Model-Based Enterprise Capabilities Matrix

2019 INCOSE International Symposium

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Model-Based Enterprise Capability Matrix Workshop

10 minutes Welcome and self-Introductions, sign-in sheet20 minutes Overview of the effort, matrix and it's user's guide

- Matrix and Users Guide purpose, history and their development plan
- 60 minutes Working session apply the matrix against a scenario
 - Two scenarios to choose from:
 - Gov't Satellite Acquisition
 - Commercial product added to an existing product line
 - Instructions for attendees
 - Split into groups of 4-6
 - Apply the matrix
 - Record findings

30 minutes Workshop out briefs

Model-Based Capability Matrix

Challenge Team Effort

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

Products and Status

- Model-Based Capabilities Matrix (MBCM) version 2.0b r4
 - Two views; Role-based view, and OSD Digital Engineering Strategy goal view
 - Same capabilities allocated differently for the 2 views
 - Prints on 3 pages of 11"X17" paper
- User's Guide version 5.2d1 new!
 - Word doc instead of PPTX charts used for UG versions 1-4
- Frequently Asked Questions (FAQs) new!
 - Useful for newcomers
- Potential products
 - Template workshop charts so you as a champion can run a workshop
 - Introductory video
- What other products would be useful to you?

Overview of the Matrix and Concept of Operations

Matrix Structure

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

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

Snapshot of Matrix – Role Based View

- Column B "DE Goals" is hidden

Capability Descriptions have been added

June 2019 Role-Based organization of Capabilities

INCOSE Model-Based Capabilities Matrix (Draft 2.0b)

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Role-Based View

					Role-Based View		
Role Based Matrix Area	Model-Based Capability Name and	Stage 0 No documented PMDSb use/trategy, or the	Stage 1 Urganization MBSL westrategy is documented as	Stage 2 Urganization MESE we strategy w documented as part of the	Stage 3	Stage 4 Urganization MESE westrategy of documented or part of the organization?	Capability Description
I. Workforce/culture	MBSE Uro Stratogy	Ma dacumente d MBSE une strategy, arthe strategy is described for adhac offorts. Each MBSE offort is stand-alone to address specific concerne.	Urganization PBSE westrategy in documents d ur part of its overall organizational strategy at the system level. The strategy is related to the overall riskstrategy.	Urganization MBS is workrategy or documented or particities organization's overall strategy at the system level. The strategy is related to the overall sink strategy. Modeling results used to inform systems on gineers constrying engineering planar and for all disciplinar	Urganization MBSE was trategy a decomented as part of the organization's overallstrategy at the enterprise level. The strategy is related to the overall riskstrategy. Modeling is integrated with business information tools and results used to inform systems engineers, program management, and allstaff agrous	Urganization MISS to use trategy or decomented or part of the organization's overall strategy at the enterprise level. The strategy is related to the overall link strategy. Modeling is integrated with business information tools and results are used to inform all staff carrows the enterprise it manage a full range of business	This is documenting the Digital Engineering/Madel Bared System Engineering (DEMBSE)strategy as part of the averallstrategy as negatisation has to provide the system/system/afrystem/enterprize. The concept is that DEMBSES is well as the hengin the averall wark and nearly.
	Common DE and MBSE Terminalogy	Appropriate terminology defined for the project or program.	Common Glazzery/Date Dictionery	Tup Tior terminulugy is defined for the enterprise.	Dircipline and engineering specialty terminalagy is added to cover lawer level madels	Common, tiered taxonomies are defined and consistent across enterprises and consistent with accepted community standards.	Azet of lexicon, taxonomies and alazzaries with know precidence.
	Madeling Baler and Respansibilities	Mudeling rules and responsibilities are not identified	Mudeling rulez and responsibilities are identified	Madeling rates and responsibilities are characterized by model-based Knowledge, Skills, and Abilities (KSAr)	Mudeling rules are provided the permissions no cessary to perform their recompribilities	People uhu need tu be active are identified and involved. Sufficientstaffing andstaffing plan ensures all roles are fulfilled.	Madeler, palicy maker, cantracting, madel curatar, madel manager, madel data manager, ASOT canfiguration managers athers.
	Madeling Development Skillr	Mudal-bared Knowledge, Skillr, and Abilitier (KSAr) are undefined and unknown. None, or ad- hacfor all/taff	Madel-bared Knauledge, Skillr, and Abilitier (KSAr) are defined for madelors, Andeling af companents of the Enterprise as System.	Middl-bard Knulledge, Skillr, and Abillitier (KSAr) are defined for roler involved uith modeling: Enterprise Architect, SE, PM, IT, modelerr, etc Navice Madelerr an full Enterprise ar System zubrystem modelr.	The provide the second se	ning corring primitization in the and the track modeling standards and evaluates the Expert model development lead the track modeling standards and evaluates the model product quality of other modelers	Mara then juur mediciins tual exportize. Thir includer exportize in madel structure for chitesture that supports all exbecquest war
I. Workforce/culture	Mødeling Urezkille	Nano, ar ad-hac far allztaff	Can generate taulstandard digital artifacts as neodod ta evaluate the Enterprise as System.	Can generate tuul curtum digital artifacts as needed tu evaluate the Enterprise as System.	Can generate curtum digital artifects ecruss tunk, models, and detazets to evaluate the Enterprise or System.	Une constructe to defining the enterprise, system, and other data needed by the complete team to perform an alyzir for IPTs, review, audits, and other technical and programmatic descirions.	This cavers a rale that all government as acquirerer team members must have to conduct model based acquirition
	Madeling-rolated Training/KSA development	Na trainina ar develanment activitier	Taal familiarity training completed. Initial experience to perform their modeler or wer roler.	Madeling as madel werz experience an zpecific taals with respect to their rale as a wer as madeler	Domanstrating rate capabilities using the models, coaching and instructing athers	Provide loadership in propuring, designing, and delivering training that is appropriate for the modeling and user roles	Multilevel training zeries, including "handron" real world("like) execution. Paul Walter to hele flesh this zection out
2. SE Processes/Methodol		Madeling ir nat in carparated ar part of the agreement processes.	Given a clear burinezz care, madeling ir applied in an ad hac manner acrazz prajectz ar pragramz	Given a clear burinezz care, madeling ir applied in a consistent manner acrozy projects or programs	Convision Convisiont model buriness care descriptions are being practiced across an enterprise	Constituent model burineses care driven planning quidance is in place and is being practiced acruss an enterprise	the zet of processes that are most important to their application. The stage descriptions may be the same for each process or tailored.
Processes/Methodol	SE Organizational Project- Enabling Processes	Madoling ir nat incorporatod ar part of the Organizational Project Enabling processor.	Givon a clear burinezz care, mudeling ir applied in an ad huc manner acruzz projectr ur programz	Given a clear burinezz caze, modelingir applied manner acrazz projectz or programz	Convirtont model burineez care descriptions are being practiced across an enterprise	Canzirtent madel burinezz care driven planning quidance ir in place and ir being practiced acrazz an enterprize	The warming of the warming of ISONEUTIBLE 19200. paragraphy 6.2.1 to 6.1.6. Platric User may work to replace the line item with the zet of processor that are mart important to their application. The zet age descriptions may be the zame for each process or tailored.
Processes/Methodol	SE To chnical Managomont Processor	Madeling ir nat incorporated ar part of the Technical Management processes.	Mudeling ur part of the processor to improve quality and models contribute to the authoritative source of truth	Madeling in the barir for the processor. Digital artifacts are used to make SE Technical Management decisions.	Madeling in the basis for the processor and is used to optimize results across the project or program.	Madeling in the basis for the processer and is used to optimize results across the enterprise.	There a realings of there a realings of ISCVIDUREDEDS2000. The reagraph to 5.3.3. Matrix Waters Water may want to replace that line item with the zet of processes that are mark important to their application. The ztage darcriptions may be the zame for a each processor stallared.
2. SE Processes/Methodol	Madel Canfiguration Management	Madel Canfiguration management ir ad hac	Madel canfiguration management ir an arrigned rale	Madol canfiguratian managomont adhoror ta artandard	Madel canfiguration management is applied to all models for asytsem	Madel configuration management is applied to all models for an enterprise	ISO/IEC/IEEE 15288.1 paragraph 6.3.5
	Madel Data Management	Madel Data Managementir ad hac	Madel data management iz an azzigned rale Madeling iz part at the processer to improve quality	Madol data manaqomont adhoror ta astandard	Madel data management ir applied ta all madelr far arytrem	Mudel data management ir applied tu all mudelr fur an enterprize	ISO/IEC/IEEE 15288.1 paragraph 6.3.6 Thur ya railiya pit hurura railiya pit ISU/IELE 15298.1 paragraphy 6.4.1 and 6.4.14. Matrix Urerz may want taroplace
Processes/Methodol	SE Technical Processes	Madeling ir nat incorporated ar part of the Technical processor.	and models contribute to the authoritative source of truth	Madeling in the baris for the processor with digital threads covering some of the processor. Digital artifacts are used to make SE decisions.	Madeling in the basis for the processes with digital threads covering all selected processes, Digital artifacts and digital tuing are used to make SE decisions.	Modeling in the barie for the processor with digital threads covering all processor Digital artifacts and digital twins are used to make SE decisions.	this line item with the set of processor that are most important to their application. The stage descriptions may be the same for each process or tailored.
Processes/Methodol ogy	Madaling Stakohaldar Reguirementr	Stakhulder requirements are nut mudelled	Stakeholder requirementz are in a requirementz 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	Enterprize and zyztemztake hulder requirements are bidirectional traceable	Stakohaldor requiremente are traceable araze enterprizez	ISO/IEC/IEEE 15288,1paragraph 6.4.2
	Madol-Barod Vorification and Validation	Nu plan fur verifying ur validating requirementr in the mudelr	Plan for verifying and validating requirements in the models	Verification and validation plan relier on model contents and analyzis via requirements "analyzis"	Madeling development processor have been established, modeling patterns, styles, and standards have been defined, and standard V&V procedures and errors and have been formulated.	Madeling development processes have been established, modeling patterns, styles, and standards have been defined, and standard V&V procedures and prostans have been formulated, findluding associated automated scripts and Consultant tool coverage within sea and be systems thankering of a sample interference of a standard standard statement of the statement of the sample statement of the statement of the statement of the statement of the statement of the statement of the statement of the statement of the statement of the statement of the statement of the statement of the statemen	150/IEC/IEEE 15288, 1 paragraphs 6.4, 1 and 6.4, 14.
3. Program/Project Processes Methodology	SE-driven Madel Plan	No documented MBSE pion	Pladels 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	Full System/Enterprize Madels are developed and applied variously accurs the product life cycle and accurs Systems Engineering organizations. Assersariate table, environments, methods, and recourses are provided.	Multiple System Madels are integrated for the enterprise. Consistent tool coverage and use uithin separate Systems Engineering Organizations. Record is tools, environments, methods, and resources are provided.	Unsurtant that cover go within sop and a Systems Engineering Urganizations across the enterprise. Multiple enterprise models are interfaced within ar across mission are as. Appropriate tools, environments, methods, and resources are provided.	Madeling ar part pf the System Engineering Planar System Engineering Management Plan. I zhauld caver the Infarm stian Technalagy (11) jinfratt vettue, madeling taalr, madeling enviranment, identify the type and purpare af madele and have by ore managed.
	ringerin graa naviatur; Managament Pringram Revietur	Revieur are not model bared. Revieu and audit ir	raentinication or model to area a sigital artiractir to ratirfy entryfexit criteria. Model resultir called out	noviou procezz u zem az encouro a ovene uren ensun oneraneo ana oree critoria az well az frazon bazelinez. Uze af digital artifactz allau farzame	revisit and quarter for more flexible revisors that some criteria are acknowledged	Encorpruse and an actionary constants on common review encored appreciation, tailaring, and the we af specific digital artifacts to meet specific criteria.	Digital arrivator and the pressure ream the numericative searce ar inute, rether ar the system measur are queries are evidence against the technical review and audit criteria, the system medels may be updated. Note that System Madels
3. Program/Project Processes Methodology	/MPR(r), Milertano roviour, pragram roviour, to chnical roviour, auditr	rot by calondar dato againrt a cantract ovont ruch ar cantract award. Digital artifactr aron't plannod far wro taratwfy ontry/oxit critoria.	oxplicitly ar productr with defined product quality. Une of digital artifactr allow for some criteria items to be addressed prior to the event.	critoria itomz ta bo addrozzod priar ta the ovent. Madel-based digital artifacts tazatiefy critoria alang uith linked narrative. Madel cantont is identified thatzatiefier critoria are linked ta external list af critoria (e.g.,	ar accomplished before the scheduled review. Produminently model-based digital artifacts with arroe ded documents taxatisfy criterie with linked narrative.	Madol: recard the acceptance of criteria items. Balling, frequent review of model contents, of identified "Knowledge Points" allowstakeholders to accept that the review is complete for that knowledge point whenever the exit criteria Unary them before are weat genergy the enforcement to mean the model	are e type of diginal antifact themselver. MPPP recent to rollect model-drives processor and model-based antifactur (e.g., e.g. entransproteceurs artistication based any process abligations and the drive antifactur). See ISO/IECHIEEE IS288.2. See GAO/INSIAD-98-56 Best Practicer furinformation on "Konsuledge Pointu"
Processes Methodology	Madel Metrics	Motriar are not used to manage the model development, quality, or offectiveness	Available metrics are reported from the various modeling tools used	Matrice, bayond thuse available from the tool configuration, are reported to address model development, quality, and offectiveness needs	Motriar are ured to manage the model development, quality, or effectivenezr for azyrtem or enterprize	Conductor the set of t	Having a madeling metrics pragram ta imprave the madeling offarts and the target system ar ontorprise.
4. Model Based Effectiveness	MadelingIntegration	Elements within a madel are not integrated	Elements within a model follow astructured approach (such as OOSEM)	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 rewable SysML blocks is created and used.	Integration across systems models for an enterprise we the same structured approach. A Library of rewable SysML blocks is created and wed	System Engineering Madel pattern ar defined by Object-Oriented Systems Engineering Method (OOSEM)
4. Model Based Effectiveness	Yorification and Validation of Models	The organization has not stated model objectives - - no basis for verification and validation of the models	The organization harztated model objectives but not model requirements . Partial V&V evaluation of the resultant model is pazzible	Madel abjectives and zame general madel requirements have been stated. Plans far Y&V evaluation of the model traceable to the model requirements have been mode.	Madel abjectives and same detailed madel requirements torspecific madels have been stated. V&I evaluation of the madels trace blocts to the madel requirements is planned and includes V&V of madeling atterns, styles and standards, suell as heving defined procedures.	Madeling 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 touls), V&V at the models is performed and updates to the models mode.	Medial abjective examples includes 1. Medialing a neuronneet (e.g., Universal command and control), 2., Medialing rzystem, webzystem, and interfacer, 3. Medialing aprastianal functionality to apparent deverity apparational reguironmetry 4. Medialing a computer James Metale Java Webzystem XM Stracescore
4. Model Based Effectiveness	Madeling Azzurance	Madel Azzurance iz nat canzidered	Madel azzurance iz defined with known z calez and methods	Madel azzurance targetr are identified in azzaciation with the effort z chedule and cart	Madel azzurance measurement and carrective actions are conducted for projects/programs	Model azzurance measurement and corrective actions are conducted for the enterprise	Per emerging research from The Aerospace Corporation. Model Assurance Level (MAL) - A measurement system for model value and quality. Identifier sisk are as related to models. ATR-2018-01074 Rev A
4. Model Based Effectiveness	Authoritative Source of Truth (ASOT)	Data and information harn't been identified to contribute to the authoritative rource of truth	No corrary data and information har been identified to contribute to the authoritative row ce 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 and a group parts of the enterprise	Data and information are discoverable to provide knowledge to strategic to near real-time decision makers agroup the life cycle and agroup the enterprise	The collection of modeling data that represents the target system(s) along with its rationale. [https://www.ecg.ard.milizerinitiations/init_de_def.html Reference NASA-STD-7009 for examples of factors for agreering "Acceptability in give "and "Oraclibility of Revulu".
4. Model Based Effectiveness	Digital Threads	Digital throads have not been identified	Digital throads have been identified.	Digital throadr havo boon ortablishod fir limited program/projocts ocross the enterprise	Digital throads have been established contributing to the authoritative source of truth for limited programs/projects across the enterprise.	Digital throads have been established contributing to the authoritative source of such for an entary ise.	integravious active animormaneanourone, esti presente organizare ne antegravio este ne antegrave este antegrave actoregravia velos activitaris en accurso presente este tra construction esta per a d'antegravio se chancie d dete, raftuero, information, and konsulados in the entegrave deterinformation-konsule de ryzteme, bared en the Digital System Madelamolates, tainform de citizen makere throughout expression file cycle by reaviling the capability to accurso integrave, and transform despression makere throughout esta zysteme i file cycle by reaviling the capability
4. Model Based Effectiveness	Digital Twin	Digital tuine have not been identified or ertablished	Digital tum (DT) typer have been identified (E.g., (DT Prototype, DT Instance, DT Aggregate, DT Environment)	Digital tuin typer have been ertablirhed; E.g., (DT Prototype, DT Instance, DT Aggregate, DT Environment)	Digital tuin typer are offectively used to make deciriour for limited a program/fyrajectr across and enterprise	Digital tuin typer are offectively used far an enterprise.	b type: France eq. a.e. d. mellfor finite at two of finite_de_dot. At mell Urgitte II turns: Phintheorated multiphyzics, multiceale, probabilistics: invalation of an ar-built system, anabled by Digital Thread, that was the bast available madely, scenar information, and input data ten inform and predict activities for afframence are the life of fiz
4. Model Based Effectiveness	Digital Artifacts	qonoratod ducumont aro nut barod un diqital artifactr	Decumentrincerperate digital artifectrruch ar model generated view.	Program/Project user a mix of documents and digital artifacts to make decisions.	Program/Project user digital artifacts to make decisions.	Enterprize desirions are based on tool and user defined digital artifacts to make desirions.	pravide data for alternative view to virvalize, communicate, and deliver date, information, and knowledge to stakeholders. (DAU Glossery)
5. Information Fechnology 5. Information	Madeling Taal Access	Mudel occerr ir bared un derktup occerr	Access to models are based on IT login	Access to models are based on role thas ed permissions	Madel access permissions are shared within an project/program	Mudol access permissions are shared within an enterprise	The access tumudels based an madeling rates.
Fechnology	Madel Bared Taal Licenzing & Access	Nane ar Unmanaged	Taullicenter and access address specific project or program needs	Taal licenses and access are cansidered far new prajects as pragrams	Contor-wide licence access for commanly wed tools	Licenze count appropriate to the role, and access-controlled by role	Hau woll an arganization manager taol liceonree
5. Information Fechnology	Callabaratian capabilitier	Callabaration by burineer tool applications (e.q., E- mail, tolocom.)	System Madel File Exchange is identified and used	Variour organizations working on different parts of model. Models are integrated by azingle organizations.	On-line, real-time collaboration amongst distributed project/program teams	On-line, real-time collaboration amongst distributed teams for am enterprise	Synchranaw and wynchranaw data rich callabaratian amaną dirtributed team
5. Modeling Tool Construction	Madel Management	Madel management ir ad hac	Madel management ir an azrigned rale	Madel management adherer ta astanard ar ta a defined approach	Madel man agement ir ir applied ta all madelr far a yztom.	Madel management is appliced to all madels for an enterprise.	Madel management is responsible for establishing policy and manage the oversight of model collection activities, model valuation, acquisition and strategic model loans, for ensuring the application
5. Modeling Tool Construction	Dirtributed Databarof Tool interoperability	Na interaporability between madel bared taals	Model Bared Tool-to-Tool har ad hoc interoperability	Partial Fodoratod Databaro Management System (FDBMS)	Main took interoperable. Supporting took interact through file transfer.	Fully Federated w/standard "pluq" and splay" interfaces. Data is interchanged among taols	A fully Federated (or Confederated) data and IT infrartructure that functions as one virtual common database. Includes astandardized interface(s) for other datazources to join the Federation (APIs, urappers, etc.)
5. Modeling Tool Construction	Madel Bared Data/Taal Independencer	Dataf I unlindependencer are nut cunridered and data ir urually rerident in the tuul ar tuul directed default directurier	DatafTuulindependencer are cunridered and planned tu enhance data independence from tuulr	Datof Taol implementations independences are monoged to allow data to be independent from tools	Date/Taal 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 partability Inter-Databased and Data Rem associations among all data items defined,	Bifurcation Opportunity: Connecting to non-MBE reportories as well as MBE reportation. One is for sharing data and the other is for sharing model artifacts.
5. Modeling Tool Construction	Inter-Databaro/Tool Data Item Accessions	Databarer/tuulr are independent	Inter-Databaro/Tool Data Itom azociationz defined	Inter-Databare/Tool Data Item azzociations defined, captured, managed	Inter-Databaroffaal Data Kom arrectoriese emono all data itemr defined, captured, managed, and traceable	Inter-Databaref nan Data New azzasatuar amang ali data New defined, captured, mongod, and traceable uhere changer in mo datazauree alertr nunerz af ather datazaureez af intended update.	Capture and manage azznciations between data itoms within and between disparate data sources. Azznciations can be traced between data itoms regardlazz of their location.
Role-Bas			atagy Cools MRCM PR DR	INT r1 MBCM-RB Capabilities' Descript			

Role-Based MBCM | DE-Based MBC

"Role-Based View"

"Role-Based capabilities definition handout"

Example "Role-Based Print Layout"

"DE Goals-Based View"

"DE Goals and Focus Areas"

Model-Based Enterprise Matrix CONOPS

Per the User's Guide

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



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

- Pre-work to apply the matrix
- "Half-day workshop"

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

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

This workshop will provide sample scenarios to apply the matrix

Sample Enterprise Transformational Objectives

Government Organization

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



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

Identify the Organization Transformation Objectives

New!

Example of Matrix Assessment

Yellow= current state, Green is desired state

Identify the Organization Transformation

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

Use Matrix results to plan the MBSE capabilities needed

DoD DE Strategy Goal	Model-Based Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stare 4
Goal 1. Use of Models		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 lisk strategu.	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 engineeric sorces 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 strategg is documented as part of the organizations overall strategg at the enterprise level. The strategg is related to the overall strategg, Modeling is integrated with business information tools and results are used to inform systems engineers, program management, and all staff scross the enterprise it manage a full strate of business concerns.
Goal 1. Use of Models		No documented MBSE plan	Models are developed for parts of the system engineering or enterprise engineering processes or for only parts of the life cycle. Appropriate tools, environments, methods, and resources are provided.	Full System/Enterprise Models are developed and applied variously across the product life cycle and across Systems Engineering organizations. Appropriate tools, environments, methods, and resources are provided.	Multiple System Models are integrated for the enterprise. Consistent tool coverage and use within separate Systems Engineering Organizations. Appropriate tools, environments, methods, and resources are provided.	Consistent tool coverage within separate Systems Engineering Organizations across the enterprise. Multiple enterprise models are interfaced within or across mission areas. Appropriate tools, environments, methods, and resources are provided.
Goal 1. Use of Models	Common DE and MBSE Terminology	Appropriate terminology defined for the project or program.	Common Glossary/Data Dictionary	Top Tier terminology is defined for the enterprise.	Discipline and engineering specialty terminology is added to cover lower level models	Common, tiered taxonomies are defined and consistent across enterprises and consistent with accepted community standards.
Goal 1. Use of Models	Model Management	Model management is ad hoc	Model management is an assigned role	Model management adheres to a standard or to a defined approach	Model management is applied to all models for a system.	Model management is applied to all models for an enterprise.
Goal 1. Use of Models	SE Agreement Process	Modeling is not incorporated as part of the agreement processes.	Given a clear business case, modeling is applied in an ad hoc manner across projects or programs	Given a clear business case, modeling is applied in a consistent manner across projects or programs	Consistent model business case descriptions are being practiced across an enterprise	Consistent model business case driven planning guidance is in place and is being practiced across an enterprise
Goal 1. Use of Models	SE Organizational Project-Enabling Processes	Modeling is not incorporated as part of the Organizational Project Enabling processes.	Given a clear business case, modeling is applied in an ad hoc manner across projects or programs	Given a clear business case, modeling is applied in a consistent manner across projects or programs	Consistent model business case descriptions are being practiced across an enterprise	Consistent model business case driven planning guidance is in place and is being practiced across an enterprise
Goal 1. Use of Models	SE Technical Management Processes	Modeling is not incorporated as part of the Technical Management processes.	Modeling is part of the processes to improve quality and models contribute to the authoritative source of truth	Modeling is the basis for the processes. Digital artifacts are used to make SE Technical Management decisions.	Modeling is the basis for the processes and is used to optimize results across the project or program.	Modeling is the basis for the processes and is used to optimize results across the enterprise.
Goal 1. Use of Models	Model Configuration Management	Model Configuration management is ad hoc	Model configuration management is an assigned role	Model configuration management adheres to a standard	Model configuration management is applied to all models for a system	Model configuration management is applied to all models for an enterprise
Goal 1. Use of Models	Model Data Management	Model Data Management is ad hoc	Model data management is an assigned role	Model data management adheres to a standard	Model data management is applied to all models for a system	Model data management is applied to all models for an enterprise
Goal 1. Use of Models	SE Technical Processes	Modeling is not incorporated as part of the Technical processes.	Modeling is part of the processes to improve quality and models contribute to the authoritative source of truth	Modeling is the basis for the processes with digital threads covering some of the processes. Digital artifacts are used to make SE decisions.	Modeling is the basis for the processes with digital threads covering all selected processes. Digital artifacts and digital twins are used to make SE decisions.	Modeling is the basis for the processes with digital threads covering all processes Digital artifacts and digital twins are used to make SE decisions.
Goal 1. Use of Models	Modeling Stakeholder Requirements	Stakeholder requirements are not modelled	Stakeholder requirements are in a requirements management tool	Stakeholder requirements in a management tool are linked to enterprise and system models and are bid directional traceable. The requirements are linked model data that provide digital attifacts 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)
	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 artifiats aren't planned for use to satisfy entrylexit criteria.	Identification of model-based digital attriacts to satisfy entrylend criteria. Model results called out exploiting as products with derined product quality. Use of digital artifacts allow for some onteria 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 attilads allow for some criteria items to be addressed prior to the event. Model-based digital antilads to satisfy criteria along with inked narative. Model content is identified that satisfies criteria are linked to external list of criteria (e.g., inperink to Vord doc).	Peview and audit is set by model data and information availability. Review process allows for more flexible reviews so that some oriteria are acknowledged as a cooropilished before the scheduled review. Predominantly model-based digital artifiacts with as-needed documents to satisfy oriteria with linked narrative.	Enterprise organizations coordinate on common review oriteria application, talloring, and the use of specific digital attracts to meet specific oriteria. Models record the acceptance of oriteria items. Rolling, frequent review of model contents, of identified "Knowledge Points" allow stakeholders to accept that the review is complete for that knowledge point whenever the exit oriteria is met.
Goal 1. Use of Models	Modeling Process quality	Modeling processes have not be identified/established	Modeling is a parallel process to engineering processes and is used to demonstrate potential modeling benefits	Modeling is the basis-of and integral-to engineering processes quality Metrics, beyond those available from the tool	Modeling enables processes to be re-engineered to minimize steps, increasing timeliness, while preserving product quality	Modeling processes re-engineered provides measurable improvements across the enterprise Consistent metrics are used across the enterprise to manage the

Use any scoring method that your team agrees-to Instead of color coding an "X" and "Check" could be used

Use Assessment Results to Plan Capabilities Improvement

- Organizational transformation strategy
- Organizational modeling capability development roadmap
 - Community of interest roadmaps
- Acquisition strategy define modeling capabilities of the acquirer and the needed capabilities of the supplier
 - Qualify potential bidders
 - Drive the RFP development and communication between acquirer/potential bidders

Use Matrix to

to plan the MBSE capabilities neede

Organiźation

- Product development planning
- System engineering plans (SEP), system engineering management (SEMP)plans
- Modeling and information technology roadmaps to provide the modeling environments and tools for the digital engineering enterprise
- Enhance processes with modeling capability
- Enhance workforce development to adopt and use modeling

Using the MBCM: Acceptance and Levels of Support

5 Stages of Acceptance Model

5 Levels of Support Model

Kubler-Ross Grief and Loss Stages	MBCM Acceptance Stages*		Level of Support	Behavior	
Denial	Listen		Maximum	"I'll lead it" "Find a way to get it done"	
Anger	Believe	Plan and Proceeding	Proactive	"I'll help and implement it" "Go the extra mile"	
Bargaining	Plan and				
	accommodate		Moderate	"I'll look for things to support this"	
Depression	Conduct the				
	plan		Minimal	"I'll do what is necessary"	
Acceptance	Assess and			"Do what I'm told"	
	Plan		None	"Go through the motions"	
*From Al Hoheb, The Aerospace				"Wait and see" "Refuse"	

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

Corporation

Matrix Effort History

Matrix Effort Pedigree and Plan

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

The products have come a long way in a short time

Matrix Development Decision Points

1. Areas/categories cover the topic groups and can be allocated to Users Guide Roles

2. Row identification

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

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

Pilot Uses

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

Positive outcomes

Workshop Activity

Choose to participate in either scenario

Workshop Scenario 1 and Instructions

Govt Team: Split into teams doing the same work

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

Scenario 1: Candidate Driving Objectives

A satellite program portfolio acquiring a new satellite to the fleet

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

Determine those that are important and supplement with others if needed

Workshop Scenario 2 and Instructions

Commercial Team:

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

Scenario 2 Candidate Driving Objectives

New!

New product in a product line with new features

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

Determine those that are important and supplement with others if needed

Workshop Out Briefs

Workshop Participation Wrap-Up and Feedback

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

Running the Workshop for a Sponsor

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

Thank You

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

Sample Modeling Objectives

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