

Model-Based Capabilities Matrix

Digital Engineering IPT
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Agenda

- INCOSE Challenge Team Effort
- Developmental History (abbreviated)
- Overview of the Matrix Structure, Products and Tailoring
- Matrix Uses
- Concept of Operations

INCOSE Challenge Team Effort

- Co-Leads:
 - Joe Hale, NASA/MSFC, joe.hale@nasa.gov
 - Al Hoheb, The Aerospace Corporation/SED, albert.c.hoheb@aero.org
- INCOSE Challenge Team:
 - Federation of those willing to assist in the development and deployment of the products; now **139** and growing
- Model-Based Capabilities Matrix (MBCM) INCOSE Challenge Team Technical Project Plan (TPP) version 2.2
 - Approved
 - Two products: MBCM and User's Guide
- 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.

Developmental History (abbreviated)

- The story begins with two independent efforts to provide a reference for enterprise and program/project organizations to assess their current and desired implementation of modeling
 - NASA MSFC MBSE Maturity Matrix
 - The Aerospace Corporation MBSE Community Roadmap
- Following a presentation of both at the OSD Digital Engineering Working Group, it was decided to combine these efforts to develop a comprehensive **Model-Based Enterprise Capability Matrix**
- Early drafts of the Matrix and User's Guide were presented at a series of Workshops at various System Engineering fora:
 - INCOSE International Workshop (Jan 2018)
 - Where the **INCOSE Challenge Team** was formed to produce a candidate INCOSE Technical Product
 - Aerospace System Engineering Forum (May 2018)
 - INCOSE International Symposium (July 2018)
 - NDIA SE Conference workshop (Oct 2018)
 - INCOSE International Workshop (Jan 2019)
 - Aerospace System Engineering Forum (Feb 2019)
 - INCOSE International Symposium (July 2019) (received final comments/mods)
 - Updated Products and submitted final version to INCOSE Tech Pubs August 29, 2019

INCOSE Challenge Team Reps from numerous Organizations, including:

- Various NASA Centers
 - LaRC, GRC, GSFC, MSFC, JPL, JSC
- The Aerospace Corporation
- Office of the Secretary of Defense (OSD)
- Space and Naval Warfare Systems Command (SPAWAR)
- US Navy
- US Air Force
- National Defense Industrial Association (NDIA)
- National Institute of Standards and Technology (NIST)
- Airbus
- Lockheed Martin
- Japan Aerospace Exploration Agency (JAXA)
- Raytheon
- Harris Corp.
- Northrup-Grumman
- Booz Allen Hamilton
- BAE Systems
- General Atomics
- Draper
- Ford
- Boeing
- Dassault Systemes
- Mitre
- MIT
- Thales

Overview of the Matrix Structure, Products and Tailoring

Matrix Structure

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

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

Products

- Model-Based Capabilities Matrix (MBCM) version 2.0d1
 - Two views; Role-based view, and OSD Digital Engineering Strategy goal view
 - Same capabilities allocated differently for the 2 views
 - Prints on 3 pages of 11”X17” paper
 - The role-based areas are:
 - Workforce/Culture
 - System Engineering Processes/Methodology
 - Project/Program Process/Methodology
 - Model Based Effectiveness
 - Modeling Tool Construction
 - Information Technology Infrastructure
 - Policy
 - OSD DE Strategy Goals are:
 - Use of Models
 - Authoritative Source of Truth (ASOT)
 - Innovation
 - Establish Environments
 - Workforce Transformation
- User’s Guide version 5.2f1
 - Includes Frequently Asked Questions (FAQs) (useful for newcomers)

Tailoring

- Use language that is important to the organization
 - E.g., NASA uses “project,” DoD uses “Program”
- Identification of individual SE processes to be addressed that are critical to success
 - E.g. CM/DM
- Addition/deletion of rows to focus on organization perspective

Matrix Uses

Matrix Uses: 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 left-most column.
- Example: Selected *Tools & IT Infrastructure* attributes are the relevant attributes for this example

Model-Based Capability Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Tools & IT Infrastructure					
Collaboration	E-mail, telecom.	System Model File Exchange.	Various organizations working on different parts of model. Full model integrated by a single organizations.	Partial On-line, real-time collaboration amongst distributed teams	On-line, real-time collaboration amongst distributed teams
Disparate Database/Tool interoperability	None	Tool-to-Tool, ad hoc interoperability	Partial Federated Database Management System (FDBMS)	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated w/ standard "plug-and-play" interfaces. Data is interchanged among tools
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, capture 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
User IF, Viewpoint/Views	N/A	Doc Gen	UI draws from Model app	UI draws from multiple models/DBs	UI supports Interrogation; multiple configs

- 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:**
 - **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**

Matrix Uses: 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 *Tools & IT Infrastructure* attributes are the relevant attributes for this example

Model-Based Capability Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Tools & IT Infrastructure					
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- 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

Matrix Uses: 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 calls to the left of the attained Stage for all assessed relevant attributes.
- Example: Selected *Tools & IT Infrastructure* attributes are the relevant attributes for this example

Model-Based Capability Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Tools & IT Infrastructure					
Collaboration	E-mail, telecom.	System Model File Exchange.	Various organizations working on different parts of model. Full model integrated by a single organizations.	Partial On-line, real-time collaboration amongst distributed teams	On-line, real-time collaboration amongst distributed teams
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- Color coding can be used to provide additional status, e.g.,
 - Green indicates attribute capability is operational
 - Yellow indicates attribute capability in active development

Matrix Uses: Tactical Planning

- Objective: Given the current capability of one or more domains/attributes of a Model-Based Enterprise, determine on 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, 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 *Tools & IT Infrastructure* attributes are the relevant attributes for this example

Model-Based Capability Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Tools & IT Infrastructure					
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User IF, Viewpoint/Views	N/A	Doc Gen	UI draws from Model app	UI draws from multiple models/DBs	UI supports Interrogation; multiple configs

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

Other Matrix Uses

- **Qualifying Bidders**
 - **Objective:** Define how the Model Based Capabilities Matrix may be used to qualify bidders to be allowed 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.
- **Source Selection (for services)**
 - **Objective:** Define how the Model Based 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 enterprise requirements and (b) select the appropriate source to meet those requirements.
 - To define the acquirer model based enterprise 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.

Concept of Operations

Model-Based Capabilities Matrix CONOPS

Per the User's Guide

Identify the Enterprise, Program, or System Transformation Objectives

- Pre-work to apply the matrix

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

- “Half-day workshop”

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

- Organization's transformation Plan
- Plan new capabilities
- Enhance processes
- Org DE compliance Plan
- SEP/SEMP
- Multi-year roadmap
- Pre-source selection Acquisition strategy
- Qualifying sources
- MBSE roles and responsibility definition

This workshop will provide sample scenarios to apply the matrix

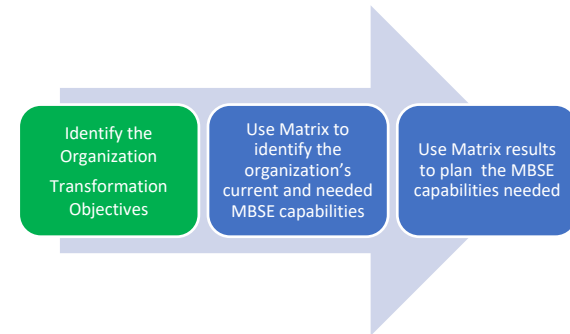
Some recommended actions to run the Matrix Assessment

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

Sample Enterprise Transformational Objectives

Government Organization

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

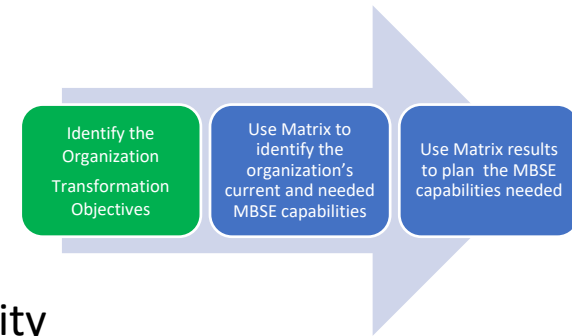


Making more-with-less, more-with-existing, more-with-more, or preserving what is possible under stressors

Sample Enterprise/Business Unit Transformational Objectives

Commercial Organization

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



Transforming the organization to make better business decisions

Example of Matrix Assessment

Green = attribute capability is operational,

Yellow = attribute capability needed

Identify the Organization Transformation Objectives

Use Matrix to identify the organization's current and needed MBSE capabilities

Use Matrix results to plan the MBSE capabilities needed

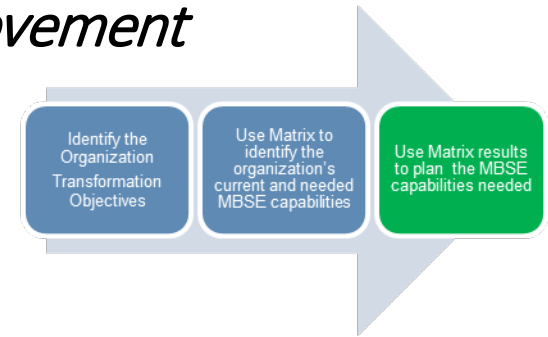
Role Based Matrix Area	DoD DE Strategy Goal	Model-Based Capability Name and Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
5. Information Technology Infrastructure	Goal 4. Establish Environments	Collaboration cap	Collaboration by business tool applications (e.g., E-mail, telecom.)	System Model File Exchange is identified and used..	Various organizations working on different parts of model. Models are integrated by a single organizations.	On-line, real-time collaboration amongst distributed project/program teams	On-line, real-time collaboration amongst distributed teams for am enterprise
6. Modeling Tool Construction	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 w/ standard "plug-and-play" interfaces. Data is interchanged among tools
6. Modeling Tool Construction	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
6. Modeling Tool Construction	Goal 1. Use of Models	User Interface (UI), Viewpoint/Views, and visualization	Model are not used to identify or define the user interface or view/viewpoints	Models allow document generation, generation of views/viewpoints	Models allow document generation, generation of views/viewpoints and custom visualization	UI supports Interrogation across the federated systems 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

Use any scoring method that your team agrees-to

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

Use Assessment Results to Plan Capabilities Improvement

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



Pilot Uses

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

Positive outcomes