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Transforming Systems Engineering Reviews

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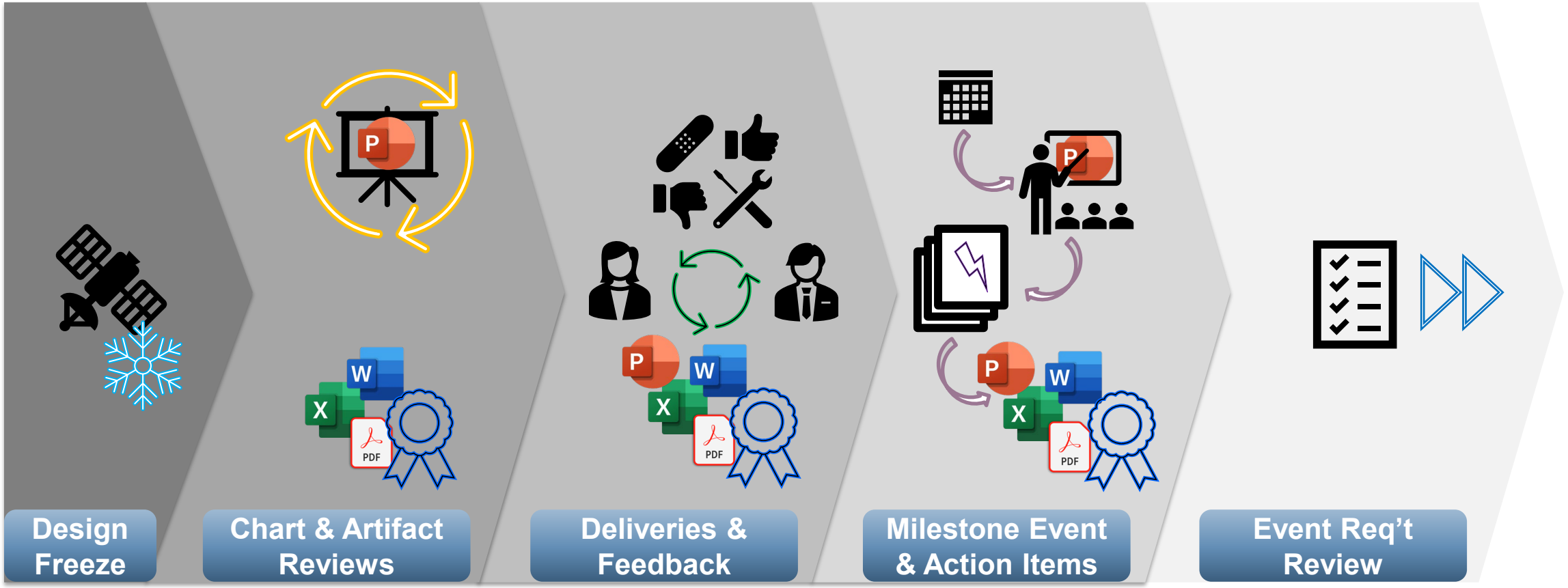
Introduction

- **Background**
  - *Milestone reviews for large development and acquisition programs have been conducted in much the same way for many decades, with only minor incremental improvements along the way*
  - *Many aspects of milestone reviews could be improved*
  - *In order to accomplish Digital Engineering transformation goals, development effort is required*

- **Description of Work**
  - *Some of the key characteristics of milestone reviews have been assessed, contrasting traditional reviews with potential near-term and far-term future states*
  - *Opportunities have been identified for leveraging of digital engineering tools and practices to support model-based reviews*
  - *Proposed transformation tasks are recommended for near-term pursuit*

CONOPS Comparison – Traditional vs DE-Enabled Reviews

Traditional Review CONOPS



Design Freeze	Chart & Artifact Reviews	Deliveries & Feedback	Milestone Event & Action Items	Event Req't Review
Snapped <X> weeks prior to event	Presentation chart dry run iterations. Static artifact snapshot releases	Contractor/Customer exchanges of chart & artifact deliveries and review comments	Calendar scheduled event execution, multi-day chart presentation, review item discrepancies identified, artifacts re-delivered <Y> months following event completion	Manual review of milestone event requirement completion and dependencies done prior to next milestone event

CONOPS Comparison – Traditional vs DE-Enabled Reviews

DE-Enabled Review CONOPS

Continuous Assessment

Design freeze not necessary

Dynamic Models & Data

Dynamic review artifacts being used in the actual development effort

Incremental Action Items

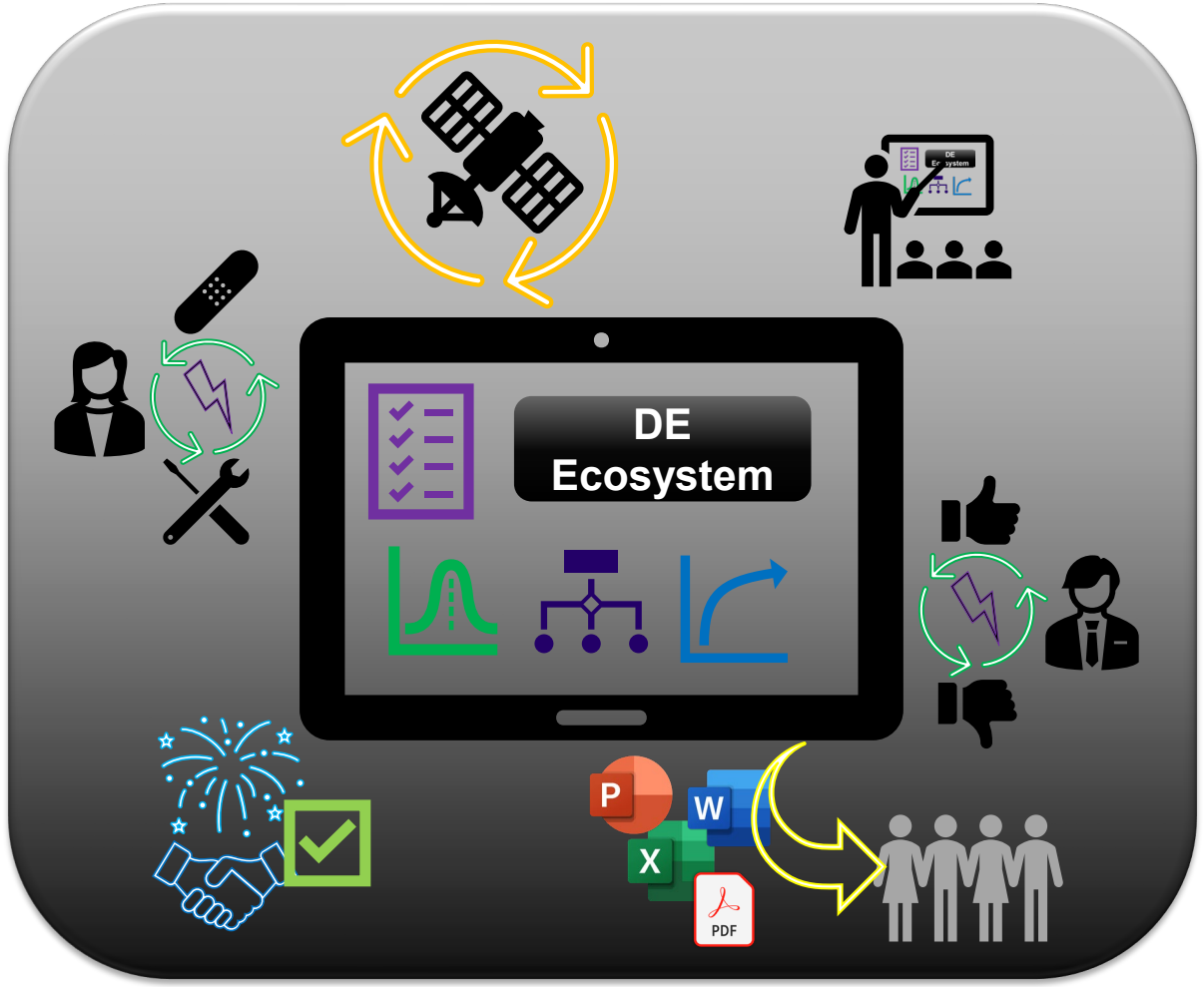
Action items incrementally addressed throughout review process

Non-Event Milestones

Milestone achieved when success criteria dashboard indicates “all green” status

Snapshot Exports

Artifacts exported from DE ecosystem for broad access



Presentation Content

Planned as views within the modeling environment

Shared Artifacts

Req’ts & artifacts shared between contractor/customer within DE ecosystem. Enables continuous & integrated review, with high visibility

Automated Notifications

Reviewers automatically notified as artifacts are updated

Review Linkage

Review milestone event requirement completion automatically linked to dependent requirements for next review milestone event

System Engineering Review Characteristics

Characteristics Overview

Key Characteristics of Milestone Reviews to Target For Transformation

Categories	General Review Parameters	Review Requirements	Review Comprehensiveness & Integration	Evidence Assessment by Reviewers
Review Characteristics	Assessment Frequency	Review Requirement Specificity / Timeliness	Depth of Review	SE Artifact Format / Ease of Access
	Success Criteria Clarity	Review Requirement Clarity	Reviewer Activity Intersection	Design Artifact Format / Ease of Access
	Review Artifact Format / Fluidity	Review Requirement Format	System Requirement Review Status	Review Requirement to Artifact Mapping Specificity
	Review Evidence Inter-Consistency	Review Requirement Organization	Milestone Requirement Review Status	
	Event Centricity	Review Requirement Vertical Connectivity	Review Comment Reconciliation	

SE Review Characteristics Evolution

Example 1: Event Centricity

Traditional Review State

- Review is centered around an “event”

Near-Future State

- Series of incremental maturity reviews converging on satisfaction of success criteria

Far-Future State

- Review is a non-event, “all-green” dashboard

Expected Transformation Benefits:

Traditional State	Future States
• Compact artifact delivery timeline, limited review period • Reviewers see data at time of event or shortly before event	• Supports incremental in-depth reviews, distributed review timeline • Reviewers familiarize with data incrementally over review period

Considerations:

- Tool planning, identification, implementation, and validation necessary to support evolution from event-based to incremental dashboard reviews (e.g. collaborative development, digital review, integrated digital environment)
- To support incremental reviews, method needed to track artifact changes and flag them for reviewer relevance or importance
- Incremental review frequency can be dynamically scheduled according to urgency of upcoming driving milestone

SE Review Characteristics Evolution

Example 2: Milestone Requirement Review Status

Traditional Review State	Near-Future State	Far-Future State
• Review status of milestone req’ts is captured by exception	• Review status of milestone req’ts is available for all req’ts in real time	• Review status of milestone req’ts is available for all req’ts in real time and connected to pertinent system req’ts

Expected Transformation Benefits:

Traditional State	Future States
• Open to risk of errors and omissions	• Provides tracking system for comprehensive milestone requirement review status • Enables high visibility of review progress

Considerations:

- Organization of review collaboration, approvals, and tracking necessary to support evolution of milestone requirement reviews
- Review criteria metrics, visualization, and linkages to actual artifact status must be established in advance of need for review

Transformation Task 1

Assess & Leverage Digital Engineering Tools for Model-Based Reviews

Model-Based SE Reviews can most effectively leverage MBSE and Digital Collaboration aspects of Digital Engineering

Digital Engineering Aspects & Tool Examples

Model-Based System Engineering

- SysML model development (Cameo, Sparx EA)
- Requirements management (DOORS)

Digital Twins

- Operational simulators (procedure validation, operator training)
- Resource planning simulators (user/network planning)

Digital Collaboration

- SysML model views (Cameo Collaborator)
- Review facilitation (Jama, DOORS Next)

Performance Modeling & Simulation

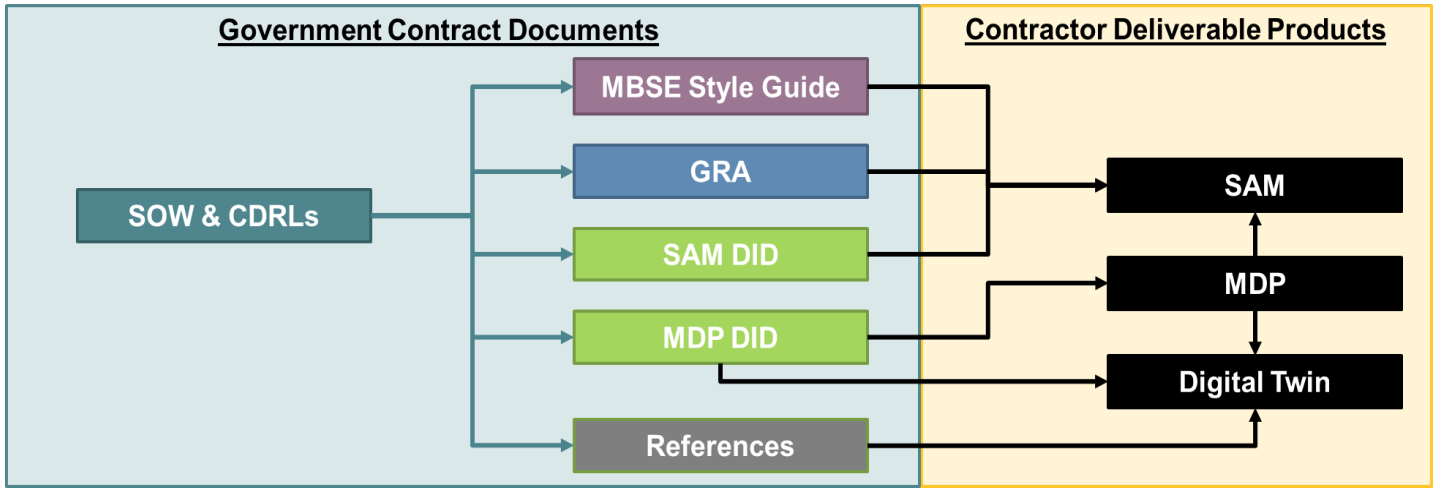
- Performance analysis (Matlab, Simulink, Excel, CAD)

Comprehensive assessment of current and potential DE tools will enable optimization of Model-Based Reviews

Transformation Task 2

Contractual Wording for DE-Enabled Programs

- **Problem Statement:** Traditional space system contract wording does not support definition of expectations related to digital engineering
- **Current Active Efforts:** Development of contractual wording and attachments to align with digital transformation objectives
  - SOW sample language, CDRLs/DIDs, style guides, reference standards
  - Incorporation of model-based reviews as standard practice



CDRL: Contract Data Requirements List

DID: Data Item Description

GRA: Government Reference Architecture

MDP: Model Development Plan

SAM: System Architecture Model

- **Future Goals:**
  - Support incorporation of model-based review content in acquisition documentation
    - Update standard SOW language to drive model-based review execution
    - Support development of Data Item Descriptions to set expectations for digital artifact deliverables
      - System architecture models, digital twins, model development plans, etc.

Transformation Task 3

Transformation of Guidance for SE Reviews

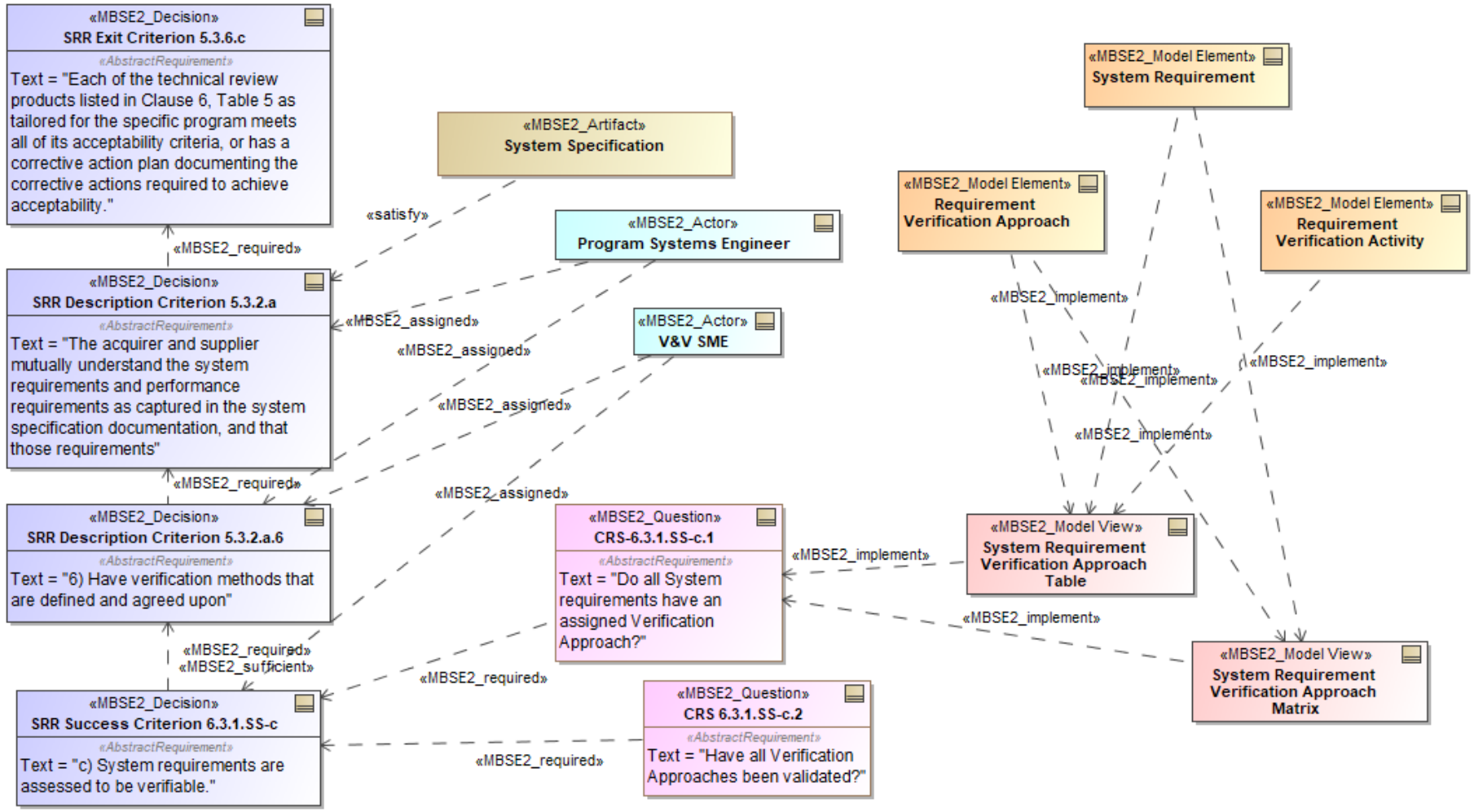
- Transformation of reviews requires transformation of current body of guidance for reviews, e.g.,
  - IEEE 15288.2: IEEE Standard for Technical Reviews and Audits on Defense Programs
  - SMC-S-021: Technical Reviews and Audits for Systems, Equipment, and Computer Software
  - NASA GSFC-STD-1001: Criteria for Flight and Flight Support Systems Lifecycle Reviews
  - etc.

- Primary areas requiring refinement
  - Assumptions that artifacts are discrete documents
  - Assumptions that reviews are discrete events
  - Insufficient detail in success criteria to facilitate unambiguous, repeatable determination of satisfaction
  - Insufficient detail on the content of products or artifacts to be reviewed
  - Insufficient detail on the requirements for connection between levels of a given review
    - e.g., top-down execution of requirement reviews, bottom-up execution of design reviews
  - Insufficient discipline to isolate and uniquely identify requirements to facilitate traceability and verification

Transformation Task 4

Transformation of Managing Traceability of Review Requirements to Implementation

- Use modern MBSE methods to trace between:
  - *Review Decisions (success criteria)*
  - *Review Actors (participants)*
  - *Review Artifacts*
  - *Review Questions (needed to inform each Criterion)*
  - *Model Views (needed to answer each question)*
  - *Model Elements (needed to populate each view)*

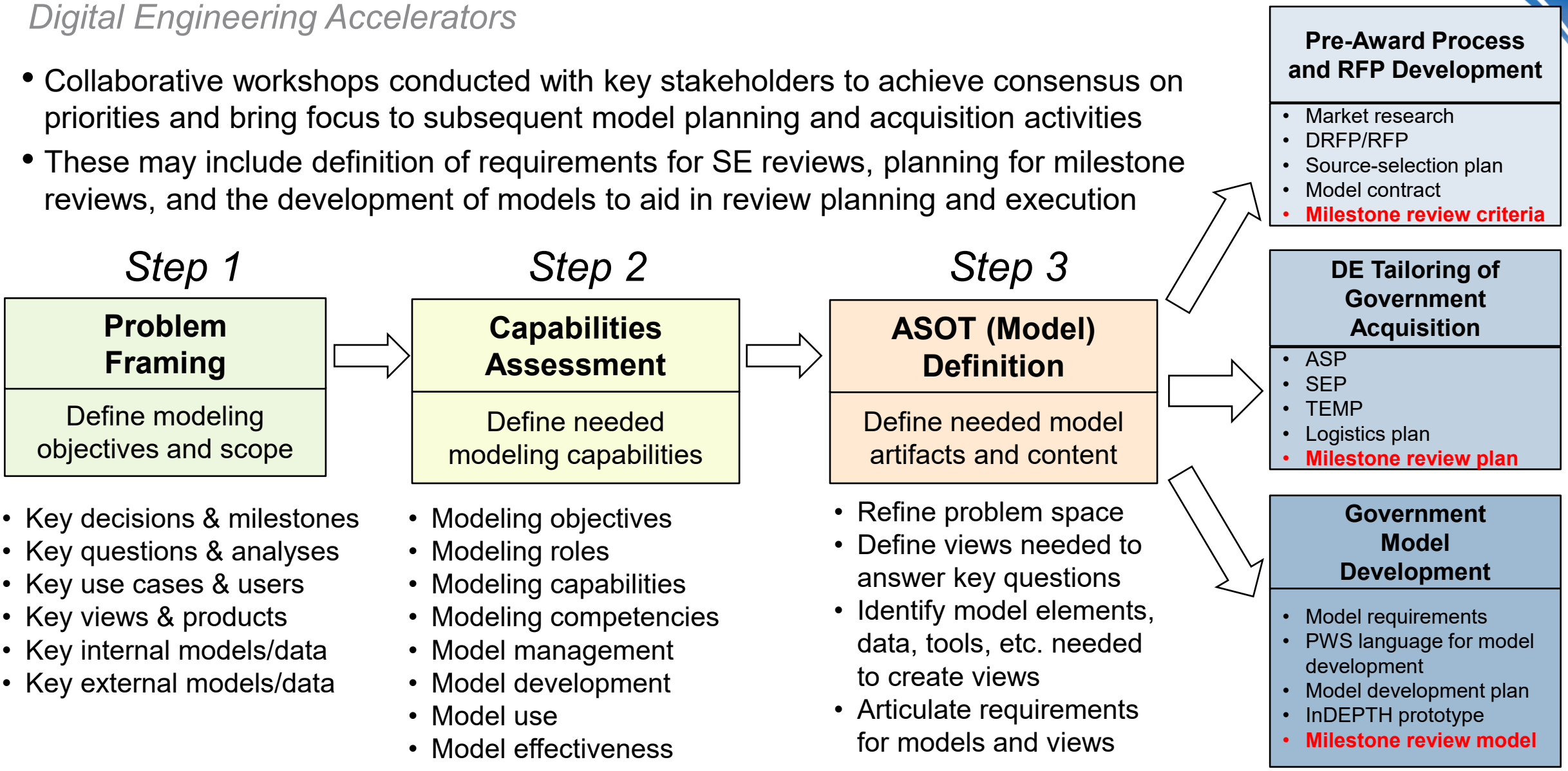


MBSE² provides a structured approach for managing the requirements and "architecture" of milestone reviews

Transformation Task 5

Digital Engineering Accelerators

- Collaborative workshops conducted with key stakeholders to achieve consensus on priorities and bring focus to subsequent model planning and acquisition activities
- These may include definition of requirements for SE reviews, planning for milestone reviews, and the development of models to aid in review planning and execution



Conclusions

Recommendations & Benefits

- **Way Ahead Recommendations**
  - ***Pursue transformation tasks***
    - Assess & leverage DE tools
    - Incorporate MBRs in acquisition documentation
    - Transform guidance and update standards
    - Apply modern MBSE methods to trace MBR elements
    - Facilitate Digital Engineering Accelerator workshops
  - ***Leverage and support programs***
    - Compile best practices from programs
    - Target product development opportunities
- **Expected Benefits of Model-Based Review Transformation**
  - ***Greater depth*** *and* ***comprehensiveness*** *of reviews due to* ***incremental assessments*** *over distributed timeline, and* ***linkages*** *between reviews and between artifacts*
  - ***Higher efficiency*** *of milestone review preparations via implementation of review* ***automation*** *and* ***elimination*** *of need for design freezes and excess configuration management steps*
  - ***Improved tracking and visibility*** *of progress toward milestone requirements for developers, reviewers, and program offices*

There is no "end state" of digital transformation for which we can declare victory and stop continuing to improve our capabilities—this is no different than the case for the mission systems we acquire

Questions?

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BACKUP

Transformation Task 3

Transformation of Guidance for Reviews

Current state of review guidance	Desired future state of review guidance
Assumptions that artifacts are discrete documents	Artifacts to be reviewed will generally be specific views generated from model ASOTs
Assumptions that reviews are discrete events	Reviews are more continuously executed through the aid of automation
Insufficient detail in success criteria to facilitate their unambiguous and repeatable satisfaction—much is left to the interpretation of the reader	Success criteria are sufficiently decomposed and refined, and dependencies captured in models to enable automated impact analysis and reduce misunderstandings
Insufficient detail on the products or artifacts to be reviewed	Artifacts to be reviewed are described in sufficient detail to establish consistent expectations up front
Insufficient detail on the requirements for connection between levels of a given review	Requirements for top-down, bottom-up, and lateral connections between related aspects of reviews are explicitly captured and traced to ensure consistency
Insufficient discipline to isolate and uniquely identify each requirement to enable explicit traceability	Success criteria are treated as requirements and traced, tracked, and managed accordingly, ideally using modern model-based methods

Transforming reviews will require transforming stakeholder expectations and guidance provided to reviewers and system developers

CONOPS Comparison

Traditional vs DE-Enabled Reviews

Example Traditional Review CONOPS	Example DE-Enabled Review CONOPS
Design freeze snapped <X> weeks prior to review milestone	Design freeze is **not necessary** since relevant information is continuously assessed in the model throughout the review process
Presentation charts are developed, undergoing several review/update iterations, and rehearsals are conducted to get them "just right"	Presentation content is planned as **views within the modeling environment** to demonstrate development coverage and maturity
Review artifacts are generated and released as snapshots under static configuration management process	Review artifacts are **dynamic models & data** being used in the actual development effort without needing to "stop work" during review period
Contractor/Customer **exchange deliveries** of several iterations of draft charts, review artifacts, and CRMs	Review r**equirements & artifacts are shared** between government and contractor within the DE ecosystem to enable review and assessment that is continuous and integrated, with high visibility
Review artifacts are **re-worked** to incorporate comments and are **re-released** under configuration management process	Review artifacts are updated within the DE ecosystem and reviewer notifications of updates are **automated**
Review milestone **event is executed** as multi-day PowerPoint presentation, usually with lots of review item discrepancies to be worked	Review milestone is a **non-event**, achieved when success criteria dashboard indicates "all green" status
Action items are resolved following review milestone event. Final charts & artifacts are delivered <Y> months following event completion	Action items are **addressed incrementally** throughout review process. Final artifacts are captured in DE ecosystem
Manual review of review milestone event requirement completion and dependencies done prior to next review milestone event	Review milestone event requirement completion **automatically linked** to dependent requirements for next review milestone event

Milestone Reviews Characteristics Evolution

General Characteristics of the Review

Traditional Review State	Near-Future State	Far-Future State
Assessment Frequency - Discrete events separated by many months, resulting in substantial risk of delay in discovering defects and providing feedback	Frequent assessment of readiness driven by semi-automated identification of general areas requiring re-review, reducing delays in discovering defects and providing feedback, supporting iterative development	Continuous, proactive assessment driven by automated identification of specific areas requiring re-review, minimizing delays in discovering defects and providing feedback, fully supporting Agile/DevOps programs
Success Criteria Clarity - Success criteria are coarse, resulting in frequent disconnects between contractor, government, and individual reviewers	Success criteria defined with sufficient granularity and clarity to minimize disconnects between contractor, govt, and reviewers	Model-based success criteria facilitate automated traceability and dashboards to continually assess review maturity
Review Artifact Format/Fluidity - Program needs to freeze development work to have the time to create unique review artifacts	Review artifacts are largely the same artifacts being used to inform and document the development effort	Review artifacts are the actual models and data being used in the development effort, so the contractor can continue to work unabated
Review Evidence Inter-Consistency - Review evidence primarily static, disconnected artifacts that often contain disconnects that are difficult to discover	Review evidence primarily dynamic, connected models and data that can be checked for consistency early and often	Review evidence are the same dynamic, connected models and data that are continuously kept consistent
Event Centricity - Review centered around an “event” in which the contractor attempts to “sell” their readiness to stakeholders	Not one review, but a series of incremental maturity reviews that establish convergence of satisfaction of success criteria	Review is a non-event, simply the time when the success criteria dashboard has finally gone “all green”

Milestone Reviews Characteristics Evolution

Parameters of Review Requirements—e.g., Success Criteria

Traditional Review State	Near-Future State	Far-Future State
Review Requirement Specificity/Timeliness - Review requirements are provided in very general terms (in a standard)	Review requirements are provided early in the program life cycle to inform development of models and views to address success criteria	Review requirements are provided in RFP to enable contractors to incorporate those requirements into their proposal
Review Requirement Clarity - Review requirements are very coarse, resulting in disconnects between government and contractor and in lack of repeatability from reviewer to reviewer	Review requirements have sufficient granularity and clarity to minimize disconnects between government and contractor and enable repeatability from reviewer to reviewer	Review requirements are so granular and clear that they can be standardized across programs and subjected to automation
Review Requirement Format - Review requirements are provided in text formats	Review requirements are provided in the form of a requirement model with traceability linkages and dependencies identified	Review requirements model is shared or synchronized between government and contractor so both are on the same page as far as requirement satisfaction status
Review Requirement Organization - Review requirements are just organized by subject matter discipline	Review requirements are sequenced by their dependencies, identifying requirements that should be assessed and closed earlier	Review requirements are connected by linkages in the model to enable automated identification of dependencies and impacts
Review Requirement Vertical Connectivity - Review requirements are, at best, simply duplicated at each level of the review breakdown structure	Review requirements are connected across the review breakdown structure to enable analysis of flowdown of requirements and flow-up of verifications	Review requirements are connected across the review breakdown structure to provide immediate feedback of requirement flowdown and verification flow-up

Milestone Reviews Characteristics Evolution

Parameters of Review Comprehensiveness and Integration

Traditional Review State	Near-Future State	Far-Future State
Depth of Review - Depth of review is constrained by disconnected evidence artifacts and limited reviewer time to sort through the chaff	Greater depth of review is facilitated by the granular connection of evidence artifacts and automation to make the most of reviewer time	Greatest depth of review is facilitated by the thorough connection of evidence artifacts and automation that the contractor is using to perform the development process
Reviewer Activity Intersection - Intersections between reviewer activities are coarsely identified by technical discipline	Intersections between reviewer activities are identified a priori, tied to specific review requirements and/or technical requirements, and provide some form of cross-disciplinary visibility	Intersections between reviewer activities are modeled a priori, tied to specific review requirements and/or technical requirements, and provide automated cross-disciplinary notification
System Requirement Review Status - Review status of system requirements is captured by exception	Review status of system requirements is available for all requirements in real time	Review status of system requirements is available for all requirements in real time and connected to pertinent review requirements
Milestone Requirement Review Status - Review status of milestone requirements is captured by exception	Review status of milestone requirements is available for all requirements in real time	Review status of milestone requirements is available for all requirements in real time and connected to pertinent system requirements
Review Comment Reconciliation - Review comments by reviewers are, at best, aggregated with limited ability to identify synergies or disconnects	Review comments by reviewers are tied to pertinent review and system requirements and allow identification of synergies or disconnects in real time	Review comments by reviewers are automatically tied to pertinent review and system requirements—including by indirect paths through the model—allowing identification of synergies, disconnects, or broader implications in real time

Milestone Reviews Characteristics Evolution

Parameters of Evidence Assessment by Reviewers

Traditional Review State	Near-Future State	Far-Future State
Systems Engineering Artifact Format / Ease of Access - Systems engineering artifacts to be reviewed are static documents, perhaps created by models	Systems engineering artifacts to be reviewed are models accessed in native modeling tools that enable more comprehensive exploration and advanced querying and reporting	Systems engineering artifacts to be reviewed are models accessed within the comprehensive DE ecosystem that enables links to analysis and design artifacts to be more comprehensively navigated
Design Artifact Format / Ease of Access - Design artifacts to be reviewed are static documents, perhaps created by models	Design artifacts to be reviewed are models accessed in native modeling tools that enable more comprehensive exploration and analysis	Design artifacts to be reviewed are models accessed within the comprehensive DE ecosystem that enables links to analysis and design artifacts and the driving requirements to be more comprehensively navigated
Review Requirement to Artifact Mapping Specificity - Review requirements are linked to entire artifacts (document, model, etc.)	Review requirements are linked to specific portions of the artifact (paragraph, model view or element, etc.) that must be reviewed	Review requirements are linked to a dynamic view that captures all relevant portions of the artifact that must be reviewed to minimize reviewer time needed to transition between artifacts