Systems Engineering Rigor Needs an Interoperability Framework

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CIMdata

THE REUSE COMPANY

- Introduction
- CIMdata Overview
- Defining PLM & Systems Engineering
- System Engineering Challenges
- Decisions Need Broad Digital Interoperability
- Introducing SES ENGINEERING Studio from The REUSE Company
- Questions & Answers
- Closing Remarks

Craig Brown, Executive Consultant

PLM Leader (Retired)
General Motors

- 40+ years of experience, 29 at GM, in systems engineering and embedded control software and the digital tools needed, both in the automotive and aerospace industries

- Appointed PLM Leader at General Motors in 2012 governing planning and execution of key PLM initiatives (Retired 2019)

- Lead Powertrain Simulation Methods Team leading to new techniques for math-based controls & calibration, tribology modeling predictions, balancing laboratory/ field/simulation practices moving work to the left. Earned Boss Kettering Award for Remote Diagnostics Patents (US and Europe)

- Joined the CIMdata team in 2019 - systems engineering, PLM governance, various PLM consulting engagements, enterprise process modeling / execution, authoring eBooks, commentaries, and white papers. Invited PLM / MBSE speaker

- Earned a B.S. in Aerospace Engineering and DFSS Black Belt

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Systems Engineering Rigor

Needs Interoperability Framework providing seamless access to concurrent information

- Product complexity is increasingly a system-of-systems problem requiring effective, efficient systems engineering management solutions from product inception through operations.

- Requirements must be written well, with no ambiguity. They must be shared as they are refined. Duplication of requirements leads to confusion, wasted time, and in extreme cases poor product performance.

Systems Engineering Rigor

Needs Interoperability Framework providing seamless access to concurrent information

- Models of all sorts (logical, functional, structural, electrical, mechanical, equational, etc.) must also be authored well, with no ambiguity. They must also be shared as they are refined. Copies of any engineering items produced within the system engineering digital thread leads to confusion and wasted time.

- Maintaining the systems engineering thread is difficult as the necessary technical processes are digitalized within organizations using many software tools (among them, existing PLM solutions), each with its own file management capabilities which causes copies of requirements lists.

Systems Engineering Rigor

Needs Interoperability Framework providing seamless access to concurrent information

- Researchers have developed ontologies that provide precise languages and standards when authoring and refining requirements, model elements, assemblies, parts, tests, and other relevant data. Computer databases can help enforce semantic clarity when an engineering item's grammar is defined and precise. Authors can then use these solutions to author the best requirements, models, and associated datum—resulting in clear, concise, precise, and measurable information.

Systems Engineering Rigor

Needs Interoperability Framework providing seamless access to concurrent information

- The Reuse Company (TRC) provides solutions for knowledge gathering, classifying, and sharing, quality enforcement, across many disciplines each with their own specific solutions, e.g., requirements databases, Logical Modeling, CAD, CAE, ALM, etc. TRC ensures interoperability by integrating with these solutions. They provide systems engineers with their SES ENGINEERING Studio—a platform that assures requirements, models, tests, parts, equations, and many other engineering items are authored correctly and shared in a controlled manner keeping them visible all the time.

TRC's SES ENGINEERING Studio is such a framework

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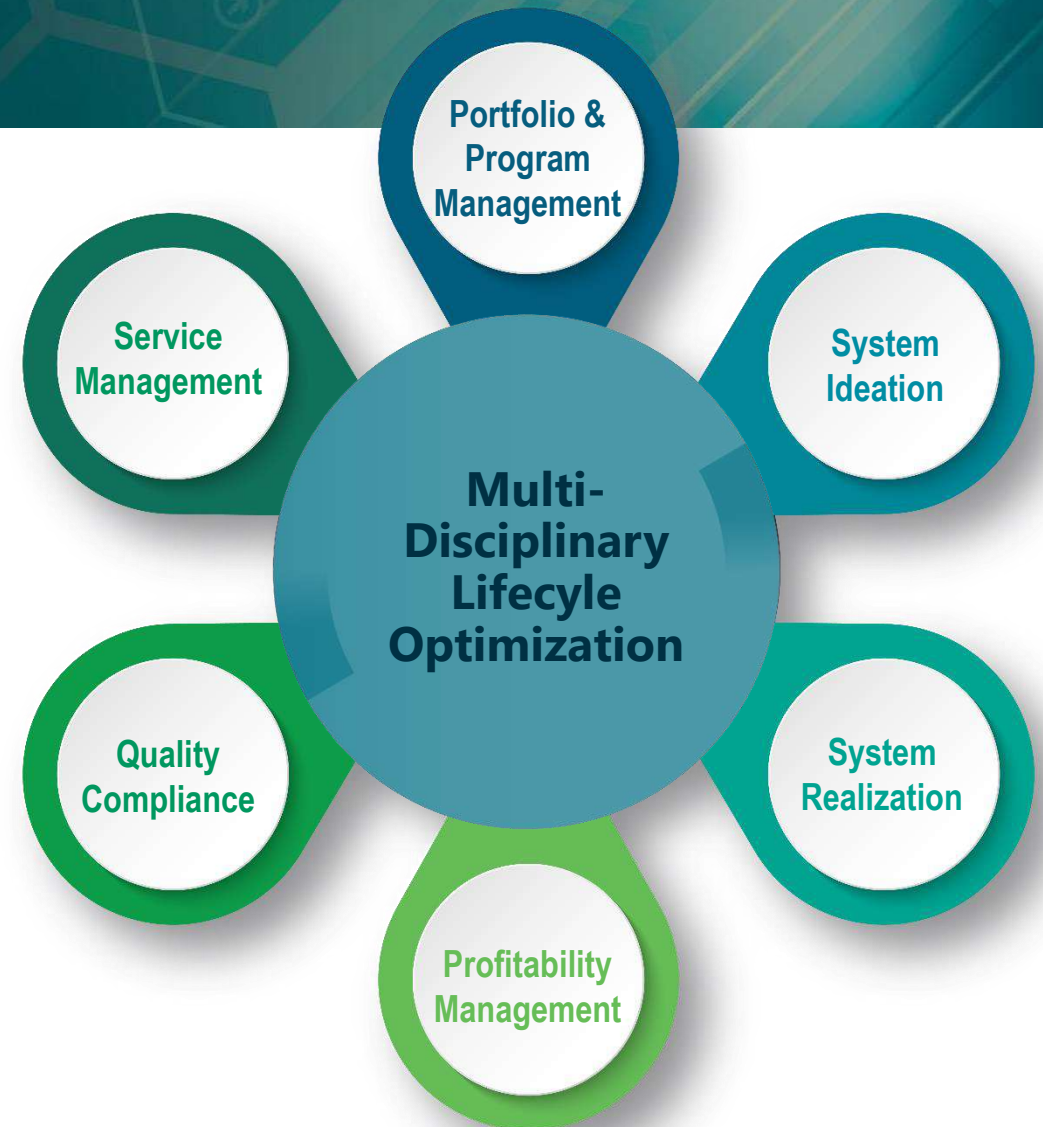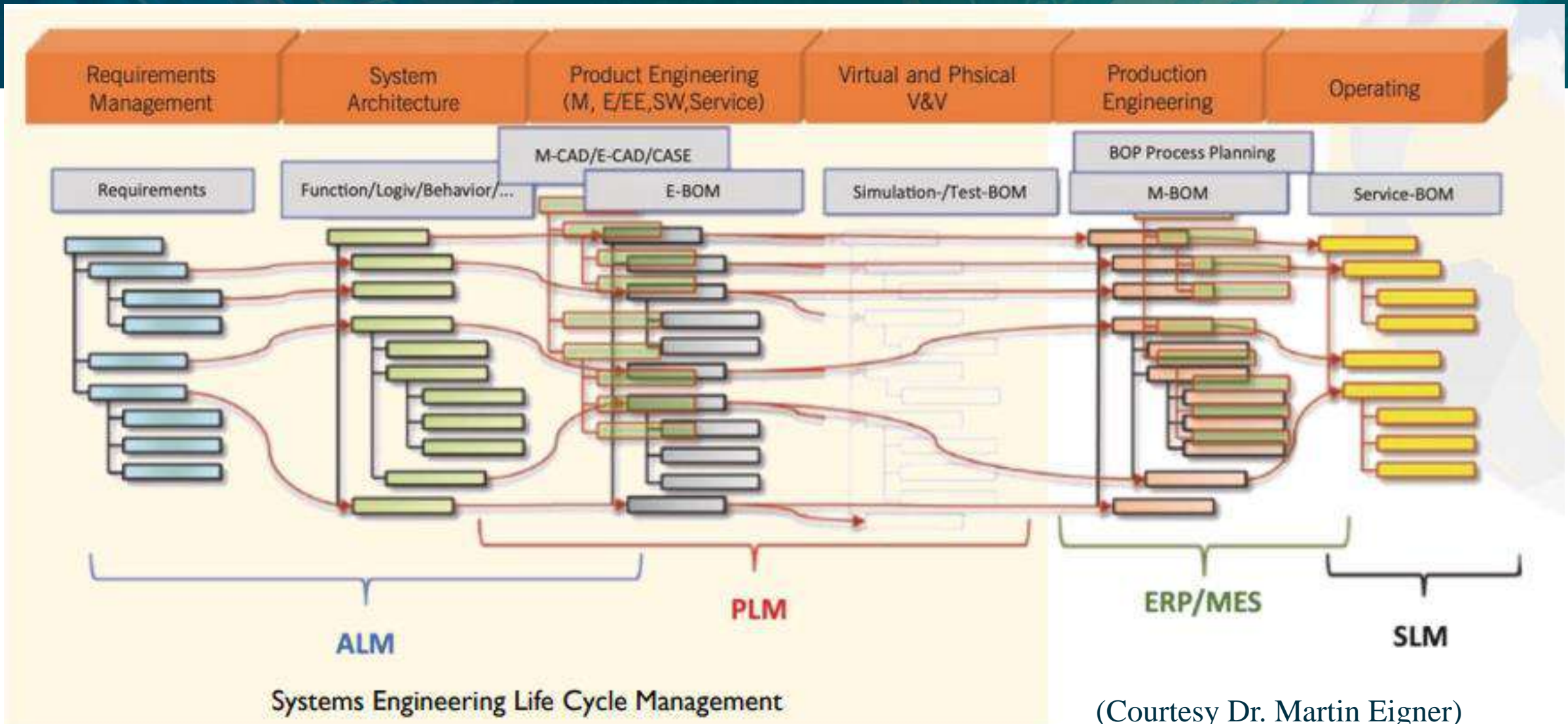- Questions & Answers
- Closing Remarks

What We Do

We help boost business performance in the age of digital transformation

Expertise that improves our clients' ability to design & deliver sustainable "right to market" products & services

Establishing a digital product innovation platform

Empowering people, processes, practices & products

Optimizing end-to-end lifecycle processes

Elevating systemic innovation

CIMdata

Unlocking the value of intellectual assets

Leveraging resources across the extended enterprise

Reducing end-to-end lifecycle costs

Mitigating risks related to product & process complexity

Our Services

Strategic advice & counsel through a comprehensive & integrated set of services

RESEARCH
Foresight

EDUCATION
Leadership

CONSULTING
Success • Invest • Transformation

• Research & analysis	• Industry conferences	• Strategic guidance
• Technology evaluations	• Seminars & webinars	• Aligning solutions with needs
• Market-specific insights	• Certificate programs	• Program management advisement
• Industry news & trends	• Best practices	• Market positioning

Select Transformation Clients

Aero & Defense

Auto/Transportation
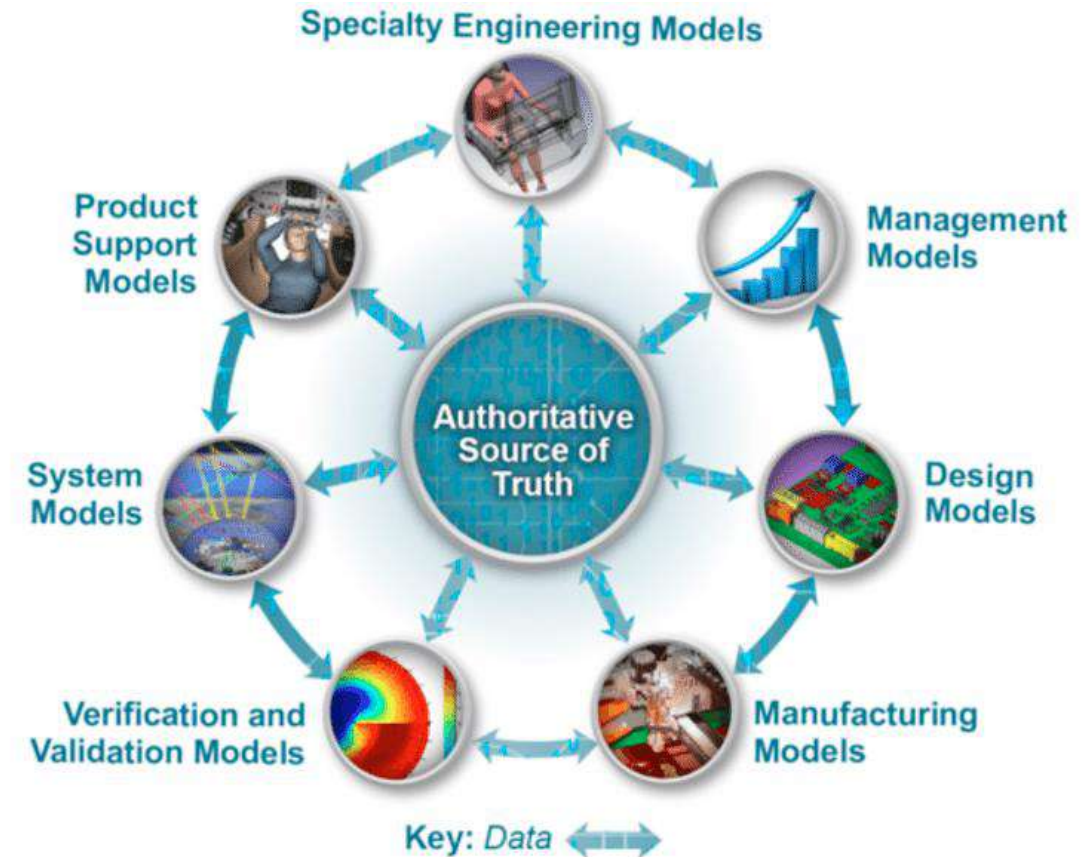

Fab & Assembly

High-Tech

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Defining PLM

Digital transformation of the lifecycle, enabled by the product innovation platform

PLM is...

- A strategic business approach powered by a consistent set of solutions
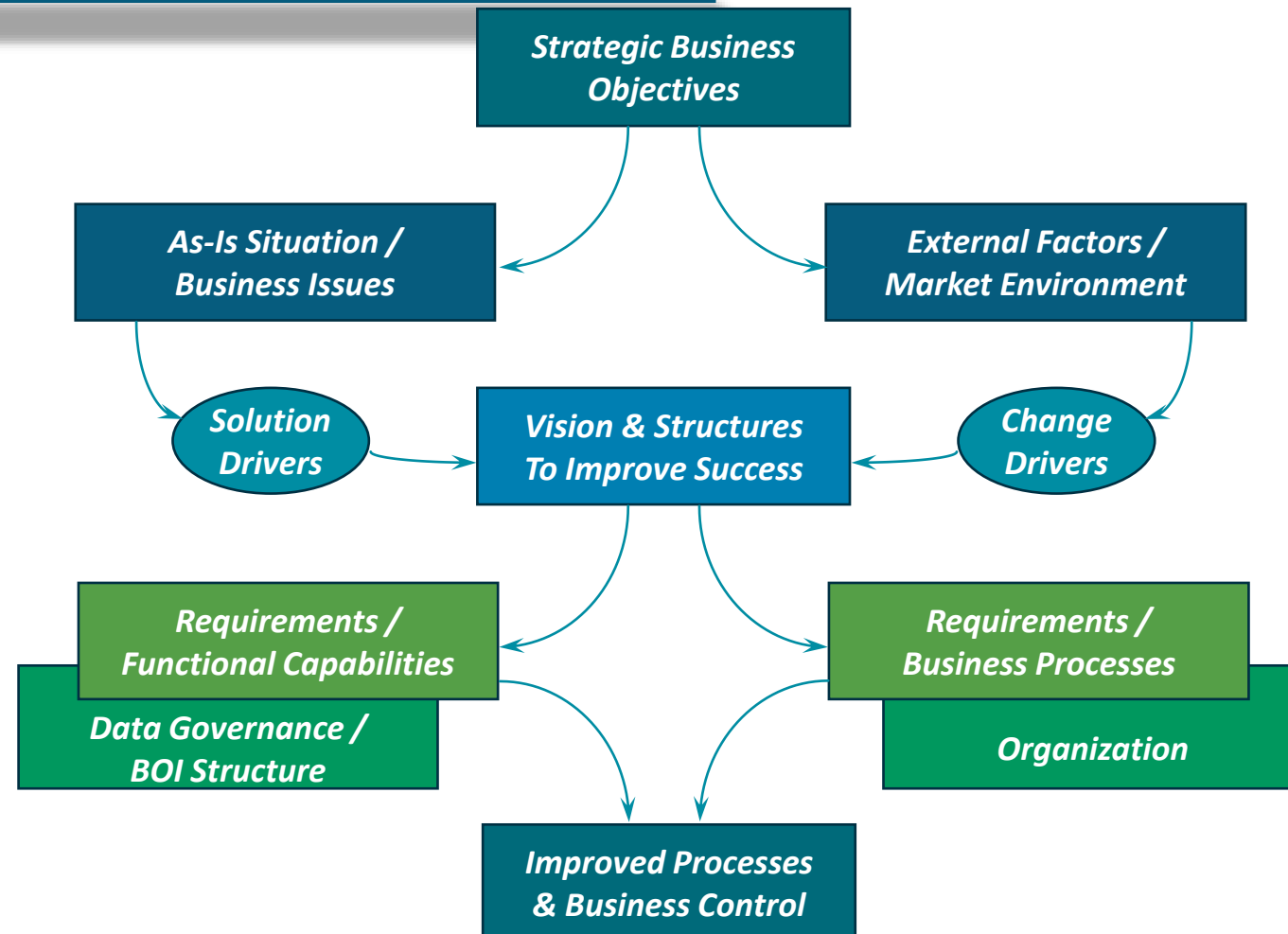- Enabled by product innovation platforms that support the extended enterprise
- An approach that spans the full lifecycle, from idea through life
- Enables a set of evolving functional domains orchestrated by an extended enterprise-level "systems of systems" approach

Portfolio & Program Management

Service Management

System Ideation

Multi-Disciplinary Lifecyle Optimization

Quality Compliance

System Realization

Profitability Management

Product Development Systems Engineering

(Courtesy Dr. Martin Eigner)

PLM's Critical Role

Spans the full lifecycle: from concept through launch and beyond

PLM is the collaborative creation, use, management, and dissemination of product-related *intellectual assets*

Virtual Products

AEC, MCAD, EDA, ALM, SE, requirements, simulations, analytics, portfolio, formulas...

Virtual Processes

Planning, design, production, operation, support, decommission, recycling...
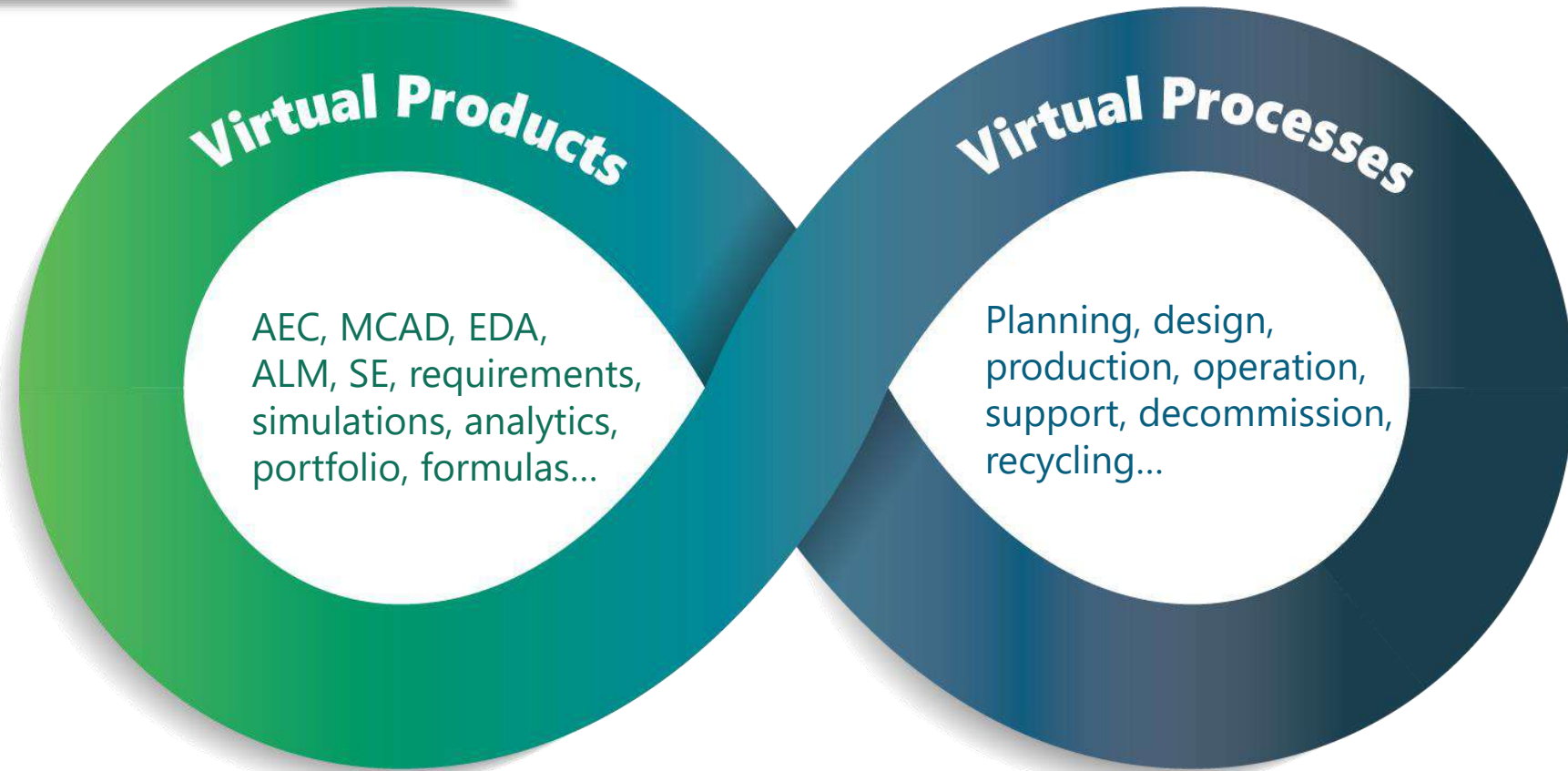
Simulation-Driven Systems Development

Practice Overview

Director: Don Tolle

Mission

- Enable adoption of Model-Based Engineering (MBE) processes and tools focused on the expanding intersection of emerging model-based systems engineering (MBSE) methods with best practice and technologies in Modeling, Simulation, and Analysis

Areas of Focus

- Providing management consulting services to industrial organizations and PLM/MBE solution providers in the effective implementation of model-based technologies, integrated processes, and industry best practices
- Research and thought leadership publications on market trends, technology gaps, industry standards, and best practices for integrating data, processes, and tools to enable MBE/MBSE

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CIMdata Foresight Model-Based Enterprises

Using Models with Known Contexts Improves Products Decisions

- Requirements Discovery
  - Balancing Wants and Desires with Needs
  - An agreement across products & enterprise

- Authoritative Source of Truth
  - Defined by DoD Digital Engineering Policy
  - Datum comes from many models

- Ontologies provide Rosetta Stone
  - Enables better systems understanding

- Interoperability Solutions Streamline
  - Collaborative access when needed
  - Refinement in near real time

(Courtesy of US DoD)

Interoperability Across Enterprise

12 critical elements of a successful digital transformation—digitalization is at the core
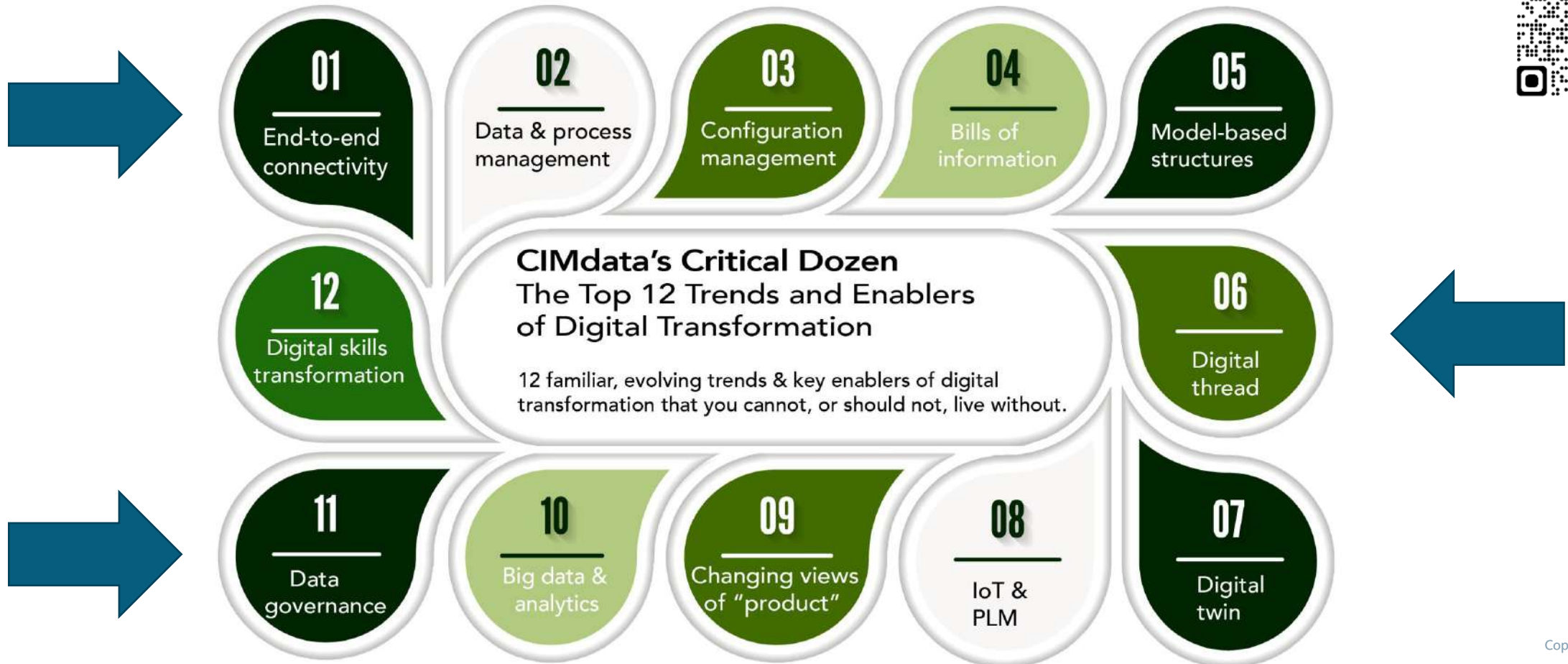
CIMdata's Critical Dozen
The Top 12 Trends and Enablers of Digital Transformation

12 familiar, evolving trends & key enablers of digital transformation that you cannot, or should not, live without.

01 — End-to-end connectivity
02 — Data & process management
03 — Configuration management
04 — Bills of information
05 — Model-based structures
06 — Digital thread
07 — Digital twin
08 — IoT & PLM
09 — Changing views of "product"
10 — Big data & analytics
11 — Data governance
12 — Digital skills transformation

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Best Practice for Digital Transformation

To improve business performance, start with strategy & end with measurable results

Strategic Business Objectives

As-Is Situation / Business Issues

External Factors / Market Environment

Solution Drivers

Vision & Structures To Improve Success

Change Drivers

Requirements / Functional Capabilities

Requirements / Business Processes

Data Governance / BOI Structure

Organization

Improved Processes & Business Control

Building & Keeping Trust Is Crucial

How can Digital Engineering help trustworthiness?

- Collaboration across organization silos is essential

- New product technologies and empirical data analytics are allowing new entrants into industries

- Virtual, contextual views of a product correlated with its usage data improves confidence as creators acquire knowledge of their customer's usages

- Requirements Engineering manages changes during development

- ALM/PLM solutions must embrace **_Interoperability_**, especially in Systems Engineering

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Introducing SES ENGINEERING Studio

SAFRAN Aircraft Engines, an early adopter, is using this Interoperability Framework

- Requirements Engineering & Quality

- Verification & Validation

- Traceability Discovery

- Knowledge Management and Patterns

- Test Cases Generation from requirements

SMART Traceability, Davy Masson (SAFRAN Aircraft Engines) and Jose Fuentes (The REUSE Company), at 2022 INCOSE International Symposium (June 2022 Detroit, USA)

Dr. Juan Llorens

- CTO at The REUSE Company
- Systems Engineering Professor at Universidad Carlos III de Madrid (Spain)
- INCOSE
  - Former President and Technical Director of AEIS (INCOSE Spain)
  - Member of INCOSE RWG / PLEWG / KMWG
  - CSEP / ESEP
- PhD in Industrial Engineering with SW Reuse as topic

ENABLING SMART SYSTEMS ENGINEERING.

We promote the digitalization of the system life cycle management …

guided by reuse,
driven by a knowledge-centric + model-based approach
(=> supporting the authoritative source of truth concept),
integrating Document Centric views inside MBSE

By…
stating an Integration Hub,
providing connectivity to all siloed tools in the ecosystem,
enabling unlimited interoperability among tools,
offering full support to technical management processes for all connections (as defined in ISO 15288)
digitalizing the life cycle management workflow
empowering Microsoft Productivity tools as pure SE solutions

SES ENGINEERING Studio
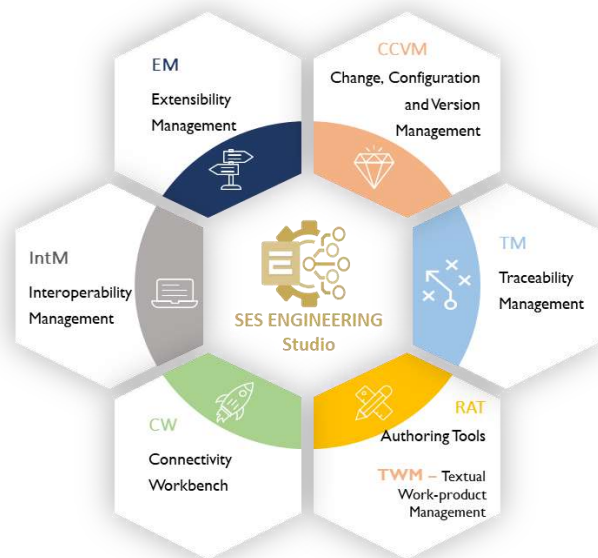
> SES is the SW solution of The REUSE Company for enabling the system lifecycle digital management by reusing and integrating the existing (or new) ecosystem of tools. This approach in based on:

- Connecting to the different tools
- Making them INTEROPERABLE and reusable. Examples:
  o Generate models in CAMEO, Rhapsody, EA, Capella from requirements in DOORS, Polarion, TeamCenter, Word, Excel, etc.
  o Generate requirements from models using the existing tools
  o Transforming models
  o Porting requirements and models between platforms (Capella,
  o Etc.
- Managing inside them ALL the technical management processes (quality, V&V, Traceability, Configuration and Change Management, etc.)
- Providing smart authoring on the tools content
- Creating a lifecycle workflow by defining tools/documents dependencies.
- Enhancing MBSE by Orchestrating a Synchronized Source of Truth (SSoT) using ontologies
- Offering MBRE (Model Based Requirements Engineering) integrating requirements and models
- Using the Ontology to Provide smart semantic services to the architecture.

TECHNICAL MANAGEMENT
Capabilities

SYSTEMS ENGINEERING SUITE

Engineering Studio

Interoperability Hub (Connectors)

Interoperability Hub (Connectors)

WORD

EXCEL

PPT / VISIO

PROJECT

OTHER TOOLS

PLM

DOORS

DOORS DB

TEAMCENTER

CAPELLA

Capella DB

CAMEO SYSTEMS MODELER

MAGIC DRAW

Magic Draw DB

RHAPSODY

Rhapsody DB

SIMULINK

Simulink

Simulink DB

creo

OpenModelica

Connector to Polarion Requirements + RAT (2.10 min)

(1.18 min)

Connector to IBM DOORS v9 (4.48 min)

RMS inside MS Word – Creating the Connection and editing requirements (5.50 min)

Managing Cameo from the Engineering Studio (3.12 min)

(5.35 min)

Managing Capella from the Engineering Studio (5.48 min)

Managing Rhapsody from the Engineering Studio (2.37 min)

(3.15 min)

Managing Simulink Models and Requirements (2.15 min)

(2.14 min)

POLARION

DOORS

MS WORD

CAMEO / MD

CAPELLA

RHAPSODY

SIMULINK

SES ENGINEERING Studio

Managing MS Porject from the Engineering Studio (2.01 min)

Managing JIRA from the Engineering Studio (2.29 min)

Managing SolidWorks from the Engineering Studio (3.32 min)

JIRA

SOLIDWORKS

Requirements and Textual Oriented Tools

	Microsoft Excel Requirements
	Microsoft Excel USDM Requirements
	Microsoft Word Documents (and Requirements)
	Reqtify
	Siemens Polarion
	Siemens Teamcenter
	SRT
	DOORS
	DNG
	PTC ILM / PTC Winschid / Integrity
	VISURE
	Reqif
	3DX
	Textual File (Plain Text)

Functional Behaviour

	Dynamic Linked Library
	FMU Connector
	Microsoft Excel Functions

Logical Modeling and Functional Modeling

	Cameo Systems Modeler
	Cameo Systems Modeler XML
	Capella
	Magic Draw XML
	Papyrus
	PowerPoint
	Rhapsody XMI
	Rhapsody
	Siemens Teamcenter
	Visio
	EA
	EA XMI
	XMI

Physical Modeling

	Altium Designer*
	Dynamic Linked Library
	Microsoft Excel Functions
	FMU Connector
	PowerPoint*
	Siemens Teamcenter*
	Simulink
	Simulink Files*
	OpenModelica
	Visio*

Others

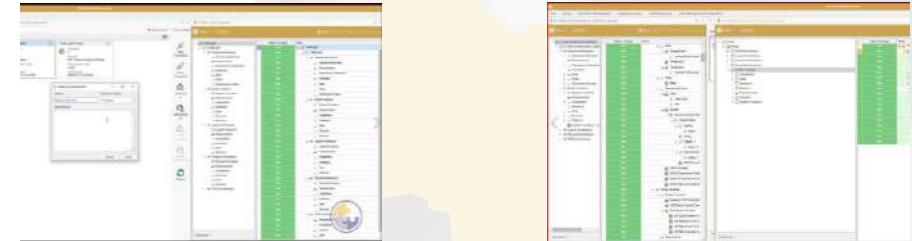|	
	ASCE
	CruiseControl .NET
	DocuWare
	Excel Tabular File
	Pure Variants
	Siemens Teamcenter
	Customer Defined Connection to own Information
	XML
	Microsoft Word
	OWL, PROTÉGÉ
	Open API
	Databases (Oracle, SQL Server, MySQL, MS Access)
	Textual File (Plain Text)
	CRML
	Multimedia
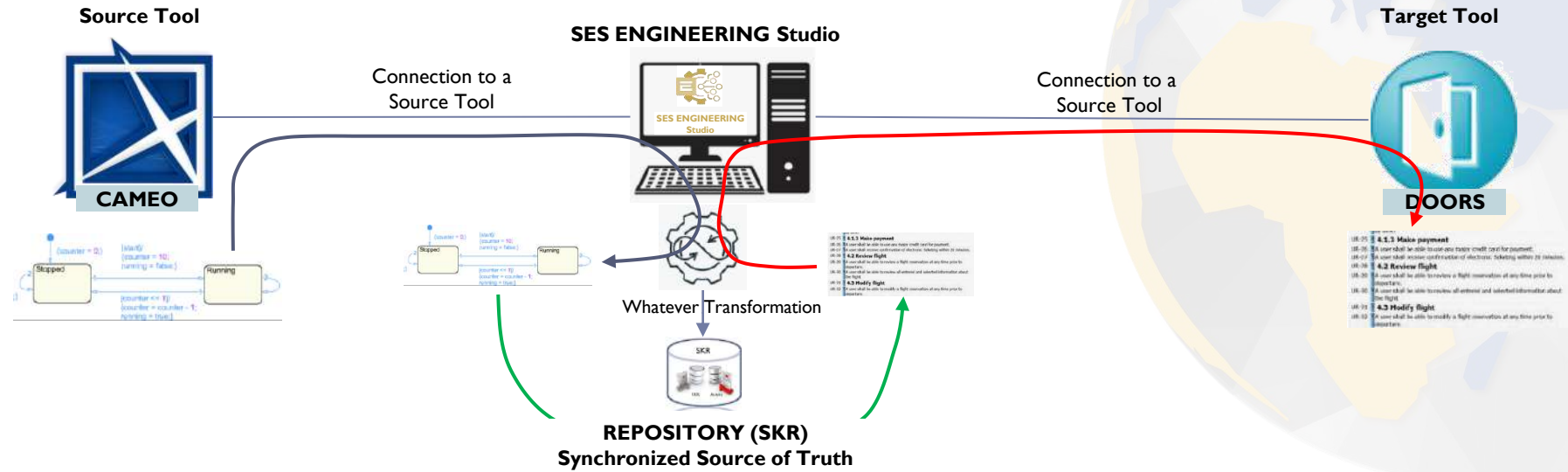
INTEROPERABILITY

- Possibility of connecting content (traceability)

- Connecting outputs from source connections to Inputs of Target connections Simulating requirements, sending information to simulations, etc.

- Automating the Digital Thread Changes in one engineering item automatically produce the changes in the manuals, etc..

- Creation of content in one connection from content of other connection Automatic generation of models, requirements, test cases etc.

- A Lifecycle Management Project can be created defining workflows of connections
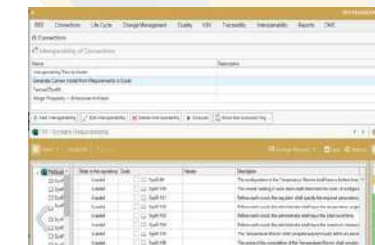
1- INTEROPERABILITY AT CONNECTION LEVEL

All
Work-products

Connection → Operation or Transformation → Connection → New or updated Work-products

CAPELLA

Copy / Add
Merge / Synchronize
Compare / Diff
All Sorts of Transformations

2- INTEROPERABILITY AT WORKPRODUCT LEVEL (Bindings)

Binding Specific properties from the different connections
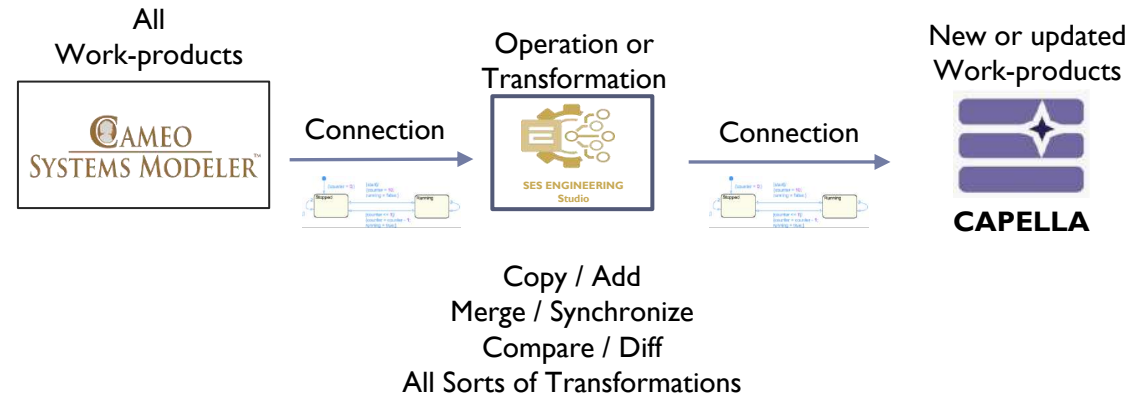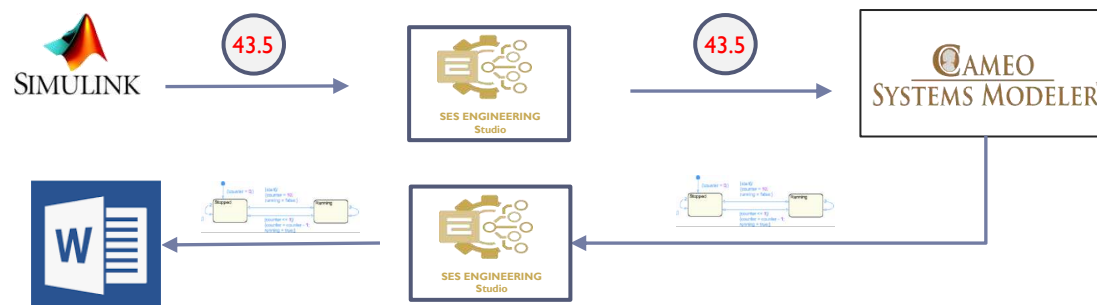
SOME EXAMPLES DEMOS

Model Round trip (Cameo->Capella) (5.55 min) and (Capella-Cameo) (3.45 min)

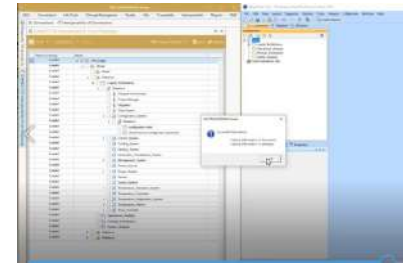Generate Models in Cameo from Requirements in Excel and synchronize the Model in Enterprise Architect (4.47 min)
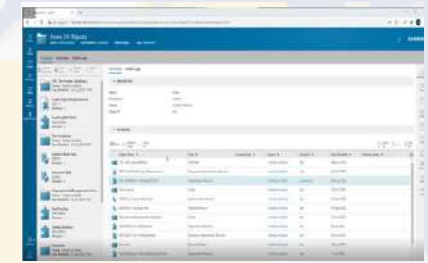

Interoperability:
Requirements Simulation (Word-Excel) (4.47 min)

When the traffic light turns yellow, the traffic light will be red after 5 seconds.

TEAMCENTER

SES ENGINEERING Studio

Generated Model

Semantic Engineering environment

Red
30 seconds — Yellow — 5 seconds
Green — 30 seconds
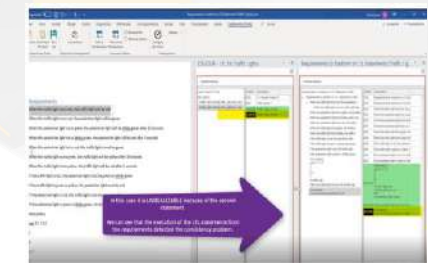
SIMULINK

Simulation

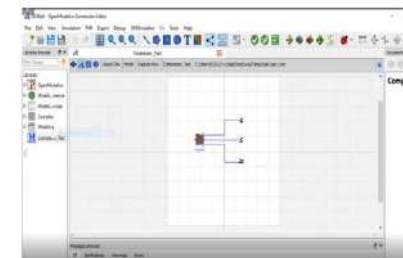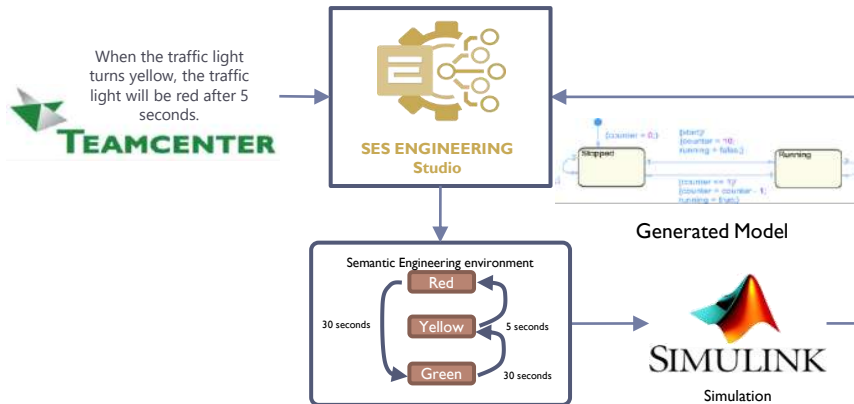Automatic Generation of Simulink State Machines from Requirements (3.01 min)

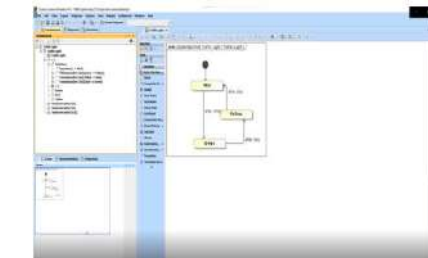Merge / Copy To / Add To Rhapsody 2 Cameo (2.20 min)
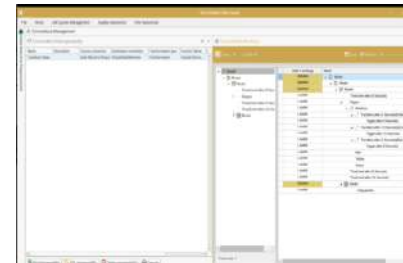
Automatic Generation of SysML from Requirements (4.03 min)

Automatic Generation of Linear Temporal Logic (LTL) from Requirements (3.23 min)

Automatic Generation of MODELICA Models from Requirements (3.52 min)

Interoperating Models: Magic Draw-Simulink (1.20 min)

Interoperability Models / Functions / Requirements Documents

System Model

CAPELLA

Transition delay in a State Machine

Functional Simulation

System Specification

Simulation results

Received Simulation Results

SES ENGINEERING Studio
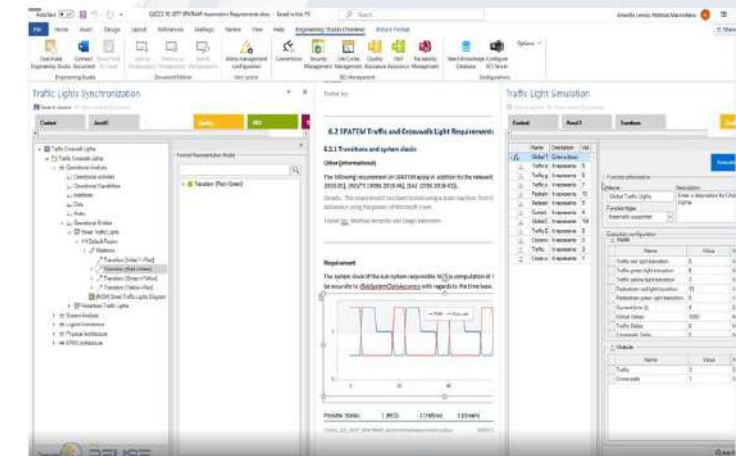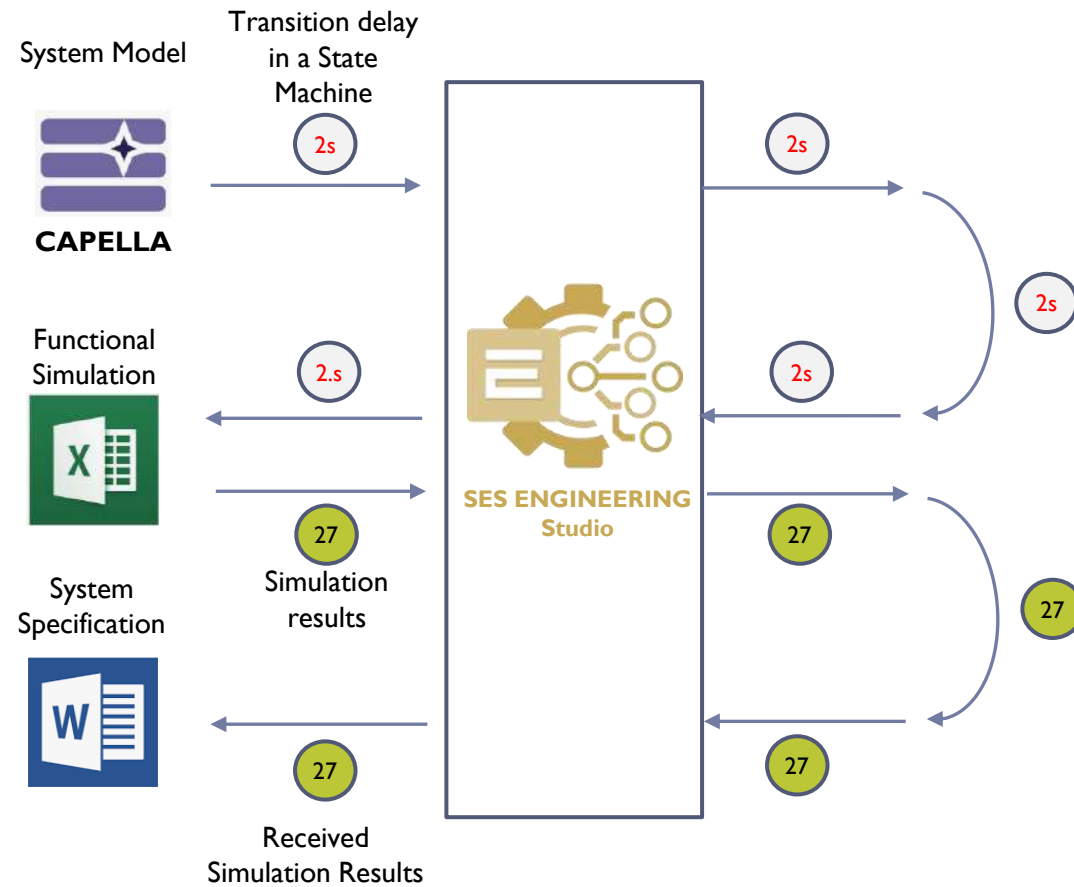
SES ENGINEERING Studio
Interoperability: Models Simulation (Capella – Excel - Word) (13.15 min)
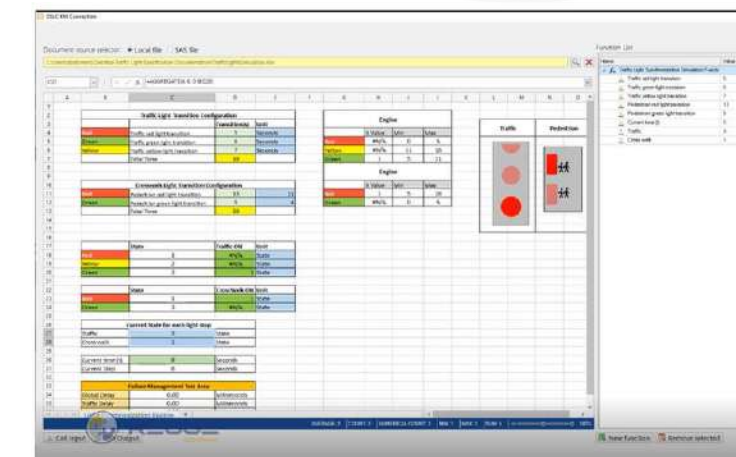
SES ENGINEERING Studio
Capella – Word – Excel: Requirements Extraction and Management, Traceability, CRUD, Quality, Authoring, Simulation against Excel (24.45 min)

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Boosting MS Word with Requirements Management capabilities

- Writing high-quality requirements in MS Word (January 31 & February 2)

- Managing Requirements in MS Word

- Transforming MS Word requirements

- Propagating changes from traceability links

- Reporting Systems Engineering artifacts through MS Word

Questions & Answers

What's on your mind?

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Closing Remarks

To remain competitive, interoperability is paramount to digital transformation

- The most innovative organizations have diverse toolsets, especially as they pursue new technologies

- ***Interoperability techniques*** and solutions are needed for effective digital transformation while allowing innovators digital tool flexibility

- Trusting the sources of truth makes them authoritative

  "Meaningful for the next decision to be made"

- The Reuse Company has developed SES ENGINEERING Studio as the interoperability framework for all kinds product data elements

CIMdata Defining What Comes Next in Digital Transformation

Strategic management consulting for competitive advantage in global markets

Serving clients from offices in North America, Europe, and Asia-Pacific

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