2018
Annual INCOSE
international workshop
Jacksonville, FL, USA
January 20 - 23, 2018

2018 INCOSE IW

Digital Engineering (DE) Capabilities Definition document

Workshop Organizers

- Co-Leads
  - Joe Hale, NASA MSFC
  - Al Hoheb, The Aerospace Corporation
- INCOSE Cognizance
  - Troy Peterson
- Working Session Organizing Committee
  - Frank Salvatore
  - Dr. Tracee Walker
  - …

Vision for the Document

- A DE Capability Definition document can help address a variety of needs, including:
  - Strategic Vision
    - Future (multidimensional) state of a mature MBx Organization
  - Roadmap
    - Often one or a few (multidimensional) vectors
  - Yardstick
    - A method to status current maturity and track progress across multiple dimensions
  - Tactical Planning
    - How to apply (limited) resources for incremental improvements across multiple dimensions
- Conceptually it will have “rows” of DE capability areas and several “columns” that allow identification of increasing organizational capability

An Approach: A Maturity Matrix

- Structure
  - Rows - Broad range of factors/attributes that directly or indirectly support/enable MBSE/MBE
  - Columns: Increasing Levels of Maturity
    - Left-most column reflects non-MBSE/MBE Capabilities (i.e., Doc-centric)
    - Right-most column reflects fully mature MBSE/MBE Capabilities
    - Intervening columns reflect increasing, incremental levels of maturity for each particular factor/attribute (row)

Attributes	Level 0	Level 1	Level 2	Level 3	Level 4
Attr1					
Attr2					
Attr3					
Attr4					

Addresses the previously identified needs:

- Strategic Vision
  - Right-most column
- Roadmap
  - Along one or more rows
- Yardstick
  - Can determine and represent current Capability along each row
- Tactical Planning
  - Based on current Capabilities (and resources), can assess where to advance (or catch-up) a particular attribute

Attributes	Level 0	Level 1	Level 2	Level 3	Level 4
Attr1					
Attr2					
Attr3					
Attr4					

Working Session Goals and WIFM

- Compile a reference document set that is immediately useful to participants and used to extract content
  - Repository has been created to kick off the planning
- Identify a document Framework to attach content
  - Ratify and/or identify concepts to adjust it later
- Split into “table topics” that have been selected as needing more fidelity
  - Flex working session design accommodates 5 or 50 so that all may contribute and benefit from discussion
- Produce a poster, framework with content, and consider a plan to move the effort forward as an INCOSE product supported by a workgroup

Developing the Product

ODSAD
DE Strategy

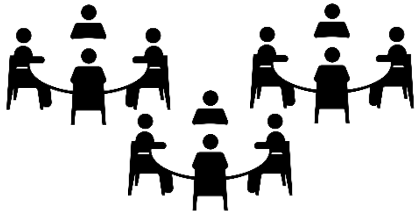
NASA
MBSE
Maturity
Matrix

Aerospace
Community
Roadmap

Additional
Reference
Docs

Repository

INCOSE IW
DE Capabilities
Doc
Framework
Brief



INCOSE IW
Working Sessions

Working Group
Outbrief
Poster

DE Capabilities
Doc
Framework and
Content

INCOSE IW
Framework
Technical
Project Plan

INCOSE IW
Products

DE Capabilities
Doc
Versions

INCOSE
Working Group?

Working Session 1 Agenda

- 15 min. Workshop overview and purpose – what to expect; note attendee numbers, and spread for report out and poster session
- 15 min. Introductions and self-introductions; record other potential documents that may be relevant to integrate
- 20 min. Stakeholder brainstorm – as a group identify potential reference documents to consider
- 20 min. NASA Presentation (familiarization and potential areas to enhance – drives breakout)
- 20 min. Aerospace Presentation (familiarization and potential areas to enhance – drives breakout)
- 20 min. Other Presentation (familiarization and potential areas to enhance – drives breakout)
- 20 min. Review of proposed framework and reference materials.
- 20 min. Discussion on the framework and record additional concepts to consider in its future organization.
- 20 min. Organizing the breakouts – show of hands for each of the breakout to create balance. Ideally 8-10 but no more than 15 per breakout. Use time for a stretch and coffee break; move to tables
- 10 min. Each breakout "host" makes introductions and explains approach, how info will be recorded, how it will be refined and shared for the poster session
  - Facilitator to tackle topics and keep pace moving. Input control. Proper brainstorming (clarification of concepts but not challenging validity).
  - Recorder to write down and assemble contributions.
  - Participants. Use reference materials and contribute knowledge/wisdom.
- Rest of the session – contribute content to the framework

Working Session 2 Agenda

- 10 minutes – welcome and sign in if not signed in from previous session
- 30 minutes -- Poster design and review. Present the poster and based on the session 1 progress do adjustments need to be made?
- 40 minutes - Any new presentations or materials to share? If so, allow for their presentation
- 10 minutes - Organize and move to breakouts (new topics)
- 10 min. Each breakout "host" makes introductions and explains approach, how info will be recorded, how it will be refined, and how it will be shared for the poster session compilation
  - Facilitator to tackle topics and keep pace moving. Input control. Proper brainstorming (clarification of concepts but not challenging validity).
  - Recorder to write down and assemble contributions.
  - Participants. Use reference materials and contribute knowledge/wisdom.
- Last hour - development process check
  - How do participants feel about the product? Useful?
  - Recommend further document development?
  - Would they like to be part of the working group if INCOSE initiates one?

Proposed MBSE/MBE Maturity Matrix

- Starting Point
  - Workforce/Culture
  - Processes/Methodology
  - Tools& IT Infrastructure
- Additional Attribute Clusters
  - Project Use
  - Policy

- Each of these Attribute Clusters are further decomposed to individual attributes

- A text description of each attribute is developed for the left-most (doc-centric) and right-most (fully mature) columns

- Finally, a text description of each attribute is developed for the intervening columns to reflect increasing, incremental levels of maturity

Additional Matrix Attributes for Consideration

- Modeling Plan and integration with acquisition and SE plans
- Tool architecture and interoperability
- Tool fit and tool fidelity
- Authoritative Source of Truth
- Digital Twin; requirements, function, physical, logical, etc..
- Digital Threads (needed before we ID artifacts)
- Digital Data identification, availability, delivery, and concept of legal records
- Decision making; SE Reviews and Audits, Independent Reviews, and IPT engagement
- Security and intellectual property

Maturity Matrix Excel

MBSE Maturity Levels	Level 0	Level 1	Level 2	Level 3	Level 4	Commentary
Workforce/Culture						
MBSE Approach/Objectives	Awareness	sub-Discipline Tool use (e.g., CRADLE, DOORS)	Full System Models. Modeling results used to inform systems engineers in system analysis, design, and integration.	Full System Models; Model views translated into more traditional views for use and understanding by organization. Modeling results support decision making.	Full System Models; Organization familiar and competent in using modeling views for key system decisions	MBSE Approach/Objectives are well defined and broadly communicated to, and understood by, Engineering, Program/Projects, CIO, S&MA, etc.
Tool Use	Limited	Partial, Standalone	General use of specific model(s) within System Engineering organizations.	General use of specific model(s) within Systems Engineering organization with understanding how external systems engineering models related.	Multiple, Heterogeneous	Expecting different tools to be used intra/inter-Center, between Gov and Contractor, and across Contractors
Modeling Skills	Novice	Training on Sub-Discipline Tools	Expert Modellers on full suystem models.	General training of systems engineering workforce on use of full system model results.	Expert	More than just modeling tool expertise. This includes expertise in model structure/architecture that supports all subsequent uses
SE-driven Model Building	None	sub-Discipline Models (e.g., CRADLE, DOORS)	Full System Models.	Multiple System Models	Mature/Complete	Model structure/architecture driven by SE objectives/analyses/uses and evidentiary artifacts
Lifecycle Coverage	Limited	Single Phases	Multi-Phases; Limited Reviews	Multi-Contiguous Phases	End-to-End, Top-to-Bottom	Across all Phases and down to lowest decomposition
Level of Institutionality	Scattered Pockets	Consistent with Systems Engineering Organizations. Varies among organizations.	Common basis across Center. Varied used within organizations and projects.	Consistent Center approach across organizations with variations as appropriate for specific system needs.	Center/Agency Wide	Tools, training, and IT infrastructure provided/maintained by Institutional resources
Training	Intro 101	Modeling	SE-Driven Model Building	Mutliple Sysem Tools	Integrated Curriculum w/ Practical Experience (Case Studies)	execution
Processes/Methodology						
Artifacts	Docs	Documents incorporate model generated views.	Docs; Model Views	Viewpoints defined	Various Media (Views) drawn from Model(s)	Defined, standardized viewpoints auto-populated from model(s). Implies model(s) are structured/architected to support these viewpoints
CM/DM/VM	Doc-managed;	Doc- managed; Generated from Model(s)	Doc-managed; Synced to Model(s)	Model-managed	Model-managed; defined/standard Viewpoints; Integrated/Coordinated Governance Structure(s), automated workflow and routing	Models/Databases are managed (vice Docs/drawings); Viewpoints reflecting SE and user objectives/analyses/needs are defined and standardized; Governance structures (e.g., Change Control Agents) are integrated and coordinated; Workflows and routing are defined, standardized, and automated
Milestone Reviews	Docs-based	Doc-based	Doc-based; Model Driven	Doc and Model Reviewed (mixed)	Model-based Review; structured, Objective-driven Viewpoints	Reviews are completely model-based (I.e., no docs/dwgs); Evidentiary artifacts include defined/standardized viewpoints that can be auto-populated from disparate, heterogeneous, models and databases
Modeling Methods	Unstructured	Various, semi-structured	Best Practices evolving; Patterns emerging	Best Practices converged; Patterns being captured, reused	Structured; Reusable patterns/models/components	Modeling methods driven by SE objectives/analyses/uses and evidentiary artifacts, includes Library of standardized and frequently used patterns/models/components
Tools & IT Infrastructure						
Tool(s)	Reqts Mgmt, XL	Full Systems Models applied variously across Systems Engineering organizations.	Consistent within separate Systems Engineering Organizations.	Center-wide license access for commonly used tools	Agency-wide license access for commonly used tools	Tools, provided/maintained by Institutional resources
Collaboration	E-mail, telecom.	System Model File Exchange.	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	Synchronous and asynchronous data-rich collaboration among distributed teams
Data Structures	System terminology defined.	Common Glossary/Data Dictionary	Top Tier Ontology	Discipline Ontologies	Common, tiered taxonomies/ontologies	A hierarchy of taxonomies and ontologies: Generic Upper Level with subordinate domain/discipline Lower Levels
Disparate DB/Tool interoperabi	None	Tool-to-Tool, ad hoc interoperability	Partial FDBMS	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated w/ standard "plug-and-play" interfaces	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.)
Inter-DB/Tool Data Item Associ	None	Associations defined	Associations defined, captured, managed	Associations defined, captured, managed	Associations among all data items defined, captured, managed, and traceable	Capture and manage associations between data items within and between disparate data sources. Associations can be traced between data items regardless of their location.
User IF, Viewpoint/Views	N/A	Doc Gen	UI draws from Model app	UI draws from multiple models/DBs	UI supports Interrogation; multiple configs	Viewpoints reflecting SE and user objectives/analyses/needs are defined and standardized; Supports interrogation, navigation, tracing, etc. of data from disparate, heterogeneous data sources
Project Use						
Type	4,5	3,4,5	2,3,4,5	2,3,4,5	All Types	Used by all Categories, Classes, Types of P/P/As
Size	Small. Stand alone.	Small to Medium. Stand alone and sub-system portions of larger systems.	Small to Large (not Programs). Stand alone and sub-system portions of larger systems.	Small to Large (not Programs). Stand alone and sub-system portions of larger systems.	Scaleable to all sizes	Scalable and/or Tailorable to all sizes of P/P/As
Policy						
Reflection in MPR(s)	Not Prohibited	Model results called out explicitly as products.	Basic modeling characteristics identified.	Model-based infrastructure reflected.	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)	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)
Contractual Mechanisms/Langua	Doc-Based	Some information delivered as models.	Information delivered as models.	Information delivered as models.	SOWs, DRDs based around model/DB exchange and/or access; Underlying processes aligned with new capabilities to meet objectives	SOWs, DRDs based around model/DB exchange and/or access; Underlying processes aligned with new capabilities to meet objectives

A Roadmap for Advancing the Practice of Model Based Systems Engineering

	Work to Date	Near Term	Longer Term	End State
Enabling Enterprise Systems Engineering	• DoDAF products built as models in modeling tools, not just pictures • Modeling pilots provide valuable experience in building models and using modeling tools • MBSE initiatives are largely stovepiped, not well coordinated	• Demonstrate & document value in MBSE transition projects • Develop interoperable methods, including common metamodels, to enable model sharing at enterprise and system levels • Improve quality and speed of engineering and technical baseline change processes	• Integrate enterprise architecture with system models to provide multi-level insight • Manage technical baselines entirely from model; documents extracted from model • Enterprise CM is model-centric • Standard metamodel enables improved model interoperability	• Improved enterprise situational awareness through federated enterprise and system models • Decisions made based on holistic assessment of impacts across all interfaces and stakeholder perspectives
Improving System Acquisition and Execution Outcomes	• Contractors deploying MBSE more frequently in Government development programs • Aerospace ATR and Workshop on MBSE Guidance for Government-Acquired Programs	• Demonstrate & document MBSE value to near-term development and acquisition programs • Develop approaches to improve mission assurance via MBSE • Refine leading indicators for proactive application of MBSE • Refine practice of model-based SE reviews and audits	• Models facilitate concurrent engineering analysis throughout life cycle to support trades • Broaden application of MBSE across portfolio of programs • MB RFPs and proposals, and MB source selections • Tight integration with specialty engineering models	• Models used as primary means to capture and communicate knowledge across life cycle • Models serve as requirements and deliverables for acquisitions • Modeling eliminates SE escapes, resulting in better, more affordable systems
Institutionalizing Evolved Systems Engineering	• Growing interest in MBSE pilot and demonstration projects provide experience in using multiple tools and methods • Improving stakeholder awareness of benefits of MBSE	• MBSE training at multiple levels • Disciplined processes for MBSE transition effort planning • Reusable framework for MBSE tool evaluation and selection • Collect metrics on MBSE value • Publicize positive experiences to build community confidence	• Standardized metamodel for improved model interoperability • Tools to facilitate model use & updates by non-modelers • Improved visual appeal of model views for non-technical stakeholders • Update IEEE 15288 to better align with MBSE practice	• SE and MBSE are synonymous • Models are used by all as the Single Source of Truth • Interoperable models enable knowledge synergy across domains and organizations • Models are transparent to users • Update IEEE 15288 to reflect MBSE as standard SE practice
Advancing the State of MBSE Tools	• Community effort largely driven by other industries • Shortfalls of existing tools becoming more apparent • Model and data interoperability between tools is still limited	• Improve federation of models with analytical and simulation tools • Improve interoperability of models between MBSE tools • Address classification, information compartmenting, and IP issues	• Model use and updates mostly done by non-model-experts • Data exchanges are largely automated with consistent semantics	• Tool selection driven more by tradeoffs of features than tradeoffs of limitations • Seamless data exchange via common data standards and collaborative frameworks