### Model-Based Capabilities Matrix

Digital Engineering IPT September 10, 2019

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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: <u>http://www.omgwiki.org/MBSE/\_</u>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)

#### 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)

omments:albert.c.hoheb@aero.org Joe.Hale@nasa.got

#### Role-Based View

Role Based	Model-Based						
Matrix Area	Capability Name and	Stage 0 Na documented MB2st westrateay, or the	Stage 1 Urganization MB2E westrateavir documented or	Stage 2 Urganization MESt westrateavist documented as part of the	Stage 3 Urganization MBSE we strategy is documented as part of the prognization?	Stage 4 Urganization MESE westrategy in documented as part of the organization's	Capability Description
		stratogy is described for ad hoc offerts. Each	part of its overall organizational strategy at the	arganization's overallstrategy at the system level. The strategy is related	avorallstratogy at the enterprire level. The strategy is related to the overall	nvorallatrato gy at the enterprize level. The strate gy is related to the overall risk	Thir ir documenting the Digital Engineering/Model Bared System Engineering (DE/MBSE) strategy ar part of the
4 Mandalana Indonesi	Morris o .	MBSE offertizztand-aleno te addrozzzpo cific	system level. The strategy is related to the overall	to the overall ricks trategy. Modeling results used to inform systems	rickstrategy. Modeling is integrated with business information tools and results	strategy. Mudeling is integrated with business information tools and results are	averall strategy an arganization has to provide the system/system af systematenterprize. The concept is that
1. workforcerculture	MBSE Ure Strategy	concorner.	ransterato-qy.	onginootz acreszystom onginooring pharoz and rer all as ciplinoz	urea to inform zyztomz engineerz, program management, and aliztarr actuzz	urea ta infarm all'etarr acraze the enterprise it manage a full range ar burness Comment him dhennessei on de lin den den sisteret etara de la deservicio de la deservicio de la deservicio de d	DEFINDSE D woo an resonant of the averall wark and refure.
1. Workforce/culture	Terminalagy	ar program.	Common Glazzery/Date Dictionery	Tup Tier terminulugy ir defined fur the enterprire.	modela	consistent with accepted community standards.	A zet of lexicon, texonomier and glazzaries with know precidence.
1 Workforce/culture	Madeling Baler and Researcibilities	Madeling rates and responsibilities are not identified	Mudeling ruler and recouncibilities are identified	Mudoling rules and responsibilities are charactorized by mudol-based Knowledge, Skills, and Abilities (KSAr)	Madeling rates are provided the permissions no cessory to perform their responsibilities	People who need to be active are identified and involved. Sufficientztaffing and staffing and staffing and staffing the second	Madeler, policy maker, contracting, model curator, model manager, model data manager, ASOT configuration manager at these.
1. Workforce/culture	Madeling Development Skillr	Mudel+bared Knuuledge, Skillr, and Abilitier (KSAr) are undefined and unknuun. Nune, ur ad- hacfar allztaff	Mudel-bared Knuuledge, Skille, and Abilitier (KSAr) are defined for modelers. Mudeling of companents of the Enterprise or System.	Madel-bared Knauledge, Skillr, and Abilitier (KSAr) are defined far raler invalved uith madeling: Enterprize Architect, SE, PM, IT, madelerr, etc Navice Madelerr an full Enterprize ar System sukrystem madels.	Madal barod Knawlodqo, Skille, and Abilition (KSAr) are defined far raior invalved with enterprice management. Expert madel development lead with experience practicing madeling an at least 1 project that successfully completed at least 3 major technical review that wed madels insupport of the	Export model development lead that sets modeling standards and evaluates the model product quality of other modelers	Mare then just medicing two lespertize. This includer expertise in model structure for chitecture that supports all zabequent was
1. Workforce/culture	Madeling Urezkille	None, or ad-hoc for all staff	Can generate taalstandard digital artifactr ar needed ta ovaluate the Enterprize ar System.	Can generate taal curtam digital artifacts as needed to evaluate the Enterprise or System.	Can generate curtum digital artifectr acruss tuuls, models, and datasets tu evaluate the Enterprise or System.	Uan antrobuts to defining the enterprove, system, and other data needed by the complete team to perform analyzir for IPTz, review, auditz, and other technical and programmatic decisionz.	Thir cavors a rate that all gavernment ar acquirerer team members mut have to canduct model based acquiritian
	Madeling-related Training/KSA		Tool familiarity training completed. Initial	Madeling as madel wors experience anspecific taals with respect to their	Domanstrating rale capabilities using the madels, caaching and instructing	Provide leadership in proposing, designing, and delivering training that is	
1. Workforce/culture	development	Na training ar develapment activities	experience to perform their modeler or wer roler.	rale ar a wer ar madeler	athers	appropriate for the modeling and wer roler	Multilevel training zeriez, including "handron" real world("like) execution. Haul Walter to help Nezh thirzection out
Processes/Methodol	SEAgroomontProcoss	agreement processes.	ad has manner across projects or programs	acreuz projecta er pregrama	enterprize	California de la company care ariven prenning quisance o in prece en a o being precticed ecraor en enterprire	the set of processes that are mort important to their application. The stage descriptions may be the same for each process or tailored.
Processes/Methodol ogy	SE Organizational Project- Enabling Processes	Madeling is not incorporated as part of the Organizational Project Enabling processes.	Given a clear buriners care, madeling ir applied in an ad has manners praisects ar maram Madeline ar park afficiency of the service to uncome analytic	Givon a clear buriness case, modeling is applied manner across projects or programs	Convirtent model burinezy care descriptions are being practiced across an enterprise	Canvirtent madel buriness care driven planning quidance is in place and is being practiced acrass an enterprise	The second period of the second
Processes/Methodol ogy	SE To chnical Managomont Processor	Madoling ir nat in carparatod ar part af tho To chnical Managoment pracezzor.	and models contribute to the authoritative source of truth	Madoling ir the barir far the pracezrer. Digital artifactr are ured ta make SE Technical Management decirianr.	Madeling ir the barir for the processes and is used to optimize results across the projector program.	Modeling in the barier for the processer and is used to optimize results a cross the enterprise.	line item with the set of processor that are must important to their application. The stage descriptions may be the same for each process or tailored.
2. SE Processes/Methodol	Madel Canfiguration Management	Madel Canfiguration management ir ad hac	Madel canfiguration management ir an azzigned rale	Mudol cunfiguratiun managomont adhoror tu aztan dard	Madol canfiguratian managomont ir applied ta all madolr far azytrom	Madel canfiguratian management ir applied ta all madelr far an enterprire	ISOVIEC/IEEE 15288.1 paragraph 6.3.5
2. SE Processes/Methodol	Madel Data Management	Madel Data Management ir ad hac	Madel data management ir an azzigned rale	Madol data manaqomont adhoror ta artandard	Madel data management ir applied ta all madels far asytsom	Mudol data mana qomont ir applied tu all mudolr fur an onterprire	ISO/IEC/IEEE 15288.1 paragraph 6.3.6
Processes/Methodol	SE Technical Processor	Madeling ir natin carparated ar part of the Technical processes.	maaaling in part of the processor to improve quality and models contribute to the authoritative source of truth	Mudeling in the baris for the processes with digital threads covering some of the processes. Digital artifacts are used to make SE decisions.	Madeling in the baris for the processes with digital threads covering all selected processes. Digital artifacts and digital twins are used to make SE decisions.	Modeling in the barin for the processor with digital threads covering all processor Digital artifacts and digital twins are used to make SE decisions.	the or annup of the or annup of the context inclusion paragraphs will and will be determined or may used to repeat the line item with the rot of processes that are mart important to their application. The stage descriptions may be the same for each encourse of willing d.
297_				Stakeholder requirementr in a management tool are linked to enterprize		,	
ogy	Madeling Stakehalder Requirementr	Stakhalder requirements are nat madelled	Stakohaldor requirementr are in a requirementr management taal	andrystem mudelr and are bi directional traceable. The requirementr are linked model data that provide digital artifactorypanning the life cycle and	Enterprire and zystem stakeholder requirements are bidirectional traceable	Stakeholder requirements are traceable aross enterprises	ISO/IEC/IEEE 15288.1 paragraph 6.4.2
Processes/Methodol ogy	Madol·Barod Vorification and Validation	Naplan far vorifying ar validating roquiromonts in the madels	Plan far vorifying and validating requirements in the models	Verification and validation plan relier on model contentr and analyzir via requirements "analyzir"	Madeling development processor have been at tablished, madeling patterns, styles, and standards have been defined, and standard V&V procedures and ernerame have been formulated.	Mudeling development processor have been astablished, modeling patterns, styles, and standards have been defined, and standard V&V procedures and processor have been formulated, fincluding asprecisted automated seriety and	ISO/IEC/IEEE 15288.1 paragraphz 6.4.1 and 6.4.14.
3. Program/Project			engineering prenterprize engineering processes or	Full System/Enterprize Madels are developed and applied variously across	Multiple System Madels are integrated for the enterprise. Consistent tool	acraze the enterprize. Multiple enterprize models are interfaced within ar	Madeling as part of the System Engineering Plan as System Engineering Management Plan. It should caver the
Processes			for only parts of the life cycle. Appropriate tools,	the product life cycle and across Systems Engineering organizations.	caverage and we within reparate Systems Engineering Organizations.	a craze mizzion are az. Appropriate toole, environmente, methode, and rezources	Information Technology (IT) infrastructure, modeling tools, modeling environments, identify the type and purpose of
mediodology	rister survey rister;	na aucampiro a nose pran	Taentirication or model over a sigital artiracurto	Revisu precess use in a che que avent unt angun entrance and entr	Hoviel and avait start by medal date and intermetion availability. Noviel	Enterprise arganizations' courainate on common review criteria application,	urgital artiraculare the product from the withoritative Source or Iruth, so that ar the system models are queried for
3. Program/Project	Management Program Review (MPD(s) Mileston semicor	Review are not model bared. Review and audit in	zatirfy ontryfoxit critoria. Madol rorultr callod aut our liaithe ar canducte with defined can dont availar	critoria ar woll ar frazon baroliner. Uro af digital artifactr allaw farzamo actoria in materia addesses dasim texto succes. Madelakara dificial	process allows for more flexible reviews a that some criteria are acknowledged	tailaring, and the use af specific digital artifacts ta meet specific criteria. Madelane and the anomators of actual internet ways and the second s	evidence against the technical review and audit criteria, the system models may be updated. Note that System Models
Processes	program review, technical	ruch ar contract award. Digital artifacts aron't	Use of digital artifacts allow for some criteria items	artifacts twatisfy criteria along with linked norrative. Model content is	digital artifacts with as needed documents to satisfy criteria with linked	model contents, of identified "Knowledge Points" allowstakeholders to accept	(o.q., ontrancolruccorr criteria bared an process abjectives as reflected in the view/vieupaints, not due creation).
Methodology	roviour, auditr	planned far we tazatirfy entryfexit criteria.	tube addressed prim tu the event.	identified that ratirfier criteria are linked to external list of criteria (e.q.,	narrative.	that the review ir complete for that knowledge point whenever the exit criteria	See ISO/IEC/IEEE 15288.2. See GAO/NSIAD-98-56 Best Practices for information on "Knowledge Points"
Processes Methodology	Madel Metricz	Matrics are not used to manage the model development, quality, or offectiveness	Available metrics are reported from the various modeling tools used	Matriar, boyand thare available fram the taal canfiguration, are reported ta addrear madel development, quality, and offectivenear needs	Motrice are used to manage the model development, quality, or effectiveness for asystem or enterprise	Consultant motivize are used across the onterprove to manage the model development, quality, or offectiveness with trend information kept and decirion making thresholds established	Having a madeling metrics pragram ta imprave the madeling offarts and the target system ar enterprise.
4. Model Based			Elementruithin a model follow artructured	approach are removed. Model. Constraints are identified and model blocks	Integration acrossystems models for a project/program use the same	Integration across systems models for an enterprise use the same structured	
Effectiveness	MadelingIntegration	Elementr uithin a mudel are not integrated	approach (ruch ar OOSEM)	structures are created.	structured approach. A Library of rewable SysML blocks is created and used. Model objectives and some detailed model requirements for specific models	approach. A Library of rewable SyzML blocks is created and wed Modeling development processes have been established, modeling patterns,	System Engineering Mudel pattern as defined by Object-Oriented Systems Engineering Methud (OOSEM)
4. Model Based Effectiveness	Verification and Validation of Models	The organization har notztated model objectives - - no baris for verification and validation of the models	The organization harstated model objectives but not model requirements . Partial V&V evaluation of the resultant model is passible	Madel abjectives and same general madel requirements have been stated. Plans for VRV evoluation of the model traceable to the model requirements have been made	have been stated. V&V evaluation of the models trace able to the model requirements is planned and includes V&V of modeling patterns, styles and standards, so used as having defined procedures.	ztyloz, and ztandar dr have been defined, and ztandard V&V procedurez and program have been formulated. (Including azzneisted automated zeripte and tauk). V&V of the madelic is performed and updates to the madele made.	Medel abjective examples includes 1. Medeling a new cancept (e.g., Universal cammand and cantral), 2., Madeling system, subsystem, and interfaces, 3. Medeling aperational functionality to generate/everify operational requirements, 4. Medeling a camples algorithm. 5. Medelsystem V&V processor
4. Model Based Effectiveness	Madeling Azzurance	Madel Azzuran ce iz nat canzidered	Madel azzurance iz defined with known z caler and methodz	Madel azzurance targetz are identified in azzuciation with the offert zchedule and cart	Madel azzurance measurement and carrective actions are conducted for projects/programs	Madel azzurance measurement and carrective actions are conducted for the enterprise	Por omorging research from The Aerospace Corporation. Model Assurance Level (MAL) - A measurement system for model value and quality. Identifier sisk areas 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 boon identified to contribute to the authoritative rource of truth	Data and Information are discoverable from specific models to address specific quaries across parts of the enterprise	Data and information provide knowledge to specific decirion makers across parts of the life cycle and across parts of the enterprise	Data and information are discoverable to provide knowledge to start ate gic to near real-time decision makers across the life sysle and across the enterprise	The callectum of modeling data that represents the target system(z) along with the rationale. https://www.acg.ord.militerinisticivestinic_de_def.html Reference NASA-STD-7009 for examples of factors for assessing "Acceptability for Use" and "Ore shifting of Results"
							nergarrizuu. seç uz animzərinət sərəzərini. 32. ası nəm vəqətəri nəzətərin əxeelərinə, sanrqarasısı, ası səmən sərərərin - ləələr ənəlytical enaçərinə ası ası ənələzəriy əsərəti kərə tə cantralla intərəfəyət ərə və həritəti dəta, zəftu are, information, ənd knowledqe in the enterprize data-information-knowledqe zyztəmz, bared on the
+. model based Effectiveness	Digital Threads	Digital threads have not been identified	Digital threads have been identified.	Digital threads have been established fir limited program/projects across the enterprise	Digital throads have been established contributing to the authoritative source of truth for limited programs/projects across the enterprise.	Urgital threads have been established contributing to the authoritative source of truth for an enterprise.	Digital System Model template, to inform decirion makers throughout asystem's life cycle by providing the capability to access, integrate, and transform disparate data into actionable information. (DAU Glossary)
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 Pratatype, DT Instance, DT Aggregate, DT Environment)	Digital tuin typer are offectively used to make desirions for limited a programs/projects across and enterprise	Digital tuin typer are offectively wedfar an enterprire.	http://fuuu.ecg.urd.malfzorfacteatevz/fact_ds_ds/bun_Depted_func_Angested multiphysics,multicale, probabilisticsimulation of an ar-built zystem, enabled by Digital Thread, that was the best available modely, zener information, and input data tumirar and predict activities/performance over the life of for
4. Model Based	N 2 18 17 1	generated ducument are not based on digital	Ducumentrin curpurate digital artifactrzuch ar	Program/Project user a mix of documents and digital artifacts to make	Process and Provide strategy of the state of	Enterprize desizione are bazed un tuul and wer defined digital artifacte tu make	provide data for alternative view to viewalize, communicate, and deliver data, information, and knowledge to the state of AUI Glassow?
5. Information	Digital Artifactr	artiracty	mader generated view.	de-curianur.	r nagram re regect urer algical artiracurte make accurent.	acculatu.	Proceedings (Deco diday any)
Technology 5. Information	Madeling Taal Access Madel Based Taal Liseasian b	Madel access is based an desktap access	Access to models are based on IT login Tent lineares and access address modifier spin star	Access to models are based on role-based permissions	Madel access permissions are shared within an project/program.	Madel access permissions are shared within an enterprise	The access to models based on modeling roles.
Technology	Access	Nano ar Unmanagod	program needs	Taallicenter and access are considered for new projects or programs	Contor-wide licence access for commonly used tools	Licenze count appropriate to the role, and access-controlled by role	Hau well an organization manager tool lice enzer
5. Information Technology	Collaboration capabilities	Callabaration by burineer tool applications (e.q., E- mail, tolocom.)	System Madel File Exchange is identified and used	Variaur arqunizations working an 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	Synchronow and arynchronow data-rich collaboration among distributed to ame
6. Modeling Tool Construction	MadelManagement	Madel management is ad has	Madel management ir an azzigned rale	Madel management adherer to axtanard or to a defined approach	Madel management is is applied to all models for azystem.	Mudel management ir appliced tu all mudelr fur an enterprize.	Madel man agement is responsible for establishing policy and manage the oversight of model collection activities, model valuation, acquisition and strategic model loons, for ensuring the application
6. Modeling Tool Construction	Distributed Database/Tool interspecability	Na interaporability between madel bared taals	Madel Bared Taal-ta-Taal har ad hac interaporability	Partial Fodoratod Databaro Managomont System (FDBMS)	Main took interoperable. Supporting took interact through file transfer.	Fully Federated w/standard "pluq-and-play" 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 datasources to join the Federation (APIs, urappers, etc.)
6. Modeling Tool	Madel Bared Date/Taol	Data/Implindependencer are not considered and data is wrually resident in the tool or tool directed default directories	Data/Taulindopondon.cor are canzidorod and planned ta enhance data independence from tank	Data/Taol implementations independences are managed to allow data to be independent from tools	DatafTaol implementations independences are managed to allow data to be independent from tools and allow import/copart to faster data watakili v	Data ir independent of took and allour for partability	Bifurcation Opportunity: Connecting to non-MBE reparitories as well as MBE reparitories. One is for sharing data and the other is for sharing model artifacts.
6. Modeling Tool	Inter-Databare/Tool Databa		Inter-Databare/Tool Data Item azzaciationz		Inter-Databaro/Taol Data itom arrectorione on maa all data itomz defined,	Inter-Databasef I an Data item associations a moniq all data items defined, captured, managed, and traceable where changes in one data source alerts	Capture and manage azzneiations between data itoms within and between disparate data sources. Azzneiations can be
Construction	Americation	Databarorftuulr are independent	defined	Inter-Databaro/Taul Data Itom azzaciatiunz defined, captured, managed	capturod, managod, and tracoablo	nunors of other datasources of intended updates	traced between data items regardless of their location.

Role-Based MBCM | DE-Based MBCW | OSD DE Strategy Goals | MBCM-RB\_PRINT\_r1 - MBCM-RB Capabilities' Descr

"Role-Based View"

"Role-Based capabilities definition handout"

Example "Role-Based Print Layout"

"DE Goals-Based View"

"DE Goals and Focus Areas"

## 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					
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, 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
User IE Viewpeint/Views	N/A	Doc Gon	III draws from Model app	UI draws from multiple	UI supports Interrogation; multiple

- 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
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, 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
User IF, Viewpoint/Views	N/A	Doc Gen	UI draws from Model app	UI draws from multiple models/DBs	UI supports Interrogation; multiple configs

- 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					
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, 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
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 it 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*

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

Identify the Enterprise, Program, or System Transformation Objectives Use Matrix to identify the organization current and needed MBSE capabilities to meet the Transformation Objectives

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

#### 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 multiyear 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



New!

#### Example of Matrix Assessment

Green = attribute capability is operational, Yellow = attribute capability needed Organization Transformation Objectives

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

Use Matrix results to plan the MBSE capabilities needed

		Model-Based					
Role Based	DoD DE	Name and					
Matrix Area	Strategy Goal	Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
					Various organizations		
					working on different parts	On-line, real-time	
5. Information			Collaboration by business	System Model File	of model. Models are	collaboration amongst	On-line, real-time collaboration
Technology	Goal 4. Establish		tool applications (e.g., E-	Exchange is identified and	integrated by a single	distributed project/program	amongst distributed teams for
Infastructure	Environments	Collaboration cap	mail, telecom.)	used	organizations.	teams	am enterprise
							Fully Federated w/ standard
		Distributed	No interoperability		Partial Federated Database	Main tools interoperable.	"plug-and-play" interfaces.
6. Modeling Tool	Goal 1. Use of	Database/Tool	between model based	Model Based Tool-to-Tool	Management System	Supporting tools interact	Data is interchanged among
Construction	Models	interoperability	tools	has ad hoc interoperability	(FDBMS)	through file transfer.	tools
							Inter-Database/Tool Data Item
							associations among all data
							items defined, captured,
		Inter-				Inter-Database/Tool Data	managed, and traceable where
		Database/Tool			Inter-Database/Tool Data	Item associations among all	changes in one data source
6. Modeling Tool	Goal 1. Use of	Data Item	Databases/tools are	Inter-Database/Tool Data	Item associations defined,	data items defined, captured,	alerts owners of other data
Construction	Models	Associations	independent	Item associations defined	captured, managed	managed, and traceable	sources of intended updates
						UI supports Interrogation	
		User Interface				across the federated	UI supports Interrogation
		(UI),	Model are not used to		Models allow document	systems Authoritative source	across the federated enterprise
		Viewpoint/View	identify or define the user	Models allow document	generation, generation of	of truth and provides	Authoritative source of truth
6. Modeling Tool	Goal 1. Use of	s, and	interface or	generation, generation of	views/viewpoints and	visualizations for decision	and provides visualizations for
Construction	Models	visualization	view/viewpoints	views/viewpoints	custom visualization	making	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

Use Matrix to

to plan the MBSE

Organization

- 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
  - GBSD
  - AF/SMC
  - AF ASE
  - NRO
  - NAVAIR
  - USA
- All have tailored the matrix to suit their needs
- Getting feedback on results is desired