be independent from tools and allow import/export to foster data portability.	Data is independent of tools and allows for portability.
6. Modeling Tool Construction	Inter-Database/Tool Data Item Associations	Databases/tools are independent.	Inter-Database/Tool Data Item associations defined.	Inter-Database/Tool Data Item associations defined, captured, managed.	Inter-Database/Tool Data Item associations among all data items defined, captured, managed, and traceable.	Inter-Database/Tool Data Item associations among all data items defined, captured, managed, and traceable where changes in one data source alerts owners of other data sources of intended updates.
6. Modeling Tool Construction	Modeling Methods	Models use any method to solve specific problems. The overall approach is not structured for consistency.	Modeling methods are planned for efforts within a project. Some structure is applied.	Modeling methods are planned for efforts within a portfolio and are consistent as possible for each project/program. Best practices are evolving; structuring patterns emerge.	Modeling methods are planned for efforts within a portfolio and are consistent as possible across projects/programs within an enterprise. Best practices converge; patterns are captured and reused.	Structured methods are planned and reused.
6. Modeling Tool Construction	Model Languages	Model languages are used ad hoc to solve specific problems, but there is no plan to ensure consistency across a program/project.	Model languages are used ad hoc to solve specific problems, with a plan to ensure consistency across a program/project.	Model languages are consistent across a program/project.	Model languages are carefully chosen to unify the program/project, enable libraries, and enable reuse.	Model languages are carefully chosen to unify the enterprise, enable libraries, and enable reuse.
6. Modeling Tool Construction	Model Libraries	Model libraries have not been identified.	Project specific model libraries are established.	Cross project model libraries are established.	Plan to leverage Project model libraries to establish curated and shared libraries for an enterprise.	Project model libraries are established and shared across an enterprise in a curated manner.
6. Modeling Tool Construction	User Interface (UI), Viewpoint/Views, and visualization	Models are not used to identify or define the user interface or view/viewpoints.	Models allow the definition of the user interface, document generation, generation of views/viewpoints.	Models allow the definition of the user interface, document generation, generation of views/viewpoints and custom visualization.	UI supports Interrogation across the federated system's Authoritative source of truth and provides visualizations for decision making.	UI supports Interrogation across the federated enterprise Authoritative source of truth and provides visualizations for decision making.
6. Modeling Tool Construction	Simulation Capability	Simulation level of value to the project not considered.	Value of simulation capability considered but not explored.	Where appropriate, simulation capability utilized on a small scale but not fully utilized.	Where appropriate, simulation capability utilized but not fully exploited.	All aspects of simulation are being utilized where appropriate including both simulation capabilities embedded in the tool and external simulations linked to MBSE artifacts.
6. Modeling Tool Construction	Modeling Process quality	Modeling processes have not been 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.	Re-engineered modeling processes provide measurable improvements across the enterprise.
7. Model Use	MBSE Institutional Adoption (e.g., agency, service, center, business unit) for Digital Engineering	Some parts of the institution have adopted MBSE (e.g., new programs/initiative, pilot programs, and business case driven) for a segment of the enterprise work: e.g. requirements management architecture, design, manufacturing, …	MBSE adoption by the Systems Engineering or Enterprise Organization.	Common implementation basis across institution with the intent to apply enterprise and system models.	Consistent institutional approach across organizations with variations as appropriate for specific needs. Consistent tool coverage and use across organizations.	Consistent institutional approach is driven by policy, practices and methods across organizations. Variations are allowed as appropriate for specific needs. Consistent tool coverage and use across organizations.
7. Model Use	MBSE Technical Innovation Process	Organization only upgrades tools, environment, and methods as driven by vendors and as standards are created or updated.	Organization commissions work to review its technology with the purpose to set direction and adopt new technologies.	Organization has a defined role for technology innovation to research and propose new technology adoption.	Organization has a defined role for technology innovation to research and propose new technology adoption. Goals are set, budgets allocated, and roadmaps are created and conducted to adopt new technologies.	Organization participates in tool vendor improvement forums, setting technological innovation through research, and involvement with standards setting bodies.
7. Model Use	Enabling Technologies	IT Infrastructure is static and not aware.	IT conducts ad hoc research and application of enabling tools and technologies.	IT aware of current trends/practices and uses roadmaps to enhance capabilities.	Applying processes to examine and anticipate how technology can be used and solve problems.	Mature process to continuously examine and anticipate how technology can be used to solve problems.
8. Modeling Policy	Intellectual Property (IP)	There is no policy covering the IP of model content.	There is policy covering the IP of model content.	The IP policy is applied to the model content.	Models across an project/program apply the IP policy to model content in the same way.	Models across enterprises apply a common IP policy to model contents in the same way.
8. Modeling Policy	Tool Governance	There is no tool governance policy.	There is tool governance policy.	Programs/projects apply the tool governance policy.	Program/projects within an enterprise consistenly apply the same tool governance policy.	Program/projects across related enterprises consistenly apply the same tool governance policy.

Role Based Matrix Area	Model-Based Capability Name	Capability Description
1. Workforce/ culture	MBSE Use Strategy	This is documenting the Digital Engineering/Model Based System Engineering (DE/MBSE) strategy as part of the overall strategy an organization has to provide the system/system-of-systems/enterprise. The concept is that DE/MBSE is used as it benefits the overall work and result.
1. Workforce/ culture	Common DE and MBSE Terminology	A set of lexicon, taxonomies and glossaries with known precedence.
1. Workforce/ culture	Modeling Roles and Responsibilities	Roles and responsibilities may include such modeling roles as: enterprise manager, program/project manager, SE, IT, Modeler, policy maker, contracting, model curator, model manager, model data manager, ASOT configuration manager or others.
1. Workforce/ culture	Modeling Development Skills	More than just modeling tool expertise. This includes expertise in model structure/architecture that supports all subsequent uses.
1. Workforce/ culture	Modeling Use skills	This covers a role that all government or acquirer team members must have to conduct model based acquisition.
1. Workforce/ culture	Modeling-related Training/KSA development	Multilevel training series, including "hands-on" real world(-like) execution.
2. SE Processes/ Methodology	SE Agreement Process	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.1.1 and 6.1.2. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored. Agreement Processes include: ► Acquisition ► Supply
2. SE Processes/ Methodology	SE Organizational Project-Enabling Processes	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.2.1 to 6.1.6. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored. Organizational Project-Enabling Processes include: ► Life Cycle Model Management ► Infrastructure Management▪Portfolio Management ► Human Resource Management ► Quality Management ► Knowledge Management
2. SE Processes/ Methodology	SE Technical Management Processes	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.3.1 to 6.3.8. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored. 6.3.1 Project Planning, 6.3.2 Project Assessment and Control, 6.3.3 Decision Management, 6.3.4 Risk Managment, 6.3.5 Configruation Management, 6.3.6 Information Management, 6.3.7 Measurement, 6.3.8 Quality Assurance
2. SE Processes/ Methodology	Model Configuration Management	ISO/IEC/IEEE 15288.1 paragraph 6.3.5. Configuration Management.
2. SE Processes/ Methodology	Model Data Management	ISO/IEC/IEEE 15288.1 paragraph 6.3.6. Information Management.
2. SE Processes/ Methodology	SE Technical Processes	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.4.1 Business or Mission Analsysisand 6.4.14. Disposal. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored.
2. SE Processes/ Methodology	Modeling Stakeholder Requirements	ISO/IEC/IEEE 15288.1 paragraph 6.4.2. Stakeholder Needs and Requirements Definition.
2. SE Processes/ Methodology	Model-Based Verification and Validation	ISO/IEC/IEEE 15288.1 paragraphs 6.4.1 Business or Mission Analsysisand 6.4.14. Disposal.
3. Program/ Project Processes Methodology	SE-driven Model Plan	Modeling is part of the System Engineering Plan or System Engineering Management Plan. It should cover the Information Technology (IT) infrastructure, modeling tools, modeling environments, identify the type and purpose of models and how they are managed.
3. Program/ Project Processes Methodology	Model Based Reviews; Management Program Reviews /MPR(s), Milestone reviews, program reviews, technical reviews, audits	Digital artifacts are the products from the Authoritative Source of Truth, so that as the system models are queried for evidence against the technical review and audit criteria, the system models may be updated. Note that System Models are a type of digital artifact themselves. MPRs recast to reflect model-driven processes and model-based artifacts (e.g., entrance/success criteria based on process objectives as reflected in the views/viewpoints, not doc creation). See ISO/IEC/IEEE 15288.2. See GAO/NSIAD-98-56 Best Practices for information on "Knowledge Points."
3. Program/ Project Processes Methodology	Model Metrics	Having a modeling metrics program to improve the modeling efforts and the target system or enterprise.
4. Model Based Effectiveness	Modeling Integration	System Engineering Model pattern as defined by Object-Oriented Systems Engineering Method (OOSEM).
4. Model Based Effectiveness	Verification and Validation of Models	Model objective examples include: ► Modeling a new concept (e.g., Universal command and control) ► Modeling system, subsystem, and interfaces ► Modeling operational functionality to generate/verify operational requirements ► Modeling a complex algorithm ► Model system V&V processes.
4. Model Based Effectiveness	Modeling Assurance	Per ATR-2018-01074 Rev A from The Aerospace Corporation. Model Assurance Level (MAL)– A measurement system for model value, content and quality. Identifies risk areas related to models and is rated 1-3; 1 has the least assurance.
4. Model Based Effectiveness	Authoritative Source of Truth (ASOT)	The collection of modeling data that represents the target system(s) along with its rationale. https://www.acq.osd.mil/se/initiatives/init_de_def.html Reference NASA-STD-7009 for examples of factors for assessing "Acceptability for Use" and "Credibility of Results."
4. Model Based Effectiveness	Digital Threads	https://www.acq.osd.mil/se/initiatives/init_de_def.html Digital Thread: An extensible, configurable, and component enterprise-level analytical framework that seamlessly expedites the controlled interplay of authoritative technical data, software, information, and knowledge in the enterprise data-information-knowledge systems, based on the Digital System Model template, to inform decision makers throughout a system's life cycle by providing the capability to access, integrate, and transform disparate data into actionable information. (DAU Glossary)

Role Based Matrix Area	Model-Based Capability Name	Capability Description
4. Model Based Effectiveness	Digital Twin	https://www.acq.osd.mil/se/initiatives/init_de_def.html Digital Twin: An integrated multiphysics, multiscale, probabilistic simulation of an as-built system, enabled by Digital Thread, that uses the best available models, sensor information, and input data to mirror and predict activities/performance over the life of its corresponding physical twin. (DAU Glossary)
4. Model Based Effectiveness	Digital Artifacts	Digital Artifact: The artifacts produced within, or generated from, the digital engineering ecosystem. These artifacts provide data for alternative views to visualize, communicate, and deliver data, information, and knowledge to stakeholders. (DAU Glossary)
5. Information Technology Infrastructure	Modeling Tool Access	The access to models based on modeling roles.
5. Information Technology Infrastructure	Model Based Tool Licensing & Access	How well an organization manages tool licenses
5. Information Technology Infrastructure	Collaboration capabilities	Synchronous and asynchronous data-rich collaboration among distributed teams
6. Modeling Tool Construction	Model Management	Model management is responsible for establishing policy and managing the oversight of model collection activities, model valuation, acquisition and strategic model loans, for ensuring the application.
6. Modeling Tool Construction	Distributed Database/Tool interoperability	A fully Federated (or Confederated) data and IT infrastructure that functions as one virtual common database. Includes a standardized interface(s) for other data sources to join the Federation (APIs, wrappers, etc.).
6. Modeling Tool Construction	Model Based Data/Tool Independences	Bifurcation Opportunity: Connecting to non-MBE repositories as well as MBE repositories. One is for sharing data and the other is for sharing model artifacts.
6. Modeling Tool Construction	Inter-Database/Tool Data Item Associations	Capture and manage associations between data items within and between disparate data sources. Associations can be traced between data items regardless of their location.
6. Modeling Tool Construction	Modeling Methods	Methods examples include but are not limited to: ► OOSEM (Object-Oriented Systems Engineering Method) ► STRATA (Vitech) ► Harmony-SE (IBM Rational Telelogic) ► RUP-SE (IBM Rational Unified Process for Systems Engineering) ► JPL State Analysis (SA) ► OPM (Dori Object-Process Methodology) ► OOA/D (Object-oriented analysis and design) ► SYSMOD (Weilkiens Systems Modeling Process) ► VAMOS (Variant Modeling with SysML) ► Alstom ASAP methodology ► Pattern-Based Systems Engineering (PBSE) ► Modeling methods driven by SE objectives/analyses/uses and evidentiary artifacts, includes Library of standardized and frequently used patterns/models/components
6. Modeling Tool Construction	Model Languages	Model Language examples: ► UML – Unified Modeling Language ► SysML – Systems Modelling Language ► SDL – System Definition Language ► STRATA (Vitech) ► Modelica ► LML – Lifecycle Modeling Language ► TOGAF – The Open Group Architecture Framework ► BPEL – Business Process Execution Language ► DoDAF – Department of Defense Architecture Framework ► UPDM – Unified Profile for DoDAF/MODAF ► UAF – Unified Architecture Framework
6. Modeling Tool Construction	Model Libraries	Creating curated model libraries that are added to, retired, loaned, updated, etc.
6. Modeling Tool Construction	User Interface (UI), Viewpoint/Views, and visualization	Viewpoints reflecting SE and user objectives/analyses/needs are defined and standardized. Supports interrogation, navigation, tracing, etc., of data from disparate, heterogeneous data sources (See ISO 42010 for definitions).
6. Modeling Tool Construction	Simulation Capability	GENESYS, Cameo, Sparx EA and Rhapsody all have built in simulation capabilities. Additionally, they all also have the ability to interface with external simulation assets such as MaTLab Simulink.
6. Modeling Tool Construction	Modeling Process quality	Having a quality program that incorporates modeling.
7. Model Use	MBSE Institutional Adoption (e.g., agency, service, center, business unit) for Digital Engineering	The level that MBSE is adopted uniformly across the target organization.
7. Model Use	MBSE Technical Innovation Process	The organization's process to adopt new modeling relevant technology.
7. Model Use	Enabling Technologies	An assessment of how enabling technology is adopted by an organization.
8. Modeling Policy	Intellectual Property (IP)	Determining if the organization has and uses IP policy effectively across the enterprise to maximize transparency while protecting IP.
8. Modeling Policy	Tool Governance	Tool governance is the establishment of policies and continuing monitoring of their implementation to include selecting tool sets, tool extensions and plug-ins, tool environments, tool procurements, licenses, and access.

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 manages a full range of business concerns.
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	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 modeled.	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	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	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 and 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 reviews 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	Model Metrics	Metrics are not used to manage the model development, quality, or effectiveness.	Available metrics are reported from the various modeling tools used.	Metrics, beyond those available from the tool configuration, are reported to address model development, quality, and effectiveness needs.	Metrics are used to manage the model development, quality, or effectiveness for a system or enterprise.	Consistent metrics are used across the enterprise to manage the model development, quality, or effectiveness with trend information kept and decision making thresholds established.
Goal 1. Use of Models	Modeling Integration	Elements within a model are not integrated.	Elements within a model follow a structured approach (such as OOSEM).	Model elements not needed and that don't fit within the structured approach are removed. Model constraints are identified and model blocks structures are created.	Integration across systems models for a project/program use the same structured approach. A Library of reusable SysML blocks is created and used.	Integration across systems models for an enterprise use the same structured approach. A Library of reusable SysML blocks is created and used.
Goal 1. Use of Models	Verification and Validation of Models	The organization has not stated model objectives -- no basis for verification and validation of the models.	The organization has stated model objectives but not model requirements. Partial V&V evaluation of the resultant model is possible.	Model objectives and some general model requirements have been stated. Plans for V&V evaluation of the model traceable to the model requirements have been made.	Model objectives and some detailed model requirements for specific models have been stated. V&V evaluation of the models traceable to the model requirements is planned and includes V&V of modeling patterns, styles and standards, as well as having defined procedures.	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). V&V of the models is performed and updates to the models made.
Goal 1. Use of Models	Modeling Assurance	Model Assurance is not considered.	Model assurance is defined with known scales and methods.	Model assurance targets are identified in association with the effort schedule and cost.	Model assurance measurement and corrective actions are conducted for projects/programs.	Model assurance measurement and corrective actions are conducted for the enterprise.
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	Distributed Database/Tool interoperability	No interoperability between model based tools.	Model Based Tool-to-Tool has ad hoc interoperability.	Partial Federated Database Management System (FDBMS).	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated with standard "plug-and-play" interfaces. Data is interchanged among tools.
Goal 1. Use of Models	Model Based Data/Tool Independences	Data/Tool independences are not considered and data is usually resident in the tool or tool directed default directories.	Data/Tool independences are considered and planned to enhance data independence from tools.	Data/Tool implementations independences are managed to allow data to be independent from tools.	Data/Tool implementations independences are managed to allow data to be independent from tools and allow import/export to foster data portability.	Data is independent of tools and allows for portability.

DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goal 1. Use of Models	Inter-Database/Tool Data Item Associations	Databases/tools are independent.	Inter-Database/Tool Data Item associations defined.	Inter-Database/Tool Data Item associations defined, captured, managed.	Inter-Database/Tool Data Item associations among all data items defined, captured, managed, and traceable.	Inter-Database/Tool Data Item associations among all data items defined, captured, managed, and traceable where changes in one data source alerts owners of other data sources of intended updates.
Goal 1. Use of Models	Modeling Methods	Models use any method to solve specific problems. The overall approach is not structured for consistency.	Modeling methods are planned for efforts within a project. Some structure is applied.	Modeling methods are planned for efforts within a portfolio and are consistent as possible for each project/program. Best practices are evolving; structuring patterns emerge.	Modeling methods are planned for efforts within a portfolio and are consistent as possible across projects/programs within an enterprise. Best practices converge; patterns are captured and reused.	Structured methods are planned and reused.
Goal 1. Use of Models	Model Languages	Model languages are used ad hoc to solve specific problems, but there is no plan to ensure consistency across a program/project.	Model languages are used ad hoc to solve specific problems, with a plan to ensure consistency across a program/project.	Model languages are consistent across a program/project.	Model languages are carefully chosen to unify the program/project, enable libraries, and enable reuse.	Model languages are carefully chosen to unify the enterprise, enable libraries, and enable reuse.
Goal 1. Use of Models	Model Libraries	Model libraries have not been identified.	Project specific model libraries are established.	Cross project model libraries are established.	Plan to leverage Project model libraries to establish curated and shared libraries for an enterprise.	Project model libraries are established and shared across an enterprise in a curated manner.
Goal 1. Use of Models	User Interface (UI), Viewpoint/Views, and visualization	Models are not used to identify or define the user interface or view/viewpoints.	Models allow the definition of the user interface, document generation, generation of views/viewpoints.	Models allow the definition of the user interface, document generation, generation of views/viewpoints and custom visualization.	UI supports Interrogation across the federated system's Authoritative source of truth and provides visualizations for decision making.	UI supports Interrogation across the federated enterprise Authoritative source of truth and provides visualizations for decision making.
Goal 1. Use of Models	Simulation Capability	Simulation level of value to the project not considered.	Value of simulation capability considered but not explored.	Where appropriate, simulation capability utilized on a small scale but not fully utilized.	Where appropriate, simulation capability utilized but not fully exploited.	All aspects of simulation are being utilized where appropriate including both simulation capabilities embedded in the tool and external simulations linked to MBSE artifacts.
Goal 1. Use of Models	Modeling Process quality	Modeling processes have not been 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.	Re-engineered modeling processes provide measurable improvements across the enterprise.
Goal 2. ASOT	Authoritative Source of Truth (ASOT)	Data and information hasn't been identified to contribute to the authoritative source of truth.	Necessary data and information has been identified to contribute to the authoritative source of truth.	Data and Information are discoverable from specific models to address specific queries across parts of the enterprise.	Data and information provide knowledge to specific decision makers across parts of the life cycle and across parts of the enterprise.	Data and information are discoverable to provide knowledge to strategic to near real-time decision makers across the life cycle and across the enterprise.
Goal 2. ASOT	Digital Threads	Digital threads have not been identified.	Digital threads have been identified.	Digital threads have been established for limited program/projects across the enterprise.	Digital threads have been established contributing to the authoritative source of truth for limited programs/projects across the enterprise.	Digital threads have been established contributing to the authoritative source of truth for an enterprise.
Goal 2. ASOT	Digital Twin	Digital twins have not been identified or established.	Digital twin (DT) types have been identified; E.g., (DT Prototype, DT Instance, DT Aggregate, DT Environment).	Digital twin types have been established; E.g., (DT Prototype, DT Instance, DT Aggregate, DT Environment).	Digital twin types are effectively used to make decisions for limited programs/projects across an enterprise.	Digital twin types are effectively used for an enterprise.
Goal 2. ASOT	Digital Artifacts	Hardcopy or business application (e.g., MS Word) generated documents are not based on digital artifacts.	Documents incorporate digital artifacts such as model generated views.	Program/Project uses a mix of documents and digital artifacts to make decisions.	Program/Project uses digital artifacts to make decisions.	Enterprise decisions are based on tool and user defined digital artifacts to make decisions.
Goal 3. Innovation	MBSE Institutional Adoption (e.g., agency, service, center, business unit) for Digital Engineering	Some parts of the institution have adopted MBSE (e.g., new programs/initiative, pilot programs, and business case driven) for a segment of the enterprise work: e.g. requirements management architecture, design, manufacturing, …	MBSE adoption by the Systems Engineering or Enterprise Organization.	Common implementation basis across institution with the intent to apply enterprise and system models.	Consistent institutional approach across organizations with variations as appropriate for specific needs. Consistent tool coverage and use across organizations.	Consistent institutional approach is driven by policy, practices and methods across organizations. Variations are allowed as appropriate for specific needs. Consistent tool coverage and use across organizations.
Goal 3. Innovation	MBSE Technical Innovation Process	Organization only upgrades tools, environment, and methods as driven by vendors and as standards are created or updated.	Organization commissions work to review its technology with the purpose to set direction and adopt new technologies.	Organization has a defined role for technology innovation to research and propose new technology adoption.	Organization has a defined role for technology innovation to research and propose new technology adoption. Goals are set, budgets allocated, and roadmaps are created and conducted to adopt new technologies.	Organization participates in tool vendor improvement forums, setting technological innovation through research, and involvement with standards setting bodies.
Goal 3. Innovation	Enabling Technologies	IT Infrastructure is static and not aware.	IT conducts ad hoc research and application of enabling tools and technologies.	IT aware of current trends/practices and uses roadmaps to enhance capabilities.	Applying processes to examine and anticipate how technology can be used and solve problems.	Mature process to continuously examine and anticipate how technology can be used to solve problems.
Goal 4. Establish Environments	Modeling Tool Access	Model access is based on desktop access.	Access to models are based on IT login.	Access to models are based on role-based permissions.	Model access permissions are shared within a project/program.	Model access permissions are shared within an enterprise.
Goal 4. Establish Environments	Model Based Tool Licensing & Access	None or Unmanaged.	Tool licenses and access address specific project or program needs.	Tool licenses and access are considered for new projects or programs.	Center-wide license access for commonly used tools.	License count appropriate to the role, and access-controlled by role.
Goal 4. Establish Environments	Collaboration capabilities	Collaboration by business tool applications (e.g., E-mail, telecom.).	System Model File Exchange is identified and used.	Various organizations working on different parts of model. Models are integrated by a single organization.	On-line, real-time collaboration amongst distributed project/program teams.	On-line, real-time collaboration amongst distributed teams for an enterprise.
Goal 4. Establish Environments	Intellectual Property (IP)	There is no policy covering the IP of model content.	There is policy covering the IP of model content.	The IP policy is applied to the model content.	Models across an project/program apply the IP policy to model content in the same way.	Models across enterprises apply a common IP policy to model contents in the same way.
Goal 4. Establish Environments	Tool Governance	There is no tool governance policy.	There is tool governance policy.	Programs/projects apply the tool governance policy.	Program/projects within an enterprise consistenly apply the same tool governance policy.	Program/projects across related enterprises consistenly apply the same tool governance policy.
Goal 5. Workforce Transformation	Modeling Roles and Responsibilities	Modeling roles and responsibilities are not identified.	Modeling roles and responsibilities are identified.	Modeling roles and responsibilities are characterized by model-based Knowledge, Skills, and Abilities (KSAs).	Modeling roles are provided the permissions necessary to perform their responsibilities.	People who need to be active are identified and involved. Sufficient staffing and staffing plan ensures all roles are fulfilled.
Goal 5. Workforce Transformation	Modeling Development Skills	Model-based Knowledge, Skills, and Abilities (KSAs) are undefined and unknown. None, or ad hoc for all staff.	Model-based Knowledge, Skills, and Abilities (KSAs) are defined for modelers. Modeling of components of the Enterprise or System.	Model-based Knowledge, Skills, and Abilities (KSAs) are defined for roles involved with modeling; Enterprise Architect, SE, PM, IT, modelers, etc.… Novice Modelers on full Enterprise or System -subsystem models.	Model-based Knowledge, Skills, and Abilities (KSAs) are defined for roles involved with enterprise management. Expert model development lead with experience practicing modeling on at least 1 project that successfully completed at least 3 major technical reviews that used models in support of the review.	Expert model development lead that sets modeling standards and evaluates the model product quality of other modelers.
Goal 5. Workforce Transformation	Modeling Use skills	None, or ad hoc for all staff.	Can generate tool standard digital artifacts as needed to evaluate the Enterprise or System.	Can generate tool custom digital artifacts as needed to evaluate the Enterprise or System.	Can generate custom digital artifacts across tools, models, and data sets to evaluate the Enterprise or System.	Can contribute to defining the enterprise, system, and other data needed by the complete team to perform analysis for IPTs, reviews, audits, and other technical and programmatic decisions.
Goal 5. Workforce Transformation	Modeling-related Training/KSA development	No training or development activities.	Tool familiarity training completed. Initial experience to perform their modeler or user roles.	Modeling or model users experience on specific tools with respect to their role as a user or modeler.	Demonstrating role capabilities using the models, coaching, and instructing others.	Provide leadership in proposing, designing, and delivering training that is appropriate for the modeling and user roles.

DoD DE Strategy Goal	Model-Based Capability Name	Capability Description
Goal 1. Use of Models	MBSE Use Strategy	This is documenting the Digital Engineering/Model Based System Engineering (DE/MBSE) strategy as part of the overall strategy an organization has to provide the system/system-of-systems/enterprise. The concept is that DE/MBSE is used as it benefits the overall work and result.
Goal 1. Use of Models	Common DE and MBSE Terminology	A set of lexicon, taxonomies and glossaries with known precedence.
Goal 1. Use of Models	SE Agreement Process	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.1.1 and 6.1.2. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored. Agreement Processes include: ► Acquisition ► Supply
Goal 1. Use of Models	SE Organizational Project-Enabling Processes	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.2.1 to 6.1.6. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored. Organizational Project-Enabling Processes include: ► Life Cycle Model Management ► Infrastructure Management▪Portfolio Management ► Human Resource Management ► Quality Management ► Knowledge Management
Goal 1. Use of Models	SE Technical Management Processes	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.3.1 to 6.3.8. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored.
Goal 1. Use of Models	Model Configuration Management	ISO/IEC/IEEE 15288.1 paragraph 6.3.5. Configuratoin Management
Goal 1. Use of Models	Model Data Management	ISO/IEC/IEEE 15288.1 paragraph 6.3.6. Information Management
Goal 1. Use of Models	SE Technical Processes	This is a rollup of ISO/IEC/IEEE 15288.1 paragraphs 6.4.1 Business or Mission Analsysisand 6.4.14. Disposal. Matrix Users may want to replace this line item with the set of processes that are most important to their application. The stage descriptions may be the same for each process or tailored.
Goal 1. Use of Models	Modeling Stakeholder Requirements	ISO/IEC/IEEE 15288.1 paragraph 6.4.2. Stakeholder Needs and Requirements Definition
Goal 1. Use of Models	Model-Based Verification and Validation	ISO/IEC/IEEE 15288.1 paragraphs 6.4.1 Business or Mission Analsysisand 6.4.14. Disposal
Goal 1. Use of Models	SE-driven Model Plan	Modeling is part of the System Engineering Plan or System Engineering Management Plan. It should cover the Information Technology (IT) infrastructure, modeling tools, modeling environments, identify the type and purpose of models and how they are managed.
Goal 1. Use of Models	Model Based Reviews; Management Program Reviews /MPR(s), Milestone reviews, program reviews, technical reviews, audits	Digital artifacts are the products from the Authoritative Source of Truth, so that as the system models are queried for evidence against the technical review and audit criteria, the system models may be updated. Note that System Models are a type of digital artifact themselves. MPRs recast to reflect model-driven processes and model-based artifacts (e.g., entrance/success criteria based on process objectives as reflected in the views/viewpoints, not doc creation). See ISO/IEC/IEEE 15288.2. See GAO/NSIAD-98-56 Best Practices for information on "Knowledge Points."
Goal 1. Use of Models	Model Metrics	Having a modeling metrics program to improve the modeling efforts and the target system or enterprise.
Goal 1. Use of Models	Modeling Integration	System Engineering Model pattern as defined by Object-Oriented Systems Engineering Method (OOSEM).
Goal 1. Use of Models	Verification and Validation of Models	Model objective examples include: ► Modeling a new concept (e.g., Universal command and control) ► Modeling system, subsystem, and interfaces ► Modeling operational functionality to generate/verify operational requirements ► Modeling a complex algorithm ► Model system V&V processes.
Goal 1. Use of Models	Modeling Assurance	Per ATR-2018-01074 Rev A from The Aerospace Corporation. Model Assurance Level (MAL)– A measurement system for model value, content and quality. Identifies risk areas related to models and is rated 1-3; 1 has the least assurance.
Goal 1. Use of Models	Model Management	Model management is responsible for establishing policy and managing the oversight of model collection activities, model valuation, acquisition and strategic model loans, for ensuring the application.
Goal 1. Use of Models	Distributed Database/Tool interoperability	A fully Federated (or Confederated) data and IT infrastructure that functions as one virtual common database. Includes a standardized interface(s) for other data sources to join the Federation (APIs, wrappers, etc.).
Goal 1. Use of Models	Model Based Data/Tool Independences	Bifurcation Opportunity: Connecting to non-MBE repositories as well as MBE repositories. One is for sharing data and the other is for sharing model artifacts.
Goal 1. Use of Models	Inter-Database/Tool Data Item Associations	Capture and manage associations between data items within and between disparate data sources. Associations can be traced between data items regardless of their location.
Goal 1. Use of Models	Modeling Methods	Methods examples include but are not limited to: ► OOSEM (Object-Oriented Systems Engineering Method) ► STRATA (Vitech) ► Harmony-SE (IBM Rational Telelogic) ► RUP-SE (IBM Rational Unified Process for Systems Engineering) ► JPL State Analysis (SA) ► OPM (Dori Object-Process Methodology) ► OOA/D (Object-oriented analysis and design) ► SYSMOD (Weilkiens Systems Modeling Process) ► VAMOS (Variant Modeling with SysML) ► Alstom ASAP methodology ► Pattern-Based Systems Engineering (PBSE) ► Modeling methods driven by SE objectives/analyses/uses and evidentiary artifacts, includes Library of standardized and frequently used patterns/models/components
Goal 1. Use of Models	Model Languages	Model Language examples: ► UML – Unified Modeling Language ► SysML – Systems Modelling Language ► SDL – System Definition Language ► STRATA (Vitech) ► Modelica ► LML – Lifecycle Modeling Language ► TOGAF – The Open Group Architecture Framework ► BPEL – Business Process Execution Language ► DoDAF – Department of Defense Architecture Framework ► UPDM – Unified Profile for DoDAF/MODAF ► UAF – Unified Architecture Framework
Goal 1. Use of Models	Model Libraries	Creating curated model libraries that are added to, retired, loaned, updated, etc.

DoD DE Strategy Goal	Model-Based Capability Name	Capability Description
Goal 1. Use of Models	User Interface (UI), Viewpoint/Views, and visualization	Viewpoints reflecting SE and user objectives/analyses/needs are defined and standardized. Supports interrogation, navigation, tracing, etc., of data from disparate, heterogeneous data sources (See ISO 42010 for definitions).
Goal 1. Use of Models	Simulation Capability	GENESYS, Cameo, Sparx EA and Rhapsody all have built in simulation capabilities. Additionally, they all also have the ability to interface with external simulation assets such as MaTLab Simulink.
Goal 1. Use of Models	Modeling Process quality	Having a quality program that incorporates modeling.
Goal 2. ASOT	Authoritative Source of Truth (ASOT)	The collection of modeling data that represents the target system(s) along with its rationale. https://www.acq.osd.mil/se/initiatives/init_de_def.html Reference NASA-STD-7009 for examples of factors for assessing "Acceptability for Use" and "Credibility of Results."
Goal 2. ASOT	Digital Threads	https://www.acq.osd.mil/se/initiatives/init_de_def.html Digital Thread: An extensible, configurable, and component enterprise-level analytical framework that seamlessly expedites the controlled interplay of authoritative technical data, software, information, and knowledge in the enterprise data-information-knowledge systems, based on the Digital System Model template, to inform decision makers throughout a system's life cycle by providing the capability to access, integrate, and transform disparate data into actionable information. (DAU Glossary)
Goal 2. ASOT	Digital Twin	https://www.acq.osd.mil/se/initiatives/init_de_def.html Digital Twin: An integrated multiphysics, multiscale, probabilistic simulation of an as-built system, enabled by Digital Thread, that uses the best available models, sensor information, and input data to mirror and predict activities/performance over the life of its corresponding physical twin. (DAU Glossary)
Goal 2. ASOT	Digital Artifacts	Digital Artifact: The artifacts produced within, or generated from, the digital engineering ecosystem. These artifacts provide data for alternative views to visualize, communicate, and deliver data, information, and knowledge to stakeholders. (DAU Glossary)
Goal 3. Innovation	MBSE Institutional Adoption (e.g., agency, service, center, business unit) for Digital Engineering	The level that MBSE is adopted uniformly across the target organization.
Goal 3. Innovation	MBSE Technical Innovation Process	The organization's process to adopt new modeling relevant technology.
Goal 3. Innovation	Enabling Technologies	An assessment of how enabling technology is adopted by an organization.
Goal 4. Establish Environments	Modeling Tool Access	The access to models based on modeling roles.
Goal 4. Establish Environments	Model Based Tool Licensing & Access	How well an organization manages tool licenses
Goal 4. Establish Environments	Collaboration capabilities	Synchronous and asynchronous data-rich collaboration among distributed teams
Goal 4. Establish Environments	Intellectual Property (IP)	Determining if the organization has and uses IP policy effectively across the enterprise to maximize transparency while protecting IP.
Goal 4. Establish Environments	Tool Governance	Tool governance is the establishment of policies and continuing monitoring of their implementation to include selecting tool sets, tool extensions and plug-ins, tool environments, tool procurements, licenses, and access.
Goal 5. Workforce Transformation	Modeling Roles and Responsibilities	Roles and responsibilities may include such modeling roles as: enterprise manager, program/project manager, SE, IT, Modeler, policy maker, contracting, model curator, model manager, model data manager, ASOT configuration manager or others.
Goal 5. Workforce Transformation	Modeling Development Skills	More than just modeling tool expertise. This includes expertise in model structure/architecture that supports all subsequent uses.
Goal 5. Workforce Transformation	Modeling Use skills	This covers a role that all government or acquirer team members must have to conduct model based acquisition.
Goal 5. Workforce Transformation	Modeling-related Training/ KSA development	Multilevel training series, including "hands-on" real world(-like) execution.

DoD DE Strategy Goal	DoD DE Strategy Goal "Shorthand" Used in the INCOSE MBEC Matrix	DoD DE Strategy Focus Areas
Goal 1. Formalize the Development, Integration, and Use of Models to Inform Enterprise and Program Decision Making	Goal 1. Use of Models	1.1 Formalize the planning for models to support engineering activities and decision making across the lifecycle 1.2 Formally develop, integrate, and curate models 1.3 Use models to support engineering activities and decision making across the life cycle
Goal 2. Provide an Enduring Authoritative Source of Truth	Goal 2. ASOT	2.1 Define the authoritative source of truth 2.2 Govern the authoritative source of truth 2.3 Use the authoritative source of truth across the life cycle
Goal 3. Incorporate Technological Innovation to Improve the Engineering Practice	Goal 3. Innovation	3.1 Establish and end-to-end digital engineering enterprise 3.2 Use technological innovation to improve the digital engineering practice
Goal 4. Establish a Support Infrastructure and Environments to Perform Activities, Collaborate, and Communicate Across Stakeholders	Goal 4. Establish Environments	4.1 Develop, mature, and use digital engineering IT infrastructures 4.2 Develop, mature, and use digital engineering methodologies 4.3 Secure IT infrastructure and protect intellectual property
Goal 5. Transform the Culture and Workforce to Adopt and Support Digital Engineering Across the Lifecycle	Goal 5. Workforce Transformation	5.1 Improve the digital engineering knowledge base 5.2 Lead and support digital engineering transformation 5.3 Build and prepare the workforce