SoSECIE Webinar

Welcome to the
2020 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time

Skype Meeting +1 (703) 983-2020, 46013573#

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NDIA System of Systems SE Committee

- **Mission**
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- **Operating Practices**
  - Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

NDIA SE Division SoS Committee Industry Chairs:
Mr. Rick Poel, Boeing
Ms. Jennie Horne, Raytheon
OSD Liaison:
Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- I have muted all participant lines for this introduction and the briefing.
- If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.
- Download the presentation so you can follow along on your own
- We will hold all questions until the end:
  - I will start with questions submitted online via the CHAT window in Skype.
  - I will then take questions via telephone; State your name, organization, and question clearly.
- If a question requires more discussion, the speaker(s) contact info is in the brief.

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2020-2021 System of Systems Engineering Collaborators Information Exchange Webinars

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June 2, 2020
SERC: Methods to Evaluate Cost/Technical Risk and Opportunity
Thomas McDermott and Cody Fleming

June 16, 2020
Challenges for Systems of Systems / Mission Engineering in a Space Acquisition Environment
Lt Col Benjamin Bennett

June 30, 2020
Mission Engineering Playbook
Dr. Judith Dahmann

July 28, 2020
Addressing Mission Engineering from a Lead Systems Integration Perspective
Dr. Warren Vaneman

More coming soon!

Digital Engineering Toolchain

Aleksandra Markina-Khusid, PhD

Ryan Jacobs, PhD

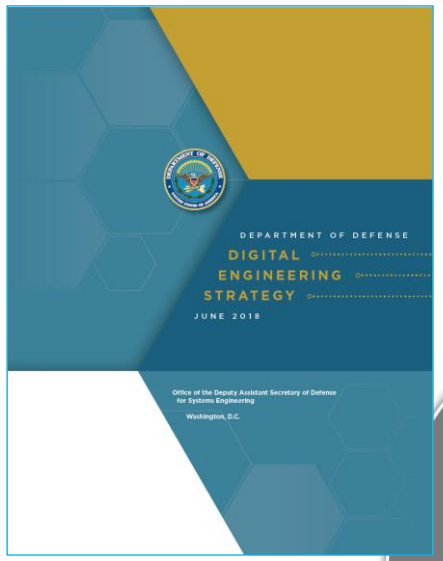
Jeff Vodov

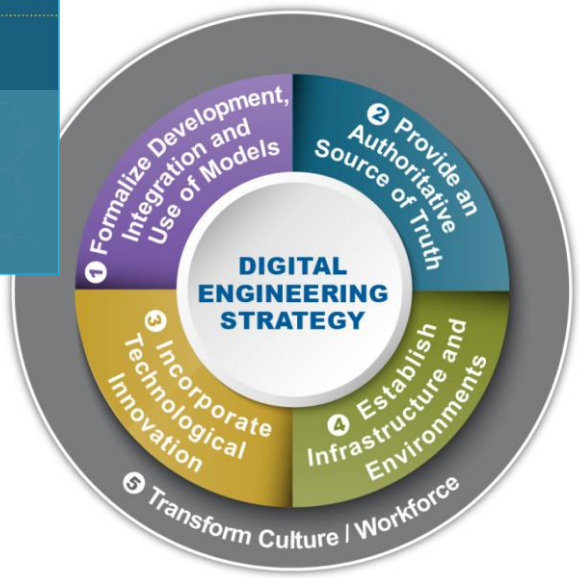
Greg Quinn

May 19, 2020

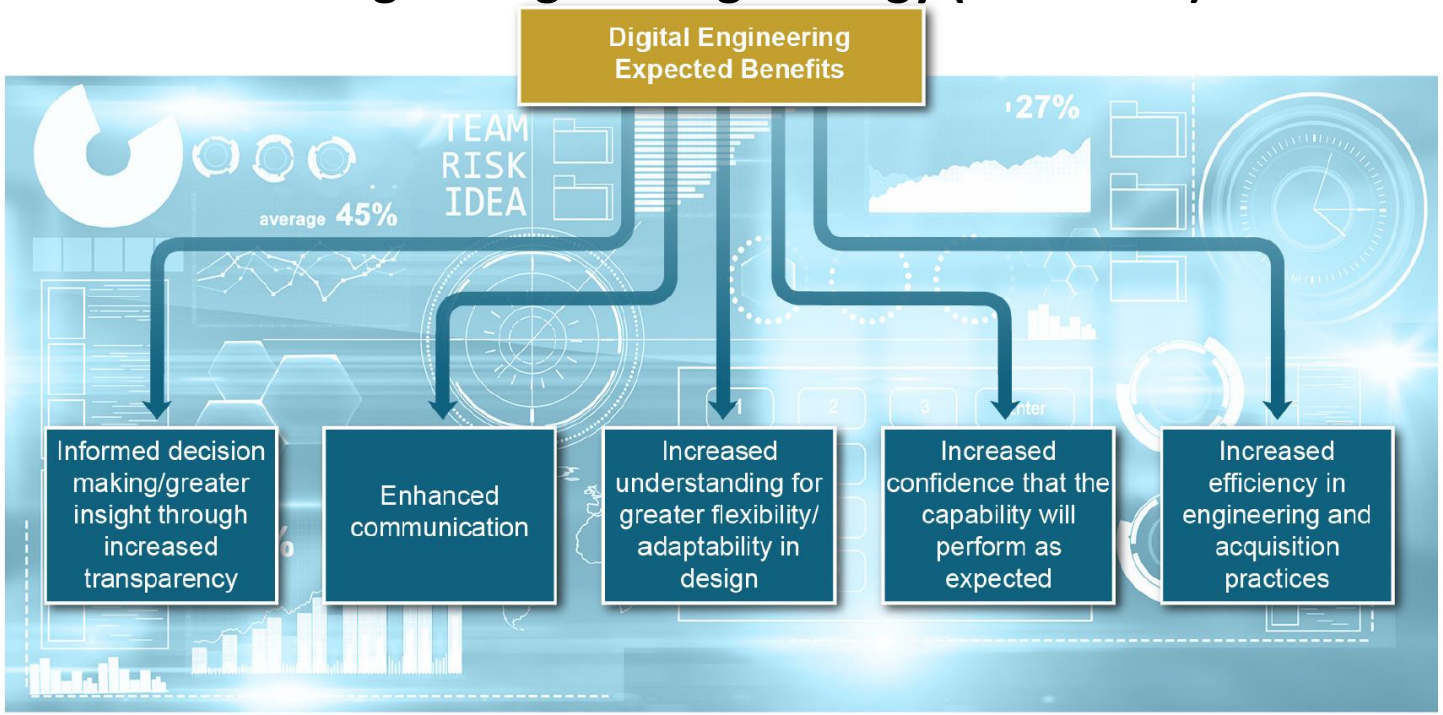
MITRE

Purpose





OSD Digital Engineering Strategy (June 2018)

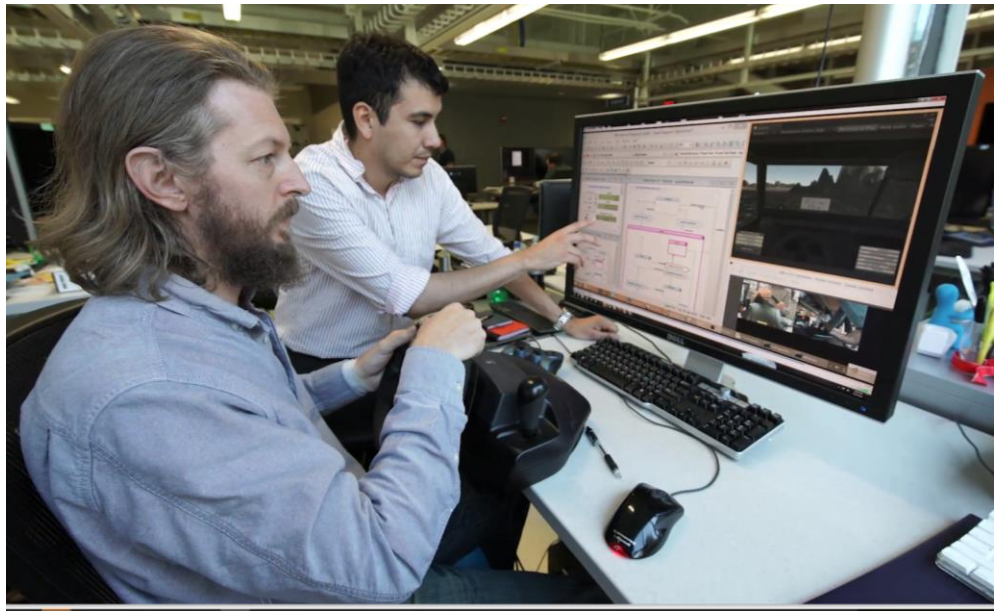


Sponsors are implementing OSD strategy
MITRE is employing modern DE practices to meet sponsor objectives

MITRE

MITRE Digital Engineering Toolchain Vision

MITRE employs a digital engineering environment that connects people, processes, tools and data across an end-to-end digital enterprise



Key Assumptions:

- **Multi-disciplinary teams are required to address sponsor needs**
  - SMEs use specialized tools of their domains
- **Data needs to be exchanged among SMEs' tools repeatedly on a given project**
- **Data needs to be "served up" in a format usable in the SME's environment**

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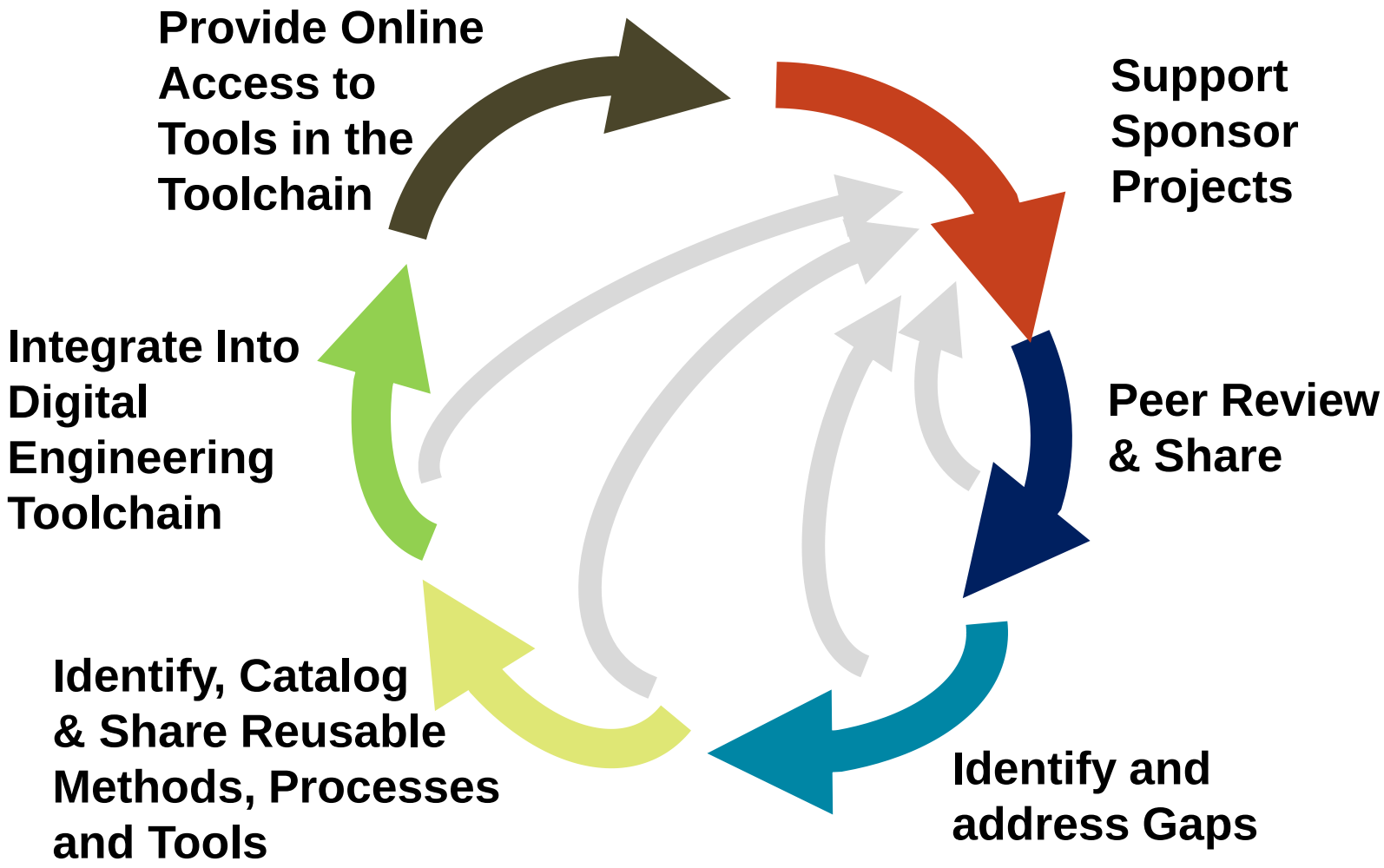
MITRE Approach To DE Capability Development



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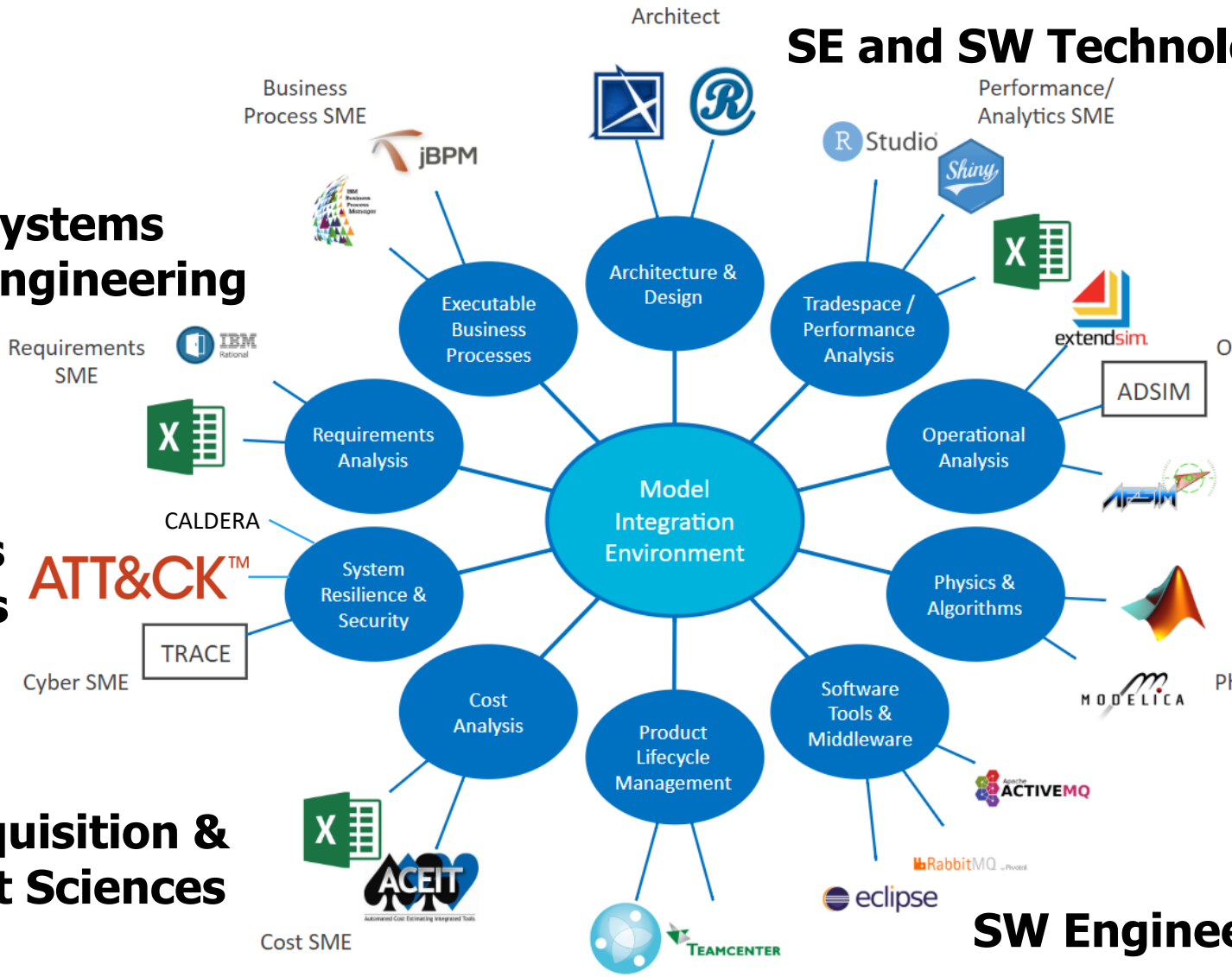
MITRE Digital Engineering Environment



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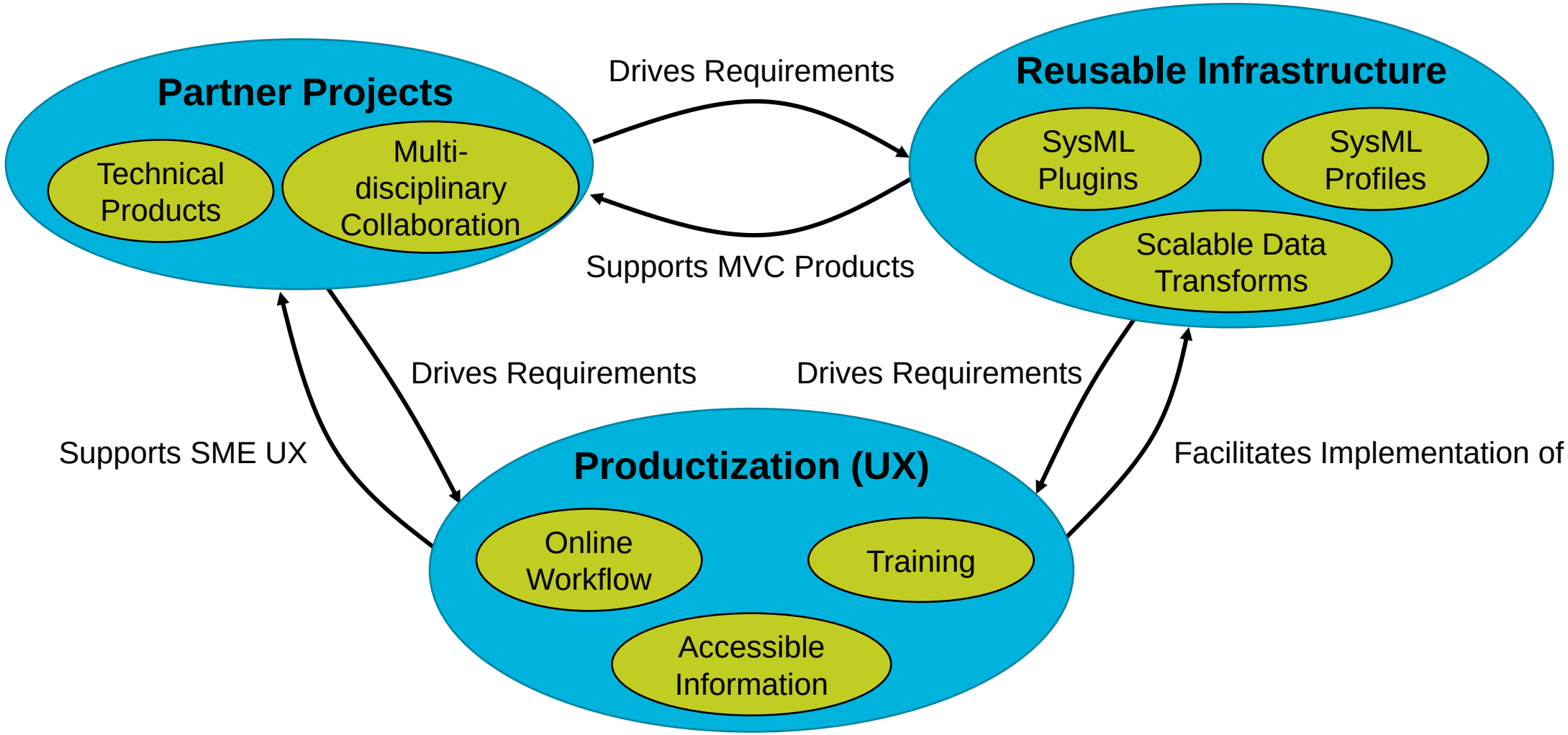
Lines of Effort



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Reusable Infrastructure

DE Toolchain Technical Requirements

The Digital Engineering Toolchain shall…

1. Use data from supported authoring tool(s) via a recognized industry standard
2. Manage links between resources across tools
3. Notify users of changes in data artifacts that are relevant to them
4. Transform model data across domain-specific notations to translate key information
5. Update data via a recognized standard – to be consumed by supported authoring tool(s)
6. Support authoring reports on information to address different stakeholder concerns, organizing them in accessible reporting dashboards
7. Support maintaining a baseline configuration for information (as well as variant configurations)
8. Support analyzing information with reasoners and analysis tools using published query end points and APIs
9. Assign access permissions
10. Use a common terminology standard for tools that are within the same domain
11. Support new tools and new types of tools (Extensibility)
12. Support new versions of tools without requiring changes to DE Toolchain (Maintainability)

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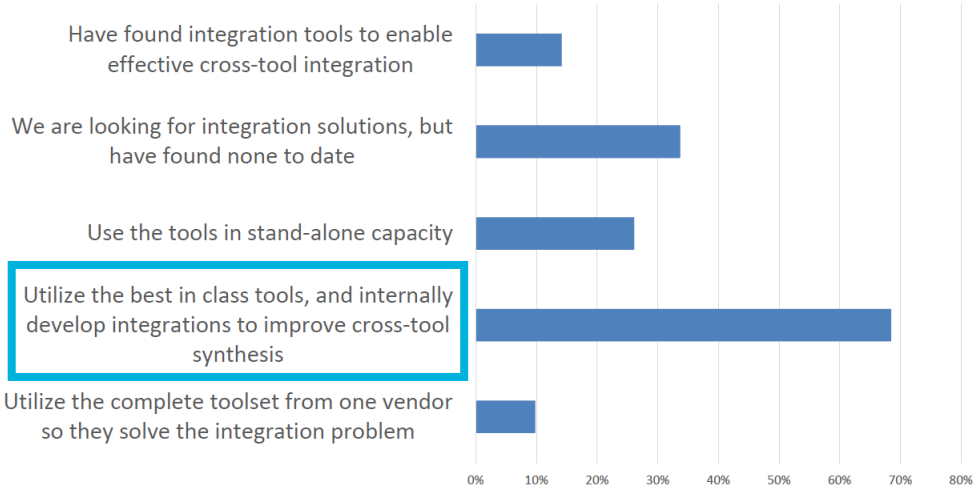
Enabling Technologies for the DE Toolchain

How does your organization address the need to integrate new tools?



Source: R. Cloutier, "2019 JPL MBSE Workshop Survey Results," Presented at the NASA JPL MBSE Symposium, 2019.

Copyright 2019, R. Cloutier Slide 7

		Model Management	Source Code Management	Traceability Across Digital Artifacts	Model Transformation	API Accessible	Plug-in Extensibility	Product Life-cycle Management	Application Lifecycle Management	Ontology Development	Host Model in Neutral Format	Visualization of Model	Integrates Rhapsody	Integrates MagicDraw	Acquires information from authoring tools	Curates, integrates, configuration manages	Verifies the consistency of federated information and measures precise differences	Analyzes information, generates reports	Notifies impacted users of engineering changes	Supports design reviews and system forensics
Intercax	Syndeia			▼	▽	▽					▽	▼	▼	▼	▼	▼	▽		▷	
OASIS	OSLC			▼	▷	▼				▽	▼		▼	▼	▼	▼	▷	▷	▷	
Sodius	SECollab	▽		▼					▽		▼	▼	▼	▼	▼	▽	▽	▷	▷	▽
	MDWorkbench				▼		▽			▽			▼	▼						
	MDAccess			▼									▼	▼	▼					
	Inter-Op				▼								▼	▼	▼					
NASA JPL - OpenMBEE	Model Development Kit (MDK)													▼	▼					
	Model Management System	▼		▽	▽	▼	▼							▼		▼	▼			
	View Editor					▼	▼					▼		▼				▼		▼
No Magic	TeamWork Cloud	▼				▼								▼	▼	▼	▼		▽	
	Cameo Collaborator					▼						▼		▼	▼			▼	▽	▼
IBM	Rhapsody Model Manager	▼		▼		▼	▽		▼		▽	▽	▼		▼	▼	▼	▼		▼
	Rational Team Concert		▼			▽	▽		▼				▼		▼	▼	▼	▼	▼	
	Rational Engineering Lifecycle Manager			▼		▽	▽	▼	▼		▽	▽	▼		▼	▼		▼		▼
DARPA	STITCHES				▷								▷	▷	▷		▷			
NASA JPL	OpenCaesar			▼	▼					▼	▼		▷	▼	▼	▼	▼	▼		
ModelBus	ModelBus	▼				▼	▼						▼							
SKAVL	PHENOM				▷					▼										
Modelica	Functional Mock-Up Interface (FMI)				▼						▼		▽	▽	▼					
Maple SOFT	MAPLE MBSE				▼								▼	▼	▼		▽			
JAMA Software	JAMA Connect					▽	▽		▼				▷	▷						
GIT	GITHUB	▼	▼			▼	▼						▽							
	GITLAB	▼	▼			▼	▼		▽				▽							
Atlassian	JIRA								▼											
	Bitbucket		▼						▽											
Microsoft	Team Foundation Server		▼			▽	▽		▼											
The Eclipse Foundation	Eclipse IDE					▼	▼						▼		▼					
Siemens	Teamcenter					▽	▽	▼					▼	▼	▼					
Dassault Systemes	3DEXPERIENCE ENOVIA					▽	▽	▼						▼	▼					
Tom Sawyer	Perspectives					▼						▼		▼	▼			▼	▷	▷

No existing technology to rule them all. Approach is to understand the workflow among SMEs and identify the right composition of technologies to facilitate repeated data exchanges among tools.

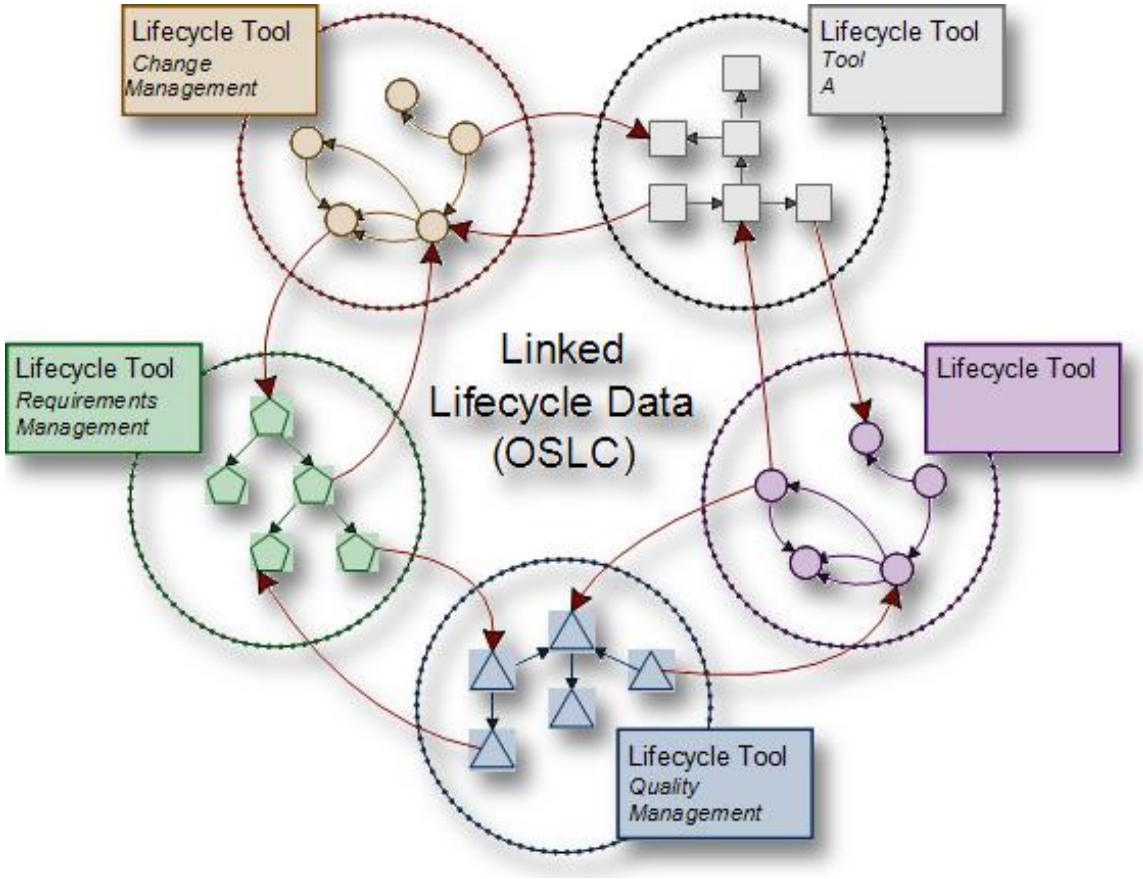
DE Toolchain Technology Matrix

Legend	
	Does Not Do
▷	Modified To Accomplish
▽	Does to an Extent
▼	Does Really Well

				Use data from supported authoring tools	Manage Links between resources	Notify users of changes	Transform model data across domains	Update data into supported authoring tool	Maintain baseline configurations	Reporting Dashboards	Support analyzing information via an API	Assign Access Permissions	Use a common terminology standard	Maintainability: new versions of tools	Extensibility: new tools and types of tools	Integrates Rhapsody	Integrates MagicDraw
$	Commercial	Intercax	Syndeia	▽	▽	▽	▽	▽		▽	▷			▼		▼	▼
	Open-Source	OASIS	Eclipse Lyo with OSLC	▽	▷	▷	▷	▽	▷		▷		▼	▽	▼	▼	▼
$	Commercial	Sodius Willert	SECollab with OSLC	▼	▼	▷	▷	▷	▼	▽	▽	▼	▼	▼	▽	▼	▼
	Open-Source	NASA JPL	OpenMBEE	▽			▷	▷	▼	▽	▽	▼		▽	▽		▼
$$	Commercial	Dassault - No Magic	Cameo TWC / Collaborator / DataHub	▼		▼			▼	▽	▷	▼	▽	▼			▼
$$	Commercial	IBM	Jazz ELM with OSLC	▼	▼	▼	▷	▽	▼	▼	▼	▼	▼	▼	▽	▼	
$	Commercial	Maple SOFT	MAPLE MBSE	▼			▽	▽		▽				▽		▼	▼
	Government	DARPA	STITCHES	▷		▷	▷	▷	▷	▷	▷	▷		▷	▷	▷	▷
	Open-Source	NASA JPL	OpenCaesar	▽	▽		▼	▽			▽		▼			▷	▼
$$	Commercial	ModelBus	ModelBus with OSLC	▼	▼				▽				▽		▼	▼	
$$$	Commercial	SKAYL	PHENOM	▽			▼	▽									
	Open-Source	The Eclipse Foundation	Eclipse Model Framework (EMF)	▷		▷	▷	▷	▷	▷	▷	▷	▷	▼	▼	▼	▼
$$	Commercial	Siemens	Teamcenter with OSLC	▼	▽	▼			▼	▼	▼	▼	▽	▼	▽	▽	▽
$$	Commercial	Dassault Systemes	3DEXPERIENCE ENOVIA	▽	▽	▼			▼	▼	▼	▼		▼	▽		▽
$	Commercial	Tom Sawyer	Perspectives	▼					▼					▼	▽	▽	▼
$	Commercial	Northwoods Software	Go JS	▽													
$$$	Commercial	Phoenix Integration	ModelCenter	▼			▼	▼								▼	▼
$$	Commercial	Mentor Graphics	Context SDM with OSLC	▼	▼				▼		▼	▼	▼	▼		▼	

Open Services for Lifecycle Collaboration (OSLC) – Functional

- **OASIS Standard (since 2013)**
- **Establish links between resources in different lifecycle tools *from within those tools***
- **Use resources in one tool to affect resources in another tool (e.g. transformation)**
- **Add new types of tools (domains)**
- **Switch versions of tools**
- **Switch tool used for a domain**



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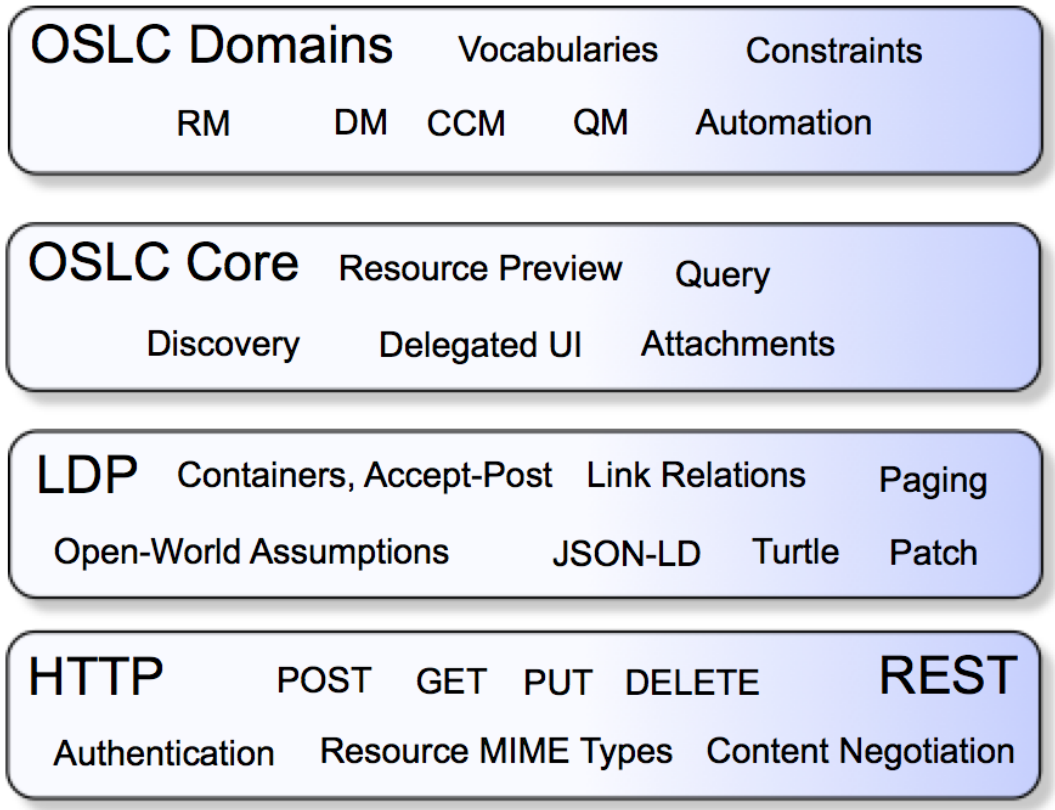
Open Services for Lifecycle Collaboration (OSLC) – Architectural

- **Domain defines vocabulary (resources) for each type of tool.**
- **OSLC Core provides cross-domain services**
  - Resource Description Framework (RDF) for syntax:

Subject	Predicate	Object
Resource	Property	Value
Book	“author”	“Bob”

  - Tracked Resource Sets (TRS) for event-based
- **Linked Data Platform (LDP)**
  - HTTP as the application protocol (not tunneled)
  - RESTful services
  - Linking data across tools via URLs
  - No copying of data



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OSLC and Tool Interoperability

Goal of OSLC is tool interoperability which requires the following:

	Interoperability Requirement (IR)	Description	How OLSC Meets Requirement
1	Physical	Network connectivity between tools	TCP/IP
2a	Application – Protocol	Specification of how data will be transferred over physical connectivity	REST (HTTP+URLs)
2b.1	Application – Data syntax	Basic syntax used to represent the data sent via the protocol	XML
2b.2	Application – Data structure	Schema used to define how the data is structured within the syntax	RDF
2b.3	Application – Data semantic	Meaning of all data elements	OSLC Resource Shapes in OSLC Specifications
3	Business Process	Overall process that tools are used to support (tools can be orchestrated or choreographed)	Delegated User Interfaces and Resource Previews but mostly process-dependent

Reference: Mihindukulasooriya, N., Garca-Castro, R., and Esteban-Gutierrez, M.: Linked Data Platform as a novel approach for Enterprise Application Integration. Center for Open Middleware, Ontology Engineering Group (2013)

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Examples of Digital Engineering Workflows on Projects

A Public Sector Program Example: Technology Insertion into a Human-Centric Process

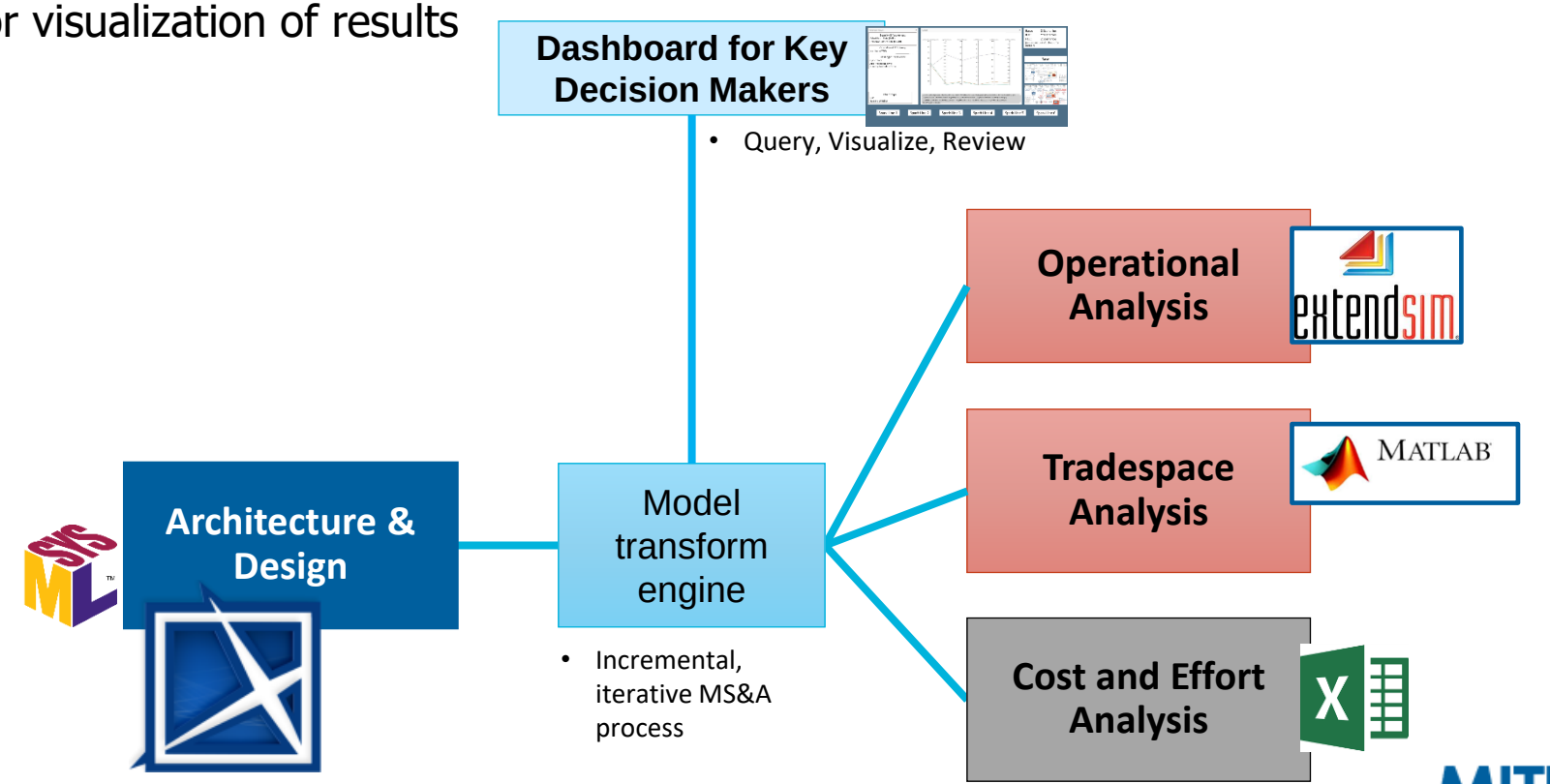
Goals:

- **Build a framework for reasoning about technology insertion into an architecture supporting a human-centric process.**
- **Understand the impact of technology choices and process design on customer experience.**
- **Key measures of effectiveness include queue lengths and wait times.**

A Public Sector Program Example: Multi-Disciplinary Digital Engineering Environment

Technical Approach:

- Capture tradespace parameterization in architecture model
- Generate run matrix for operational simulation from SysML model
- Use MATLAB for preliminary data exploration and analysis
- Built interactive dashboard for visualization of results



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Architecture - Operational Analysis Workflow

Architecture SME

Step 1, Architect makes updates to Biometrics model

Modeling tool

Step 2, Architect runs the Tradespace plugin to generate valid designs csv

Step 3, OR SME is notified of change by email

Valid Designs

CSV 1,2,3

Operations Researcher

Analysis Tool

Step 4, OR SME runs the simulation

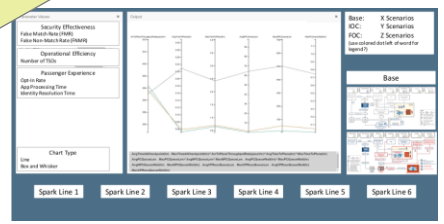
extendsim

Step 5, Extendsim produces results csv

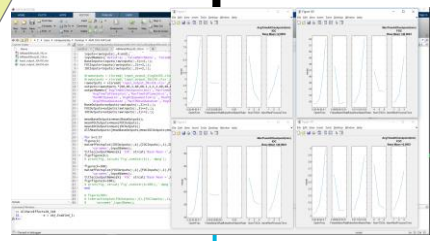
CSV 1,2,3

Integrated Model Environment

Step 9, Visualize results



Step 8, Operational SMEs provide feedback and iterate



MATLAB

Step 6, Systems Analyst runs analysis and visualizes results

Step 7, Review changes to model with Operational SMEs

Operations SME

Systems Analyst

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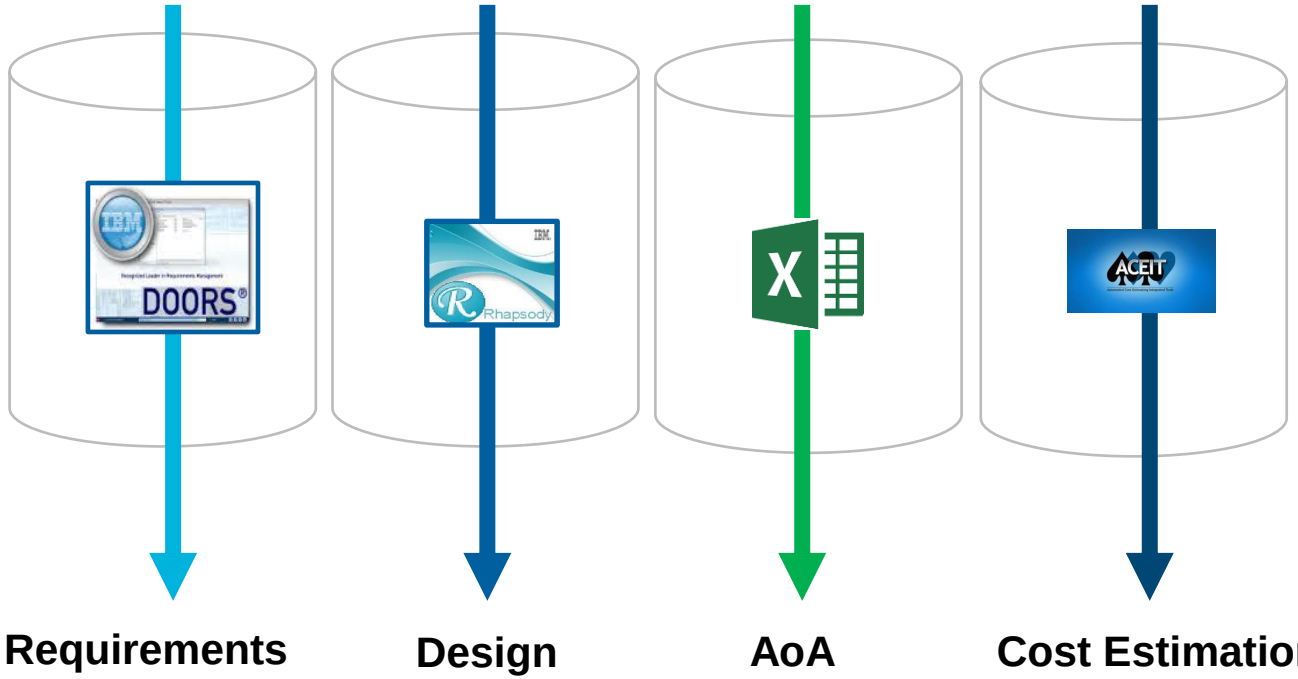
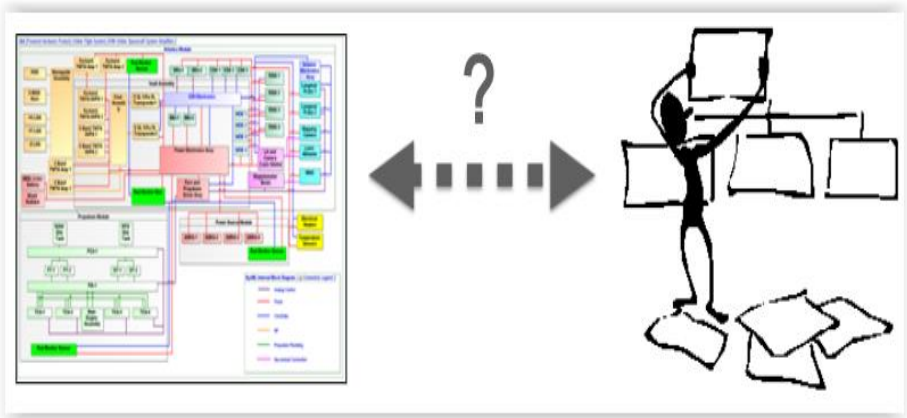
A DoD Program Example: Eliminate Stovepipes

- **Development Stovepipes**



- **Programmatic and Technical sides not connected**



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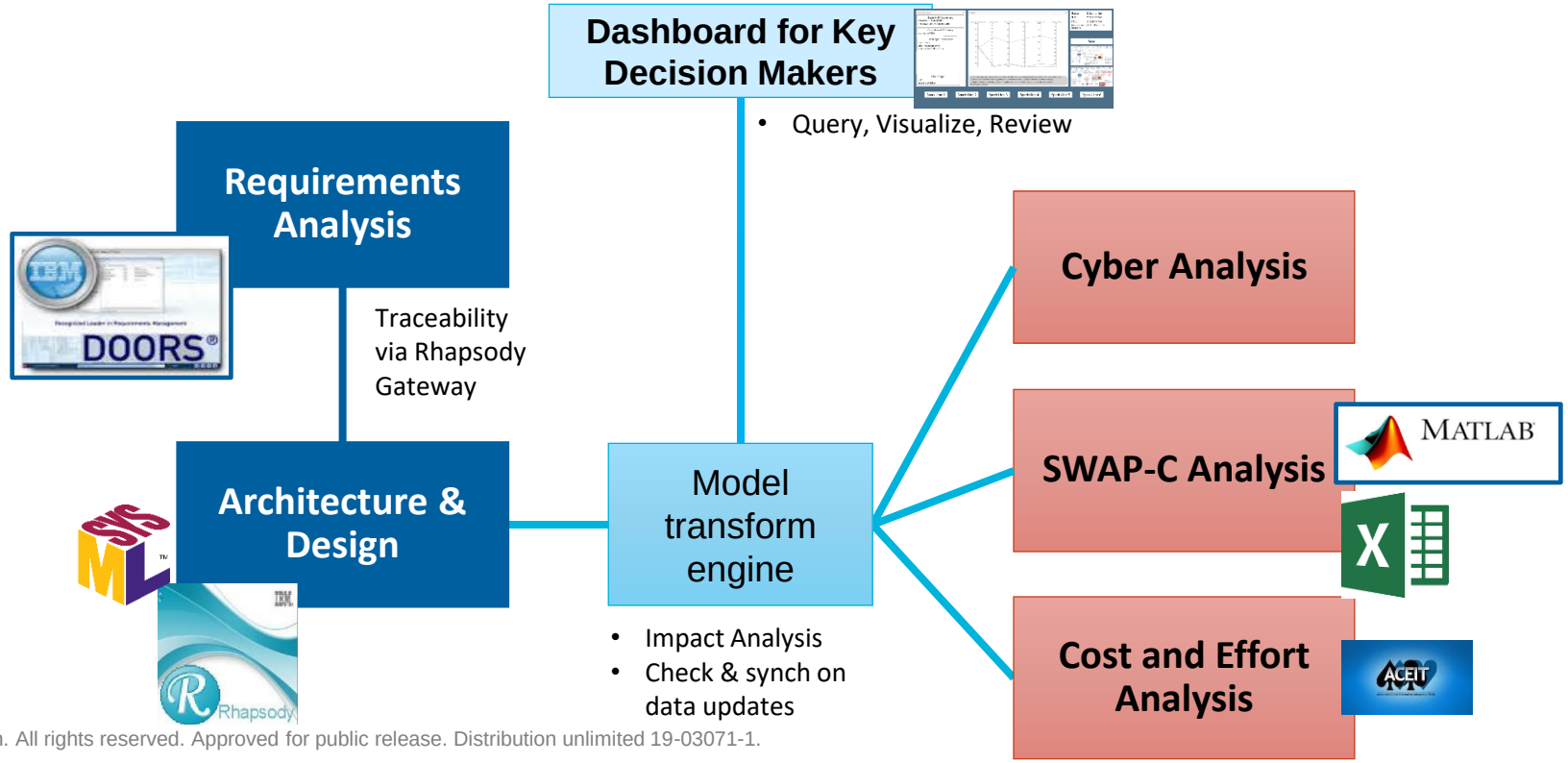
A DoD Program Example: Multi-Disciplinary Digital Engineering Environment

Technical Approach:

- Link Architecture & Design to other relevant disciplines (Cyber, SWAP-C, Cost) via a scalable model transform
- Perform synchronization of data based on user notifications
- Perform Impact Analysis; Query and Review without having to open an Authoring tool



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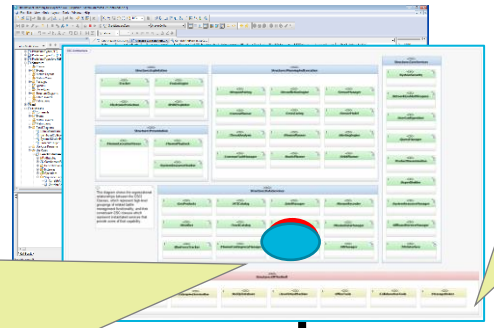
Architecture - Cost Analysis Workflow

Authoring Tool



Step 1, Architect makes updates… OR identifies a GRA component to analyze

Step 2, Architect saves a new model baseline

Step 2.1, WBS updated via a model transform

Work Breakdown Structure (WBS)

Step 3, Cost SME is notified of change

Integrated Model Environment

Architecture SME

Cost SME

Step 6, Architect is notified of updated cost estimate and accepts change to model

Step 5, Cost SME saves a new baseline

Step 4, Cost SME updates the analysis

Analysis Tool

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Lessons Learned

- **No existing tool addresses all DE integration and interoperability challenges**
  - Commercial/open source tools provide indicators on where industry is going
- **Need to utilize existing standards as much as possible**
  - Custom solutions are often difficult to deploy and productize in sponsor environments
- **DE adoption will only be possible if users can work in their disciplinary tools**
  - Need to integrate existing engineering workflows and make it easier for users to do their day-to-day job
- **DE is challenging to implement technically and programmatically**
  - Incremental use case driven progress can help with technical scalability and required stakeholder buy-in