International Council on Systems Engineering
A better world through a systems approach

Insights from the Field: Applying the Capability & Maturity Assessment Framework (C-MAF)

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C-MAF Background

Maturing Digital Engineering Enterprises

Need: Numerous organizations are required to transition their workforce and tooling to digital forms. This is not a binary transformation. How does an organization know what to do or where to focus to begin or mature their digital transformation?

Objective: Provide comprehensive guidance for organizations who that are adopting digital engineering.

C-MAF: A framework which integrates and refines strategy, processes, and tooling requirements from existing guidance. The C-MAF has established patterns to implement enterprise specific guidance.

What do the guidance sources cover?

- Individually, the guidance sources cover the 'why', 'what', and 'how well'.
- Collectively, they cover the three most important pillars for setting, executing, and measuring maturation progress towards a strategy.

Source	Reason for use (or what question is being answered)	**Concepts of policy or guidance activities/ capabilities** that would need to exist **at an enterprise level**	**Concepts of maturity** (i.e., to what level an organization is doing things)	**Explicit DE Ecosystem requirements** from tooling and interoperability capability perspectives
2018 DoD Digital Engineering Strategy	**The "why":** Primary source for direction and action.	✓	*0*	*Very light*
INCOSE Model-Based Capability Maturity Matrix (MBCM)	**The "what":** Workflow and organization concept focus. Primary source for maturity concepts.	*Very light*	✓	*Very light*
DoD DE Ecosystem Requirements	**The "how (well)":** Out of OUSD(R&E). Only source with solid tooling focus, but does not cover concepts outside the DE Environment.	0	0	✓

Quick Structure Recap

Sheet	Purpose
Explanation	High-level overview of the C-MAF, its sources, its structure, and its usage intent
Dashboard	Complete set of profile charts from the main assessment groups derived from the 2018 DoD DE Strategy (i.e., corresponding to goals 1 through 5)
Gs1-2 DE DEV AND EXEC	Activity-specific decomposition of 2018 DoD DE Strategy goals 1 and 2; **Focused on DE capability development and execution**
G3 TECH INNOVATION	Activity-specific decomposition of 2018 DoD DE Strategy goal 3; **Focused on technological innovation associated with advancing DE practice**
G4 DE ECOSYS INFR	Activity-specific decomposition of 2018 DoD DE Strategy goal 4; **Focused on DE Ecosystem infrastructure and capability needs to support effective DE practice**
G5 WORKFORCE DEV	Activity-specific decomposition of 2018 DoD DE Strategy goal 5; **Focused on workforce development, including identifying needs, training, measuring, and collaborating**
G5 ORG TRANSFORM	Activity-specific decomposition of 2018 DoD DE Strategy goal 5; **Focused on organizational transformation, especially higher-level leadership, policy, or guidance needs to support effective DE practice**
BASE-2018 DoD DE Strategy-14pts	The complete set of 2018 DoD DE Strategy goals decomposed: 5 main goals, 14 goal components, specified sub-components
BASE-INCOSE MBCM-SORT ID	The complete INCOSE MBCM; Assigned unique row IDs based on DoD goal, INCOSE role-based name, and INCOSE's model-based name
BASE-OUSD(R&E) Ecosys Reqts	The complete DoD OUSD(R&E) DE Ecosystem Requirements list (from the 12/2022 draft version); Assigned unique row IDs based on its category and subcategory abbreviations

Example Page

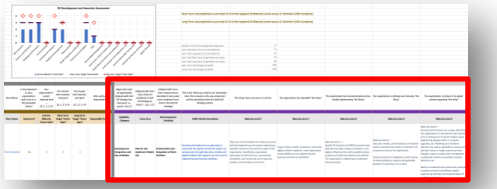
Near Term: Accomplished a sum total of 14 of the targeted 18 Maturity Levels across 17 Activities (78% Complete)

Long Term: Accomplished a sum total of 14 of the targeted 26 Maturity Levels across 17 Activities (54% Complete)

Number of Activities Designated Important	17
Sum Total Near Term Current Maturity	14
Sum Total Long Term Current Maturity	14
Sum Total Near Term Target Maturity Levels	18
Sum Total Long Term Target Maturity Levels	26
Near Term Percentage Complete	78%
Long Term Percentage Complete	54%

Short Name	*Is this important to your organization right now or in the forseeable future?*	*Your organization's current maturity level -- (0, 1, 2, 3, 4)*	*Your shorter-term maturity level goal -- (0, 1, 2, 3, 4)*	*Your longer-term maturity level goal -- (0, 1, 2, 3, 4)*	*Who will be responsible?*	*Major Goal Area of Applicability (Aligned with DoD DE Strategy top-level goal, i.e., goals 1 thru 5)*	*(Aligned with Goal Focus Areas as numbered in DoD DE Strategy as Goal.n -- e.g., 5.1)*	*(Aligned with Focus Area Components as described in text under each numbered Focus Area in the DoD DE Strategy)*	*This is the "What you need to do" description. Here, this is based on the sub-component activity description from the cited DoD Strategy portion.*	*"The thing" does not exist or is ad hoc.*	*The organization has identified "the thing"*	*The organization has communicated and has started implementing "the thing"*	*The organization is refining and maturing "the thing"*	*The organization is mature in its digital practice regarding "the thing"*
Short Name	**Important?**	**Current Maturity *Insert Date***	**Near-Term Target *Insert Date***	**Long-Term Target *Insert Date***	**Responsible Party?**	**Capability Category**	**Focus Area**	**Sub-Component (Activity)**	**CMAF Activity Description**	**Maturity Level 0**	**Maturity Level 1**	**Maturity Level 2**	**Maturity Level 3**	**Maturity Level 4**
Work Activities	Yes	2	3	4		**Development, Integration, and Use of Models**	**Plan for and Implement Model Use**	**Orchestration and Integration of Work Activities**	**Develop and implement an approach to represent the system of interest and/or its components through data sets, models, and digital artifacts that support use and reuse in engineering and business activities.**	There are no formal plans for model use across technical engineering and systems engineering activities relevant to the business needs of the organization. Specifically, organization approaches to technical use, requirements traceability, and structured use of data sets, models, and simulations are ad hoc.	Types of data, models, simulations, and other digital artifacts needed to meet organization responsibilities across engineering and business activities are identified.	Maturity Level 1 + Specific DE (inclusive of MBSE) processes that describe how data, models, simulations, and digital artifacts will be used to guide business practices and technical decisions are defined. The organization is beginning to implement these processes.	Maturity Level 2 + Data sets, models, and simulations are actively used to represent the system of interest or its components across the organization. Initial processes for feedback on performance of these activities to support the applicable phase(s) of acquisition are in place.	Maturity Level 3 + Structured DE practices are in place that allow the organization to vet potential requirements prior to Request for Proposal release, assess engineering change orders or program upgrades, etc. Modeling and simulation activities are used as applicable to assess and optimize resource usage, examine process changes, support supply-chain management routing and inventory quantities, business decisions, etc. Metrics are defined and continuously analyzed to guide consistent and effective digital engineering activities and implementation of model-based practices.

Example Page



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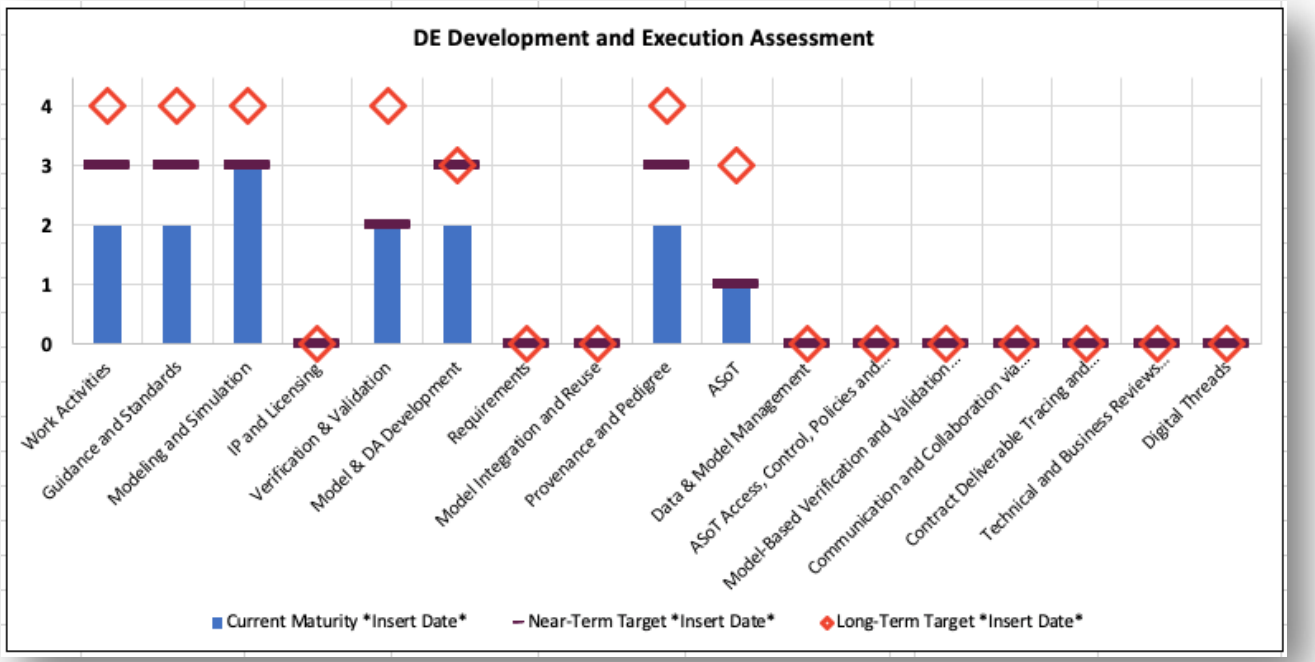
Example Page

Short Name	Is this important to your organization right now or in the forseeable future?	Your organization's current maturity level -- (0, 1, 2, 3, 4)	Your shorter-term maturity level goal -- (0, 1, 2, 3, 4)	Your longer-term maturity level goal -- (0, 1, 2, 3, 4)	Who will be responsible?
Short Name	**Important?**	**Current Maturity *Insert Date***	**Near-Term Target *Insert Date***	**Long-Term Target *Insert Date***	**Responsible Party?**
Work Activities	Yes	2	3	4	

Example Page



Evaluation of Organizations

Organization A

Organizational Summary





Objective

- Generate system requirements for use on updating an existing sub-system on a program of record
- Evaluate multiple supplier's proposed updates to the existing system (arch and design)

Application Domain

- Electro-magnetic Spectrum Operations
- Hardware
- Firmware
- Software

Organizational Composition

- Integrated Product Team
- FTE < 20
- Primarily DoD civilians
- Some military, some suppliers
- Small team, focused purpose with mostly mandated infrastructure

DE Maturity

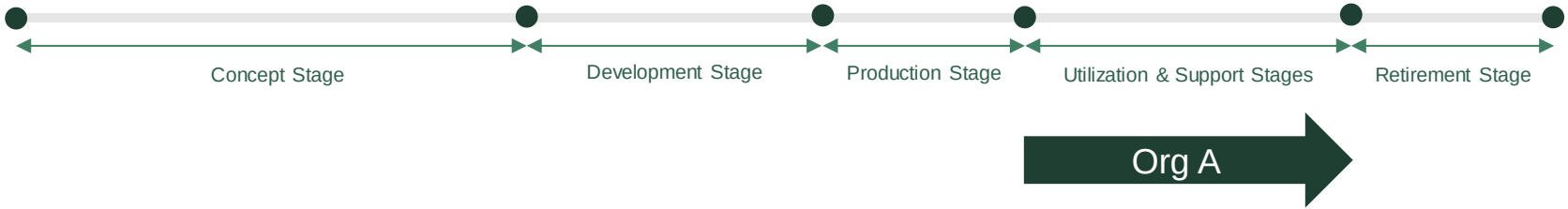
- Some MBSE practitioners
- Other M&S tools
- Other digital engineering tools (DOORS, etc.)
- Experience with interoperability between tools

Challenges

- Inconsistent quality of model-based artifacts
- Lack of standardized traceability between engineering change proposals, requirements, and system design
- Multiple data protections levels and related policy constraints for DE tooling

Lifecycle Phases – Org A

Organization A primarily matures system requirements for a specific, well-scoped subsystem on a larger complex system based on rapid prototyping, evaluations, and engineering change proposals.



Organization A has applied DE for ~2 years

Organization A: Integrated Product Team for one sub-system

Insights from the field

Application

- 6 sessions, totaling 11 hours
- Little tailoring of maturity level language
- 4-6 participants from the team with 1 team member strong in SE, the rest were domain SME's that were interested in MBSE and DE
- Added priority levels as proxies for value streams
- 46 capabilities deemed important
- Near-term goal dates: 1-2 years out
- Long-term goal date: 2-4 years out

Results

- Mostly productive discussion during evaluation
- Fairly scoped targets
- C-MAF is informing activities to perform in an ad hoc roadmap, just in time implementation

Maturity Phase	0s	1s	2s	3s	4s
Curr.	33	7	2	4	0
Near	2	23	15	6	0
Far	2	2	17	21	4

Organization B

Organizational Summary





Objective

- Generate capability requirements for use on programs of record
- Steer long-term DoD investments through research, experiments, and influence

Application Domain

- Networking
- Command and Control

Organizational Composition

- 20 < FTE < 50
- 8 teams
- Majority DoD civilians
- Some military
- Mid-sized org, focused purpose with mostly mandated infrastructure

DE Maturity

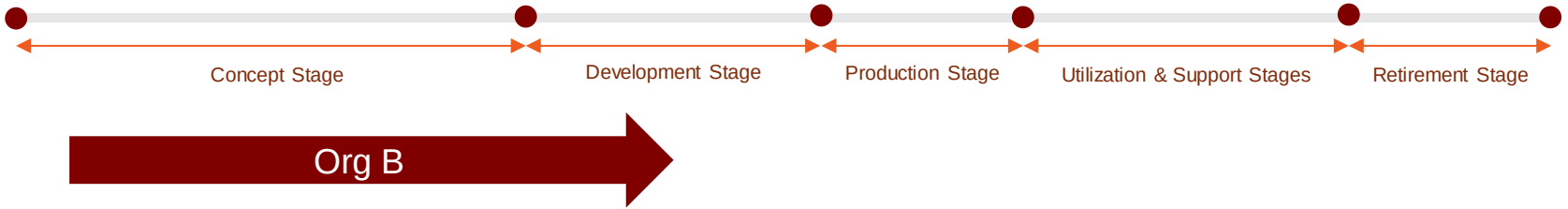
- Some MBSE practitioners
- Standard business software
- Some experience with interoperability between tools

Challenges

- Quality of requirements and quality of handoff
- Lack of linkage between requirements and architecture
- Organizational knowledge not easily discoverable

Lifecycle Phases – Org B

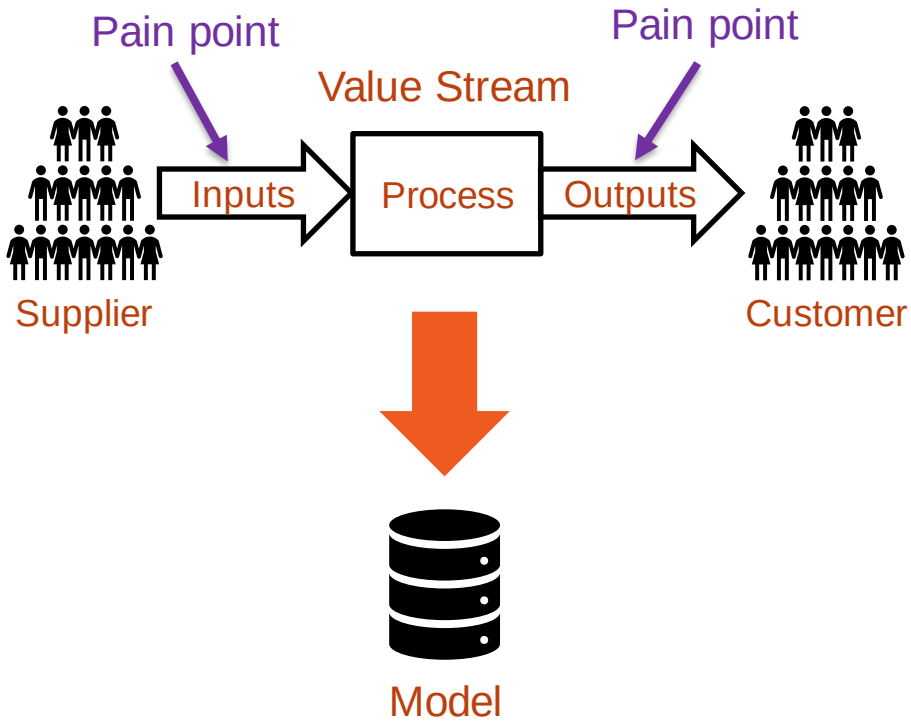
- Organization B primarily provides capability requirements during pre-acquisition as part of the Joint Capabilities Integration and Development System (JCIDS) process
- After an initial capabilities document is released, they take an advisory role through the rest of development



Organization B has applied DE for ~1 year

Inputs to the Evaluation

- SIPOC with pain point elicitation focused at the interfaces
- Helped level-set org B and give better visibility across the organization
- Also helped GTRI understand the context for the evaluation and provide better guidance during evaluation



Organization B: C-MAF

Insights from the field

Application

- 6 sessions, totaling 11 hours
- Little tailoring of maturity level language
- 4-6 participants from a single branch with the most SE and DE knowledge, representing the rest of org B's branches
- All branches participated in early value stream mapping exercises
- All 57 capabilities deemed important
- Near-term goal date: 1 year out
- Long-term goal date: 4 years out

Results

- Mostly productive discussion during evaluation
- Fairly ambitious targets
- C-MAF is actively informing activities to perform in the roadmap

Maturity Phase	0s	1s	2s	3s	4s
Curr.	52	4	1	0	0
Near	0	32	22	3	0
Far	0	9	6	13	29

Lessons Learned

Form and Format of the C-MAF

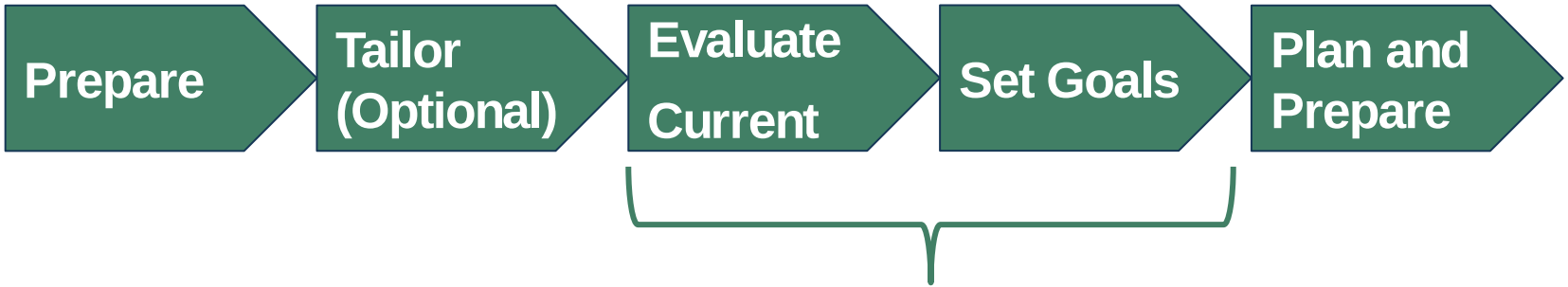
Spreadsheet Form

- Criticisms
  - Some navigation "clunky"
  - Short names insufficient for traceability to sources
  - Tracing to external tools and methods for implementing in a roadmap is difficult
- Praises
  - Low barrier to entry

Model-Based Form

- Criticisms
  - Not as accessible or understandable for non-modelers
  - Takes additional setup time
- Praises
  - Subsequent evaluations are easy to conduct
  - Easy comparison and trend-tracking across instances
  - Good traceability to model-based roadmap

Applying C-MAF



Lesson: Do these sequentially per row – high cognitive cost for switching

Preparation

Prepare

- Requires empowered decision makers and a wide range of SMEs
- **2-hours is the "sweet spot"**
- Scoping:
  - Discuss available resources prior to evaluation
  - Establish and review critical needs – value streams

Tailoring

Tailor (Optional)

- **Unlikely to happen the first round**
  - Not enough organizational knowledge the first round
  - Expect more tailoring in subsequent evaluations
- Only consider adding rows after completing a Capability Category (column H)
- Significant time commitment – **add to estimates here if performing tailoring**

Evaluation of Current Maturity

Evaluate Current

- Quickly determine if row is important; if not, move on
  - Especially **between 0 and 1, easy to "get wrapped around the axle"**
  - **Bring them back to the column headers** to keep them focused
- Some rows are tricky – **the organization has to identify its needs (level 1), but doesn't have the authority or resources to do the other levels**
- Having a decisive leader from the organization helped keep things moving

Setting Near- and Long-Term Goals

Set Goals

- Discuss level of effort and capture potential tasks to achieve near-term goals
- Determine if row contains foundational or critical needs for **near-term**
  - **Does it contribute to or enable the value streams?**
- Make sure the “responsible party” is in the room when assigned to the row
- Having a decisive leader from the organization helped keep things moving

Planning and Preparing

Plan and Prepare

- Evaluate list of short-term goals against available resources
  - Reduce number of near-term goals if necessary
- Use the long-term goals as a backlog for fiscal year planning
- Create roadmap
- **Be wary of using C-MAF as a 'report card'** to grade teams or organizations

C-MAF Product Status and Q&A

Product	Status
C-MAF Spreadsheet	Released
C-MAF Model (UAF)	Planned by end of 2025
C-MAF User's Guide	Released
C-MAF Developer's Guide	Released

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Backup

Case Study Overview

Characterizing the Elements of the Case Study

Characterizing the Organization

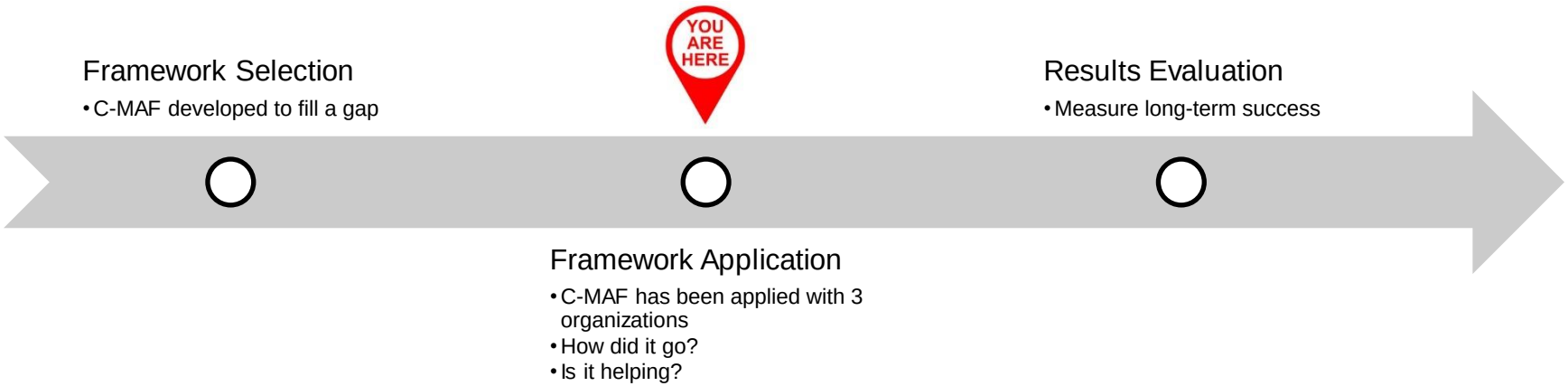
- Size
- Where in the Acquisition Life Cycle do they work?
- How many were involved with the C-MAF evaluation?
  - Characterization of those involved
- Application domain
- DE maturity estimate (DE ≠ MBSE)
  - MBSE
  - Other M&S tools
  - Other digital tools
  - Interoperability between tools
- Organization hierarchy

Characterizing the C-MAF Application

- Where in the organizational hierarchy is C-MAF being applied?
- What degree of tailoring was performed?
- How many of the capabilities were deemed important?
- How long did it take to perform the evaluation?
- How far out were the near-term and long-term goal dates?
- Results of the evaluation
  - Current
  - Near-term
  - Long-term
  - Observations
- Outcomes

Case Study Approach: The Long View

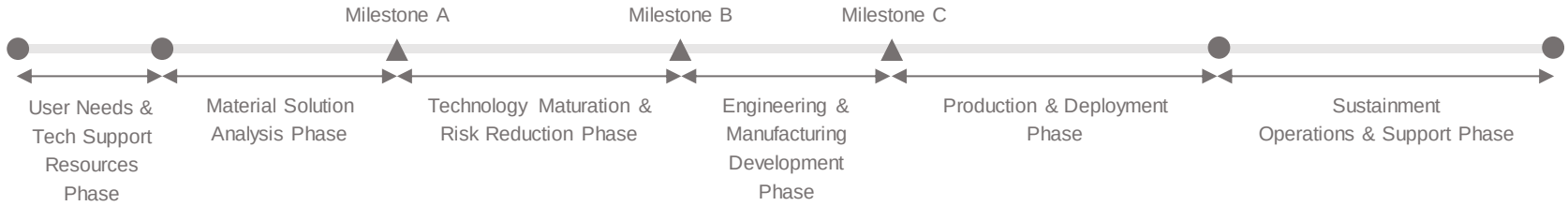
Research question: Can an assessment framework help organizations transform into digital enterprises effectively and efficiently?



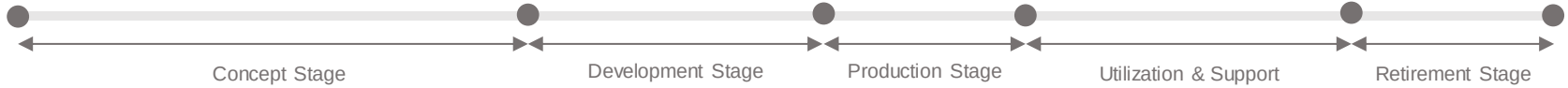
Life Cycle Translation Slide

DoD to ISO 15288

US Department of Defense (DoD)



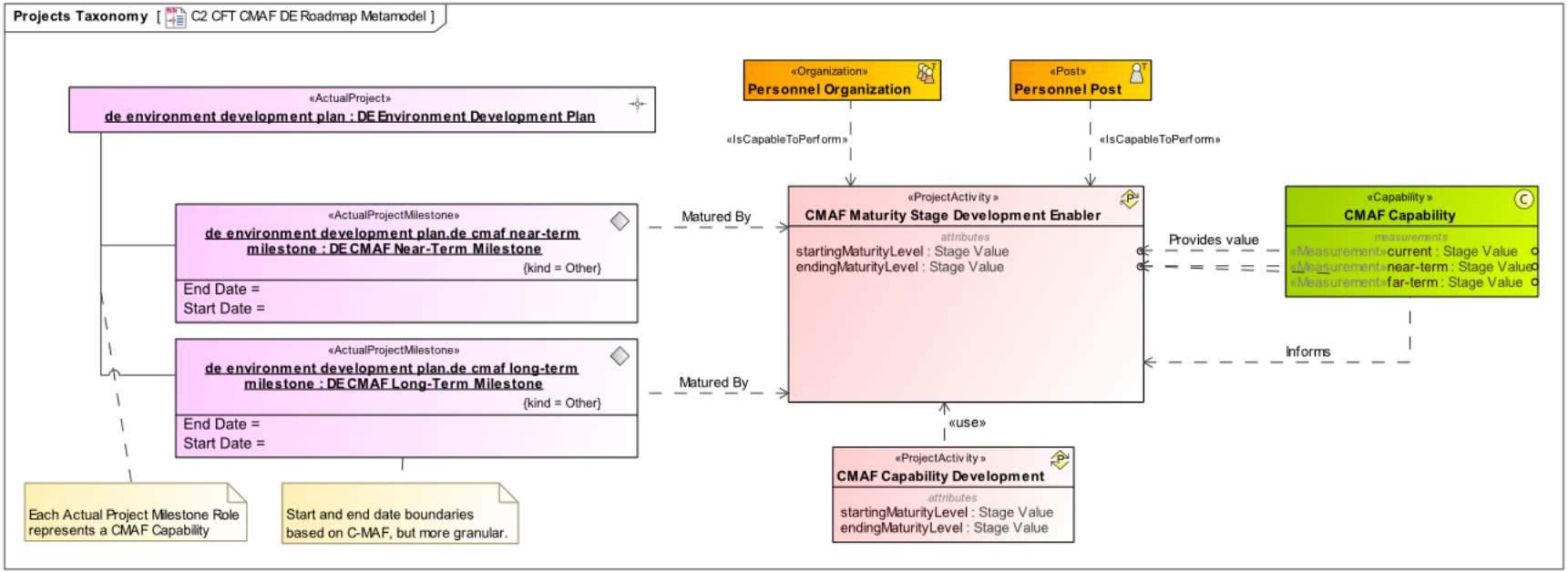
Generic Life Cycle (ISO 15288)



After C-MAF

Linking to Roadmap

Model-Based Approach



Sample Roadmap Table

Criteria

Scope (optional): es,Low-Level C-MAF Maturation Activity Enablers ... Filter:

#	DE CMAF Goal	Corresponding C-MAF Capability	Name	Starting Maturity Stage	Start Date	Ending Maturity Stage	End Date	Responsible Personnel
1	Technology Innovation	Analytic Methods & Processes for Data-Driven Decisions	Identify and document key stakeholders and decision makers	Stage 0		Stage 1		
2	Technology Innovation	Analytic Methods & Processes for Data-Driven Decisions	Identify and document the data sources for making data-driven decisions	Stage 0		Stage 1		
3	Technology Innovation	Analytic Methods & Processes for Data-Driven Decisions	Identify and document the decision making processes	Stage 0		Stage 1		
4	Technology Innovation	Analytic Methods & Processes for Data-Driven Decisions	Identify what types of business decisions need to be made	Stage 0		Stage 1		
5	Technology Innovation	Analytic Methods & Processes for Data-Driven Decisions Prototyping of Technology Capabilities	Establish the processes for capturing feedback from key stakeholders	Stage 0		Stage 1		
6	Technology Innovation	Analytic Methods & Processes for Data-Driven Decisions Prototyping of Technology Capabilities	Identify and document the processes for capturing feedback from key stakeholders	Stage 0		Stage 1		
7	DE Development and Execution	ASoT Access, Control, Policies and Procedures	Define the process for how the organization will deem a digital artifact as authoritative	Stage 0		Stage 1		
8	DE Development and Execution	ASoT Access, Control, Policies and Procedures	Define the processes to govern the commitment of an authoritative digital artifact to an ASoT	Stage 0		Stage 1		