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NDIA

25TH ANNUAL
SYSTEMS & MISSION ENGINEERING CONFERENCE

November 1 – 3, 2022 | Orlando, FL | NDIA.org/SME

MONDAY, OCTOBER 31

1:00 – 5:00 PM

REGISTRATION
PENINSULA FOYER

TUESDAY, NOVEMBER 1

8:00 AM – 5:00 PM

REGISTRATION
PENINSULA FOYER

8:00 – 8:10 AM

OPENING REMARKS
PENINSULA 1-7

Holly Dunlap
Principal System Security Engineer, Cyber Supply Chain Risk Management, The MITRE Corporation
NDIA Systems Engineering Division Chair

The Hon. David L. Norquist
President and CEO, National Defense Industrial Association

8:10 – 8:40 am

KEYNOTE: SYSTEMS & MISSION ENGINEERING CAPABILITES
PENINSULA 1-7

Elmer Roman, SES
Director, Mission Integration, Mission Capabilities Office of the Under Secretary of Defense for Research and Engineering

8:40 – 9:10 am

NETWORKING BREAK
PENINSULA FOYER

9:10 – 9:40 am

LAY OF THE LAND & STRATEGIC INITIATIVE
PENINSULA 1-7

Chris Collins, SES
Executive Director, Developmental Test, Evaluation, and Assessments (ED, DTE&A), OUSD(R&E)

Dr. Sandra Hobson, SES
Deputy Director, Strategic Initiatives, Policy and Emerging Technologies Director, Operational Test and Evaluation Office of the Secretary of Defense

9:40 – 10:55 am

DIGITAL TRANSFORMATION IN SUPPORT OF TEST & EVALUALTION PANEL

PENINSULA 1-7

Dr. Laura Freeman
Deputy Director, Virginia Tech National Security Institute, Assistant Dean for Research, College of Science
Moderator

Chris Collins, SES
Executive Director, Developmental Test, Evaluation, and Assessments (ED, DTE&A), OUSD(R&E)

Dr. Sandra Hobson, SES
Deputy Director, Strategic Initiatives, Policy and Emerging Technologies Director,
Operational Test and Evaluation Office of the Secretary of Defense

Mark Kassan
Technical Director, Engineering and Technical Management Directorate, Air Force Nuclear Weapon Center
Tentative

Policarpio Sorbanis
Engineering Manager, Aeronautics Sector

David Harrison
Associate Fellow, Space, Lockheed Martin

Chris Carhart
Senior Engineer, Boeing Company

10:55 – 11:25 am

AWARD CERMONY

PENINSULA 1-7

Holly Dunlap
NDIA Systems Engineering Division Chair
Award Presenter

BOB RASSA EXCEPTIONAL SERVICE AWARD

Bob Rassa
Awardee

Robert Scheurer
Systems Engineering / Technical Fellow Boeing Defense, Space, & Security - St. Louis
Awardee

LT GEN THOMAS R. FERGUSON AWARD

Rolf Siegers
Engineering Fellow, RTX Corporate Architecture Board
Individual Award Winner

Object Management Group Space Domain Task Force &
INCOSE Space Systems Working Group CubeSat Systems Reference Model Team
Group Award Winner

TESTER OF THE YEAR AWARDS

Jeff Bilco
Senior Manager, Boeing Test & Evaluation, Engineering Strategy, Technology & Initiatives
Chair Test & Evaluation Division, NDIA
Award Presenter

Chris Collins
Executive Director, Developmental Test, Evaluation, and Assessments (ED, DTE&A), (OUSD(R&E))
Award Presenter

THE WALTER W. HOLLIS AWARD

Jeff Bilco
Chair Test & Evaluation Division, NDIA
Award Presenter

Mike Rabens
Chair Industrial Committee on Operational Test & Evaluation, NDIA
Award Presenter

Hon Bob Behler
Awardee

11:25 am - 12:25 pm

LUNCH BREAK

PENINSULA 1-7

12:25 – 1:10 pm

FEATURED SPEAKER

PENINSULA 4

Dr. Tim Grayson
Special Assistant to the Secretary of the Air Force

1:10 – 1:55 pm

CHINA AEROSPACE STUDIES INSTITUTE UPDATES

PENINSULA 4

Dr. Brendan Mulvaney
Director, China Aerospace Studies Institute

1:55 – 2:55 pm

SYSTEMS ENGINEERING TRANSFORMATION IN THE DIGITAL WORLD

PENINSULA 4

Holly Dunlap
Principal System Security Engineer, Cyber Supply Chain Risk Management, The MITRE Corporation
Moderator

Chris Schreiber
Chief Engineer, Information Technology & Digital Enablement, LM Space Systems Company

Dr. Katrina Mansfield
S&T Deputy Director, Acting, Acquisitions and Systems, Army Futures Command

Christopher Garrett
Technical Advisor for Architectures, AFLCMC/EN-EZ

Allan Dianic
Director, Software Engineering, SE&A OUSD (R&E)

Chris DeLuca
Director, Specialty Engineering, SE&A, OUSD (R&E)

2:55 – 3:10 pm

NETWORKING BREAK

PENINSULA FOYER

The NDIA has a policy of strict compliance with federal and state antitrust laws. The antitrust laws prohibit competitors from engaging in actions that could result in an unreasonable restraint of trade. Consequently, NDIA members must avoid discussing certain topics when they are together at formal association membership, board, committee, and other meetings and in informal contacts with other industry members: prices, fees, rates, profit margins, or other terms or conditions of sale (including allowances, credit terms, and warranties); allocation of markets or customers or division of territories; or refusals to deal with or boycotts of suppliers, customers or other third parties, or topics that may lead participants not to deal with a particular supplier, customer or third party.

CONCURRENT BREAKOUT SESSIONS

TRACK NAME	1A1 – Digital Engineering	1A2 – Architecture / MOSA	1A3 – Mission Engineering / System of Systems	1A4 – System Security Engineering	1A5 – Test & Evaluation
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR	John Daly & Chris Schreiber	Bob Scheurer & Rebecca Hicks	Dr. Judith Dahmann	Cory Ocker	Jeff Bilco & Mike Rabens
3:10 – 3:40 pm	DE-24798 Digital Engineering Strategy for DHS **Yonas Nebiyeloul-Kifle** Senior Advisor Department of Homeland Security **Kerry Wilson** Deputy Director Department of Homeland Security, Under Secretary of Science and Technology, Office of Science & Engineering	Arch/MOSA-24810 Implementing an ARINC 661 CDS with MOSA **John Macauley** Manager, Application Engineering Ansys	ME/SOS-24789 Mission Engineering – Panel **Dr. Judith Dahmann** Technical Fellow, The MITRE Corporation *Moderator* **Elmer Roman** Director, Mission Integration Office of the Under Secretary of Defense for Research and Engineering **Nicole Hutchison** Principal Investigator Systems Engineering Research Center **Tom McDermott** Research Director Stevens Institute of Technology **John Daly** Chief Engineer Booz Allen Hamilton **Dr. Peter Korfiatis** Department Manager, Systems Engineering Innovation Center MITRE Corporation	SSE-24774 System Security Committee & Track Welcome **Cory Ocker** System Security Engineer Raytheon Technologies	Test & Evaluation -ICOTE Invitation Only
3:40 – 4:10 pm	DE-24571 Digital Engineering Trade Study Example: NASA Ranger Program **Mark Payton** Digital Engineer SAIC	Arch/MOSA-24660 A Model-Based Approach to Evaluating Architecture Specifications for MOSA Compliance **Dr. Awele Anyanhun** Senior Research Systems Engineer Georgia Tech Research Institute		SSE–24760 Program Protection and Secure Cyber Resilient Engineering Initiatives **Melinda Reed** Systems Security Director OUSD (R&E)	
4:10 – 4:40 pm	DE – 24612 Lessons Learned on Data, Systems, and Organization modeling in UAF **Charles Stirk** Senior Research Engineer GTRI			SSE-24594 Joint Federated Assurance Center Modernization 2022 **Brian Nowotny** JFAC Director OUSD(R&E) **Dr. Mark Winstead** Systems Security Engineering Department, Chief Engineering MITRE	
4:40 – 5:10 pm	DE-35000 Digital Engineering the Next Chapter **Daniel Hettema** Director, Digital Engineering Modeling & Simulation OUSD (R&E)				

5:10 pm	**RECEPTION**

WEDNESDAY, NOVEMBER 2

CONCURRENT BREAKOUT SESSIONS

TRACK NAME	2A1 – Digital Engineering	2A2 – Architecture/MOSA	2A3 – Mission Engineering / System of Systems	2A4 – System Security Engineering	2A5 – Test & Evaluation / Program Management
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR	John Daly & Chris Schreiber	Ed Moshinsky & Mike Franco	Dr. Judith Dahmann	Cory Ocker	Jeff Bilco
8:00 – 8:30 am	Agile-24812 Challenges and Success Patterns to Delivering Capabilities Faster **Dr. Suzette Johnson** NG Fellow, Lean Agile Northrop Grumman **Robin Yeman** Chief Technical Officer Catalyst Campus for Technology & Innovation	Arch/MOSA-24764 Preview of an Enterprise Product Architecture (EPA) to Support a Modular Open Systems Approach (MOSA) **Dr. Thomas DuBois** CTO JHNA	ME/SOS-24791 NDIA Systems Engineering Division Mission Engineering Initiative **Dr. Judith Dahmann** Technical Fellow The MITRE Corporation	SSE-24589 Office of the Under Secretary of Defense for Research and Engineering Software Assurance Roadmap **Steven Grice** Software Assurance Technical Director OUSD (R&E)	T&E-24509 Automation of Test Case Generation and Software System Modelling **Dr. Michael Lingg** Principal Computer Engineer Array Of Engineers
8:30 – 9:00 am	DE-24510 Collaborative Modeling - Agile Model-Based Systems Engineering **Ken Kubo** Director, Engineering Technologists Northrop Grumman Space Systems	Arch/MOSA-24597 An Update to the Comprehensive Architecture Strategy (CAS) and its Supporting Architecture Body of Knowledge **Scott Wigginton** Experimental Developer U.S. Army DEVCOM AvMC	ME/SOS-24795 Mission Engineering and Complexity **Dave Chesebrough** Vice President Government, Defined Business Solutions	SSE–24595 A Comprehensive Look at Software Assurance Through DevSecOps **Bradley Lanford** Systems Security Contract Support OUSD(R&E)	T&E-24512 Advancing M&S in Acquisition Test and Evaluation **Dr. Jason Daly** Department Chief Engineer, Defense Systems Engineering MITRE
9:00 – 9:30 am	DE-24657 Leveraging Model-Based Systems Engineering Tools and Techniques to Build Enterprise Knowledge Models **Patrick Bains** Lead Systems Engineer Booz Allen Hamilton	Arch/MOSA-24609 A MOSA for Directed Energy Weapon Systems **Walter Roscello** Lead Scientist U.S. Navy	ME/SOS-24797 Relationship of Mission Engineering to Systems of Systems Engineering **Dr. Judith Dahmann** Technical Fellow The MITRE Corporation	SSE-24593 Secure Cyber Resilient Engineering (SCRE) Design Code **Melinda Reed** Systems Security Director OUSD (R&E)	SSE-24518 Summary of the Ongoing OUSD DT&E Cyber Analytics Landscape Task **Sarah Standard** Cybersec/Interop Tech Dir D DTE&A OUSD (R&E)

9:30 – 10:00 am	**BREAK**				
TRACK NAME	**2B1 – Digital Engineering**	**2B2 – Architecture/MOSA**	**2B3 – Mission Engineering / System of Systems**	**2B4 – System Security Engineering**	**2B5 – Test & Evaluation / Program Management**
ROOM	Peninsula 1-3	Peninsula 4	Peninsula 5-7	Biscayne 1-2	Canaveral 2-3
MODERATOR	John Daly & Chris Schreiber	Ed Moshinsky & Mike Franco	Dr. Judith Dahmann	Cory Ocker	
10:00 – 10:30 am	DE-24524 Accelerating Digital Transformation of Engineering: Progress by the NDIA / INCOSE DEIX Working Group (DEIXWG) **Sean McGervey** Director, Model-Based Enterprise Dassault Systems	Arch/MOSA-24770 Achieving MOSA Benefits: "A Decision Framework for Choosing MOSA Metrics" **Steve Henry** Professor DAU	ME/SOS-24653 Context is Everything! **Matthew Hause** Principal System Strategy, Inc.	SSE-24471 Accelerating Modernization of Software Systems Engineering with a Special Emphasis on the New Version of IEEE SWEBOK (v.4.0) and the New Software Security Knowledge Area **Dr. Kenneth Nidiffer** Professor George Mason University	T&E-24631 Technical Debt as a Potential Leading Indicator for Test and Evaluation **Zakaria Ouzzif** Chief Engineer Raytheon Technologies
10:30 – 11:00 am	DE-24604 Digital Engineering Standardization - Current Landscape and Future Development **Celia Tseng** Sr Manager A&D Industry Dassault Systems	Arch/MOSA-24517 Digital Engineering Tool Selection Criteria **Frank Salvatore** Senior Systems Engineer OUSD (R&E)	ME/SOS-24538 The Israel Air Force take on System of Systems Engineering for International Platform Integration **Maj Tzvika Kaminsky** Chief System Engineer Israel Air Force	SSE-24540 Using Product Cybersecurity to Implement Software Assurance **Randall Brooks** Principal Engineering Fellow Raytheon Technologies	T&E – 24637 The Evolution of Systems Verification and Validation in Vehicle Simulation Modeling at ERDC **Dr. Jessica Lyons** Research Social Scientist Engineer Research Development Center
11:00 – 11:30 am	DE-24763 How to "Digital Viewpoint Model (DVM) **Ken Zhang** MBSE Chief Engineer for the Space and Airborne Systems Sector L3Harris	Arch/MOSA-24568 Don't Play the Telephone Game: Ensuring Architectural Fidelity **Michael Vinarcik** Director SAIC	ME/SOS – 24535 Applied Digital Engineering – A Case Study in Using Space System Architectures to Understand Program and Mission Risks **Lauren Hale** Sr. Engineering Specialist System of Systems Engineering Office The Aerospace Corporation	SSE-24759 Application of Marking and Distribution Statements on Controlled Technical Information **Melinda Reed** Systems Security Director OUSD (R&E)	PM – 24784 Systems Engineering Planning and Architecture Challenges In an Agile Culture **Gordon Kranz** Chief Engineer Enlightened IPM

11:30 am – 12:00 pm	DE-24483 Adventures in Building a Digital Engineering Ecosystem **Julie DeMeester** Engineering Fellow Raytheon Technologies	Arch/MOSA-24519 Agile/MOSA/Microservice Architectures – Stronger Together **Kurt Mohr** Engineering Fellow Raytheon	ME/SOS-24794 Applying Mission Engineering to the U.S. Department of Defense Rapid Defense Experimentation Reserve **Dr. Judith Dahmann** Technical Fellow The MITRE Corporation	SSE - 24678 Risk and Issue Revisited in Systems Security Engineering **Dr. Mark Winstead** Chief Engineer, System Security The MITRE Corporation	PM – 24674 A Retrospective on Model-based Systems Engineering in Undergraduate Engineering Education **LT Col Jeff Newcamp, USAF** Director United States Air Force Academy's Systems Engineering Program
12:00 – 1:00 pm	**LUNCH BREAK**				
TRACK NAME	**2C1 – Digital Engineering**	**2C2 – Architecture/MOSA**	**2C3 – Mission Engineering / System of Systems**	**2C4 – System Security Engineering**	**2C5 – Program Management**
ROOM	**PENINSULA 1-3**	**PENINSULA 4**	**PENINSULA 5-7**	**BISCAYNE 1-2**	**CANAVERAL 2-3**
MODERATOR	John Daly & Chris Schreiber	Laura Hart & Tamara Hambrick	Dr. Judith Dahmann	Cory Ocker	
1:00 – 1:30 pm	DE-24792 Improved Data Fusion in Digital Twins: A Requirements Analysts **Laura Hugill** Analyst Department of Defense	Arch/MOSA-24548 DoD MOSA Implementation Guidance **Nadine Geier** Director Systems Engineering OUSD (R&E)	ME/SOS-24435 Model-Based Capability Planning and Enterprise Portfolio Management **Dr. James Martin** Aerospace Corporation, UAF Revision Task Force with OMG	SSE – 24761 Addressing Critical Program Information Challenges **Randy Woods** SSE & Anti-Tamper Director OUSD(R&E)	PM-24515 A Rocket Scientist's Approach to Continuous Innovation and Improvement **Andy Inkeles** Risk and Innovation Lead USSF National Security Space Launch Program
1:30 – 2:00 pm	DE-24677 Application of the Digital Thread Through the Digital Engineering Framework for Integration and Interoperability **Daniel Dunbar** Research Assistant Stevens Institute of Technology	Arch/MOSA-24572 Architecting Deep Learning Models to Enable AI Capability to Complex Adaptive Systems Architectures **Richard Threlkeld** PhD Student University of Missouri, Science and Technology	ME/SOS-24646 An Enterprise Portfolio Management Framework for Mission Planning, Engineering, and Acquisition **Dr. Warren Vaneman** Professor of Practice Naval Postgraduate School	SSE-24591 Secure Cyber Resilient Engineering (SCRE) Practice **Melinda Reed** Systems Security Director OUSD (R&E)	PM-24619 From Lessons Learned to Lessons Applied: A Digital Paradigm Shift **Paul Wach** Senior Engineer Virginia Tech

2:00 – 2:30 pm	DE-24776 Digital Twin to Detect Nuclear Proliferation: A Case Study **Christopher Ritter** Director, DICE/Dept Manager, Digital Eng. Idaho National Laboratory	Arch/MOSA-24816 Long Term Trends in Security Threats and an Approach for Integrating Them into System Architecture and Design **Larri Rosser** Engineering Fellow Raytheon Intelligence and Space	ME/SOS-24667 Mission Engineering-based Portfolio Management **Dan DeLaurentis** Professor Purdue, University's School of Aeronautics and Astronautics	SSE-24676 Where to Step – A Guide to Minefield of Modeling Complex Security Systems **Mitchell Brooks** Cyber Systems Engineer System Security, Inc.	PM-24641 Can Systems Engineering Enhance Policy Development? **Dr. Steven Dam** President and COO SPEC Innovations
2:30 – 3:00 pm	**BREAK**				

TRACK NAME	2D1 – Digital Engineering	2D2 – Architecture / MOSA	2D3 – Mission Engineering / System of Systems	2D4 – System Security Engineering	2D5 - Physics Based Model Simulation
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR		Laura Hart & Tamara Hambrick Scheurer	Dr. Judith Dahmann	Cory Ocker	David Allsop
3:00 – 3:30 pm	DEIXWG Workshop **Sean McGervey** Director, Model-Based Enterprise Dassault Systems **Risa Gorospe** Solutions Consultant, CATIA No Magic, Dassault Systems Technical Lead, INCOSE Digital Engineering Information Exchange Working Group (DEIXWG) **Ken Zhang** MBSE Chief Engineer for the Space and Airborne Systems Sector L3Harris **Celia Tseng** Sr Manager A&D Industry Dassault Systems	Arch/MOSA-24552 SE Modernization Across the Program Lifecycle **Nadine Geier** Director Systems Engineering, OUSD (R&E)	ME/SOS-24778 Mission Engineering Applied to System of Systems Architecture Analysis **Dr. Peter Korfiatis** Department Manager The MITRE Corporation	SSE–24526 Cyber Supply Chain Risk Management (C-SCRM) a System Security Engineering Role in the Future of Systems Engineering **Holly Dunlap** Principal System Security Engineer Cyber Supply Chain Risk Management The MITRE	PBMS-24613 Machine Learning-Based Surrogate Modeling of Human Vehicular Vibrational Injuries **Will Kirkpatrick** Graduate Research Assistant Mississippi State University
3:30 – 4:00 pm		Arch/MOSA-24516 Architecting for the Cloud: A SysML-Based Profile for Cloud Deployments **Jonathan Backhaus** Engineering Fellow ManTech International Corporation	ME/SOS–24606 Digital Threads: Benefits, Challenges, And Practices **Eran Gery** Solutions Architect IBM	SSE-24607 Building Hardware Assurance with Trusted Suppliers: Creating Multi-layered Security **Dave Chesebrough** Vice President Government Defined Business Solutions	PBMS– 24785 Incorporating Technical Measures of Performance into Project Metrics **Nick Pisano** President and CEO SNA Software, LLC
4:00 – 4:30 pm		Arch/MOSA-24504 Eight Components of an Autonomous, Self-Healing System **Matthew Kehret** CTO, Senior Director Technology, Integratison & Accel Raytheon Missiles and Defense, Digital Technology	ME/SOS-24611 Method for Developing SoS Architectures using SysML Model Federation **Chris Swickline** Digital Engineer SAIC	SSE–24490 Criticality of Software Supply Chain Security **Alan Hohn** Director, Software Strategy Lockheed Martin	
4:30 – 5:00 pm		Arch/MOSA-24544 Modeling a Space Launch System Using the Unified Architecture Framework (UAF) **Logan Mitchell** Junior Systems Engineer Quantum Research International	ME/SOS-24582 Operationally Responsive Mission Engineering (ORME) **Ray Etter** President/Chief Engineer TerraConcepts, LLC	SSE – 24815 Capability-Based Security Engineering for Strategy Formulation and Stakeholder Alignment **Rick Dove** Independent Strategist	

THURSDAY, NOVEMBER 3

CONCURRENT BREAKOUT SESSIONS

TRACK NAME	3A1 – System Security Engineering / Digital Engineering	3A2 – Architecture/MOSA	3A3 – Specialty Engineering / Safety & Environmental Engineering	3A4 –Agile	3A5 – Physics Based Model Simulation
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR	John Daly & Chris Schreiber	Ed Moshinsky & Karl Shephard	Tim Sheehan & Diane Dray	Ken Kubo	David Allsop
8:00 – 8:30 am	SSE-24777 Implementing Software Bill of Materials (SBOM) in DoD Acquisition **Bradley Lanford** Systems Security Contract Support OUSD(R&E)	Arch/MOSA-24817 Standardization of Model Based Acquisition (MBAcq) **Laura Hart** Engineering Research Engineer Lockheed Martin	SE/SEE-24586 DoD Sustainability Program and the DoD Sustainable Technology Evaluation and Demonstration (STED) Program **David Asiello** Director of Sustainability & Acquisition OASD EI&E	Agile–24491 Starting the Transition From DevOps to DevSecOps **Allan Matthews** Senior Principal Software Engineer Raytheon Technologies	PBMS-24698 Progress Towards Improving the Models in Model Based Systems Engineering with High Fidelity Physics **Dr. Scott Morton** Associate Director for CREATE DoD HPCMP
8:30 – 9:00 am	SSE-24771 Missing In Action: Mission Impact Assessment **Teresa Merklin** Cyber Fellow Lockheed Martin Aeronautics	Arch/MOSA-24638 Can Data-Driven Systems Engineering Meet the Goals of SE Modernization? **Dr. Steven Dam** President & COO SPEC Innovations	SE/SEE-24511 Data Centricity: Multi-Directional Flow of Specialty Engineering Data Throughout the Life Cycle **Chris DeLuca** Director for Specialty Engineering OUSD (R&E)		E&T-24610 Competency-Based Online Education Using AFIT's Avolve Application **Richard Sugarman** Department Head Air Force Institute of Technology
9:00 – 9:30 am	DE-24657 Leveraging Model-Based Systems Engineering Tools and Techniques to Build Enterprise Knowledge Models **Patrick Bains** Lead Systems Engineer Booz Allen Hamilton	Arch/MOSA-24679 Standardized Analytic Viewpoint Overlays (AVOs) **Laura Hart** Engineering Research Engineer	SE/SEE-24649 Regulatory and Sustainability Challenges for the Automotive Industry **Drew Rak** Program Manager Toyota Motor North America	Agile-24514 Software Science & Technology Strategic Vision, Goals, and Focus Areas **Allan Dianic** Director, Software Engineering & Prototyping, OUSD (R&E)	E&T – 24545 Systems Engineering Modernization (SE MOD) Key Enablers for System Development on DoD Programs **Dr. Robert Raygan** Prof. of Engineering Mgmt., DAU CNE Defense Acquisition University
9:30– 10:00 am	**BREAK**				

TRACK NAME	3B1 – Digital Engineering	3B2 – Architecture/MOSA	3B3 – Specialty Engineering / Safety & Environmental Engineering	3B4 – Agile	3B5 – Education & Training
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR	John Daly & Chris Schreiber	Ed Moshinsky & Karl Shephard	Tim Sheehan & Diane Dray	Ken Kubo	Dr. Robert Raygan
10:00 – 10:30 am	DE-24658 Transforming Systems Engineering Reviews **Toni Nolder** Space Architecture Department Aerospace Corporation	Arch/MOSA-24672 Dynamic Capability Investment for Emerging Missions **Mike Franco** Chief Architect, Processes & Tools Chief Architect Boeing Defense, Space & Security	SE/SEE-24622 Implementation Guide: Model-Based Systems Engineering (MBSE) for System Safety **Trung Hoang** Safety Engineer Naval Ordnance Safety & Security Activity (NOSSA)	Agile-24525 Defining a Measurement Framework for Digital Engineering **Tom McDermott** Research Director Stevens Institute of Technology	E&T-24636 Implementing SysML 2.0 – Part 2 **Michael Campbell** Senior Systems Engineer, Manager of Innovation SPEC Innovation
10:30 – 11:00 am	DE-24551 Analyzing Digital Engineering Data: Transforming the Way We Think About Model Reviews **Heidi Jugovic** Digital Engineer Chief SAIC	Arch/MOSA-24808 Model For a Purpose: Scoping an Architecture Model Using the ASDP Digital Transformation Contract Language **Brad Kukurza** Systems Engineering Manager The Boeing Company	SE/SEE-24675 Sustainability Analysis in the Adaptive Acquisition Framework **Michael Bruckner** Principal Engineer Manager Noblis	Agile-24559 Agile and DevSecOps in the DoD Space Acquisition Environment **Dr. Michael Orosz** Research Associate Professor and Research Director USC Information Sciences Institute	E&T-24584 When Worlds Collide: Leveraging MBSE/SysML for DoDAF Architectures in Programs and Formal Requirements **Maj Brandon Froberg, USAF** Chief Integration & Interoperability Branch Air Force Special Operations Command

11:00 – 11:30 am	DE-24663 Solution Debt in the Age of Digital Engineering **Dr. Heidi Davidz** Intelligent Systems Engineering SME **ManTech International Corporation**	Arch/MOSA-24651 Modeling System Configurations Over Time **Matthew Hause** Principal System Strategy, Inc.	SE/SEE-24521 Strategic Alternate Sourcing Program Office (SASPO): Alternate Sourcing and Diminishing Manufacturing Sources and Material Shortages **Jerry Zamora** Chief, Strategic Alternate Program Office 448th Supply Chain Management Wing	Agile-24684 Digital Transformation in NSSL Quality Engineering: Establishing the Digital Data Chain Framework through the Provenance Chain Transparency Platform **Maj Juan Mayssonet** NSSL Quality Engineering Branch Launch Enterprise	SEMOD Panel **Dr. Robert Raygan** Prof. of Engineering Mgmt., DAU CNE Defense Acquisition University
11:30 am – 12:00 pm	DE-24750 Modeling Information to Support Systems Engineering Technical Reviews Based on DOD Data Item Descriptions (DIDs) **Robert Wojcik** Senior Member of the Technical Staff CMU/SEI	Arch/MOSA-24639 What is Systems Engineering? **Dr. Steven Dam** President & COO SPEC Innovations	SE/SEE 24696 Using Model Based System Engineering to Identify Safety Critical Functions in Airworthiness Certifications **Capt Jeff King, USAF** Instructor of Systems Engineering Air Force Institute of Technology	Agile-24693 Integrating Elements of Digital Engineering into Agile Software Acquisition Training **Curtis Jefferson** Software Tech Expert HA AFMC DoE Systems Engineering Division	
12:00– 1:00 PM	**LUNCH ON OWN**				

TRACK NAME	3C1 – Digital Engineering	3C2 – Architecture / MOSA / Program Management	3C3 – Specialty Engineering / Safety & Environmental Engineering	3C4 – Agile	3C5 - Education & Training
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR	John Daly & Chris Schreiber	Bob Scheurer & Rebecca Hicks	Tim Sheehan & Diane Dray	Ken Kubo	Dr. Robert Raygan
1:00 – 1:30 pm	DE-24577 Architecting the Digital Thread Enabling the Digital Transformation (DTx) of Raytheon Missiles and Defense **Tara Trumbull** Senior Principal Systems Architect **Deborah Thomas** Senior Principal Systems Engineer Raytheon Missiles and Defense	Arch/MOSA-24799 An Acquisition System Meta Model **Chris Garrett** Senior Leader U.S. Air Force	SE/SEE-24755 Poly-fluorinated Alkyl Substances Primer and Update **Col Tim Sheehan, BRANCH (Ret)** Engineering Fellow Raytheon Technologies	Agile-24605 Exploring the Enablers of Post-Production Change for Flexible System Design **Aditya Singh** NSF Research Traineeship Fellow The George Washington University	E&T-24775 2022 SSE Workforce Development Sampling and Feedback Analysis **Matthew Lee** System Security Engineer Raytheon Technologies
1:30 – 2:00 pm	DE-24685 Ready One: Delivering Digital Engineering and the Digital Thread **David Ewing, Jr.** Director Digital Engineering Digital Thread & Tool Federation Leader Engineering Innovation Factory SAIC	Arch/MOSA-24804 The Intellectual Property (IP) Thread in Digital Engineering and Acquisition implementation in the Department of Defense (DoD) **John Daly** Chief Engineer Booz Allen Hamilton	SE/SEE-24682 Regulation Impacts and Management Steps of Hydrofluorocarbons (HFCs) Drawdown for the U.S. Department of Defense (DoD) and Defense Industrial Base (DIB) **Dr. Kari Meier** Greenhouse Gases & Sustainable Chemistry (ODASD (E&ER))	Agile-24520 Codemmandos: Empowering Agile/ DevSecOps Citizen Developers with No-code & Scripting **Maj Brandon Froberg, USAF** Chief Integration & Interoperability Branch Air Force Special Operations Command	
2:00 – 2:30 pm	DE-24506 Creating a Digital Foundation Through the Development of a Digital Thread **Cathrin McCaghren** Systems Engineer Raytheon Missile Defense		SE/SEE-24627 Impacts to the U.S. Department of Defense and Defense Industrial Base from the Toxic Substances Control Act **Dr. Patricia Underwood** Director, Chemical & Material Risk Management ODASD (EI&E)	Agile-24522 System Test Verification: The Digital Thread Lynchpin Between Systems Engineering Requirements Development and Software Deployment **Yvonne Green** Senior Manager Software Engineering Raytheon Technologies	E&T-24596 Cross Domain Solutions Tutorial **Burhan Adam** Policy Guidance & Standards Director OUSD (R&E)
2:30 – 3:00 PM	**BREAK**				

TRACK NAME	3D1 – Digital Engineering	3D2 – Project Management / Mission Engineering / System of Systems	3D3 – Specialty Engineering / Safety & Environmental Engineering	3D4 – Agile	3D5 – Education & Training
ROOM	PENINSULA 1-3	PENINSULA 4	PENINSULA 5-7	BISCAYNE 1-2	CANAVERAL 2-3
MODERATOR	John Daly & Chris Schreiber		Tim Sheehan & Diane Dray	Ken Kubo	Dr. Robert Raygan
3:00 – 3:30 pm	DE-24528 Converging MBSE Methodology **Ryan Noguchi** Senior Engineer Specialist, Space Architecture Department The Aerospace Corporation		SE/SEE-24680 Joint System Safety Standards Working Group MIL-STD-882E Initiative **Lori Hales** Senior Acquisition ESOH Analyst Booz Allen Hamilton		E&T-24541 A Digital Twin Simulation Equivalence Principle **Richard Boyd** CEO Ultisim, Inc.
3:30 – 4:00 pm	DE-24556 Utilizing Automation and Ontologies to Design, Deploy, and Sustain an Effective Model Governance Program **Dr. Heidi Davidz** Intelligent Systems Engineering SME ManTech International Corporation		SE/SEE-24474 How to Use Physics-based Digital Human Models Early In Systems Design and During Test and Evaluation **Travis Klofenstein** Executive Director for Programs University of Iowa Technology Institute		E&T-24617 Simulation Training Environment for Digital Engineering **Paul Wach** Senior Engineer Virginia Tech
4:00 – 4:30 pm	DE-24575 MBSE Model Management Pain Points – Wait, this looks familiar! **Barry Papke** Industry Process Success Team, Senior Manager Dassault Systems – CATIA/No Magic		SE/SEE-24647 Hybrid Digital Twin Technology for Predictive Maintenance **Reni Raju** Director, Business Development – FA&D Ansys		
4:30 – 5:00 pm	DE-24642 A Common Ontology: The Rosetta Stone for Exchanging Data between Different Digital Engineering Tools, Languages, and Frameworks **Dr. Warren Vaneman** Professor of Practice Naval Postgraduate School				

THE AEROSPACE CORPORATION

Transforming Systems Engineering Reviews

Toni Nolder
Ryan Noguchi
The Aerospace Corporation

NDIA Systems and Mission Engineering Conference
03 Nov 2022

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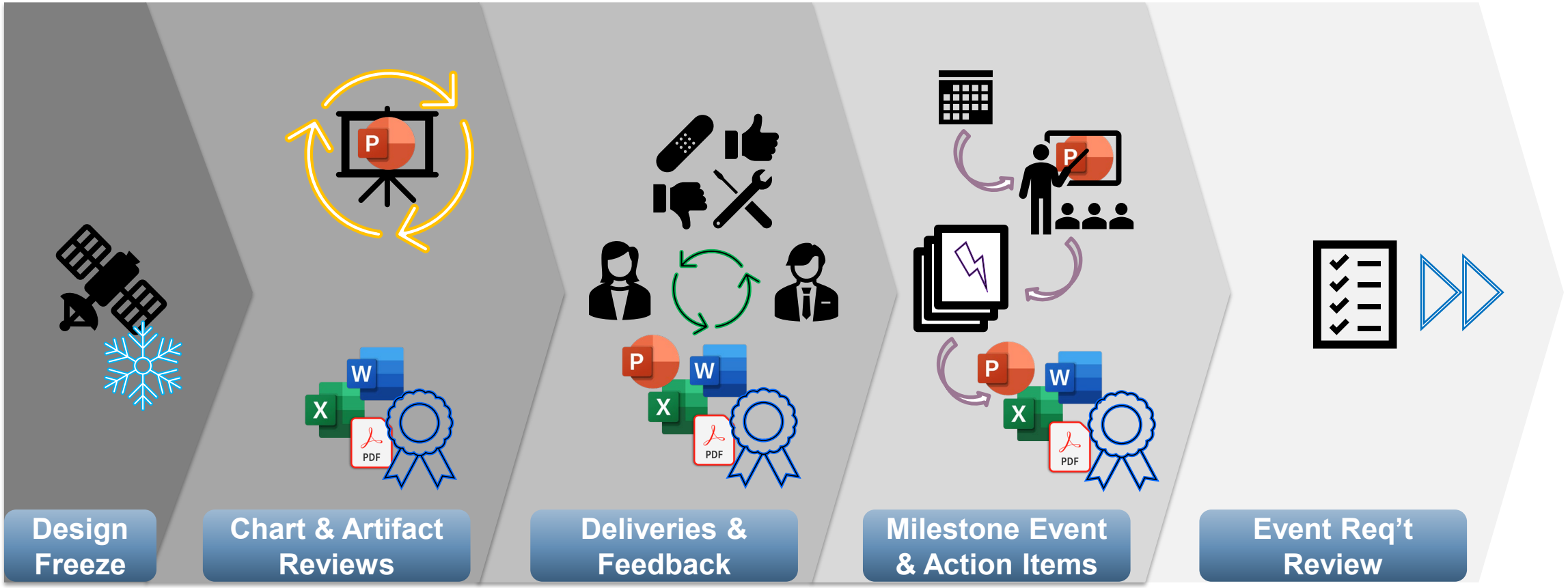
Introduction

- **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

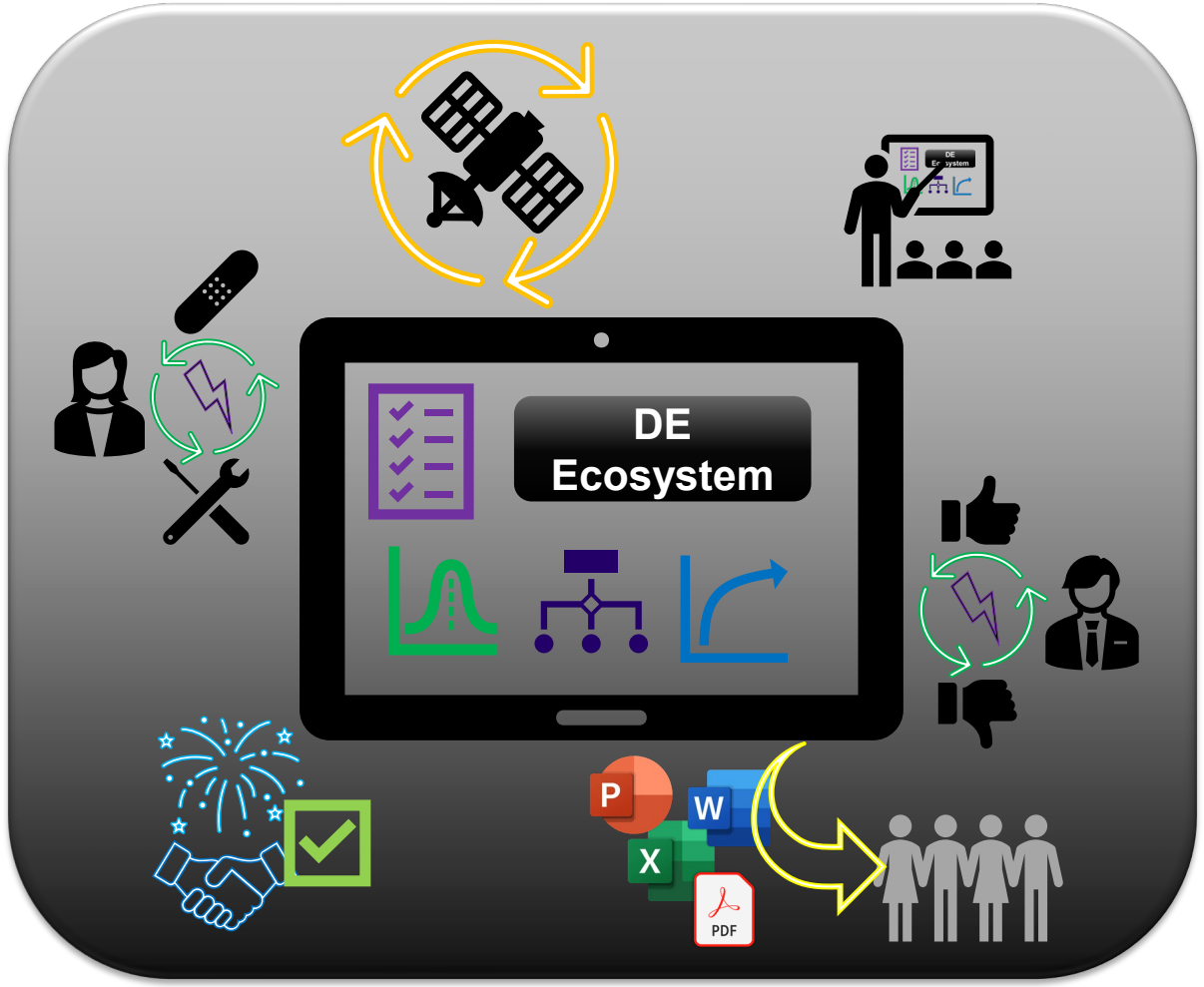
Action items incrementally addressed throughout review process

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

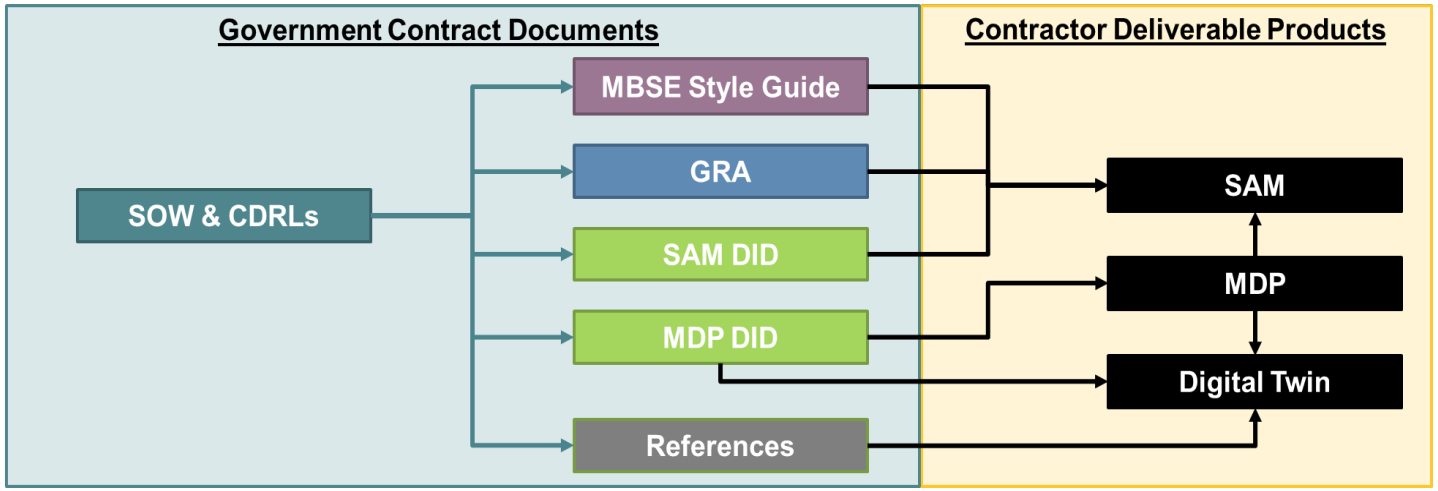
- Performance analysis (Matlab, Simulink, Excel, CAD)

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

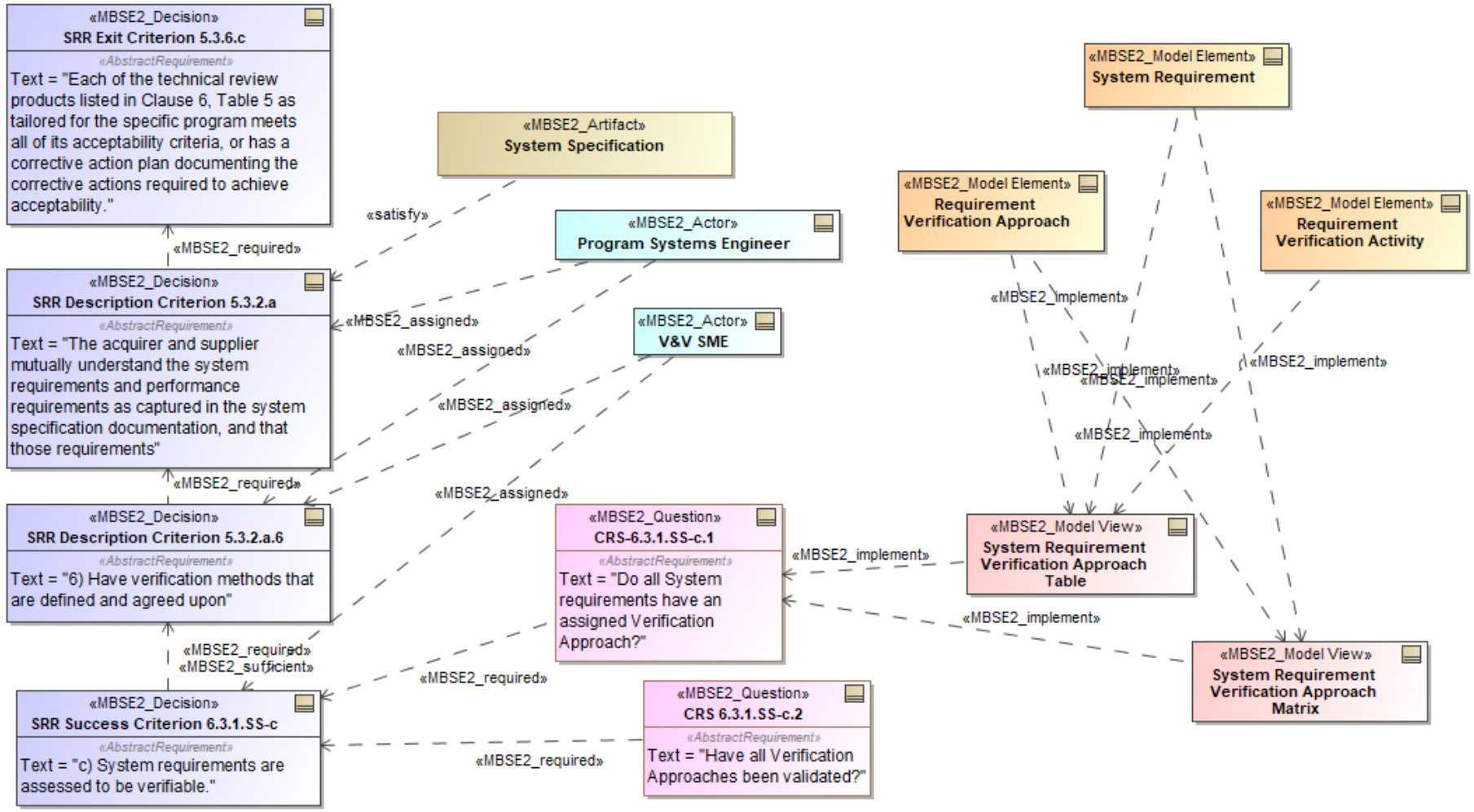
- Transformation of reviews requires transformation of current body of guidance for reviews, e.g.,
  - IEEE 15288.2: IEEE Standard for Technical Reviews and Audits on Defense Programs
  - SMC-S-021: Technical Reviews and Audits for Systems, Equipment, and Computer Software
  - NASA GSFC-STD-1001: Criteria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

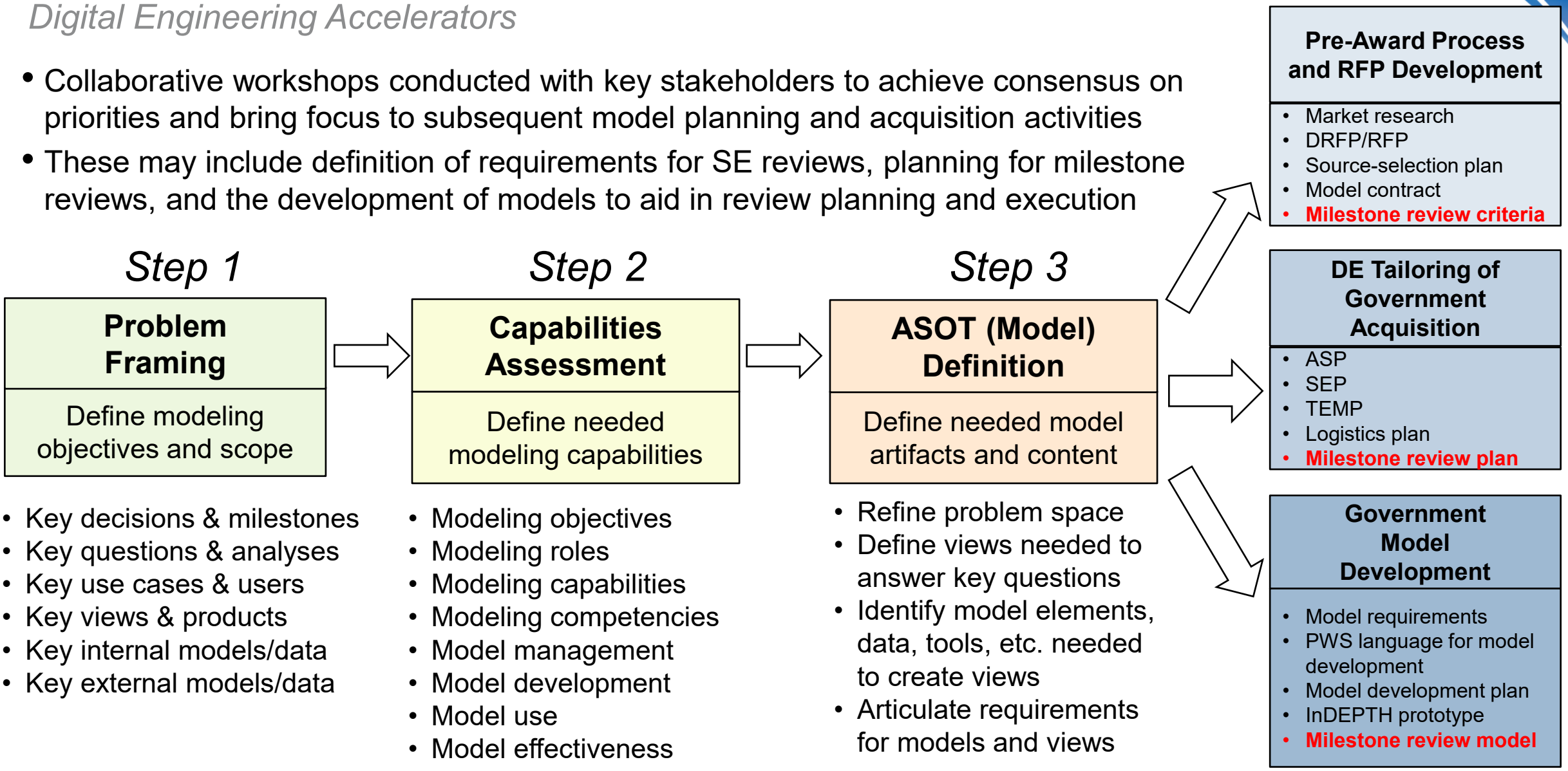


MBSE² provides a structured approach for managing the requirements and "architecture" of milestone reviews

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

Reviewing Digital Engineering Data

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Abstract

- As programs spend time and money to transform their engineering information from documents to digital data, many fail to realize returns by not fully exploiting the rich data they have created. This presentation discusses how to get value from the investments made in creating models, simulations, databases, and other digital artifacts by changing the way we think about how we consume that data for reviews and other types of analysis. In this presentation, we discuss how to use Digital Engineering (DE) techniques to review DE data and gain new insights, do advanced model analysis, speed up the review process, and catch more errors than traditional review processes. Three dimensions to considering when constructing a model review approach and a three step process are discussed with an emphasis on Model Based Systems Engineering (MBSE) artifacts in the context of a digital thread. Practical examples of specific techniques used on real world defense programs will be provided to demonstrate the analysis.

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Reviewing Digital Engineering Data: Setting Expectations

- Scope: For this presentation, what is a review?
  - Peer Review
  - Milestone Review
  - Technical Interchange Meetings (TIMs)
  - "Review" is broadly used here and can mean anything from casual internal analysis of DE content to formally approving a baseline.
- Focus in this presentation is MBSE, but you cannot talk about establishing review processes without considering architectural models in the broader DE context

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3 Critical Aspects of Reviews to Consider

- **Analytical Techniques**: If we review models like we traditionally review documents:
  - We have wasted the expense of building a model (if we USE it like a document, why not just build it as a document?)
  - We will waste time using manual methods that we could have done semi-automatically or with computer-assisted techniques
  - We will miss more errors than necessary & fail to exploit opportunities the rich data set we created give us to:
    - buy down risk of errors in complex systems
    - increase the quality of reviews
  - We will continue to focus on trivial, easy-to-catch errors at the expense of meaningful, expensive, complicated errors
- **Review & Commenting Tools**:
  - The relevant data may live in multiple software applications; we must review it as a cohesive whole or incur the weaknesses that stovepipes create
  - The tools we choose MUST enable review, approval, and configuration management of **data in database(s)**, not looking at pictures and saying "that looks about right" or "please spell out the acronyms"
- **Workflows, Approvals & Configuration Management**
  - Review processes must not "lock down" work if we are to use DE to achieve speed of relevance
  - Baselines will span authoring tools and therefore must be held in a different layer than the individual authoring applications
  - Are there QM/QA artifacts that need to be generated? Are they still relevant?

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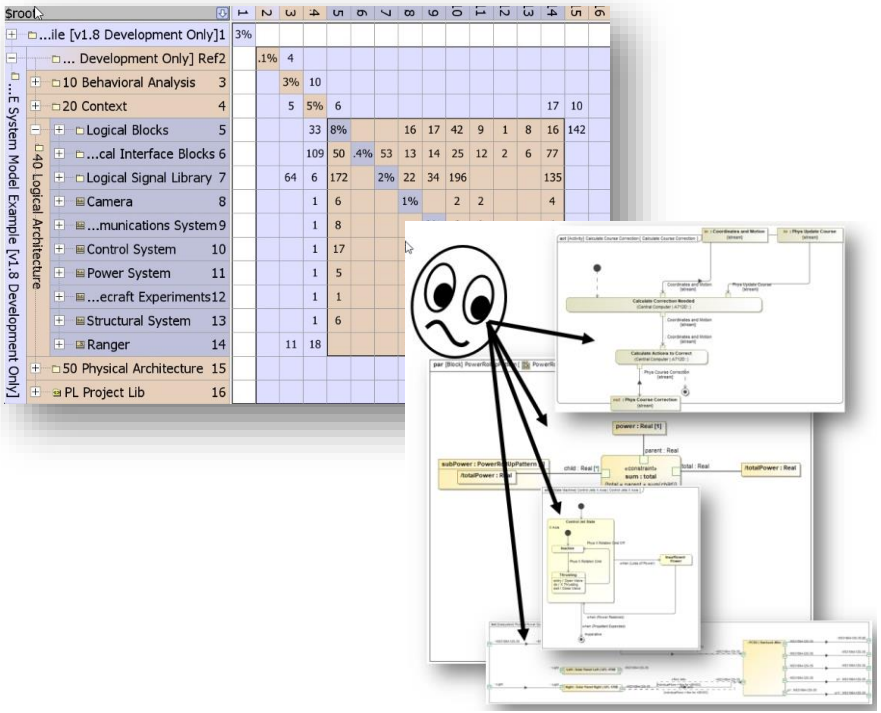
What is it?

- A Treadmill or an Overpriced Clothes Rack?

- A Model or an Overpriced Document?



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Some MBSE Analytical Techniques for Reviews

- Criteria vs Content tables (see next slide)
- Automated Validation
  - For SAIC Style
  - For other styles
  - For architectural quality indicators (future)
- Model Analysis Models
  - Add the model under review as a usage and re-scope pre-created tables, matrices, & relation maps (future)
  - Allows you to view the model data in more data-centric views than diagrams, whether or not the model creators made those views
- External Applications
  - Lattix: architecture quality metrics such as coupling, cohesion, & cycles (more in the future)
  - Aras/Other PLM tool: traceability analysis to other data sets
  - M&S: characterization of architectures, solutions, etc. This data may be interconnected with the model; use it!
  - Tom Sawyer? WHAT ELSE IS POSSIBLE? We have a structured data set; what can we do with it??

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Identifying Specific Artifacts To Address Review Criteria

#	Name	Contributes to Goals	Relevant Processes	Content Artifacts
1	Use Cases	SFR	Associate Use Cases with Actors() Create Actors() Create Use Cases()	Use Case Elements Use Cases Use Cases - STYLE part 1 Use Cases - STYLE part 2 Use Cases - STYLE part 3 Use Cases - STYLE part 4
2	System Requirements	CDR TRR Test Planning SRR SFR	Import Existing Requirements() Create Requirements from Architecture()	System Requirements System Requirements Trace/Derive/Refine
3	Subsystem Requirements	CDR TRR Test Planning	Import Existing Requirements() Create Requirements from Architecture()	
4	Component Requirements	CDR TRR Test Planning PDR	Create Requirements from Architecture() Import Existing Requirements()	

- Import criteria as Business Requirements or Source Content artifacts
  - DID outlines
  - Entry/Exit criteria
  - Trade study criteria
  - Model Content Plan, etc.
- Set up tables & matrices to trace model elements/views to criteria (use any dotted-line relationship that isn't being used elsewhere)
- Content vs Criteria tables establish the content is capable of satisfying the criteria and point reviewers at what is relevant to the review (*example in free SAIC Validation Tool*)

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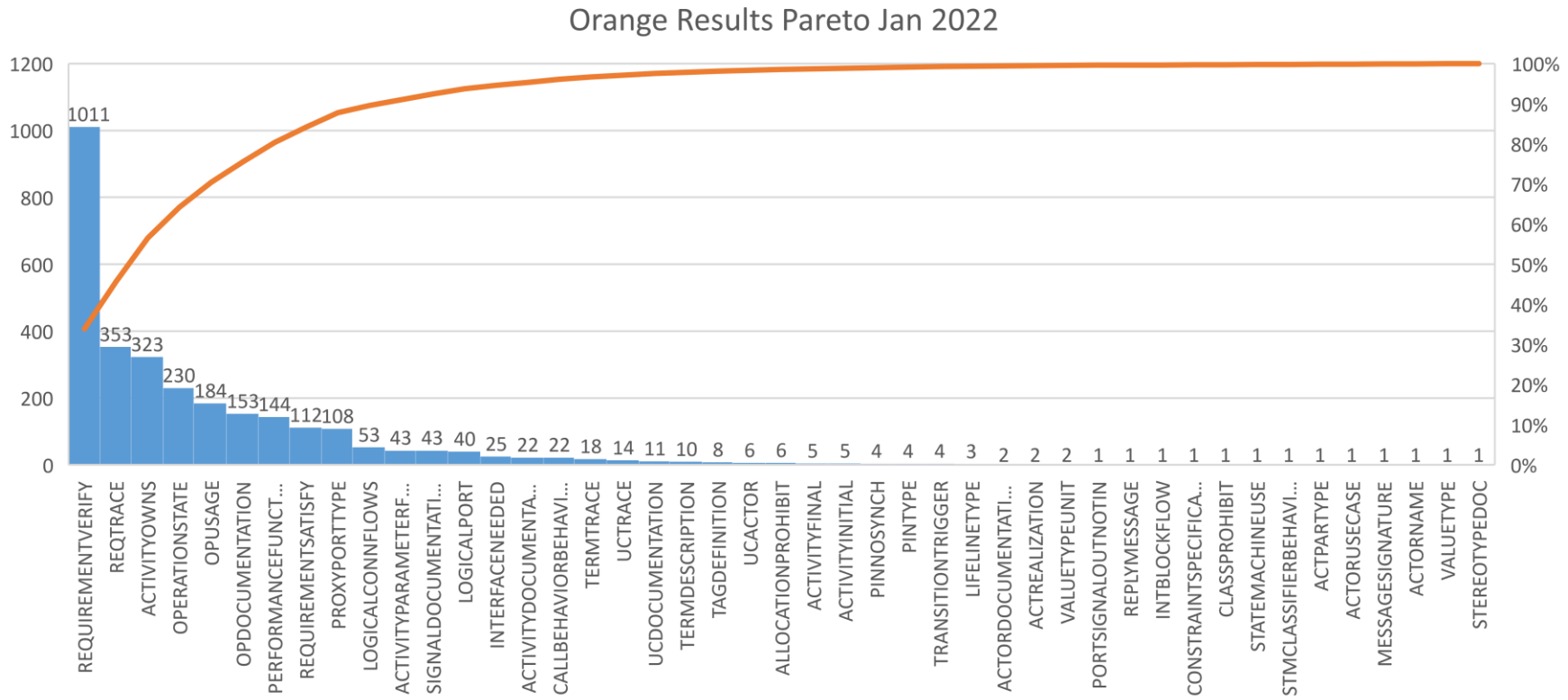
Example of Model Data Analytics



How to interpret validation results with errors in the thousands (2938)

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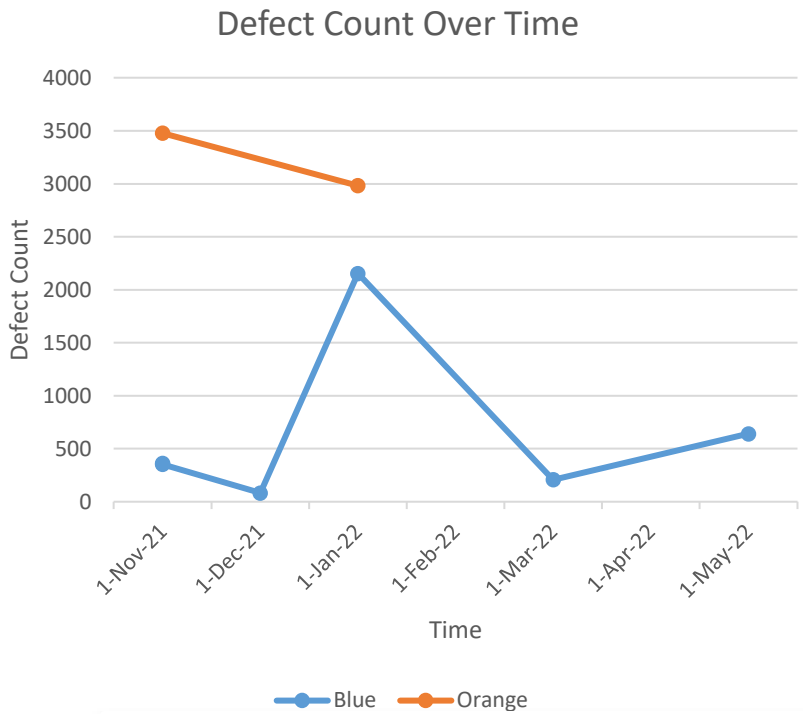
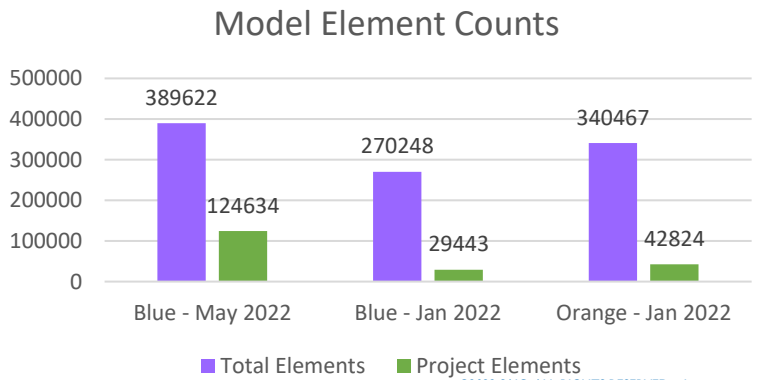
Insights from Defect Tracking Over Time



Which contractor do you think has the more mature baseline?

- What can we learn from looking at defect counts over time?
  - Orange has not made a delivery in 5 months… Why?
  - Why was does Orange have so many initial errors?
  - Why did Blue spike in Jan?
- Should we expect to see a steady burn down of defects over time?
  - Hint: the answer is NO… but why?



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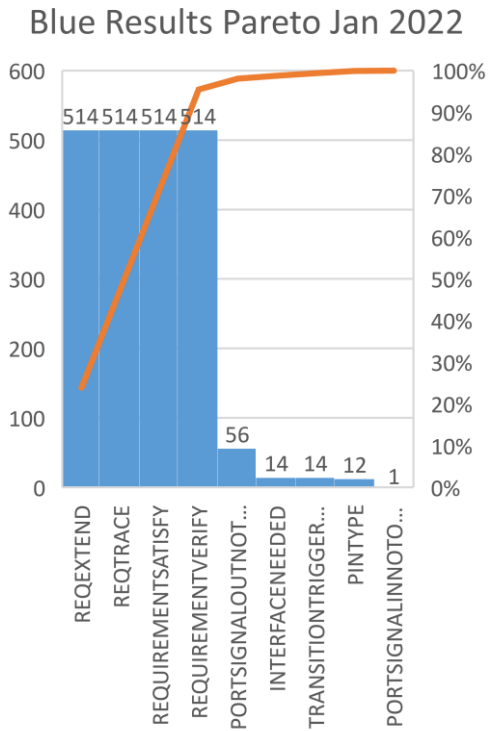
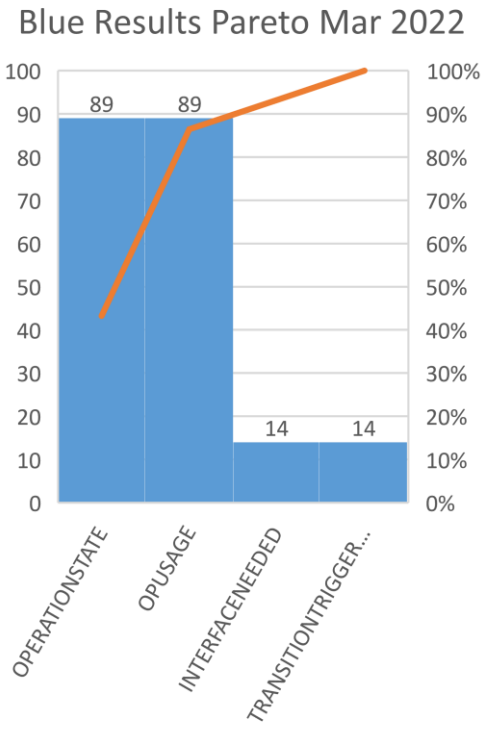
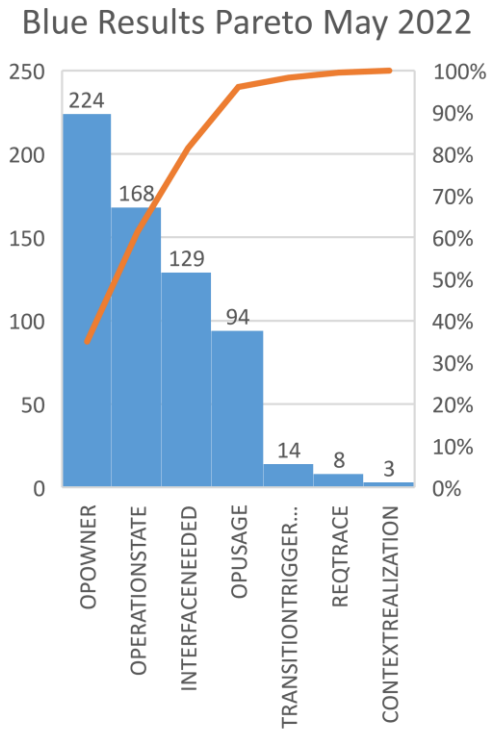
Snapshots of Data Can Tell a Story Over Time







Can we infer what progress has been made over time?

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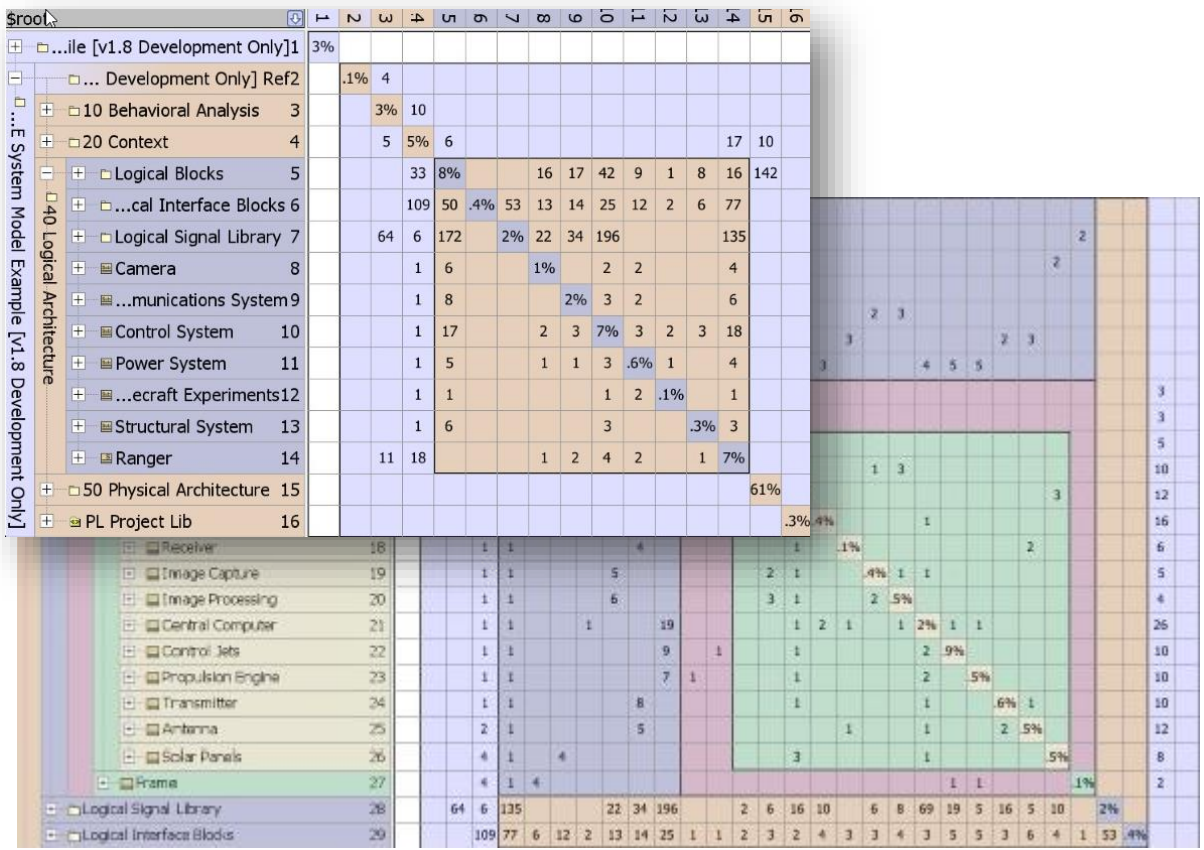
Example of Advanced Review: Design Structure Matrices



Images from Lattix

DSM is a promising technique with opportunities for semi-automation of analysis of complex, modeled architectures

- Partitioning **Algorithms**
- Metrics!
- One way of understanding, and perhaps even quantifying, architecture *goodness*

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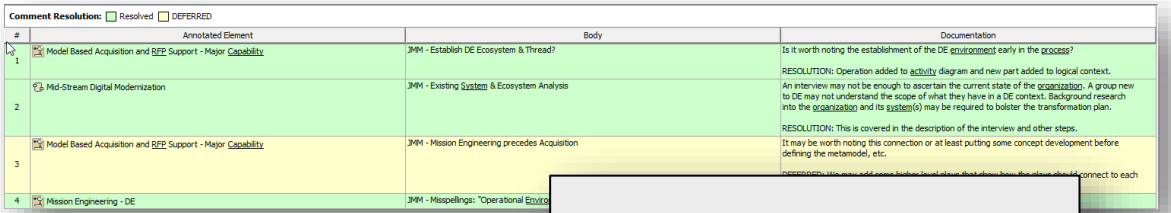
Some MBSE Review & Commenting Tools

- The authoring tool itself
  - Use "Problem" and annotate commented elements
  - Attach a legend that tracks resolution
  - Best for peer/internal reviews
- Cameo Collaborator
  - Future presentation will have more details
- Publishing the data to documents
  - *sigh*
  - Will be more expensive and time consuming than you think
- Aras/Other PLM Tool?
  - More broadly user-friendly than authoring tools
  - SOME access to data vs diagrams
  - Should be capable of capturing/resolving comments formally
  - We haven't really tried this yet in production



Comment Resolution: Resolved DEFERRED

#	Annotated Element	Body	Documentation
1	Model Based Acquisition and RFP Support - Major Capability	JMM - Establish DE Ecosystem & Thread?	Is it worth noting the establishment of the DE environment early in the process? RESOLUTION: Operation added to activity diagram and new part added to logical context.
2	Mid-Stream Digital Modernization	JMM - Existing System & Ecosystem Analysis	An interview may not be enough to ascertain the current state of the organization. A group new to DE may not understand the scope of what they have in a DE context. Background research into the organization and its system(s) may be required to bolster the transformation plan. RESOLUTION: This is covered in the description of the interview and other steps.
3	Model Based Acquisition and RFP Support - Major Capability	JMM - Mission Engineering precedes Acquisition	It may be worth noting this connection or at least putting some concept development before defining the metamodel, etc. DEFERRED: We may add some higher level plays that show how the plays should connect to each
4	Mission Engineering - DE	JMM - Misspellings: "Operational Enviro	

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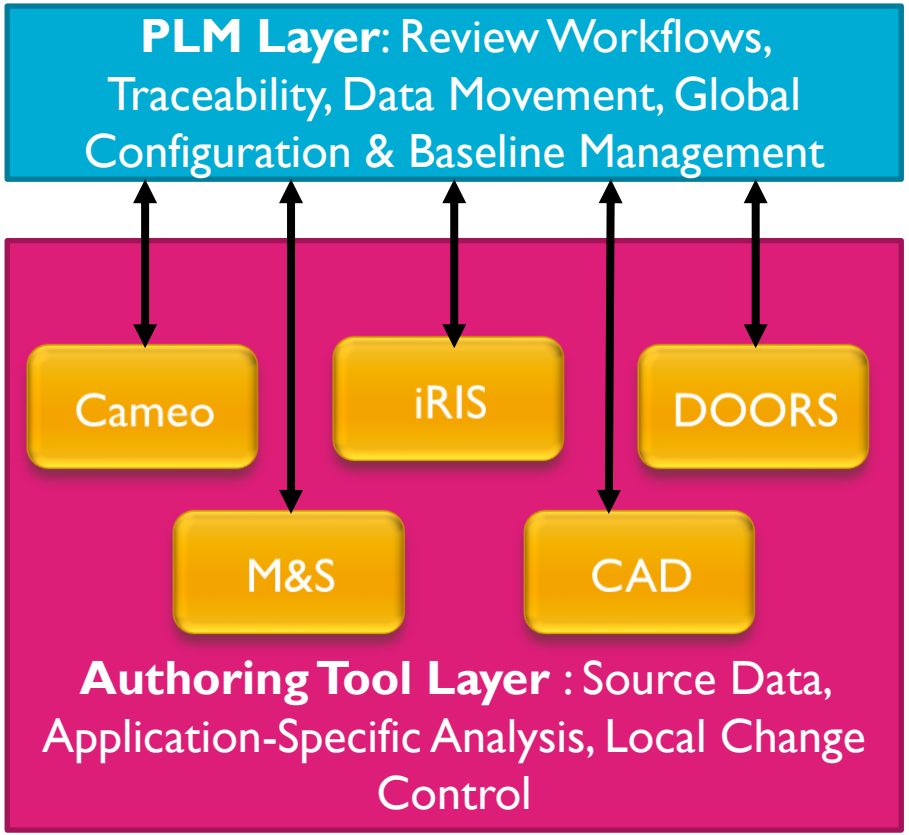
PLM-Based Review Workflows and Baseline Management Concept

- PLM tools can:
  - manage multiple data types (SEIT, Detailed Design, OMS, Logistics, M&S, etc.)
  - have a long history of successfully establishing review workflows,
  - have proven capability to manage data access controls,
  - have robust baseline management capabilities
- The baseline can be held in a PLM tool while work continues in the authoring tools
- PLM tools with 2-way connectors can also push approved baseline data from one tool into another (digital thread backbone), allowing more control over what data is shared between applications



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3 Step Process for Digital Engineering Reviews

Review Input Prep:

- Style Validation Results
- Problem-area Pointers
- Advanced Analysis Results
- Criteria vs Content tables & matrices

MBSE Expert

SME Review:

- Managed Workflow
- Global Data Views
- Diagram Views
- Comments
- Sign-Offs

Domain Expert

Baseline Mgmt:

- Global Baselines
- Authoritative Source of Truth
- Digital Thread Data Movement

CM/DM Expert

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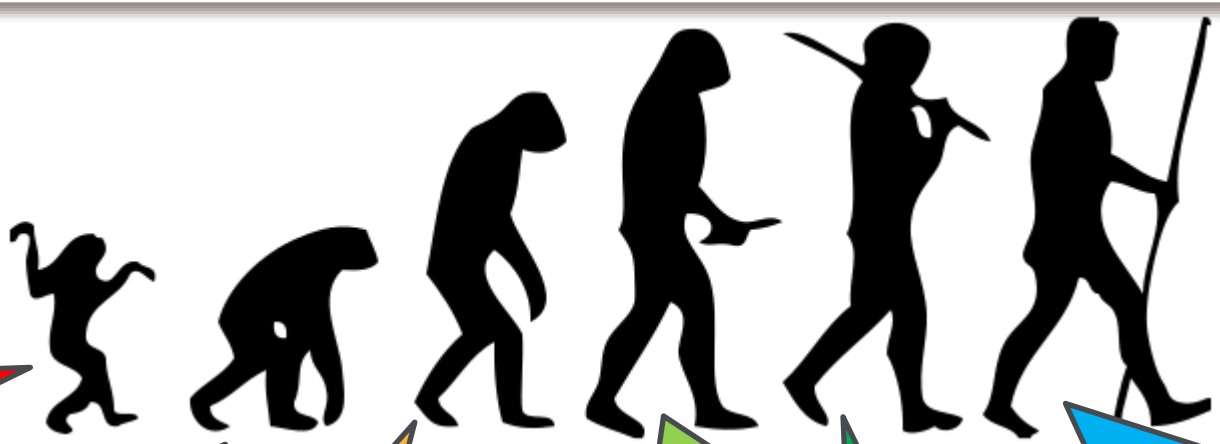
Building Models Well is Only the First Step in the DE Transformation Journey



No Architecture

Architecture Pictures in PowerPoint

Graphical Interpretation of Architectures using Diagrams in Models

Semi-Automated Analysis of Modeled Architectures

Comparing Architecture Models to the Real World

Semi-automatic Sustainment of Implemented Architecture & Update of Architecture Models

Image by Wikimedia Commons

Using Models Well is the Key to Results

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Questions/Discussion

SAIC DE Profile & Validation Rules:

https://www.saic.com/digital-engineering-validation-tool

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Solution Debt in the Age of Digital Engineering

Matthew Taylor, Dr. Heidi Davidz, Dr. Doug Orellana

Approved for Public Release

Agenda

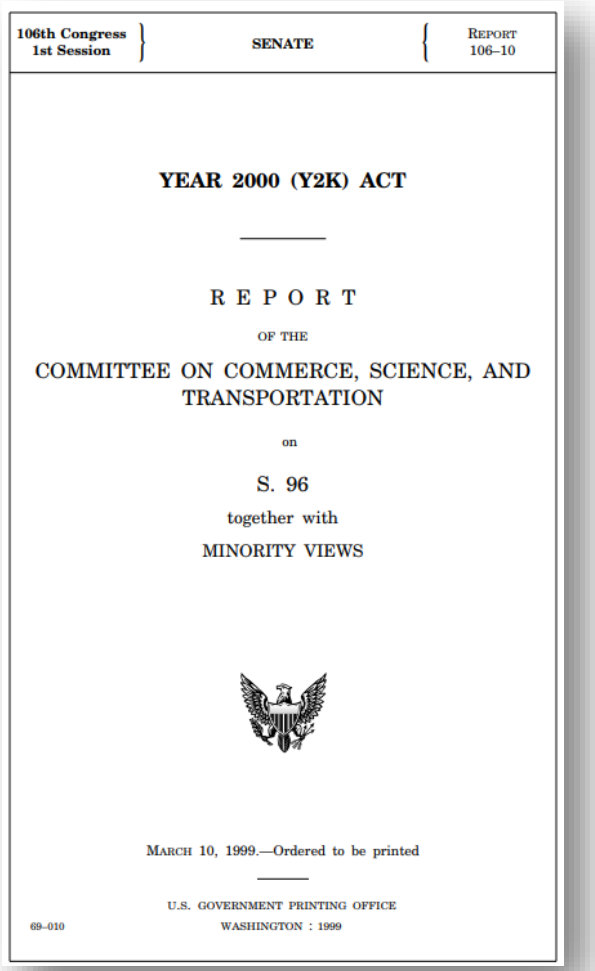
The Debt Metaphor → Solution Debt → Digital Engineering and Debt → Evaluating Your Debt

- The traditional definitions of debt are too narrow in the context of complex missions and systems
- Solution debt attempts a more comprehensive view across discipline and lifecycle
- Digital Engineering approaches avoid some debts, but magnify others
- The Solution debt concept can provide a useful context to categorize and evaluate debt

Y2K – It became a punchline, but had a real cost…[24,25,26,27]

Estimates of up to **$1 Trillion** spent in just the United States

- Estimates of $8.5B spent by the federal government
- $250M by Chase Manhattan Bank alone


106th Congress
1st Session

SENATE

REPORT
106–10

YEAR 2000 (Y2K) ACT

REPORT

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

on

S. 96

together with

MINORITY VIEWS

MARCH 10, 1999.—Ordered to be printed

U.S. GOVERNMENT PRINTING OFFICE

69–010 WASHINGTON : 1999

…all because memory and processing used to be so precious most software stored only two digits of the year – even after that wasn't strictly necessary.

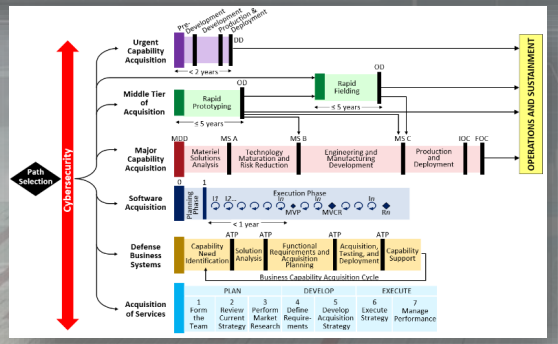
This was brought up as a debt to be paid as far back as 1971.

Common Debt Causes & Industry Forces (1 of 2) 1,2,3,4,5,6,7

Time Pressure

Limited Skills

DoD Restructures Acquisition, Technology Office to Improve Military Lethality, Speed



DEFENSE INNOVATION UNIT

Gartner

Lack of Skills Threatens Digital Transformation

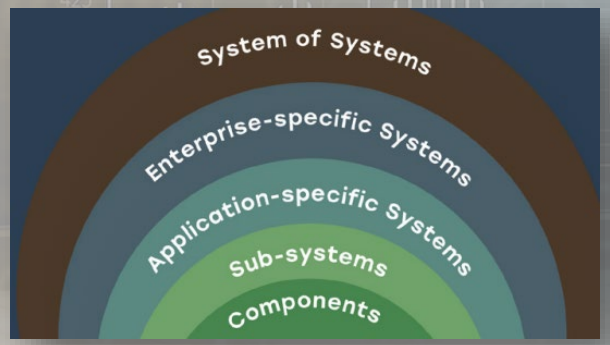
HBR

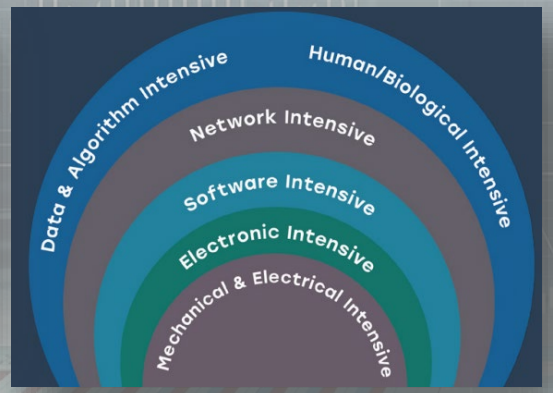
Digital Transformation Is About Talent, Not Technology

Common Debt Causes & Industry Forces (2 of 2) [1,8,9,10]

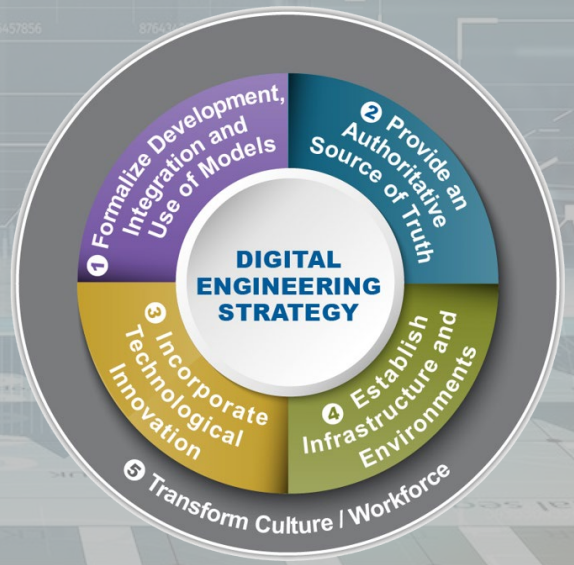
Complex Design

Limited Standards





SUMMARY OF THE
JOINT ALL-DOMAIN COMMAND & CONTROL
(JADC2)
STRATEGY



How standardized is DE today? In terms of…

- Technologies
- Processes
- Methods
- Tools
- Languages
- Environments
- Industry Standards

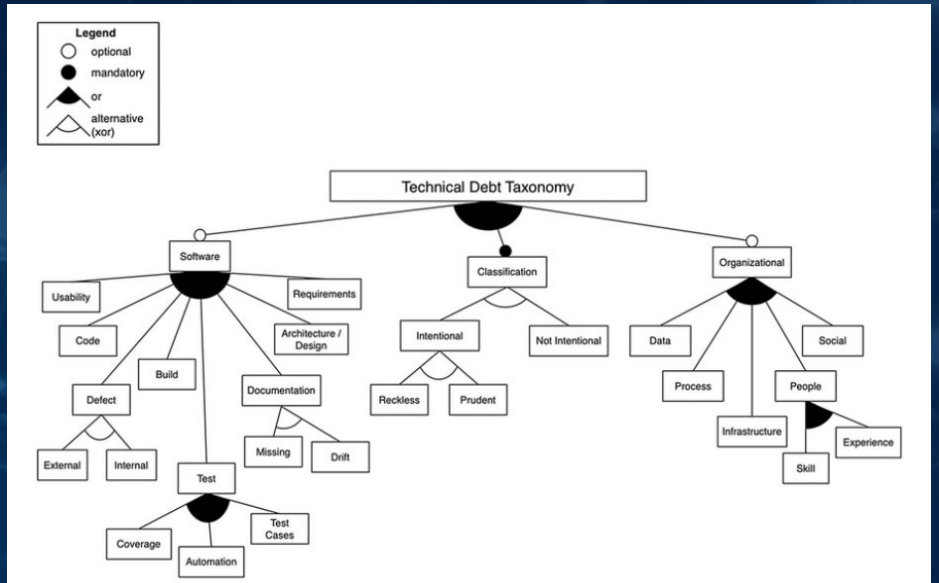
The Debt Metaphor… Is not just for Software [17,18,19,20]
… Is not Limited to Development Phases

Tech debt literature is almost exclusively focused on software.

"Technical debt is a concept in **programming**…" [18]

"Tech debt, also known as technical debt or **code debt**…" [19]

"technical debt, a term **specific to software** application **design and development**." [20]



Technical debt taxonomy

Systems Engineers & Enterprise Architects…
Worry about debt incurred at the solution level and spanning the lifecycle!

Introducing a Broader Term… Solution Debt

The traditional definition of technical debt is too narrow for the concerns of Systems Engineers and Enterprise Architects.

SE's and EA's care deeply about software, but also about many other facets of technology and business.

What are the debt drivers in delivering an overall solution? What will be more expensive in the solution or its ecosystem to fix or pay back later?

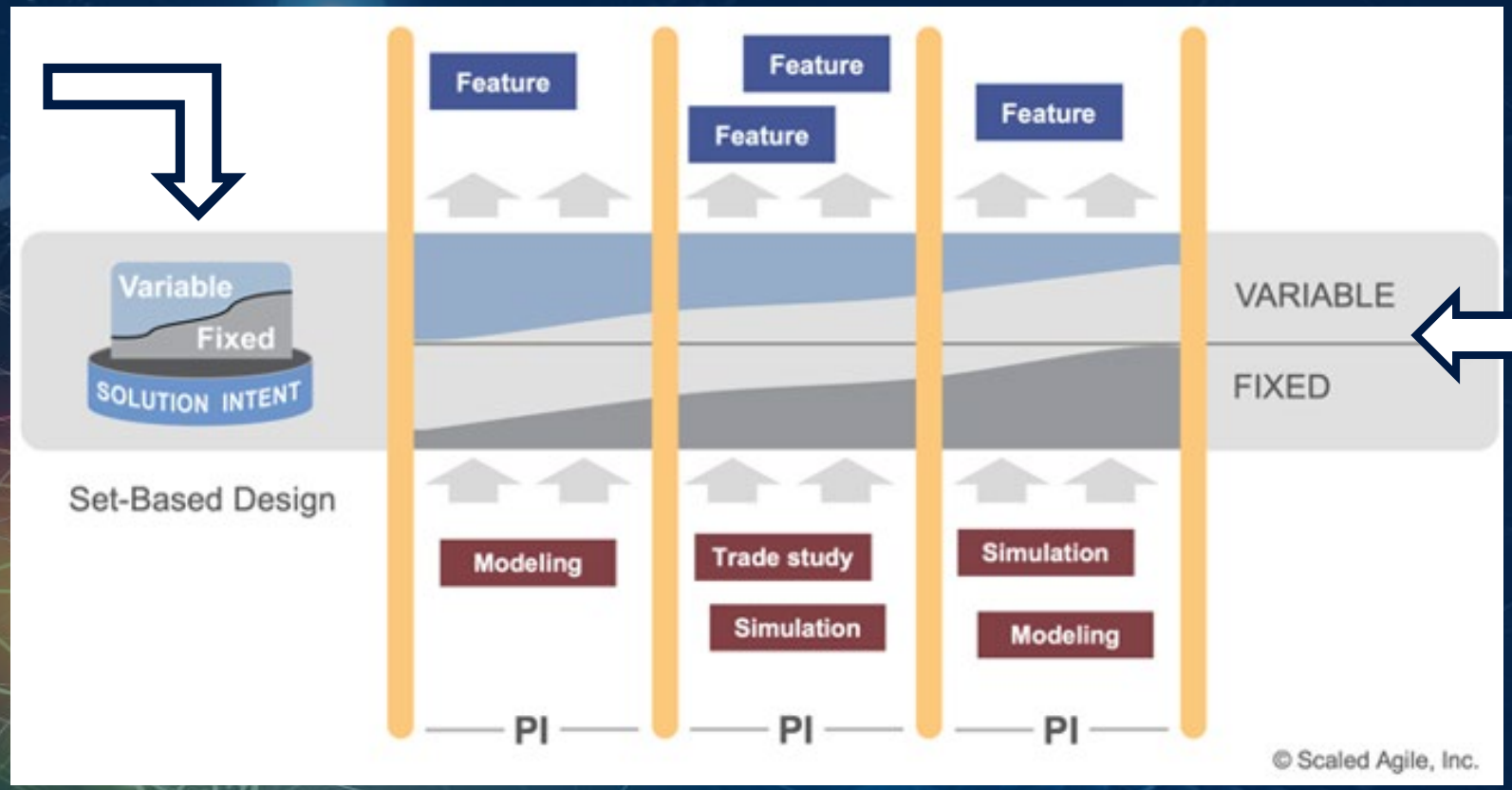
This is SOLUTION DEBT.

Solution debt is the extra effort (interest payments) required to overcome undesirable complexities in a solution and/or its supporting ecosystem - encountered during its analysis, design, development, or deployment.

Solution Debt Correlation with Solution Intent [28]

What is being built

How will it be built



Plateau of acceptable debt risk

Technical Discoveries

Solution Debt Decomposition & Common Symptoms [16]

Solution Debt Decomposition			Symptoms (non-exhaustive list)
Solution Debt	Business Debt	Management Debt	Inconistent views of roles/responsibilities, Unchecked resistance to change
		Supply Chain Debt	Reliance on single sources, Lack of visibility into supply sub-tiers
		Innovation Debt	Lack of differentiating capability, Unbalanced R&D portfolio
		Infrastructure Debt	Insufficient facilities or equipment, Lack of internal/external collaboration capability
		People Debt	Poor workforce morale, Missing skills or experience
		Process Debt	Ineffecient process, Undocumented process
		Service Debt	Ill-defined service level agreement, high service switching cost
		Social Debt	Strained interactions with stakeholders, Soiled reputation internally or externally
	Lifecycle Debt	Production Operation	Uncharacterized value streams, Inability to meet contracted volumes
		Architecture Debt	Unintended system behaviors, Lack of variation management
		Technical Data Package Debt	Incomplete specification, Inconsistent model methods and style
		Security Debt	Limited cyber recovery planning, Conflicting classification guides
		Obsolescence Debt	Surprise lifetime buys, Obsolete inventory
		Design Debt	Design for export not considered, Lack of design guidance
		User Interface Debt	Unnecessary cognitive load on user, Lack of realiable interpretation
		Requirement Debt	Unverifiable requirements, Incomplete traceability
		Code Debt	Duplicated code, Poor code metrics
		Defect Debt	Unmanaged backlog, Uncorrected major defects
		Test Debt	Lack of control and observability points, Unrepeatable test results
		Technology Debt	Ad-hoc technology adoption, Solution no longer effective in intended environment
		Build & Validation Debt	Lack of automated validation suite, Ill-defined dependencies
		Data Debt	Ad-hoc data controls, No data disposal plan

Digital Engineering Aspirations

- Facilitate better solutions, faster
- Navigate change
- Reduce risk
- Achieve greater mission assurance

Background Image by kjpargeter on Freepik

DE Capabilities Solve Problems, but Understand the Debt Potential (partial set of examples)

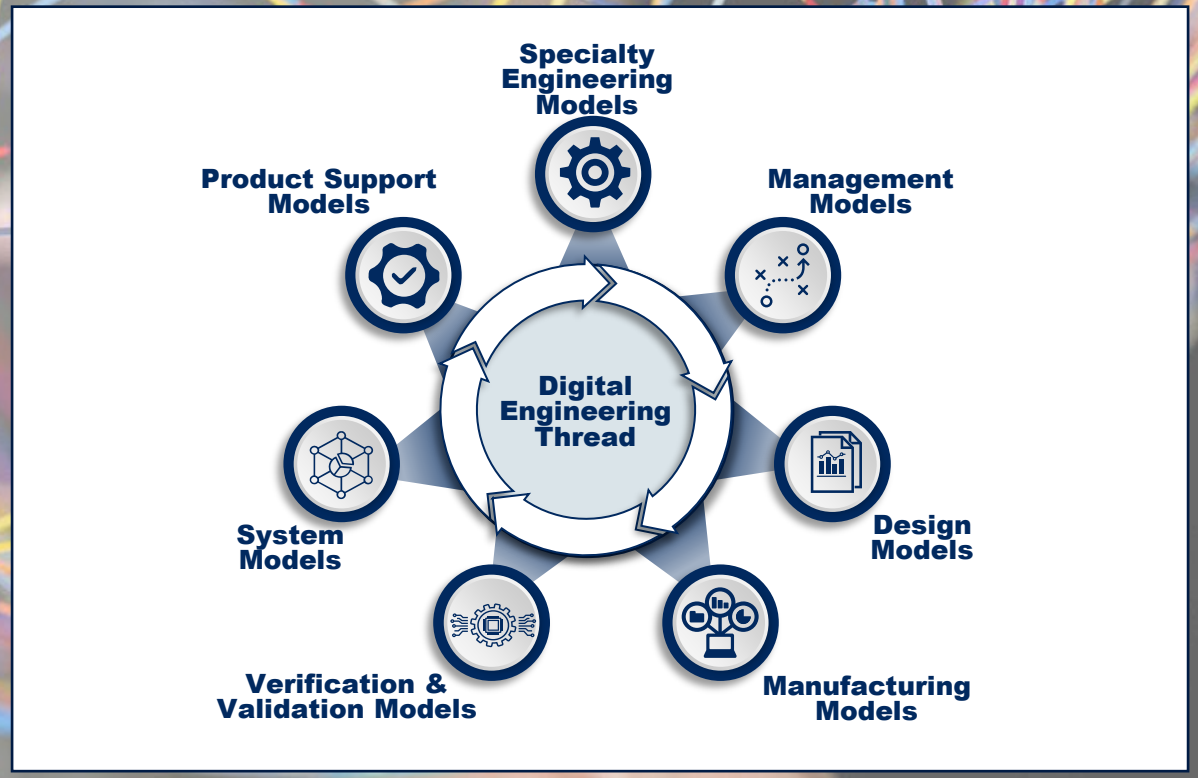
Solution Debt	Business Debt	Management Debt
		Supply Chain Debt
		Innovation Debt
		Infrastructure Debt
		People Debt
		Process Debt
		Service Debt
		Social Debt
	Lifecycle Debt	Production Operation
		Architecture Debt
		Technical Data Package Debt
		Security Debt
		Obsolescence Debt
		Design Debt
		User Interface Debt
		Requirement Debt
		Code Debt
		Defect Debt
		Test Debt
		Technology Debt
		Build & Validation Debt
		Data Debt

- Bespoke tool and repository integrations
- Lack of DE skills in the workforce
- Immature DE processes and methods
- Architecture connected throughout lifecycle
- More complete specification
- Robust design analysis spanning digital thread
- Early virtual integration
- Increased automation
- Connected, Authoritative Sources
- Bad Data Proliferation

DE capability:
- Mitigates debt
- Incurs debt

Example: Digital Engineering and Data Debt [12,13,14,22,23]

- Experian: The cost of bad data is 15% to 25% of revenue for most companies
- IBM: Businesses lost $3 trillion dollars per year due to bad data
- Gartner: Every year, poor data quality costs organizations an average $12.9 million



Digital threads connect data in a useful way, but also potentially 'super spread' bad data.

How does one evaluate debt? [15,21]

Impact

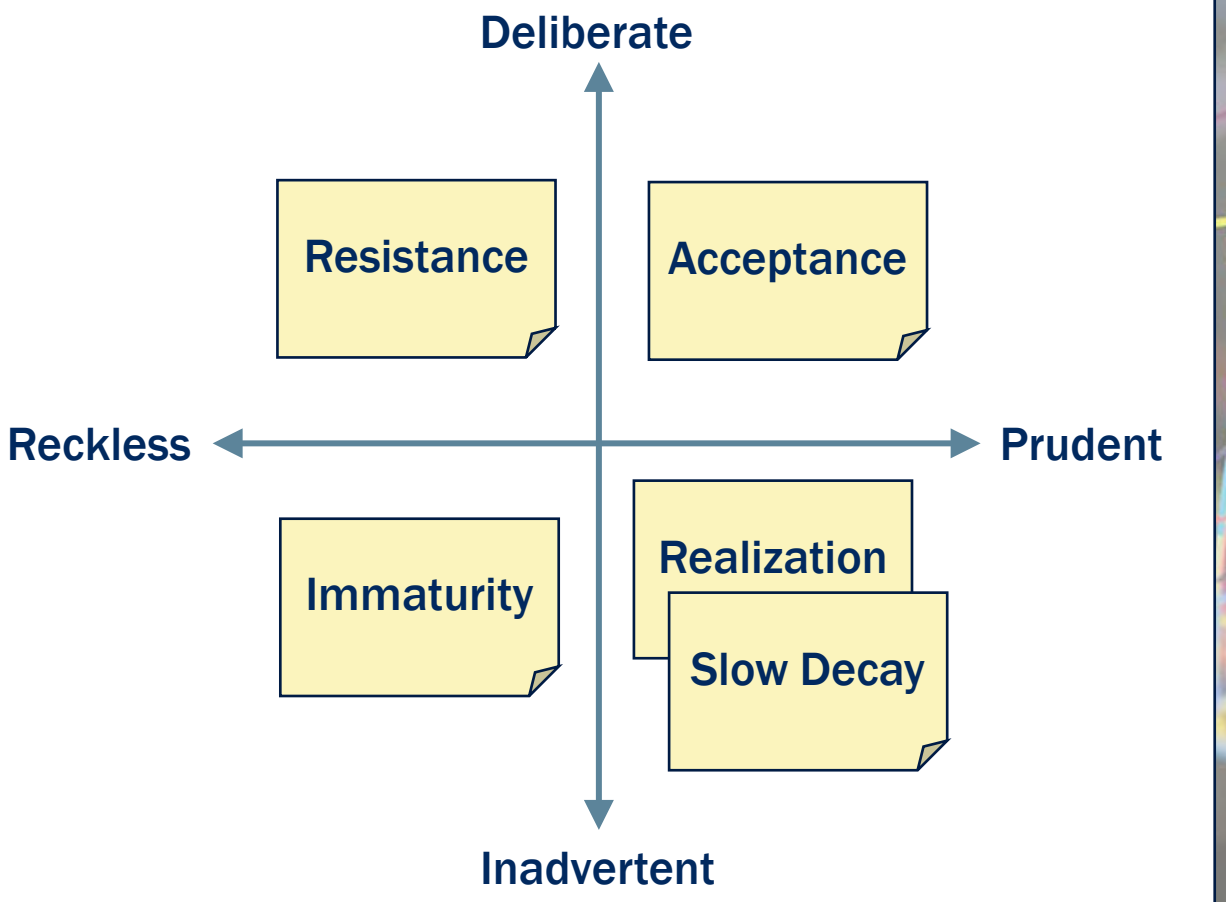
Fix Cost

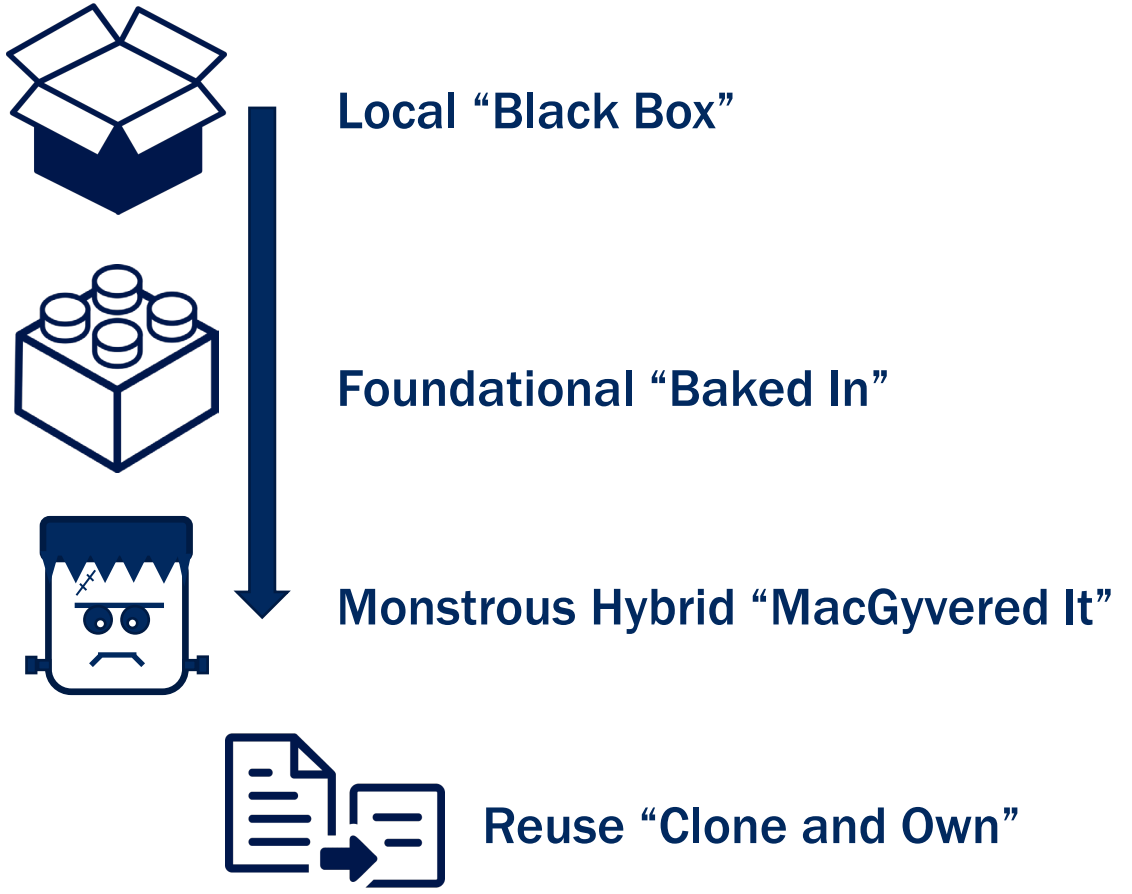
Contagion

Who pays?
(Directly?, Indirectly?)

Access Denied?
(No ability to impact)

Are there common types of debt? [11,15]





Evaluate to Inform a Debt Reduction Plan

Impact 2/5

Fix Cost 3/5

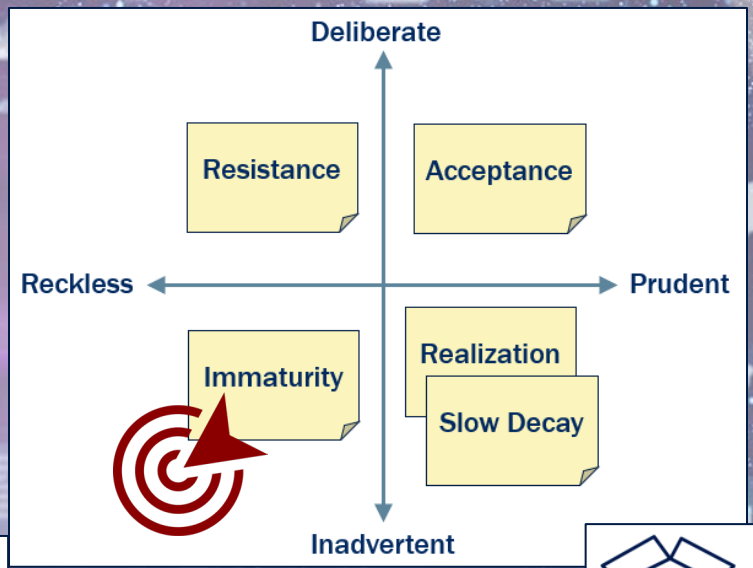
Contagion 4/5

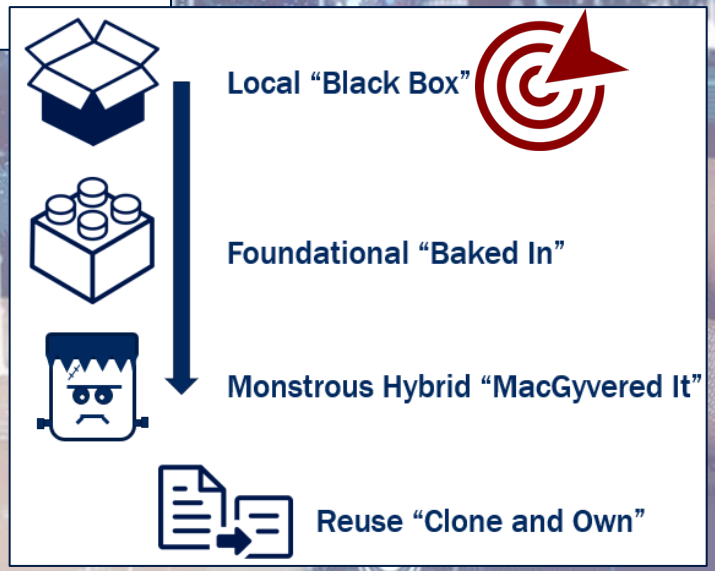
Who pays?
(Directly?, Indirectly?)

Oh no, my customer!

Access Denied?
(No ability to impact)

Yes, I need...





Future Work

Expand and formalize the framework for action:

1. Formalize a solution debt taxonomy with definitions
2. Evaluate current program debt, using the techniques presented
3. Link evaluated program debt to risks, and explore linkages to governance which may ‘guardrail’ certain kinds of debt
4. Determine a program debt reduction plan and timeline
5. Execute the debt reduction plan

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Thank you

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Dr. Heidi Davidz, Heidi.Davidz@ManTech.com

Modeling Information to Support Systems Engineering Technical Reviews Based on DoD Data Item Descriptions (DIDs)

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DM21-0984

Outline

Background

Approach/Process

Benefits

Next Steps

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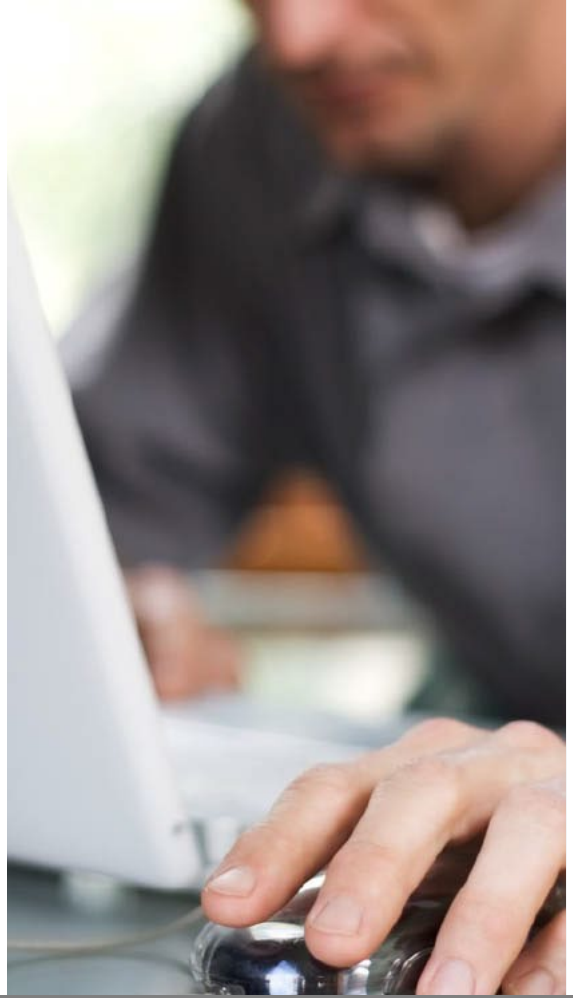
Background



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Background

The SEI conducted this effort as part of a work plan for the U.S. Army Combat Capabilities Development Command Aviation & Missile Center (DEVCOM AvMC) Integrated Mission Equipment (IME) project.

- Part of the job was to “develop and present the next steps in comprehensive model-based engineering (MBE) deliverables.”
- This work is based on a previous project that related existing data item descriptors (DIDs) to modeling efforts.
- This effort is based on the Navy Systems Engineering Technical Review (SETR) process.
- The resulting product provides guidelines for modeling information to support specific SETR reviews regardless of the DIDs used.

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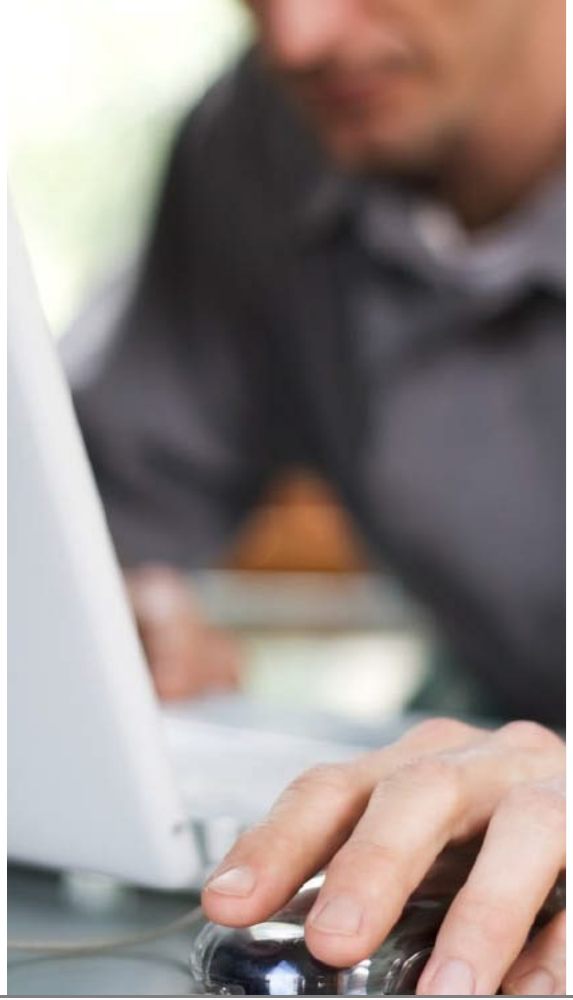
Approach/Process



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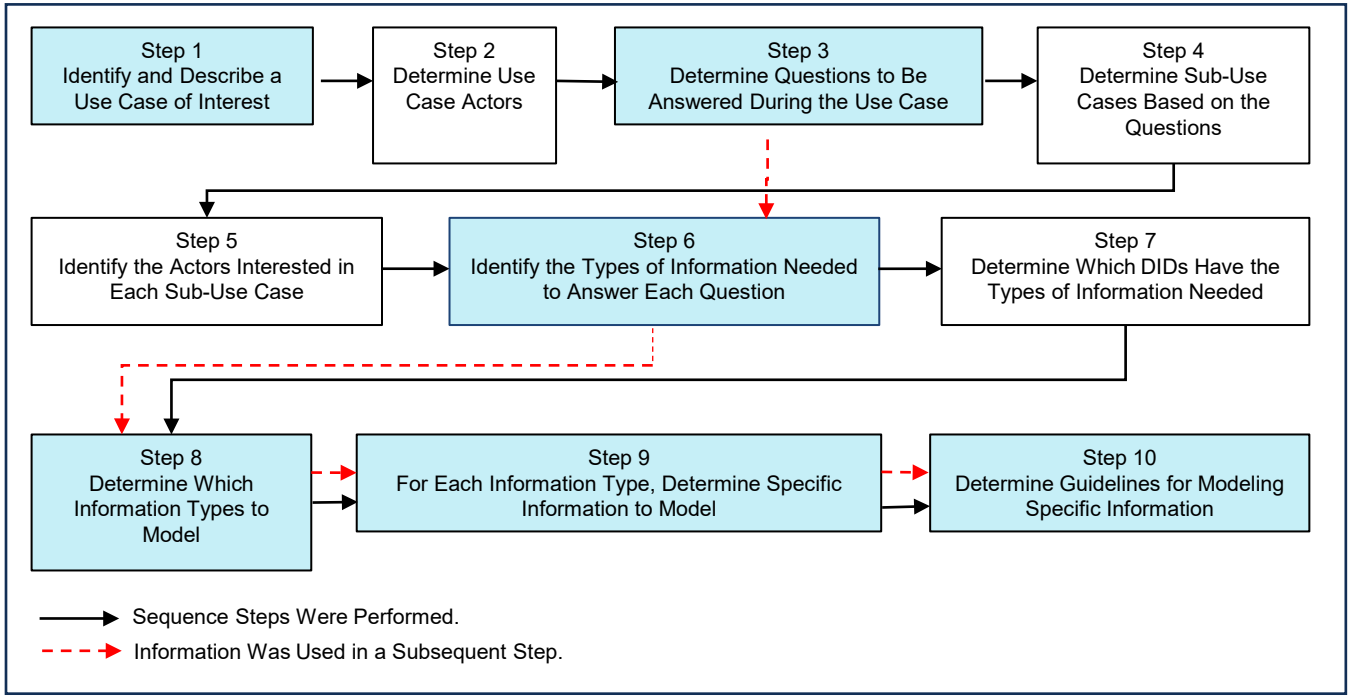
Final Process

Changes were made during the project - final process:



The following slides discuss the steps in the blue boxes.

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Step 1: Identify and Describe a Use Case of Interest

- 7 SETR reviews of potential interest were identified; due to time constraints, we only worked on SRR-II, SFR, SSR, PDR, and CDR.
- 5 primary use cases were developed for the 5 aforementioned SETR reviews that describe how models would be used during those events.
- 40 sub-use cases were developed across the 5 primary use cases, each focusing on specific areas of interest.

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Step 1 Example: Primary/Sub-Use Cases for SETR Reviews

Primary Use Cases	Sub-Use Cases
UC-01 – Conduct SRR-II	• SRR-UC-01.a – Requirements Baseline • SRR-UC-01.b – Operational Effectiveness and Suitability • SRR-UC-01.c – Key Performance Areas/Key Performance Parameters • etc.
UC-02 – Conduct SFR	• SFR-UC-01.a – Functional Decomposition • SFR-UC-01.b – Capability Development Document • SFR-UC-01.c – Technology Readiness Level • etc.
UC-03 – Conduct SSR	• SSR-UC-01.a – Requirements Baseline • SSR-UC-01.b – Software Design Readiness • SSR-UC-01.c – Software Test Plan • etc.
UC-04 – Conduct PDR	• PDR-UC-01.a – Allocated Baseline/Interfaces/Architecture • PDR-UC-01.b – Test, Evaluation and Certification • PDR-UC-01.c – Analysis • etc.
UC-05 – Conduct CDR	• CDR-UC-01.a – Design/Specification/Traceability/Baseline • CDR-UC-01.b – Test, Evaluation and Certification • CDR-UC-01.c – Analysis • etc.

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Step 3: Determine Questions to Be Answered During the Use Case

- The goal was to determine what questions might be asked during each use case that could be answered using models.
- For example, 94 SRR use-case questions were identified.
- The questions were derived from the SETR manual and other government sources.
- The questions were the basis for the following activities:
  - analyzing the types of information needed
  - identifying specific information needs
  - recommending what information to model to support SETR reviews
  - developing modeling guidelines

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Step 3 Example: SRR Use-Case Questions

- Has the quality of GFE/GFI been verified?
- Is the developing contractor's (including subcontractors) requirements baseline traceable to the government's requirements baseline?
- Has the contractor appropriately decomposed the performance requirements to the scope of the effort under contract?
- Is there an approved system specification with sufficiently conservative requirements to provide for design trade space for the EMD phase?
- Is there a preliminary allocation of system requirements to hardware, human, and software subsystems?
- Are training requirements/objectives listed in the speciation?
- Have environment, safety, and occupational health requirements been addressed, as applicable?
- Have system constraints (interfaces, physical, electrical, etc.) been specified?
- Are the system requirements sufficiently detailed and understood to enable system functional definition and functional decomposition?
- Do the system requirements address system performance?
- Do the system requirements address reliability, availability, and maintainability (RAM)?
- Is there a reasonable expectation of providing an operationally effective and suitable final system?
- Does the contractor's technical baseline cover everything that is needed to satisfy the government's KPPs and KSAs?
- Are the system requirements testable? How will availability be measured?
- Have the tailorable, non-tailorable, derived, and correlated requirements been established within the framework of a candidate physical architecture?
- Has a technical risk assessment been executed to characterize the understanding of requirements and verification procedures, representing the ability of the contractor to comply with the government's performance baseline?
- Has a program execution risk assessment characterized the ability to achieve the CDD-specified capabilities within program budget and schedule?
- Is there an approved EMD phase SEP that addresses cost and critical path drivers?
- Is there an approved life cycle sustainment plan?
- Are the system requirements traced to higher level capability needs?
- etc.

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Steps 6: Identify the Types of Information Needed to Answer Each Question

- For example, 128 information types were identified for the 94 SRR use-case questions identified in Step 3.
- Multiple information types were needed to answer most questions.

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Step 6 Example: Information Types Needed to Answer SRR Questions

- Allocated Baseline Requirements
- CDD Requirements
- Derived Requirements
- Design Constraints
- Each Function's Inputs, Processing, Outputs
- External Interface Requirements
- Human Factors Considerations
- Interface Requirements
- Internal Development Baseline
- Mission Requirements
- Operational Environment/Mission Requirement Associations
- Program Staffing
- Requirements Allocation and Rationale
- Requirements Traceability
- Software Certification Plan
- Software Requirements
- System Functional Overview
- System Requirements
- Technical Performance Measures (TPM)
- Testing Method for Each Requirement
- Use Cases
- etc.

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Step 8: Determine Which Information Types to Model

- While all the information types identified in Step 6 could be modeled, some seemed more worthwhile to model to support the use cases.
- For example, to support the SRR use case, it seemed worthwhile to model some information types but not others:
  - Requirements
  - Use cases
  - Functions
  - Interfaces
  - ~~Program staffing~~
- The focus was on information types that seemed most worthwhile to model to support the stated purpose of each use case.

Legend

- Information Types that Seemed Worthwhile to Model to Support the SRR Use Case
- ~~Information Types That DID NOT Seem Worthwhile to Model to Support the SRR Use Case~~

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Step 8 Example: Information Types to Model for SRR

- ~~Allocated Baseline Requirements~~
- CDD Requirements
- Derived Requirements
- Design Constraints
- Each Function's Inputs, Processing, Outputs
- External Interface Requirements
- Human Factors Considerations
- Interface Requirements
- ~~Internal Development Baseline~~
- Mission Requirements
- Operational Environment/Mission Requirement Associations
- ~~Program Staffing~~
- ~~Requirements Allocation and Rationale~~
- Requirements Traceability
- ~~Software Certification Plan~~
- Software Requirements
- System Functional Overview
- System Requirements
- Technical Performance Measures
- ~~Testing Method for Each Requirement~~
- Use Cases
- etc.

Legend

- Information Types that Seemed Worthwhile to Model to Support the SRR Use Case
- ~~Information Types That DID NOT Seem Worthwhile to Model to Support the SRR Use Case~~

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Step 9: For Each Information Type, Determine Specific Information to Model

- Determine specific information to model for each information type identified in Step 8.
- Only some of the specific information associated with the information types identified seemed essential to include in models to support the use cases. Other specific information seemed "nice to have" but non-essential.
- For example, to support the SRR use case, essential and non-essential specific information to model for the Requirement information type might be:
  - Requirement ID
  - Requirement description
  - ~~Author~~
  - ~~Creation date~~
  - ~~Planned increment~~

Legend

- Essential specific information to model for the Requirement information type
- ~~Non-Essential specific information to model for the Requirement information type~~

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Step 9 Example: Specific Information for SRR Use-Case Models

Information Type to Model: Requirement

Specific Information to Model	Essential
Requirement ID	Yes
Requirement Description	Yes
Requirement Rationale	--
Requirement Categories	--
Owner	--
Qualification Provisions	--
Status	--
Risks	--
Other Requirement Attributes	--
Associations to Parent Requirements	Yes
Associations to Child Requirements	Yes
Associations to Other Requirements	Yes
Associations to Other Artifacts	--
Associations to Use Cases	Yes

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Step 10: Determine Guidelines for Modeling Specific Information

- Guidelines were developed regarding modeling specific information identified in Step 9:
  - modeling techniques
  - modeling languages/frameworks
  - modeling tools
- For the SRR and SFR use cases, guidelines were provided for the following information types:
  - Requirements
  - Use Cases
  - Functions
  - Interfaces

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Step 10, Example 1: Modeling Guidelines for SRR

Models to Consider for Requirement Information

				Modeling Frameworks		Modeling Languages			Modeling Tools					
Modeling Categories	E	C	Modeling Techniques	DoDAF	UAF	SysML	UML	AADL	MS Office	Cameo EA	Enterprise Architect	Rhapsody	DOORS	OSATE/AADL
Behavioral		*	Activity diagrams			x	x			x	x	x		
		*	Communication diagrams				x			x	x	x		
		*	Dataflow diagrams								x			
		*	Interaction overview diagrams				x				x			
		*	Sequence diagrams			x	x			x		x		
		*	State machines			x		x		x	x			
Textual			Use cases											
		*	Quality attribute scenarios											
	*		Tables/matrices						x		x	x	x	
	*		Requirement databases										x	
	*		Descriptive paragraphs			x	x		x	x	x	x	x	
Associational	*		Allocation tables/matrices			x				x		x	x	
	*		Allocation diagrams					x				x		x

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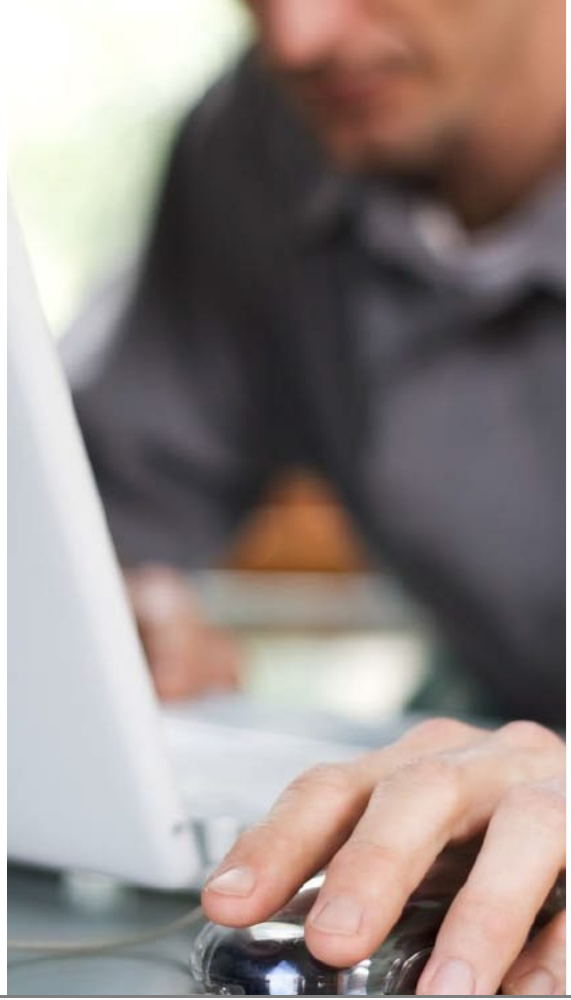
Benefits



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Benefits

The Government Program Office receives the following benefits:

- guidance to help build government models
- information that can help assess models provided by contractors
- information that can be used in a Request for Proposal

Contractors receive the following benefits:

- guidance to help build system and software models
- information about potential modeling tools and languages

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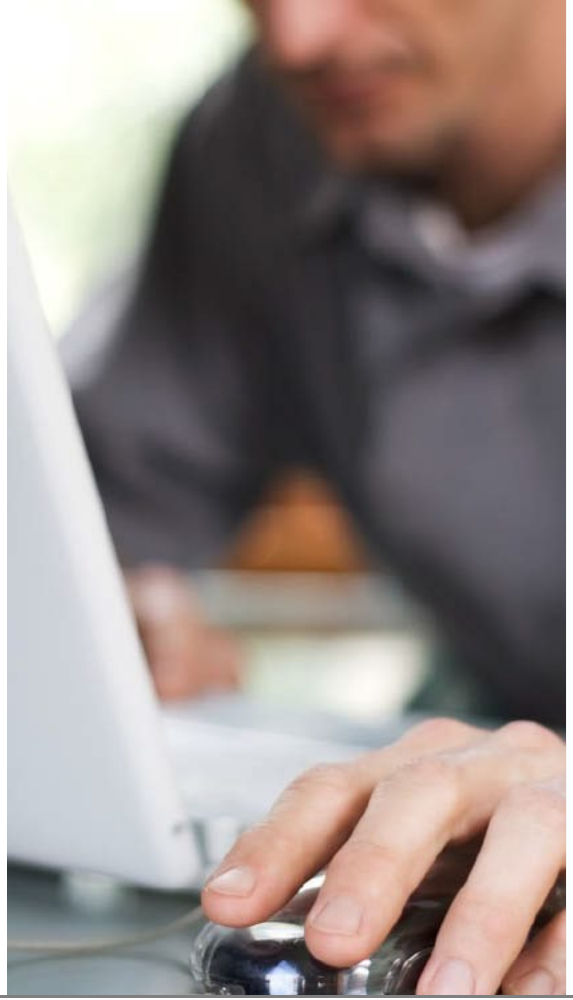
Next Steps



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Next Steps

The next steps are to

- identify a program that can pilot using the information produced and provide feedback
- continue to perform process steps for additional SETR events
- develop guidance for model views to help government program offices and contractors

Two SEI reports will be published in the near future:

- Modeling to Support DoD Acquisition Lifecycle Events
- Guidance for Tailoring DoD Request for Proposals (RFPs) to Include Modeling

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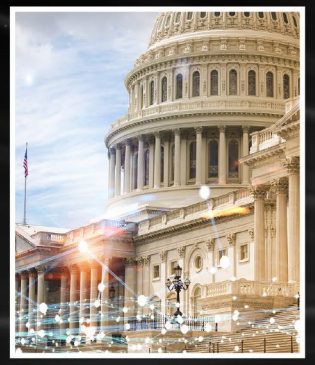
ManTech
Securing the Future



Securing the Future

Utilizing Automation and Ontologies to Design, Deploy, and Sustain an Effective Model Governance Program

Dr. Heidi Davidz, Dr. Douglas Orellana, Tammy Bogart, Wayne Thomasson

Approved for Public Release

Executive Summary

Model Governance Automation

Utilize automation and ontologies to design, deploy, and sustain an effective model governance program. Ensure veracity of artifacts, establish transparency, improve communication, increase trust.

FOUNDATION – Utilize elastic model governance guide for model governance system, digital engineering (DE) infrastructure, individual and composite models

AUTOMATION – Employ widget to scrape constituent models for information

INTEGRATION – Use ontology-first digital thread integration platform

LEVERAGE – Leverage extensive data governance practice

DELIVERY – Apply governance to aid DE to deliver results to fulfill mission needs

Agenda

Why Governance?

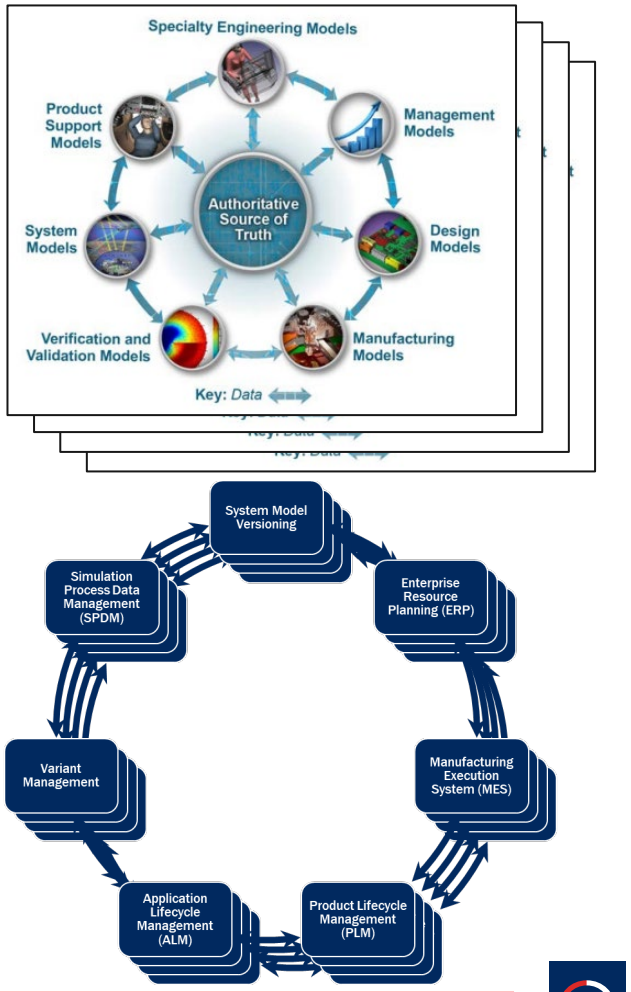
Digital Engineering (DE) is an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal

Use models

Different domains

Distributed data management

Many organizations



Reality

Governance across a digital thread must address a set of data management tools to ensure quality for decision making

What is Model Governance?

- Documented decisions, rights, and accountabilities
- for model related processes,
- executed according to an agreed upon set of rules
- which describe:
  - who can take
  - what actions with
  - what models,
  - when, under
  - what circumstances, using
  - what methods.

Adapted from Pak, Rebekah, “A3 Data Governance: Data Governance Introduction and General Process,” May 2021

Governance vs. Management

Model Governance

Model Management

Model Governance ensures Model Management is happening

Adapted from Ladley, John, "Data Governance: How to Design, Deploy, and Sustain an Effective Data Governance Program, 2nd Edition, Academic Press, 2020.

Two Sides of the Same Coin

Primary Responsibilities

- Define accountability
- Enact policy into procedure
- Provide model and infrastructure transparency
- Monitor quality and compliance
- Report results

Transparent

Collaborative

Measurable

Adapted from Pak, Rebekah, “A3 Data Governance: Data Governance Introduction and General Process,” May 2021

Governance Guide Provides Structure to Organize DE Execution

Earlier Work

Model Governance Guide

As Digital Engineering (DE) employs a digital thread with a broad range of interconnected models, it can be difficult to govern linked models across disciplines and contractual boundaries. This approach includes:

GUIDANCE – Model-based guidance with in-model work instructions,

INTEGRATION – Integration of the overall model governance system, DE Ecosystem (DEE) infrastructure, individual models, and composite models,

PURPOSE – Traceability of model purpose and resolution of technical debt,

VALIDATION – Automated validation for insight on compliance,

FLEXIBILITY – Customization for flexibility and tailoring (fleX-engineering™).

Structure

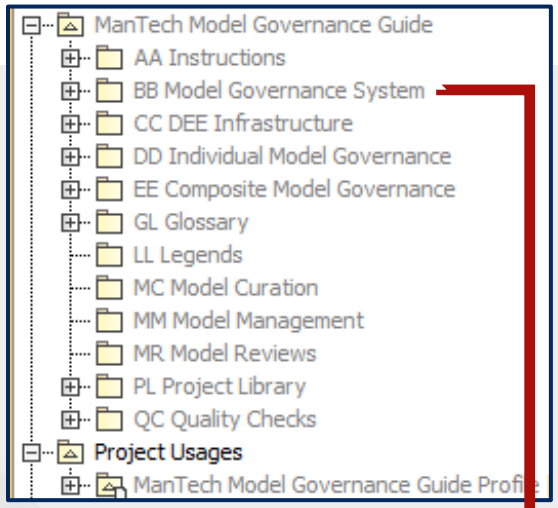
Design Model Governance System

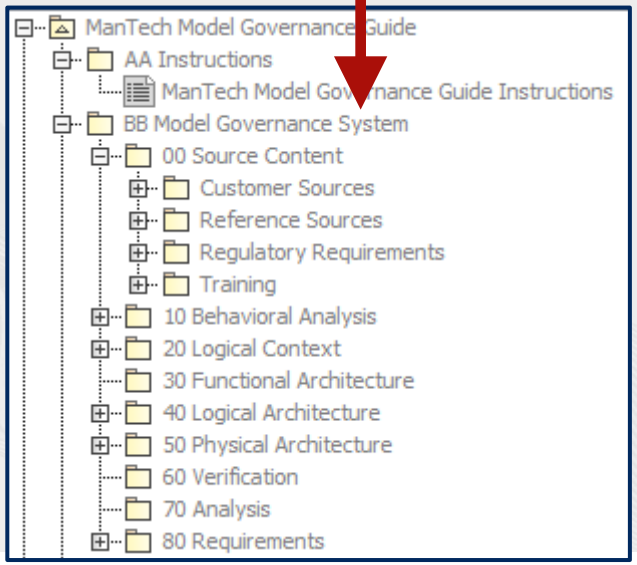
Design DEE Infrastructure

Model Governance Guide

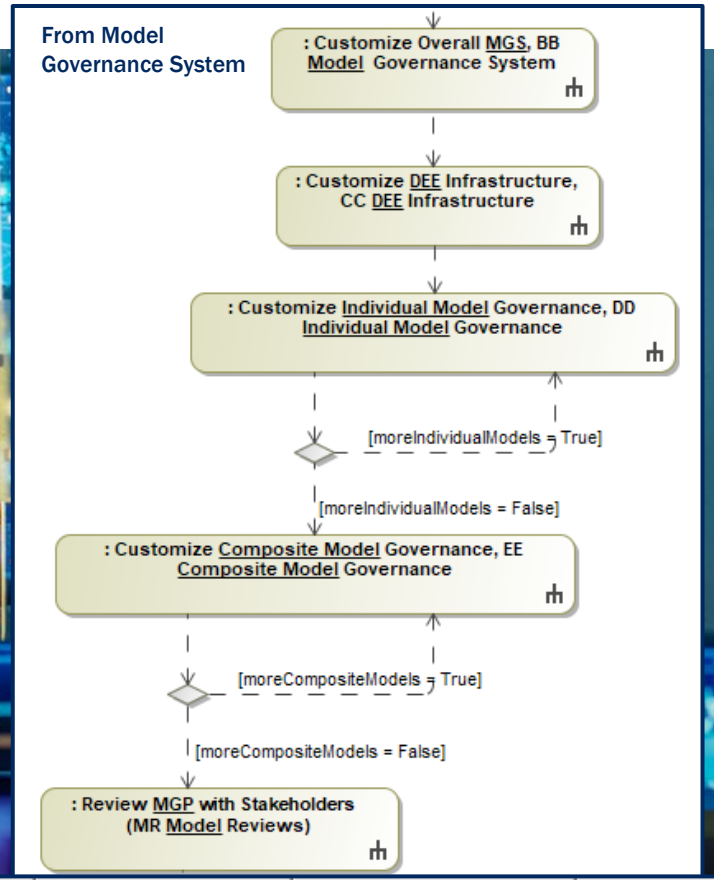
Govern Individual Models

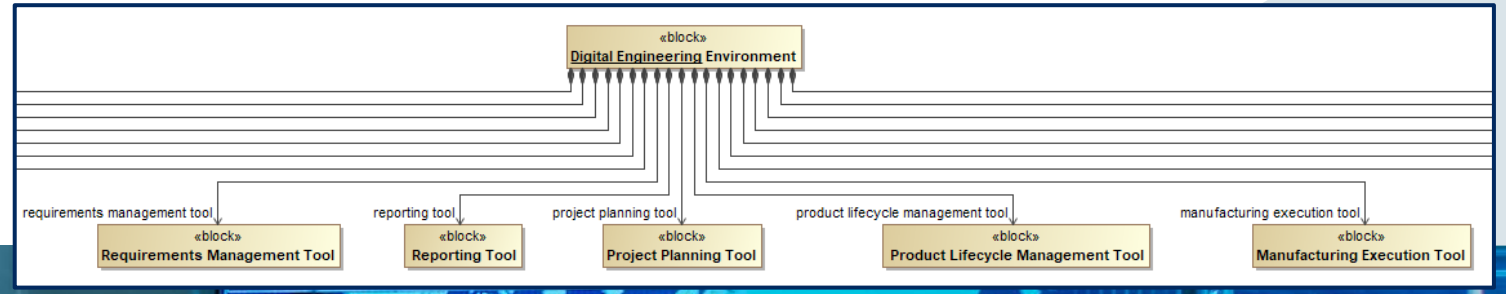
Govern Composite Models

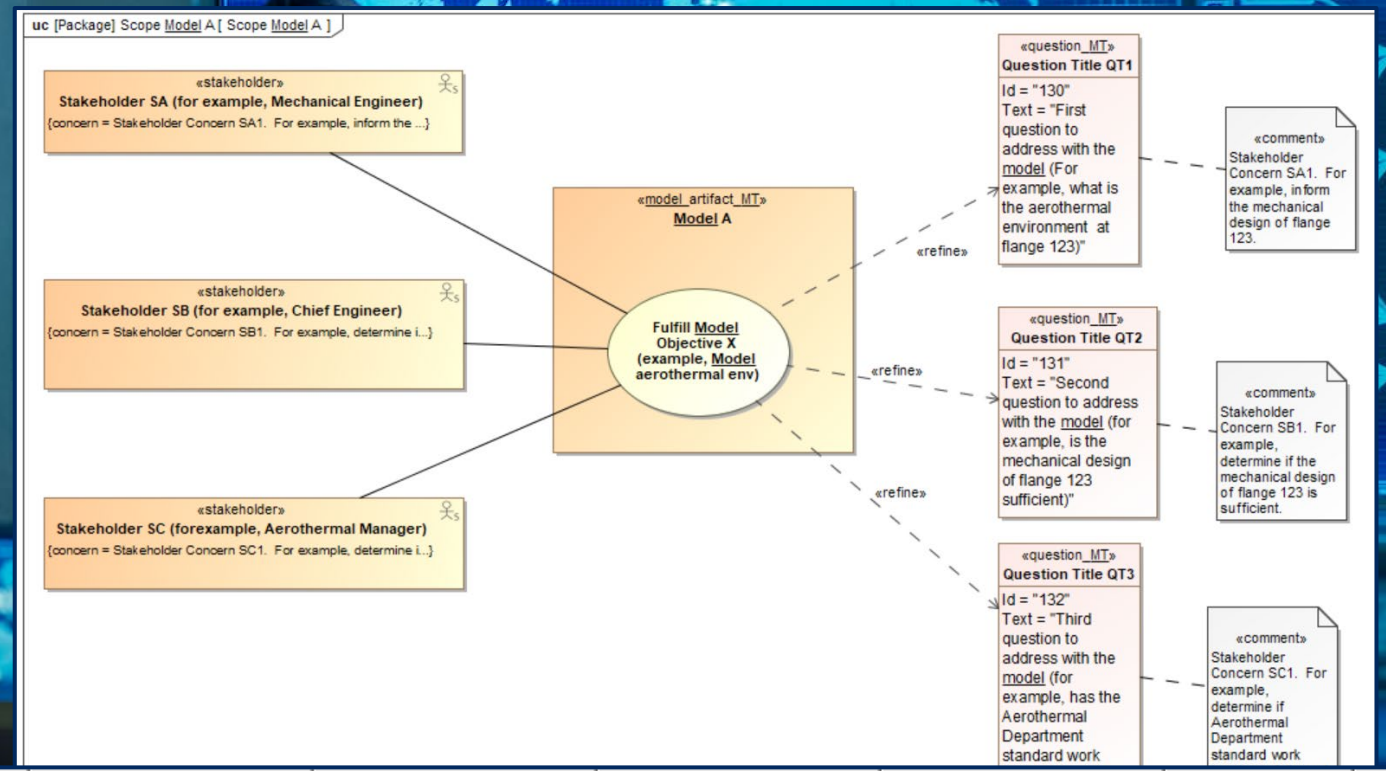




Model Snapshots







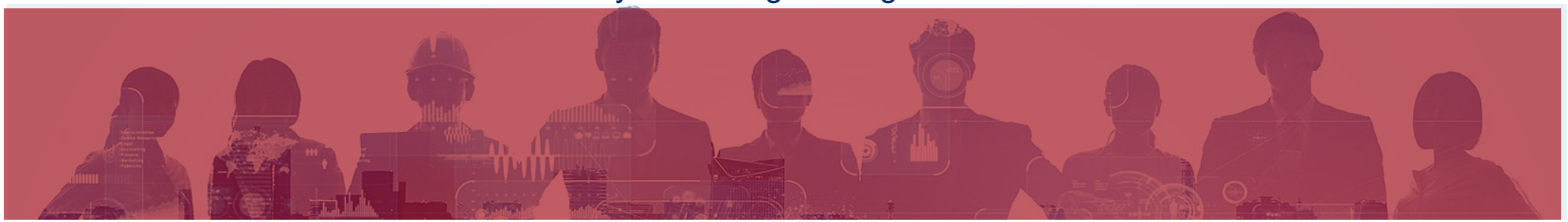
#	Name	Documentation	Associated Assumptions	Associated Risks	Traced to Standards	Use Cases	Questions2	Satisfies	Allocated To	Location
1	Model A	This is the description of Model A...	Assumption B Assumption A	Risk R1	Standard 1 (for example, I Best Practice 3 (for examp Standard 2 (for example, (	Fulfill Model Objective X (e	Question Title QT1 Question Title QT2 Question Title QT3	23 Modeling Questions MGSG-116 Risk MGSG-2 Model Name	ansys : ANSYS	AWS AppStream

Ensure Models and Infrastructure Address Program Needs

User Statement

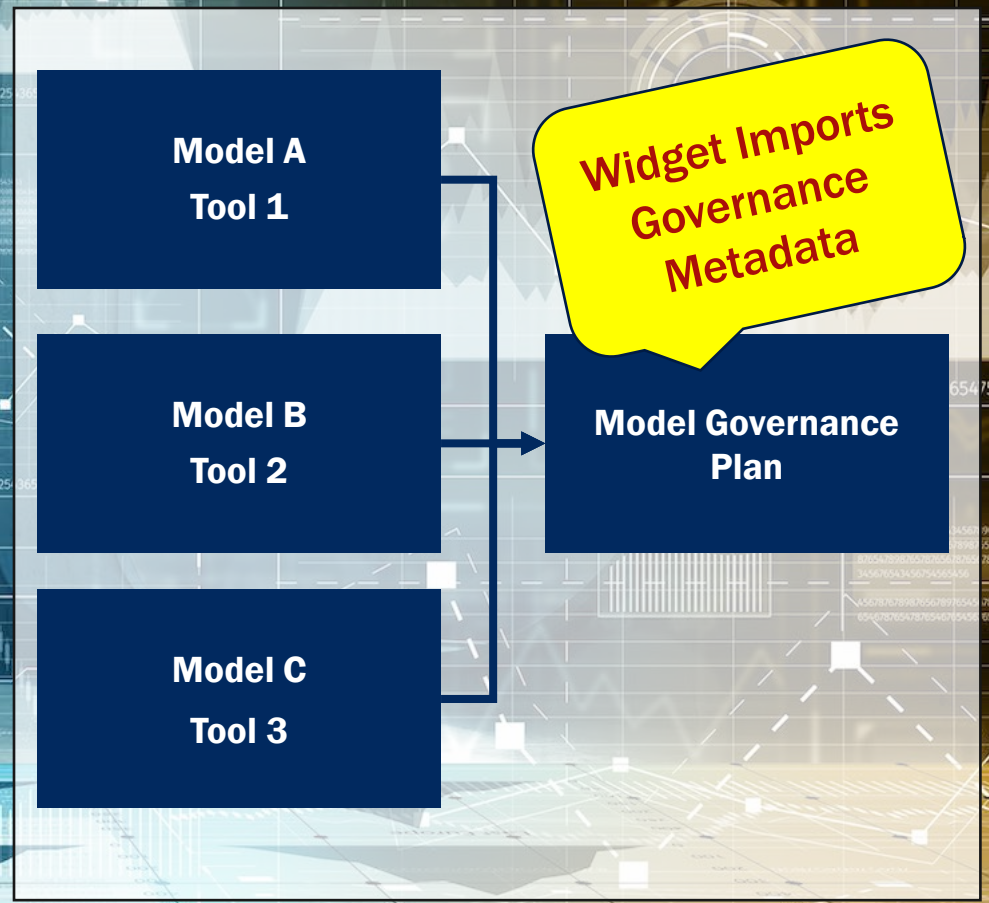
"The Model Governance Guide provided our team with a framework for developing data governance rules and techniques to execute a rigorous enterprise modeling program. Establishing a set of model controls is no different and just as important as establishing Security Controls in the Cybersecurity discipline. With this effort, our customer will improve their business process management, degree of data integrity, and communication and transparency among Stakeholders. Without Model Governance the desired degree of model and data integrity cannot be achieved."

Mark Stimeling and Rebecca Quintero
ManTech Marine Systems Engineering Directorate



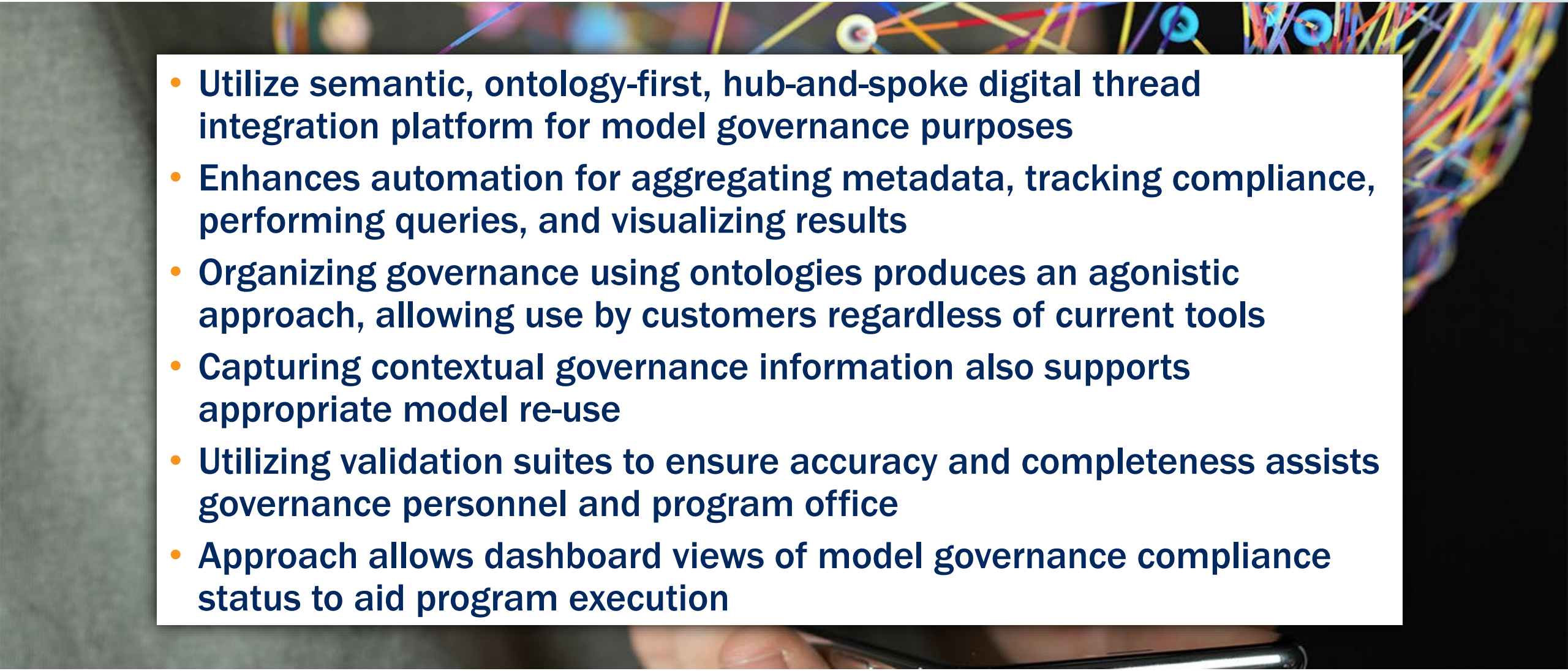
Updates Add Automation

- Automation and ontologies utilized to reduce manual effort
- Widget automatically scrapes constituent models across an ecosystem to report governance information
- Automating ingestion of governance data reduces chance for error
- Where governance metadata are lacking, user interface guides input of missing information



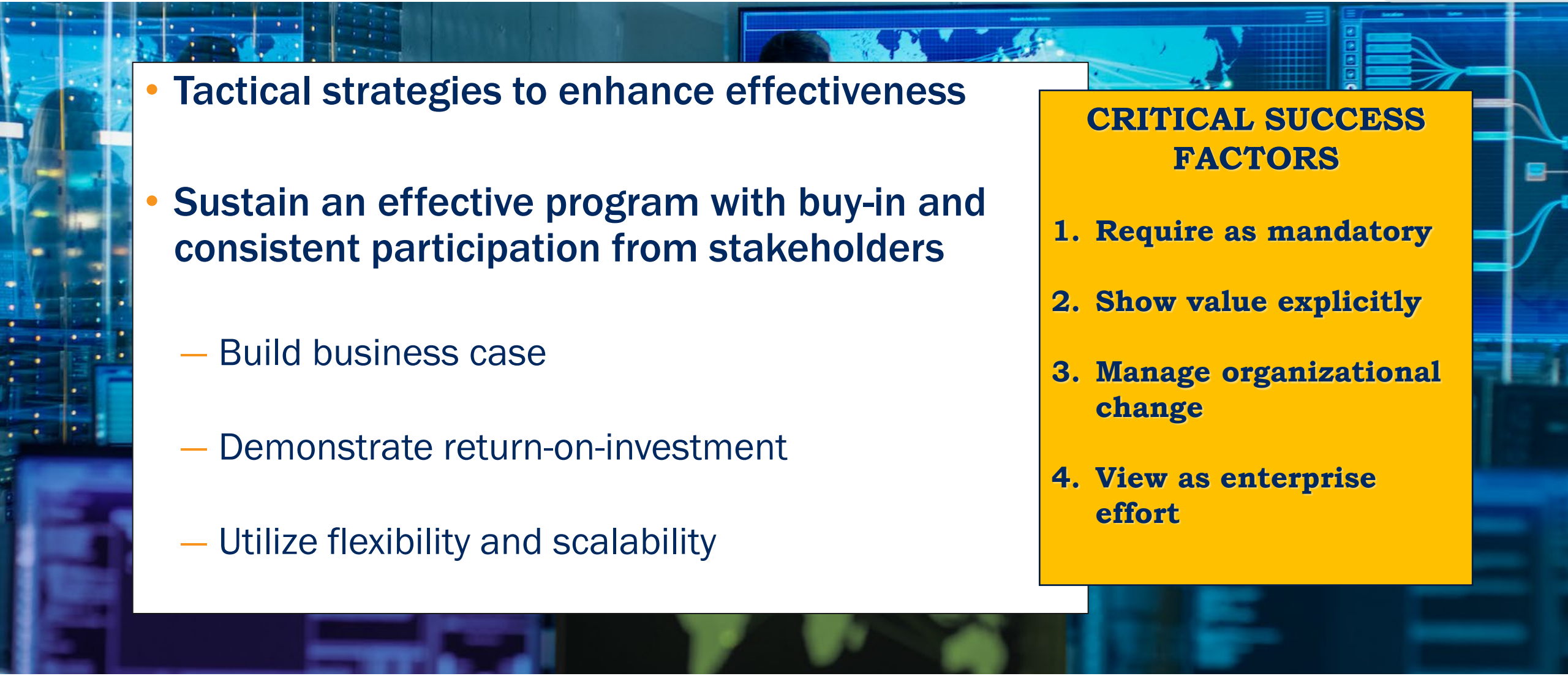
Utilize Automation to Populate Governance Information

Semantic Integration Aids Governance



- Utilize semantic, ontology-first, hub-and-spoke digital thread integration platform for model governance purposes
- Enhances automation for aggregating metadata, tracking compliance, performing queries, and visualizing results
- Organizing governance using ontologies produces an agonistic approach, allowing use by customers regardless of current tools
- Capturing contextual governance information also supports appropriate model re-use
- Utilizing validation suites to ensure accuracy and completeness assists governance personnel and program office
- Approach allows dashboard views of model governance compliance status to aid program execution

Sustain an Effective Model Governance Program



- Tactical strategies to enhance effectiveness
- Sustain an effective program with buy-in and consistent participation from stakeholders
  - Build business case
  - Demonstrate return-on-investment
  - Utilize flexibility and scalability

CRITICAL SUCCESS FACTORS

1. **Require as mandatory**
2. **Show value explicitly**
3. **Manage organizational change**
4. **View as enterprise effort**

Adapted from Ladley, John, "Data Governance: How to Design, Deploy, and Sustain an Effective Data Governance Program, 2nd Edition, Academic Press, 2020.

Demonstration

Next Steps

Evolve Governance Approach to Enhance Digital Fabric Solutions and Services for Customers

Additional Capabilities

- Implement program lessons learned
- Extend digital fabric reach
- Extend metadata scraping
- Evolve governance ontology
- Optimize strategy

References

- Ladley, John, “Data Governance: How to Design, Deploy, and Sustain an Effective Data Governance Program, 2nd Edition, Academic Press, 2020.
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An Enterprise Portfolio Management Framework for Mission Planning, Engineering, and Acquisition

Presented to

NDIA Systems & Mission Engineering Conference

1-3 November 2022

Dr. Warren Vaneman, ESEP wvaneman@nps.edu
Prof. Ron Carlson rrcarlso@nps.edu
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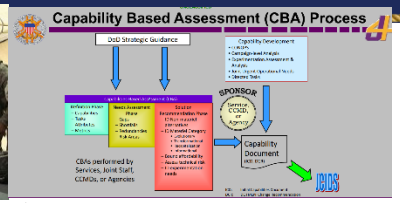
Background

- Mission success requires a careful orchestration between mission planning, engineering, and analysis of the mission, and an acquisition strategy that acquires systems, and assembles system of systems for mission-capability satisfaction.
- The challenge is to develop a mission architecture that demonstrates continuity of mission capabilities from the Strategic Objectives and Policies to the individual platforms.

This paper develops a mission framework that defines the structure that provides traceability from the policy and operational drivers of the mission, to the system of systems that satisfy the mission capabilities, and finally to the individual system's hardware and software.

Intersection of Mission-Based Disciplines



Mission Planning
- Identify mission capabilities
- Develops Concepts of Operations(scenarios)
- Capability-Based Planning
- Assess risk

Mission Capabilities Defined

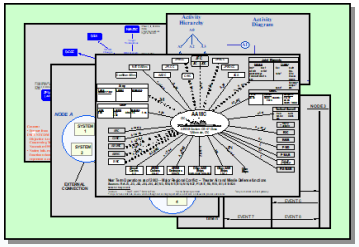
Mission Capabilities Provided

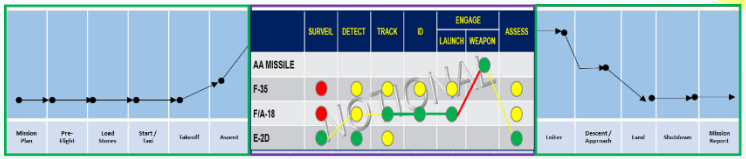
Operational Plans

Initial Capabilities Description

Mission Engineering
- Evaluates mission capabilities
- Analyzes Concepts of Operations(scenarios)
- Defines the mission (capability) architecture

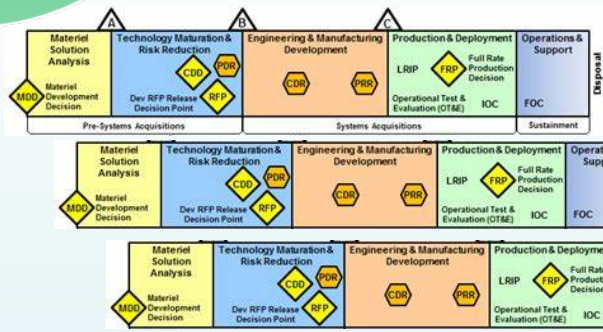
Lead Systems Integration
- Develops System of Systems Architecture
- Engineers and manages capabilities and interdependencies among constituent systems





Prepare/Config | Effects Chain | Post Mission Tasks

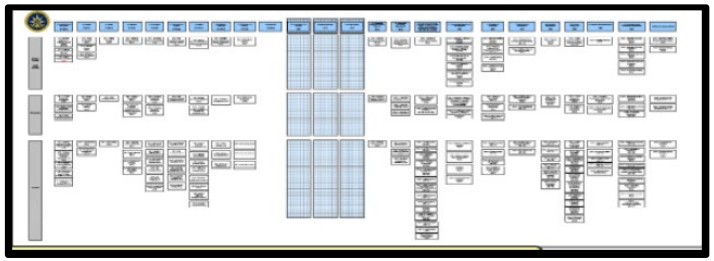
Mission Capabilities Specified

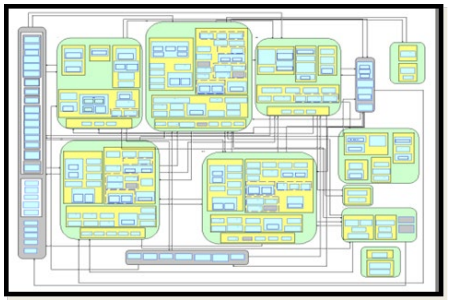


SoS Capability Development Document

Mission Architecture Levels

Enterprise Architecture-The process of translating vision and strategy into an effective and cohesive enterprise by communicating and improving the key requirements, principles and models that describe the enterprise's future state and enable its evolution.





SoS Architecture-The process of describing the structure of a SoS, its decomposition into constituent systems, the relationship between this systems, and the relationship with the external environment.

Systems Architecture-The structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.

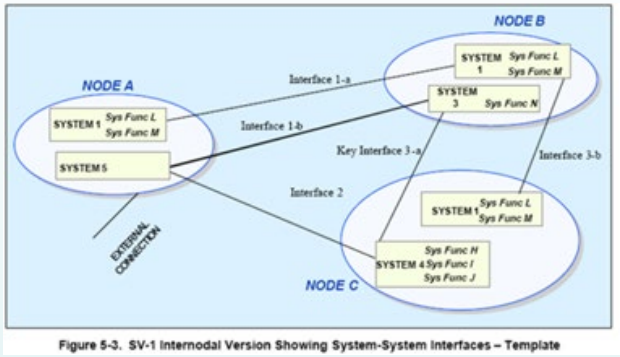


Figure 5-3. SV-1 Internodal Version Showing System-System Interfaces – Template

10-Layers within the Mission Architecture

10. Strategic Objectives and Policies
- Top-level strategic guidance

9. Enterprise Mission Area
- Mission Areas

8. Enterprise Mission Threads
- Mission scenarios

7. Enterprise Mission Tasks
- Universal Tasks required to accomplish the mission

6. SoS Mission Operations
- System of Systems Concept of Employment

5. SoS Mission Structures
- Structure of platforms and systems that comprise the SoS

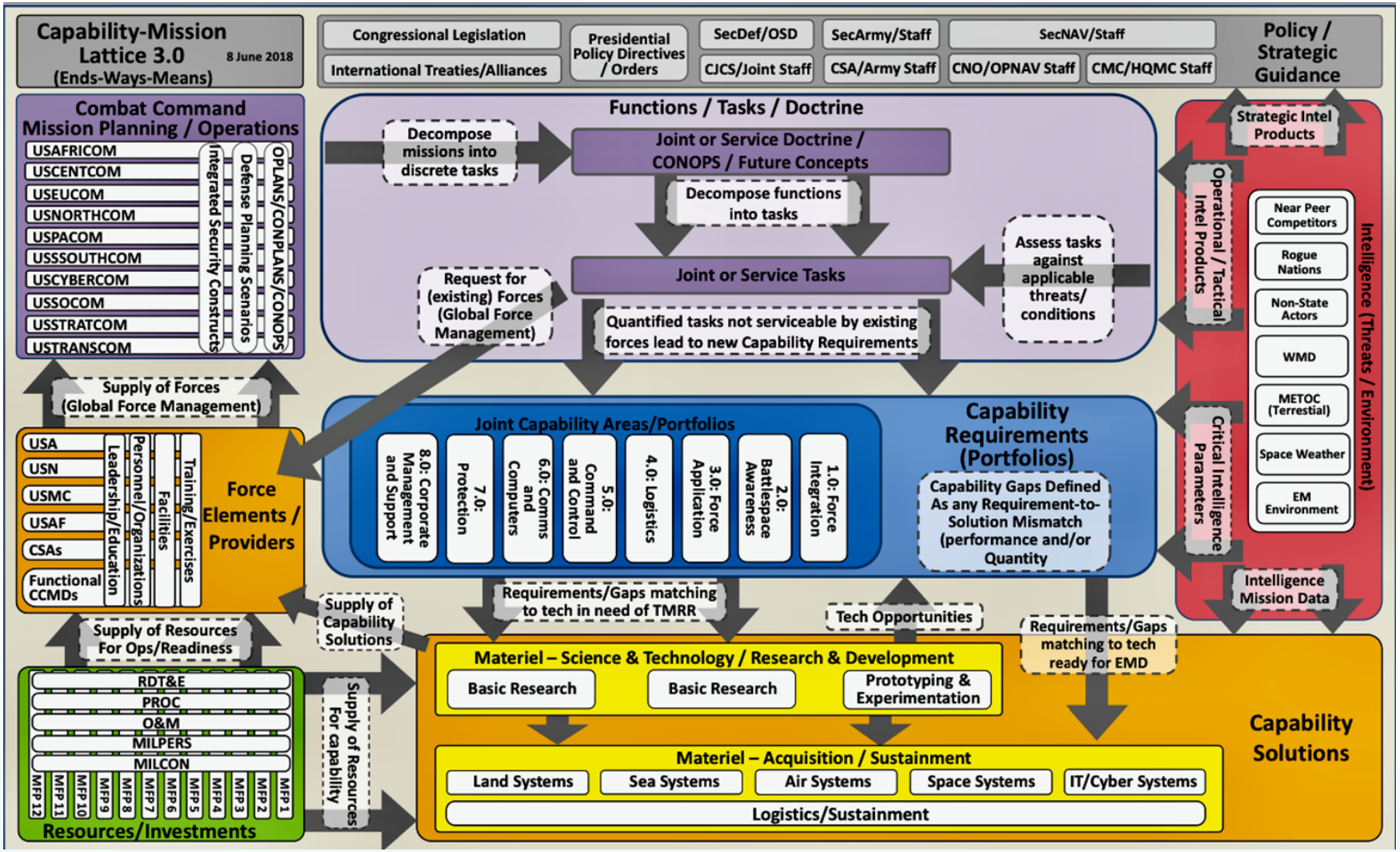
4. Platforms

3. Systems

2. Sub-Systems

1. Assemblies and Components

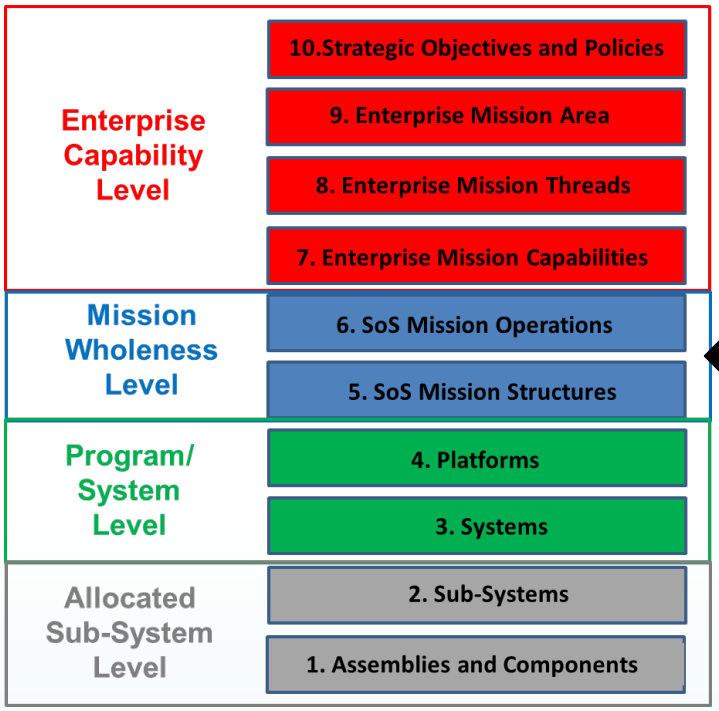
Capability-Mission Lattice

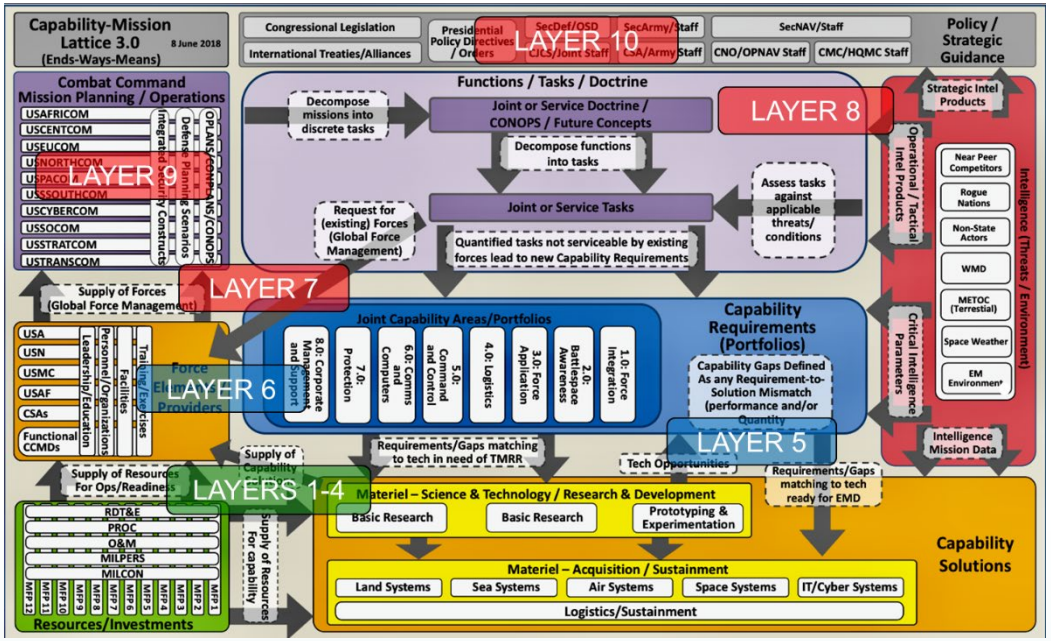


The **Capability-Mission Lattice** is used as an integrating construct for identification of capability requirements and the development of capability solutions.

Mission Architecture + Capability-Mission Lattice

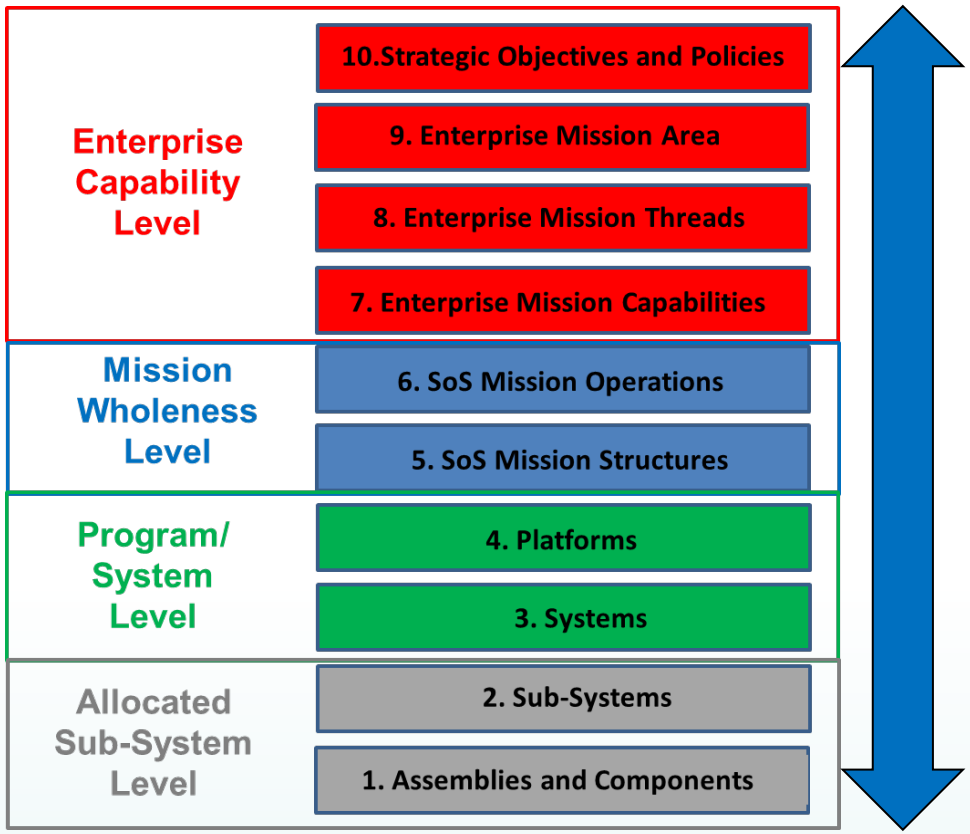
The 10-Layer Mission Architecture is correlated with and implements the JCIDS Capability-Mission Lattice within a modeling environment.





The combination of the Mission Architecture and the Capability-Mission Lattice provides a roadmap of how mission strategies can be implemented.

The Mission Architecture Purposes



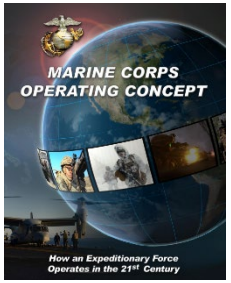
- Assists in making prioritization and budget decisions based on mission capabilities that are not being addressed or are being overly addressed.
- Provides a framework for insight and discovery of functions, systems, and services that exists with the mission architecture.
- Provides traceability of mission-capabilities from strategic objectives to individual systems.

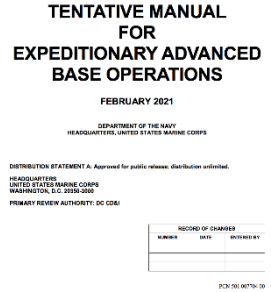
Force Design 2030 Use Case

"War is both timeless and ever changing. While the basic nature of war is constant, the means and methods we use evolve continuously."

-MCDP-1

Force Design 2030
March 2020

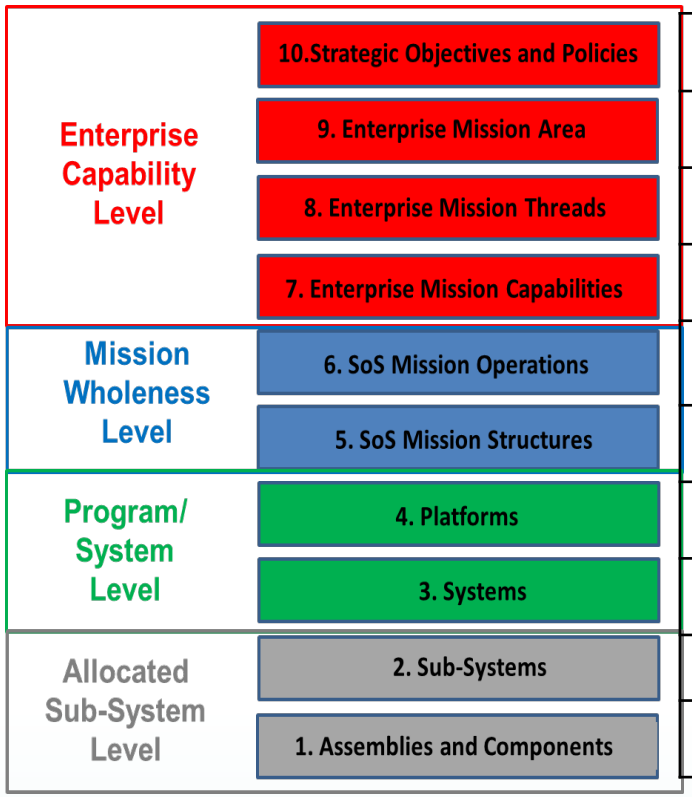




- Establish a focus area for force development pertinent to National and Naval Strategy.
  - Operational Employment of USMC Forces consistently retains the **FLEXIBILITY** to conduct a wide variety of missions to meet National objectives.

- Focused on:
  - **Littoral Maneuver and Sustainment**
  - **Maritime Reconnaissance/Counter Reconnaissance**
  - **Long-Range Precision Fires**
  - **Operations in the Information Environment**

Using the 10-Layer Mission Architecture



Commandant's Planning Guidance
Expeditionary Advanced Base Operations (EABO)
Coordinate Air and Missile Defense
Conduct Short Range Ground Based Air Defense
Deny hostile UAS from targeting Expeditionary Forces
Ground Base Air Defense (GBAD)
Joint Light Tactile Vehicle (JLTV)
Marine Air Defense Integrated System (MADIS)
MK 2 Radar / C2 Systems
Receiver / Transmitter / Display Panel

Marine Corps Force Design 2030

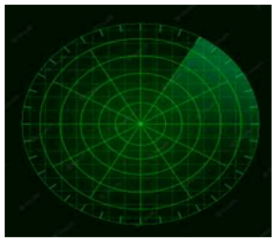
The 10-Layer mission architecture can help determine the required mix of force structure and essential equipment needed to fulfill the USMC desired missions and adapt to changes. This application will show areas that must grow and be equipped to support the missions as well as forces and equipment that may not be required to adapt to the changing USMC missions.

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited

Using the 10-Layer Mission Architecture

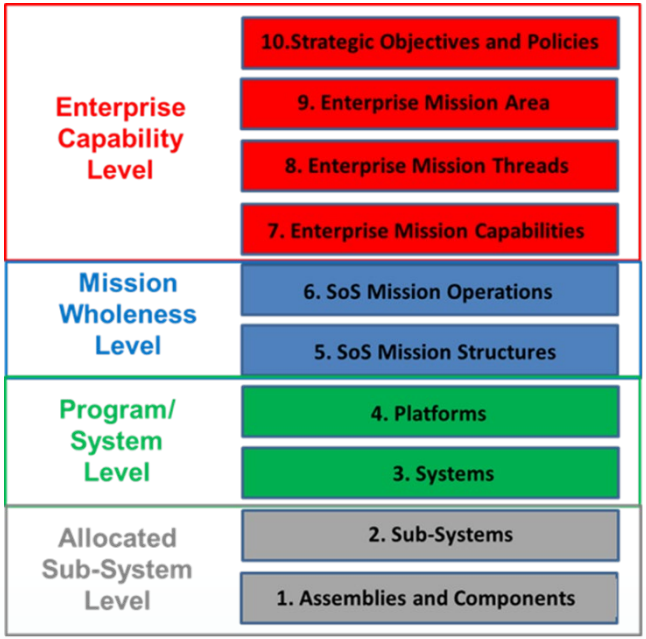
Strategic Objectives & Policies (Layer 10)	Enterprise Mission Areas (Layer 9)	Enterprise Mission Threads (Layer 8)	Enterprise Mission Capabilities (Layer 7)	SoS Mission Operations (Layer 6)
Strategic Objective: Provide U.S.Indo-Pacific Command (U.S. INDOPACOM) and the Commander, 7th Fleet with a fight-tonight, stand-in force capability to persist inside an adversary's weapon systems threat range, create a mutually contested space, and facilitate the larger naval campaign. 	Mission Areas: • Distributed Maritime Operations (DMO) • Littoral Operations in a Contested Environment • **Expeditionary Advanced Base Operations (EABO)** 	Mission Threads for EABO: • **Coordinate Air and Missile Defense Actions** • Support Maritime Domain Awareness • Support Operations in the Information Environment • Conduct Expeditionary Strike • Attack Enemy Maritime Targets 	Support Coordinated Air & Missile Defense: • Conducts fires • Conduct reconnaissance • Conduct counter-reconnaissance • Conduct anti-air warfare • Conduct air control • Conduct airspace surveillance • **Conduct short range ground based air defense** • Provide forward arming and refueling points 	SoS Mission Operations for conducting Short-Range Ground Based Air Defense: • Enable joint kill chains through multi-domain C5ISR • Secure key maritime terrain • Provide ground based naval strike missiles • Support AAW and ASUW kill webs • **Deny hostile UAS and loitering munitions from targeting Expeditionary Forces**

Using the 10-Layer Mission Architecture

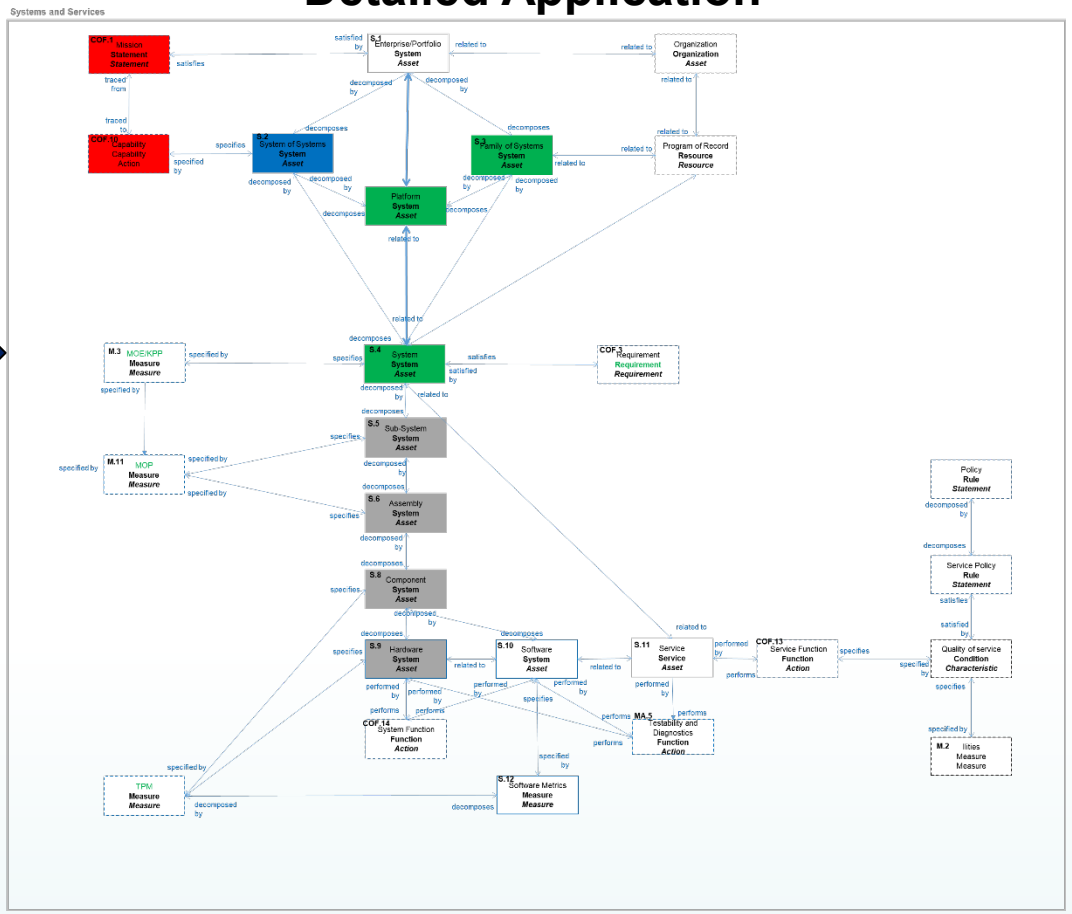
SoS Mission Structures (Layer 5)	Platform (Layer 4)	System (Layer 3)	Sub-Systems (Layer 2)	Assemblies & Components (Layer 1)
Deny hostile UAS and loitering munitions from targeting Expeditionary Forces: **GBAD** • C2 Nodes • Ground radars • Marine Air Defense Integrated System (MADIS) • Target tracking 	• **Joint Light Tactical Vehicle (JLTV)** 	• **Marine Air Defense Integrated System (MADIS)** 	• MK1 turret launched sparrow missiles • **MK2 360 radar and C2 system** 	• **Radar Receiver** • **Radar Transmitter** • Power • **Display Panel** • Control Panel • Etc. 

10-Layer Mission Architecture Related to a Conceptual Data Model

High-Level Description



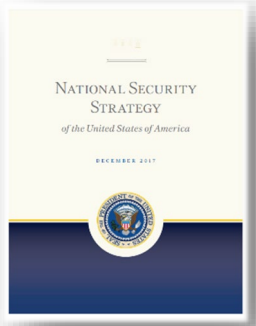
Detailed Application

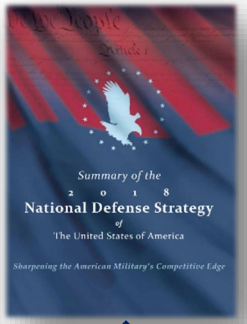


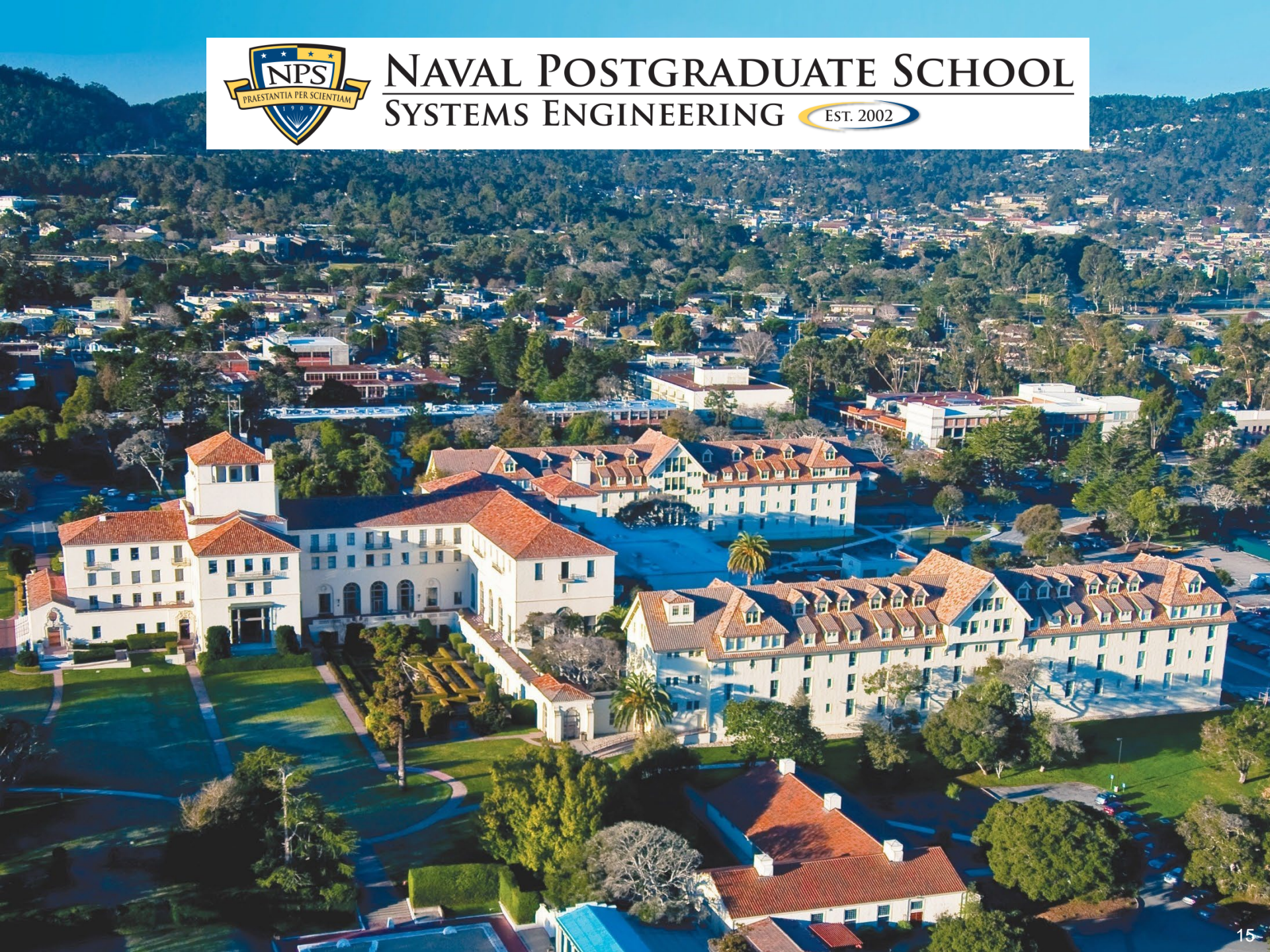
Please Join Us on Thursday for a Follow-on Discussion in the 3D1-DE track
Abstract 24642 – A Common Ontology: The Rosetta Stone for Exchanging Data between Different Digital Engineering Tools, Languages, and Frameworks

Summary

- The 10-Layer Mission Architecture:
  - Shows the continuity of mission-capabilities from strategic objectives to individual systems.
  - Assists in making prioritization and budget decisions based on mission capabilities that are not being addressed or are being overly addressed.
  - Provides a framework for insight and discovery of functions, systems, and services that exists with the mission architecture.
- The 10-Layer Mission Architecture depicts mission data as an “Executive Summary” for detailed analysis performed at lower-levels.



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NAVAL POSTGRADUATE SCHOOL
SYSTEMS ENGINEERING
EST. 2002

Public Release Approved

Can Data-Driven Systems Engineering Meet the Goals of SE Modernization?

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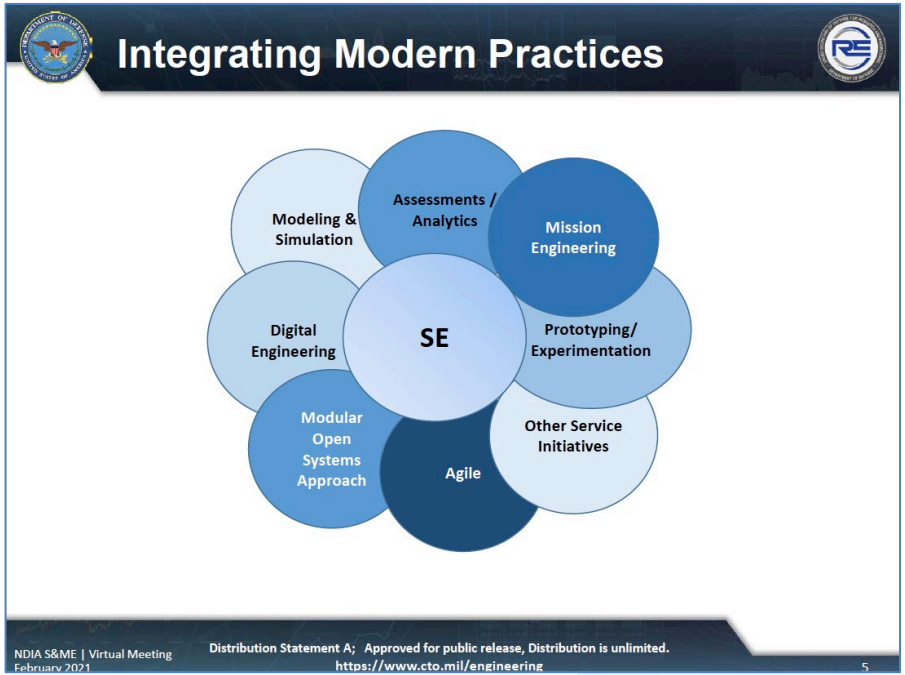
OSD's Initiative: Systems Engineering Modernization

- The Department of Defense (DoD) Office of the Under Secretary of Defense (USD) for Research and Engineering has identified a number of "systems engineering practices" that require "integration"
- The objective is to "modernize systems engineering to support the delivery of capability to meet mission needs"
- Congress also has provided legislative direction in four of these practice areas:
  - Digital Engineering
  - MOSA
  - Mission Engineering
  - Agile Development



SE Modernization – SERC 's View

aka "The Bomb Cyclone Diagram"

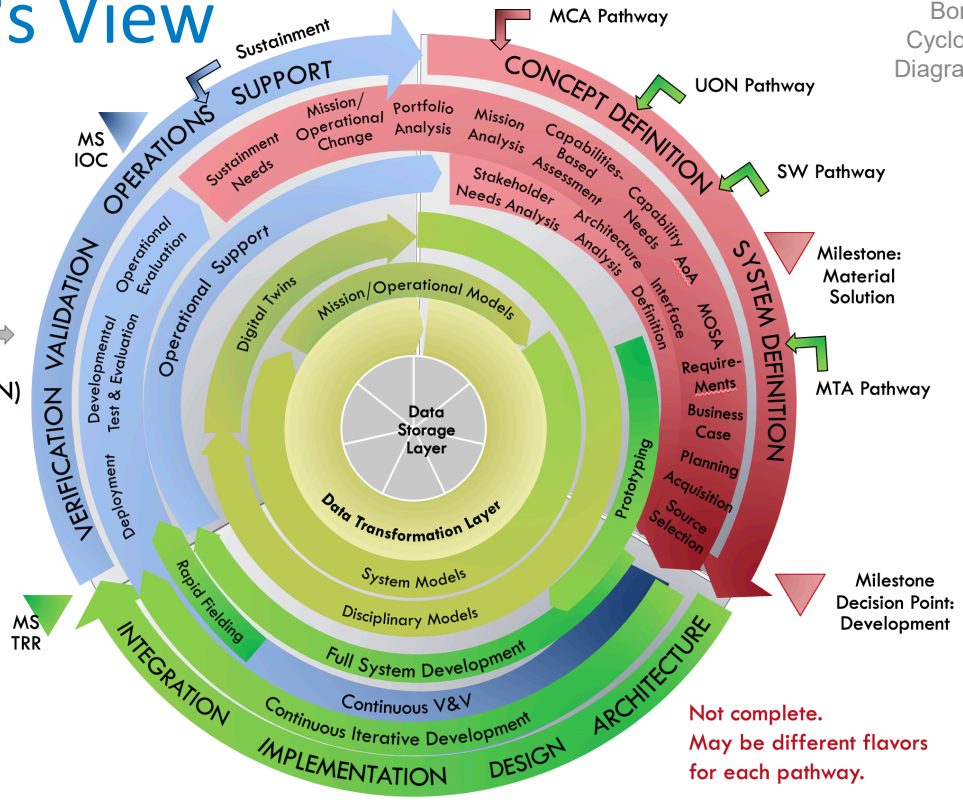
From https://sercuarc.org/systems-engineering-modernization/?utm_source=newsletter&utm_medium=email&utm_content=Systems%20Engineering%20%28SE%29%20Modernization&utm_campaign=SERC%20UPDATES%20JUN%202022 accessed 6/22/2022

"…this view emphasizes the DE transformation using a layered model with <u>data storage and transformation</u> at the core…"

NOTIONAL VIEW: FULL SE MODERNIZATION LIFE CYCLE

- Cyclic nature of modern SE
- Still milestone-based
- SE core principles in every Acq pathway
- Flexible system life cycle entry points:
  Learn-Build-Measure (MCA)
  Build-Measure-Learn (Mid-Tier, SW, UON)
  Measure-Learn-Build (Sustainment)
- Continuous Iterative Development processes (around the circle)
- Continuous Data Management and Transformation processes (at the core)

Learn	Needs analysis & Planning
Build	Implementation
Measure	Test, Evaluation, Support
Data & Models	



Not complete.
May be different flavors for each pathway.

So to implement this approach we need to be data-driven in systems engineering

What's Data-Driven Systems Engineering (DDSE)?

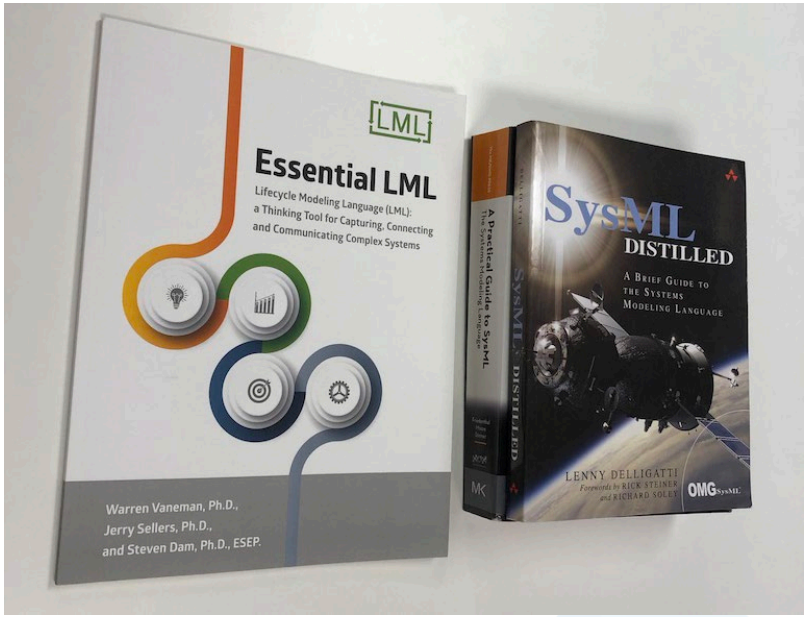
- To integrate the "modern engineering practices" we need a common language, not just a set of models
- By using a language driven approach, we can focus on the data and less on the form ("model")
- This data-driven approach needs a new way to think about systems engineering – hence DDSE
- We define DDSE as:
  - *the transformation of user needs to requirements for design engineering and the transformation of design engineering data into verified and validated system-level information for decision makers to make better decisions throughout the lifecycle*
- This definition refocuses us on the underlying basis for systems engineering and explicitly identifies the benefit to all stakeholders
  - Design engineers get clear, easy to understand requirements
  - Decision makers get the information they need to make good decisions
- Fortunately there already exists such a language to meet this need: the Lifecycle Modeling Language (LML)

SPEC INNOVATIONS

Lifecycle Modeling Language (LML)

LIFECYCLE MODELING LANGUAGE

- LML was developed by a group of systems engineers who realized that SysML was not meeting the needs of the systems engineering and program management communities
- LML is current managed by the not-for-profit organization: Lifecycle Modeling Organization (LMO)
- The Steering Committee is led by Dr. Warren Vaneman, USN CAPT (retired) and Professor of Practice at the Naval Postgraduate School (NPS)
- LML is taught in over 200 universities around the world, including MIT, George Mason University, Stevens Institute of Technology, West Point, NPS, Air Force Academy
- LML is easy to learn, use, and extend
- Visit http://www.lifecyclemodeling.org

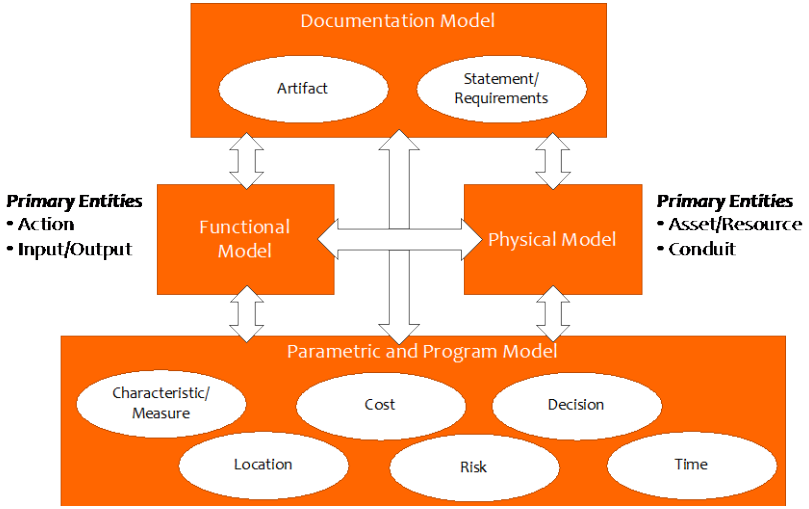


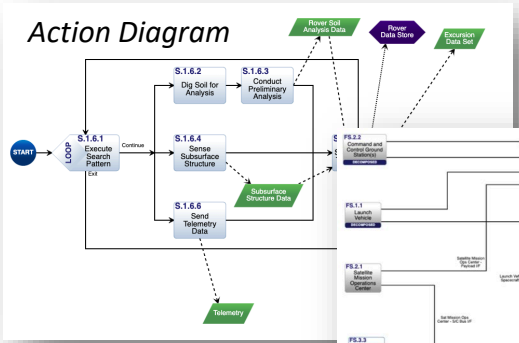
LML has proven to provide a strong ontology for systems engineering and program management and forms the basis for Data-Driven Systems Engineering (DDSE)

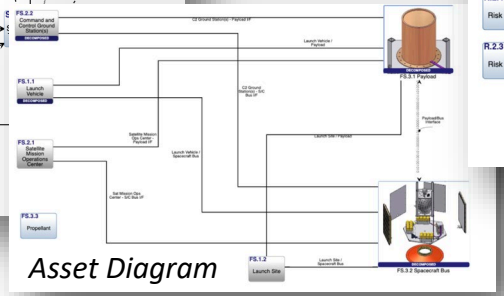
SPEC INNOVATIONS

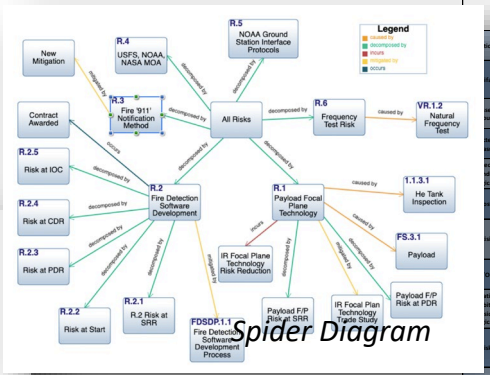
LML Overview

- A simple, easy to use set of classes (nouns)
- Maps to DoDAF, UAF, SysML, BPMN, etc.
- Connected by two-way relationships (verbs)
- Easily extended
- Contains data elements for all the SE Modernization practices









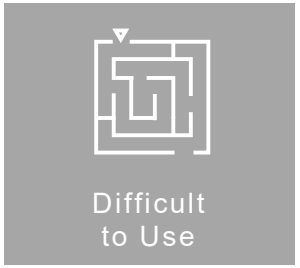
	Action	Artifact	Asset (Resource)	Characteristic (Measure)	Connection (Conduit, Logical)	Cost	Decision	Input/Output	Location (Orbital, Physical, Virtual)	Risk	Statement (Requirement)	Time
	decomposed by* related to*	references	(consumer) performed by (produces) (uses)	specified by	-	incurs	enables results in	generates receives	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
	referenced by	decomposed by* related to*	referenced by	referenced by specified by	defines protocol for referenced by	incurs referenced by	enables referenced by results in	referenced by	located at	causes mitigates referenced by resolves	referenced by (satisfies) source of traced from (verifies)	occurs
	(consumed by) performs (produced by) (used by)	references	decomposed by* orbited by* related to*	specified by	connected by	incurs	enables made responds to results in	-	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
	specifies	references specifies	specifies	decomposed by* related to* specified by*	specifies	incurs specifies	enables results in specifies	specifies	located at specifies	causes mitigates resolves specifies	(satisfies) specifies traced from (verifies)	occurs specifies
	-	defined protocol by references	connects to	specified by	decomposed by* joined by* related to*	incurs	enables results in	transfers	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
	incurred by	incurred by references	incurred by	incurred by specified by	incurred by	decomposed by* related to*	enables incurred by results in	incurred by	located at	causes incurred by mitigates resolves	incurred by (satisfies) traced from (verifies)	occurs
	enabled by result of	enabled by references result of	enabled by made by responded by result of	enabled by result of specified by	enabled by result of	enabled by incurs result of	decomposed by* related to*	enabled by result of	located at	causes enabled by mitigated by result of resolves	alternative enabled by traced from result of	date resolved by decision due occurs
	generated by received by	references	-	specified by	transferred by	incurs	enables results in	decomposed by* related to*	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
	locates	locates	locates	locates specified by	locates	locates	locates	locates	decomposed by* related to*	locates mitigates	locates (satisfies) traced from (verifies)	occurs
	caused by mitigated by resolved by	caused by mitigated by references resolved by	caused by mitigated by resolved by	caused by mitigated by resolved by specified by	caused by mitigated by resolved by	caused by incurs mitigated by resolved by	caused by enables mitigated by results in resolved by	caused by mitigated by resolved by	located at mitigated by	caused by* decomposed by* related to* resolved by*	caused by mitigated by resolved by	occurs mitigated by
Statement (Requirement)	(satisfied by) traced to (verified by)	references (satisfied by) sourced by traced to (verified by)	(satisfied by) traced to (verified by)	(satisfied by) specified by traced to (verified by)	(satisfied by) traced to (verified by)	incurs (satisfied by) traced to (verified by)	alternative of enables traced to results in	(satisfied by) traced to (verified by)	located at (satisfied by) traced to (verified by)	causes mitigates resolves	decomposed by* traced to* related to*	occurs (satisfied by) (verified by)
Time	occurred by	occurred by	occurred by	occurred by specified by	occurred by	occurred by	date resolves decided by occurred by	occurred by	occurred by	occurred by mitigates	occurred by (satisfies) (verifies)	decomposed by* related to*

SPEC INNOVATIONS

How Do We Implement DDSE?

- Since we need to cover all aspects of systems engineering in a data-driven approach we need tools to support this activity, as we cannot maintain this vast amount of data without using database technologies
- Those tools should include requirements analysis, functional/object analysis, modeling and simulation, verification and validation, risk analysis, cost analysis, and schedule analysis as a minimum
- The tools should also support modern computer architectures with cloud computing being the most common today
  - Secure clouds are currently available at all levels of security for any Department or Agency
- The tools also need to have an open architecture to enable easy movement of data between tools as we cannot expect the world to adopt only one tool!
- So let's look at tools today

Most of Today's Systems Engineering Tools Are *Based on 20th Century Technology*



- Learning full SysML/UML often takes months
- Dozens of options are present on many views
- Drawings usually must be redrawn (ex. the Sequence, Activity, and BDD)
- Required desktop software installation to modify the models

- Lack of built-in variance simulation (Monte Carlo Simulation)
- Activity Diagrams do not have to be executable

- Focus is typically only on drawing models
- Most organizations use additional tools for requirements management, test management, and Monte Carlo simulation

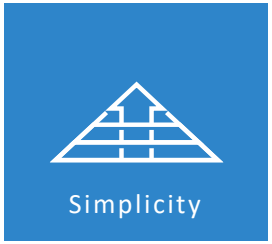
- Model conflicts during commits (no real-time collaboration)
- Models typically only communicate to the SE domain
- Server collaboration software often does not scale and users suffer long download/commit times (>20 min)

So is there a set of tools that can meet this need?

SPEC INNOVATIONS

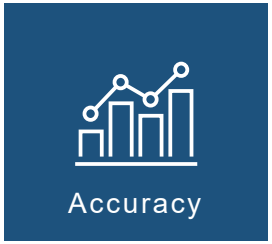
- First release: 2012
- Cloud-Native
- AI/NLP
- Agile

Innoslate – A 21st Century Solution



- Common options at the forefront
- Primary tool language is easy to learn (LML)
- Works with no installation, in a web browser
- Autogenerated diagrams and dashboards (concordance)

- Real-Time Collaboration (Group Chat/Real Time)
- Easy Communication to other stakeholders (not just SEs)
- Proven Model-Based or Data-Based Review (MBR/DBR) capability



- Full Discrete Event Simulator which simulates cost, schedule, and performance is integrated into the Action Diagrams
- Full Monte Carlo Simulator to simulate variance
- NLP/ML for Requirements Quality and Traceability
- Intelligence View

- Tested to over 10 Million entities and 1,000 simultaneous users
- Cloud hardware auto-scales
- Software designed to scale

- Full requirements analysis and management capability with Requirements View
- Full modeling capability (SysML/LML/IDEF0)
- Test Center (Test Suites and Test Cases)
- Documents View (CONOPS, Project Plan, and Test Plan)

- Automatically generate and/or use other representations (SysML, DoDAF)
- Import from other RM tools (IBM DOORS CSV and ReqIF, Excel CSV)
- Integrations with STK, MatLab, and GitHub
- Open Java, REST, and JavaScript APIs

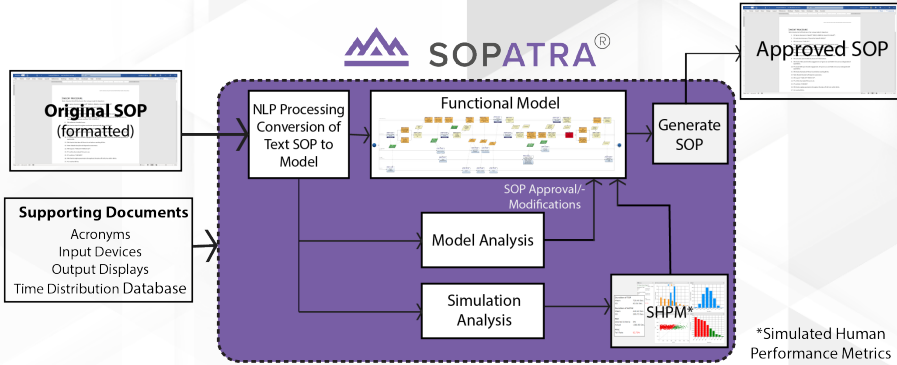
SPEC INNOVATIONS

Sopatra®

We designed Sopatra with the overall goal to demonstrate the improved creation of Standard Operating Procedures (SOPs) by the automated creation and verification of SOPs using a digital assistant (DA)

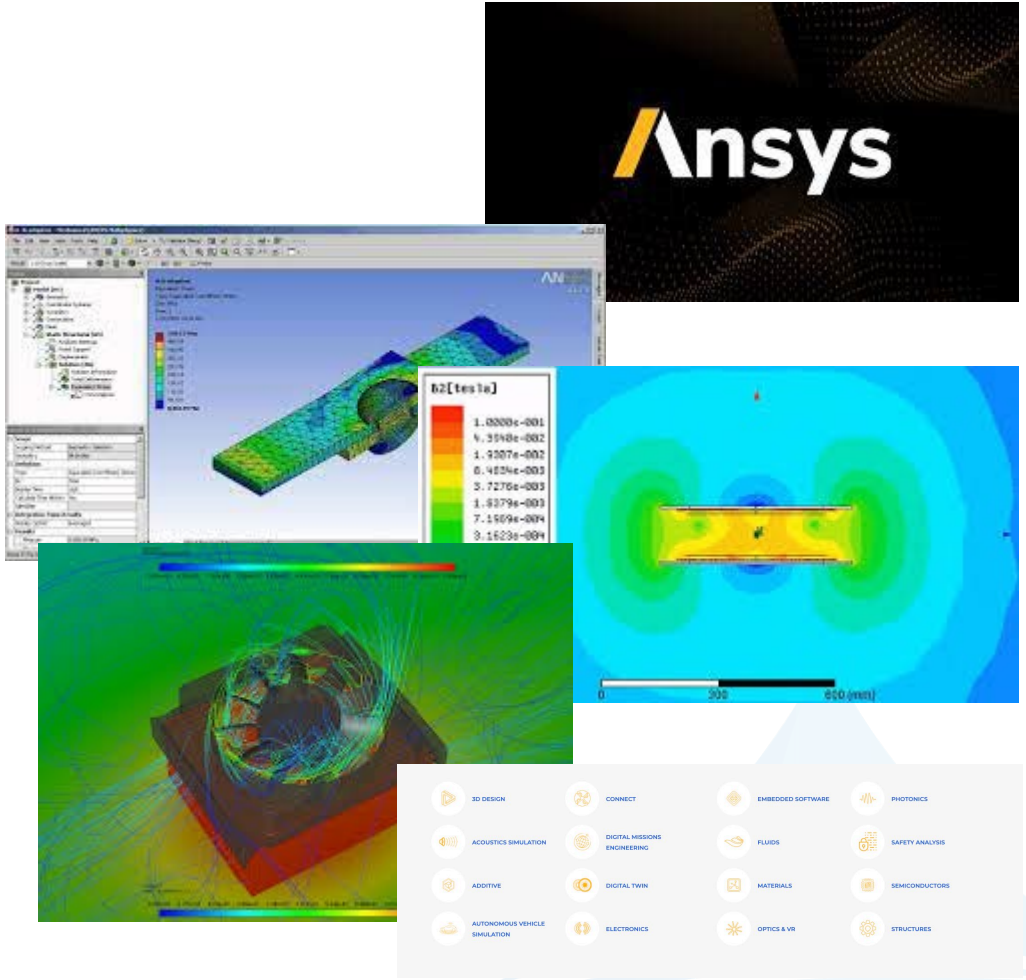
Sopatra is a digital assistant that will convert text to an LML Action Diagram and execute the simulation automatically to check all possible paths through the procedure.

- Uses Natural Language Processing (NLP) for interacting with the systems engineering development environment (i.e. creating the behavior model)
- Provides configuration management and revision management of massive models
- Develops executable simulation of the behavior model
- Built on Innoslate®



Ansys

- The Ansys tool suite is the “gold standard” of design engineering tools
- With their recent acquisition of AGI, they brought the premier geospatial analysis tool (STK) into their tool set
- With the recent acquisition of Phoenix Integration, they brought an amazing way to integrate a variety of common modeling and simulation tools – ModelCenter
- They are exploring porting what they can to cloud computing environments, however for system engineering, we need to mostly be concerned with providing the design engineers with good requirements and receive the results of the design engineering activities

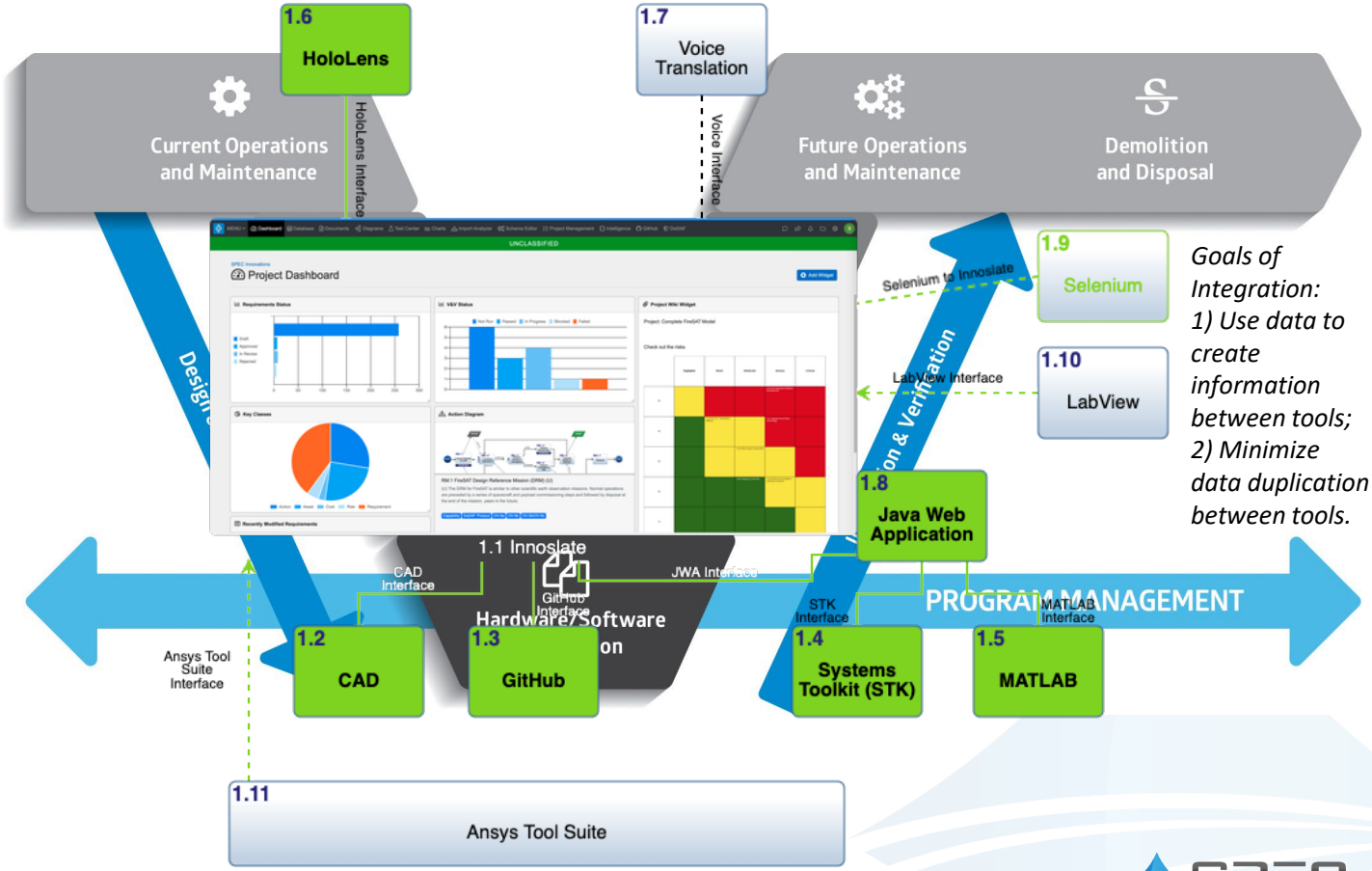


Innoslate Integrates Systems Engineering Activities Across the Entire Lifecycle

Innoslate's Digital Ecosystem

SPEC Innovations is an Ansys Partner

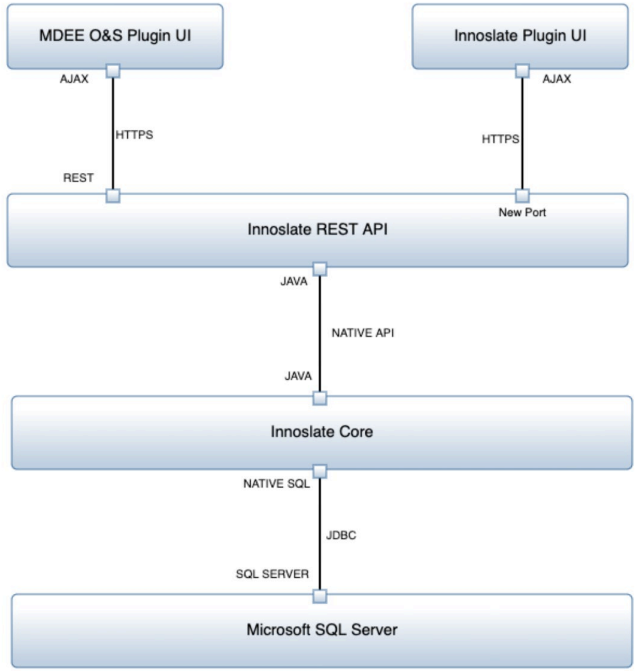
- Innoslate® provides a complete DDSE/DDE environment
- A JWA is used to interface between the Innoslate cloud tool and desktop tools
- We have directly integrated a number of key design engineering technologies to complete the digital thread
- Several other tools are being added to enhance the current capability



Goals of Integration:
1) Use data to create information between tools;
2) Minimize data duplication between tools.

Innoslate® Uses a MOSA Architecture

- Plugins are viewpoints of the Innoslate database
- Plugin features
  - Not a standalone application (requires Innoslate Core)
  - All authentication is through Innoslate Core with the options for:
    - Single-Sign-On CAC (Default)
    - Native Email/Password (Optional)
    - LDAP (Optional)
  - All data is stored in the U.S. Government managed SQL database using Innoslate Core (***no data lock***)
  - Innoslate REST API facilitates plugin data exchange



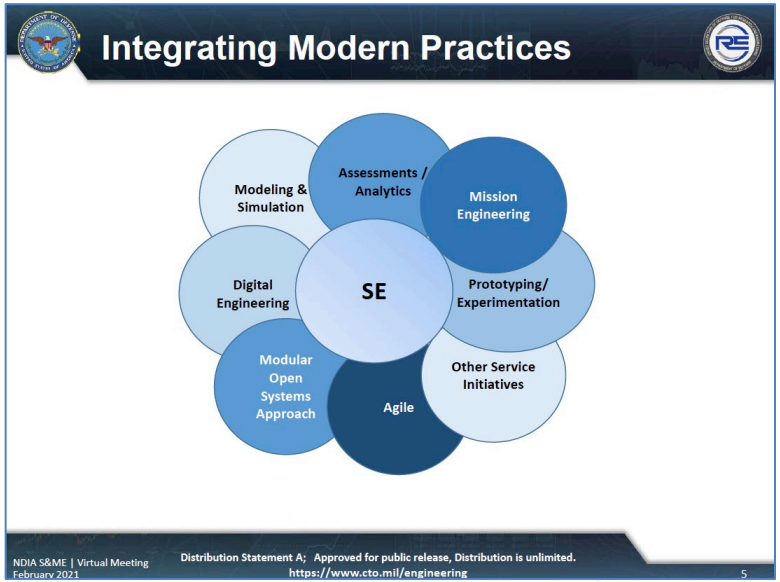
Modular Open Systems Approach (MOSA) Architecture Enables Architecture to Operations (DEVOPS)

How Does LML, DDSE, and the Innoslate/Ansys Tool Suite Support SE Modernization?

- Digital Engineering
  - Innoslate, Sopatra, and the Ansys Tool Suite provide the full range of tools needed to create digital twins
- MOSA
  - Functional analysis focuses on functions that can be allocated in many different ways – Innoslate provides a complete functional (and object) analysis capability
  - LML & Innoslate have unique interface diagrams to enable better definition of the interfaces
  - Innoslate's MOSA architecture enables modular use of the data too
- Mission Engineering
  - Integration of the Innoslate discrete event simulator with STK enables us to plan, analyze, organize, and integrate operational and system capabilities to achieve desired effects
- Agile Development
  - Innoslate provides direct integration to software engineering tools (GitHub and Selenium – in near future) and provides Kanban Boards and other Agile tools
  - Can align Sprints and Epics with standard SETR events by conducting Data-Driven Reviews

Summary

- SE Modernization requires us to use 21st Century technologies to design and build the future
- We need to use these technologies to break down the walls we have erected between these modern practices
- LML and the Innoslate/Ansys digital engineering tools will help us break down those walls and create the digital ecosystem needed



It's all really about doing system engineering well!

Public Release Approved

What Is Systems Engineering?

INCOSE's Definition of Systems Engineering

- "Traditional Definition"
  - "Systems Engineering (SE) is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on holistically and concurrently understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying, validating, and evolving solutions while considering the complete problem, from system concept exploration through system disposal. (INCOSE 2012, modified.)"
- INCOSE Fellows' Definition
  - "A transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods."

Source: SE Body of Knowledge (https://www.sebokwiki.org/wiki/Systems_Engineering_Overview) Accessed 10/10/2022

INCOSE's Primary Focus of Systems Engineering Today

- INCOSE's Definition of MBSE
  - "Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."
- The original idea was to transform systems engineering from "document-based" to "model-based"
- By this definition, we have been doing MBSE every since someone used a template to draw a picture
- SysML has been proposed as "The MBSE Language" by many

Does SysML meet all the needs of systems engineering?

What Do Systems Engineers Do?

- To determine if SysML is sufficient, we first need to identify what systems engineers do and how SysML supports those activities
- The essence of Systems Engineering is optimization
  - We optimize cost, schedule, and performance, while mitigating risk in each area
  - We optimize the design across all the engineering disciplines

We solve problems, but we need to do so in a way people understand and have confidence in the solution

Cost, Schedule, and Performance Optimization

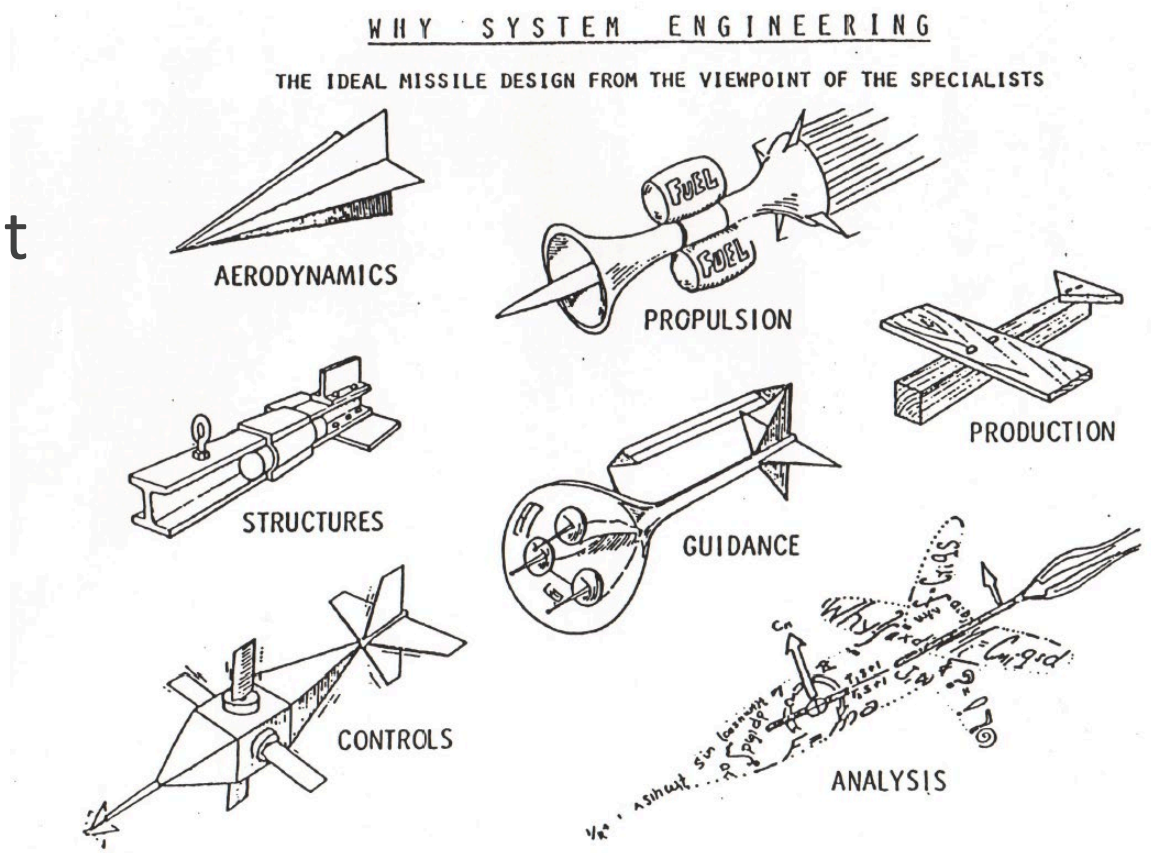
- Cost estimating is an engineering job
  - Requires engineering judgement and experience
  - Conducts trade-off studies for the system, which includes cost
  - Often creates the technical portion of the work breakdown structure (WBS)
- Schedule estimating requires engineering input
  - Also requires engineering judgement and experience
  - Knowledge of the detailed development processes
- Performance requires modeling and simulation
  - Used to predict performance over entire lifecycle
  - Traded off with other factors

A shared responsibility with program management

Too often cost and schedule get fixed early in the program and so performance degrades

Optimizing the Design

- Classic picture seems funny, but a lot of truth in it
- Balancing all the different perspectives requires significant judgement and temperament
- Requires being a translator between all these different languages
- Must be seen as an “honest broker”



Software is just another detailed design discipline – SysML is based on a software “language”

How Can SE Be “Faster, Better, and Cheaper”?

- Faster comes from executing many processes and tasks in parallel
  - Tools can help us keep the information coherent, while many activities occur
  - Enables large number of technical stakeholders to collaborate on same design at the same time
  - Enables communication of progress to non-technical stakeholders
- Better comes from greater accuracy
  - Simulators provide means to test processes before they are implemented
  - Rule checkers verify drawings are created uniformly
  - Advanced techniques can even identify quality factors in requirements
- Cheaper comes from taking less time to do the job
  - Tools must be easy enough to use that it takes less time to perform a task

An MBSE Methodology must be used to enable these benefits

MBSE Methodology

- Methodology is defined by:
  - Technique
  - Processes
  - Tools
- In systems engineering the technique is the language
  - IDEF
  - SysML
  - LML
- Language consist of nouns, verbs, adjectives, and adverbs
  - A diagramming framework does not provide these explicitly
  - Language requires an ontology

A key goal of any technique should be a means to capture the information needed

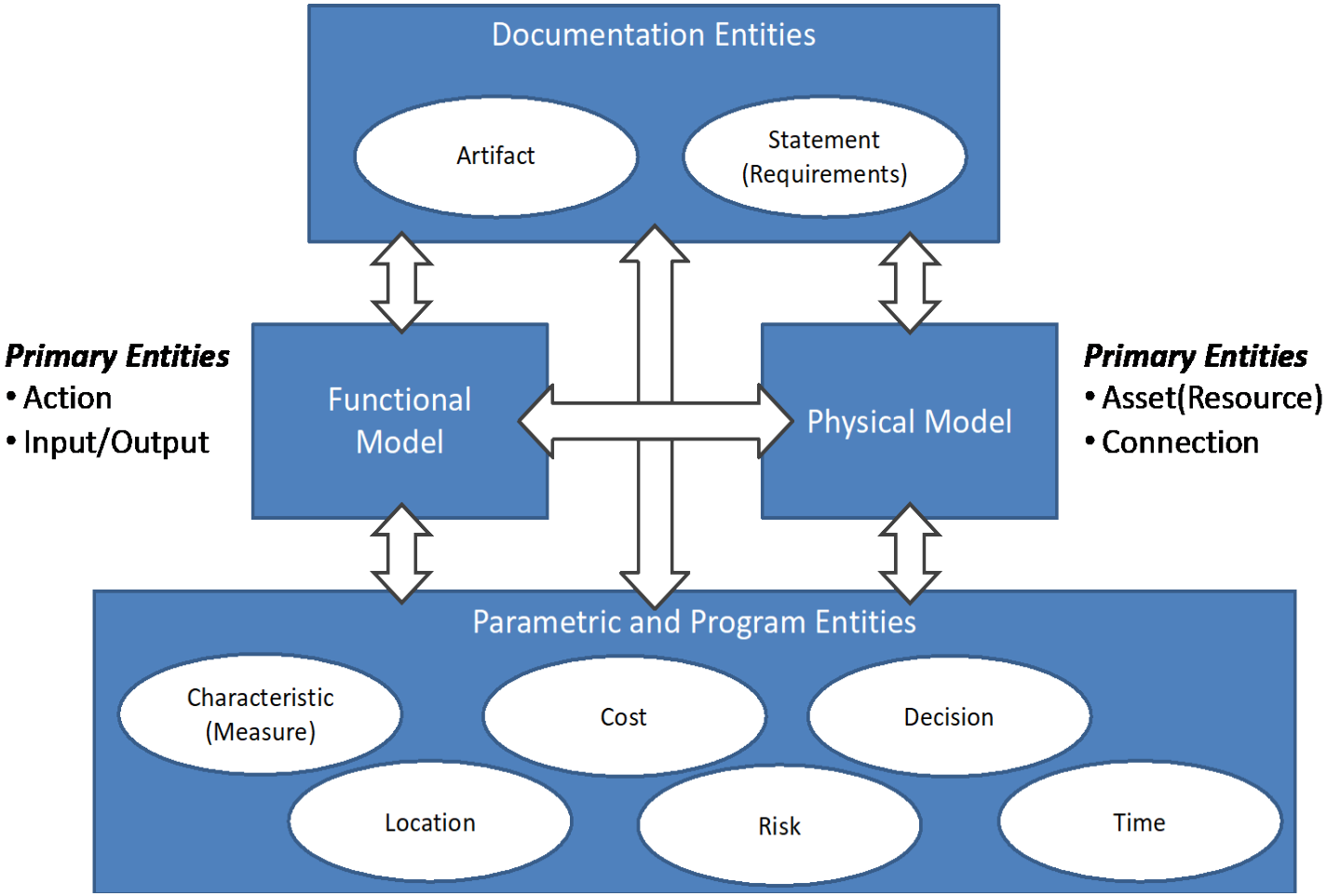
LML – A Real MBSE Technique

- LML consists of an ontology and a small set of “mandatory” diagrams
- Diagrams are used to visualize information
- LML contains 12 primary and 8 child classes as a basis
- The number of diagram types that would be required to fully express all this information visually is roughly 20! or 10^{18}
- LML was designed as a language for systems engineering and program management, by systems engineers and program managers

LML Classes have proven to capture at least 80% of the information needed

LML Entity Classes and Models

- All four models are built from the entities in the diagram
- Types of each class can be used to distinguish entities within each class (e.g., Action, Activity, Function, Task, etc.)
- Typing can be implemented as an enumerated attribute or label
- Attributes on the entities represent the adjectives for the language



This simple set of classes have many relationships between them

LML Relationships

- Same verb forms in each direction (e.g., performed by/performs)
- All hierarchical relationships are the same terms (decomposed by/decomposes)
- Attributes on relationships also provide the needed adverbs for the language

	Action	Artifact	Asset (Resource)	Characteristic (Measure)	Connection (Conduit, Logical)	Cost	Decision	Input/Output	Location (Orbital, Physical, Virtual)	Risk	Statement (Requirement)	Time
Action	decomposed by* related to*	references	(consumes) performed by (produces) (seizes)	specified by	-	incurs	enables results in	generates receives	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
Artifact	referenced by	decomposed by* related to*	referenced by	referenced by specified by	defines protocol for referenced by	incurs referenced by	enables referenced by results in	referenced by	located at	causes mitigates referenced by resolves	referenced by (satisfies) source of traced from (verifies)	occurs
Asset (Resource)	(consumed by) performs (produced by) (seized by)	references	decomposed by* orbited by* related to*	specified by	connected by	incurs	enables made responds to results in	-	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
Characteristic (Measure)	specifies	references specifies	specifies	decomposed by* related to* specified by*	specifies	incurs specifies	enables results in specifies	specifies	located at specifies	causes mitigates resolves specifies	(satisfies) spacifies traced from (verifies)	occurs specifies
Connection (Conduit, Logical)	-	defined protocol by references	connects to	specified by	decomposed by* joined by* related to*	incurs	enables results in	transfers	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
Cost	incurred by	incurred by references	incurred by	incurred by specified by	incurred by	decomposed by* related to*	enables incurred by results in	incurred by	located at	causes incurred by mitigates resolves	incurred by (satisfies) traced from (verifies)	occurs
Decision	enabled by result of	enabled by references result of	enabled by made by responded by result of	enabled by result of specified by	enabled by result of	enabled by incurs result of	decomposed by* related to*	enabled by result of	located at	causes enabled by mitigated by result of resolves	alternative enabled by traced from result of	date resolved by decision due occurs
Input/Output	generated by received by	references	-	specified by	transferred by	incurs	enables results in	decomposed by* related to*	located at	causes mitigates resolves	(satisfies) traced from (verifies)	occurs
Location (Orbital, Physical, Logical)	locates	locates	locates	locates specified by	locates	locates	locates	locates	decomposed by* related to*	locates mitigates	locates (satisfies) traced from (verifies)	occurs
Risk	caused by mitigated by resolved by	caused by mitigated by references resolved by	caused by mitigated by resolved by	caused by mitigated by resolved by specified by	caused by mitigated by resolved by	caused by incurs mitigated by resolved by	caused by enables mitigated by results in resolved by	caused by mitigated by resolved by	located at mitigated by	caused by* decomposed by* related to* resolved by*	caused by mitigated by resolved by	occurs mitigated by
Statement (Requirement)	(satisfied by) traced to (verified by)	references (satisfied by) sourced by traced to (verified by)	(satisfied by) traced to (verified by)	(satisfied by) specified by traced to (verified by)	(satisfied by) traced to (verified by)	incurs (satisfied by) traced to (verified by)	alternative of enables traced to results in	(satisfied by) traced to (verified by)	located at (satisfied by) traced to (verified by)	causes mitigates resolves	decomposed by* traced to* related to*	occurs (satisfied by) (verified by)
Time	occurred by	occurred by	occurred by	occurred by specified by	occurred by	occurred by	date resolves decided by occurred by	occurred by	occurred by	occurred by mitigates	occurred by (satisfies) (verifies)	decomposed by* related to*

The relationships enable complex interactions and visualizations between different entity classes

LML Class Attributes

- Each class has a set of common attributes and attributes specific to a specific class
- The common ones are: name, number, description. Every entity class has these attributes.
- The LML specification provides the specific attributes for each class
- Add other attributes as needed
- Can also use Characteristics class to provide common or floating attributes

Example of Action Class Specific Attributes

Attribute	Data Type	Description
duration	Number	duration represents the period of time this Action occurs.
percent complete	Percent	percent complete represents the percentage this Action is complete.
start	DateTime	start represents the time when this Action begins.
type	Text	type provides aliases for the entities. For Action these can include: Activity, Capability, Event, Function, Mission, Operational Activity, Program, Service Orchestration, Simulation Workflow, Subprocess, System Function, Task, Training, Use Case, Work Process, Workflow

Class attributes should be added only when they will be used by most instances of that class

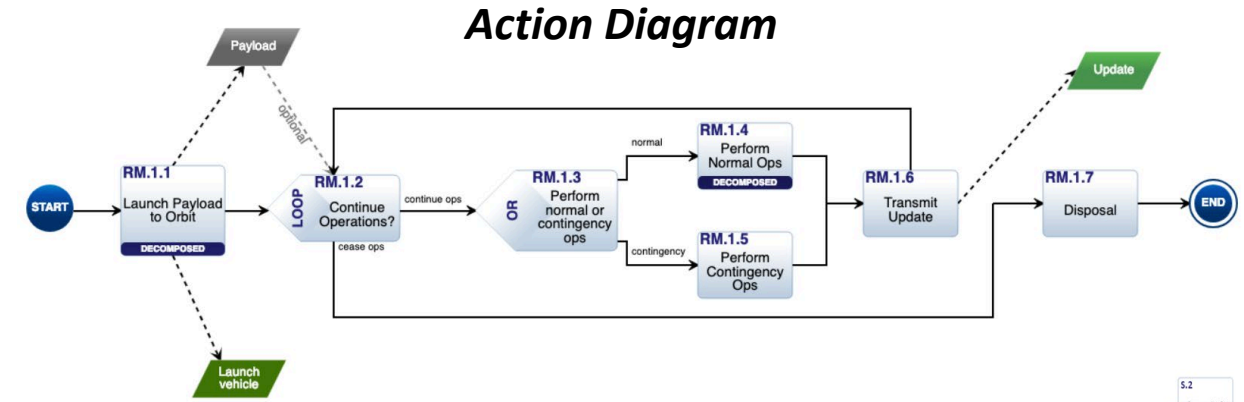
LML Relationship Attributes

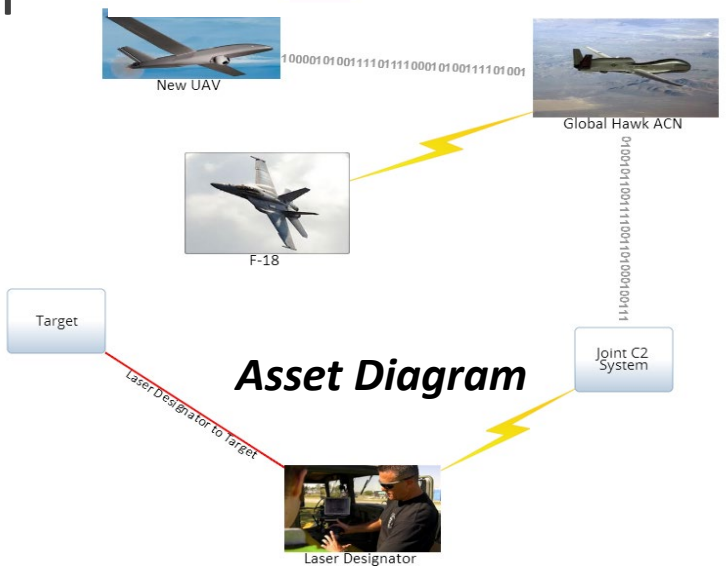
- Attributes on relationships provide a means to modify the relationship information
- The value of the attribute can be different depending on the direction of the relationship (e.g. *related to* vs. *relates*)
- Examples:
  - *context* is used on the *related to/relates* relationship to better describe how the entities relate to one another
  - *amount* is used on the *consumes*, *produces*, and *seizes* relationships to enable resource modeling
  - *trigger* is used on the *receives* relationship to determine if the Action needs to wait for a specific Input/Output entity before executing. This relationship is critical for sequencing Actions

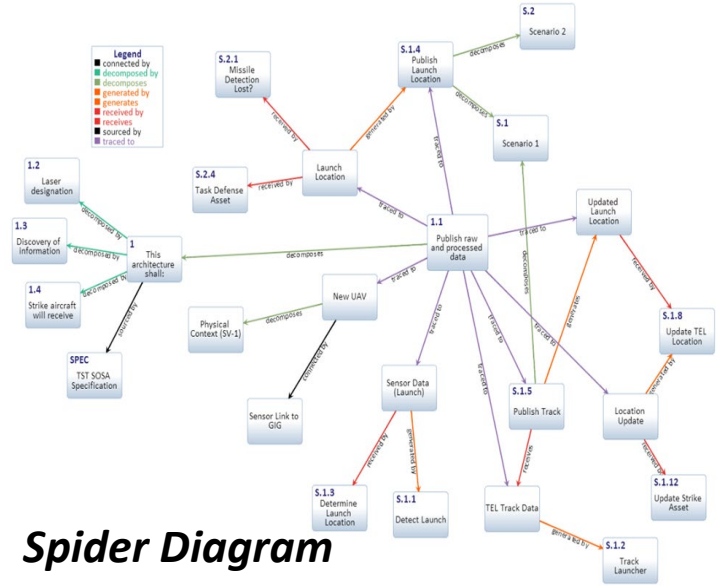
Relationship attributes should be added only when they will be used by most instances of that relationship

LML Diagrams

- 3 “Mandatory” diagrams
  - Behavioral (Action)
  - Physical (Asset)
  - Traceability (Spider)
- Additional diagrams types are recommended using common forms, e.g.
  - Timeline
  - Risk Matrix
  - …
- All 9 SysML diagrams can be generated from LML







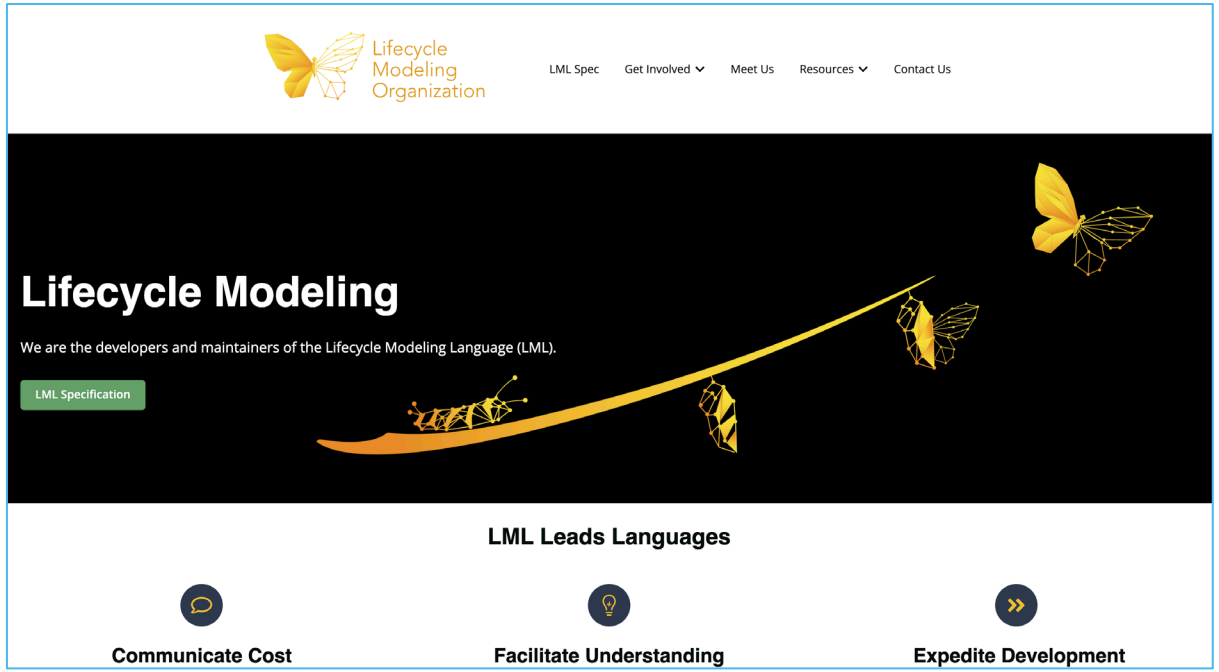
You should be able to visualize the information anyway you need

LML Enables Us to Move from MBSE to DDSE

- We define DDSE as:
  - *the transformation of user needs to requirements for design engineering and the transformation of design engineering data into verified and validated system-level information for decision makers to make better decisions throughout the lifecycle*
- This definition refocuses us on the underlying basis for systems engineering and explicitly identifies the benefit to all stakeholders
  - Design engineers get clear, easy to understand requirements
  - Decision makers get the information they need to make good decisions
- By using a language driven approach, we can focus on the data and less on the form (”model”)
- This data-driven approach gives us a new way to think about systems engineering, thus enabling us to focus on our job

For More on LML

- Go to https://www.lifecyclemodeling.org/
- Download the latest version of the specification at https://www.lifecyclemodeling.org/specification



MBSE Model Management

Full Lifecycle Configuration Management of MBSE Models

Chris Garrett, SL
Systems Engineering

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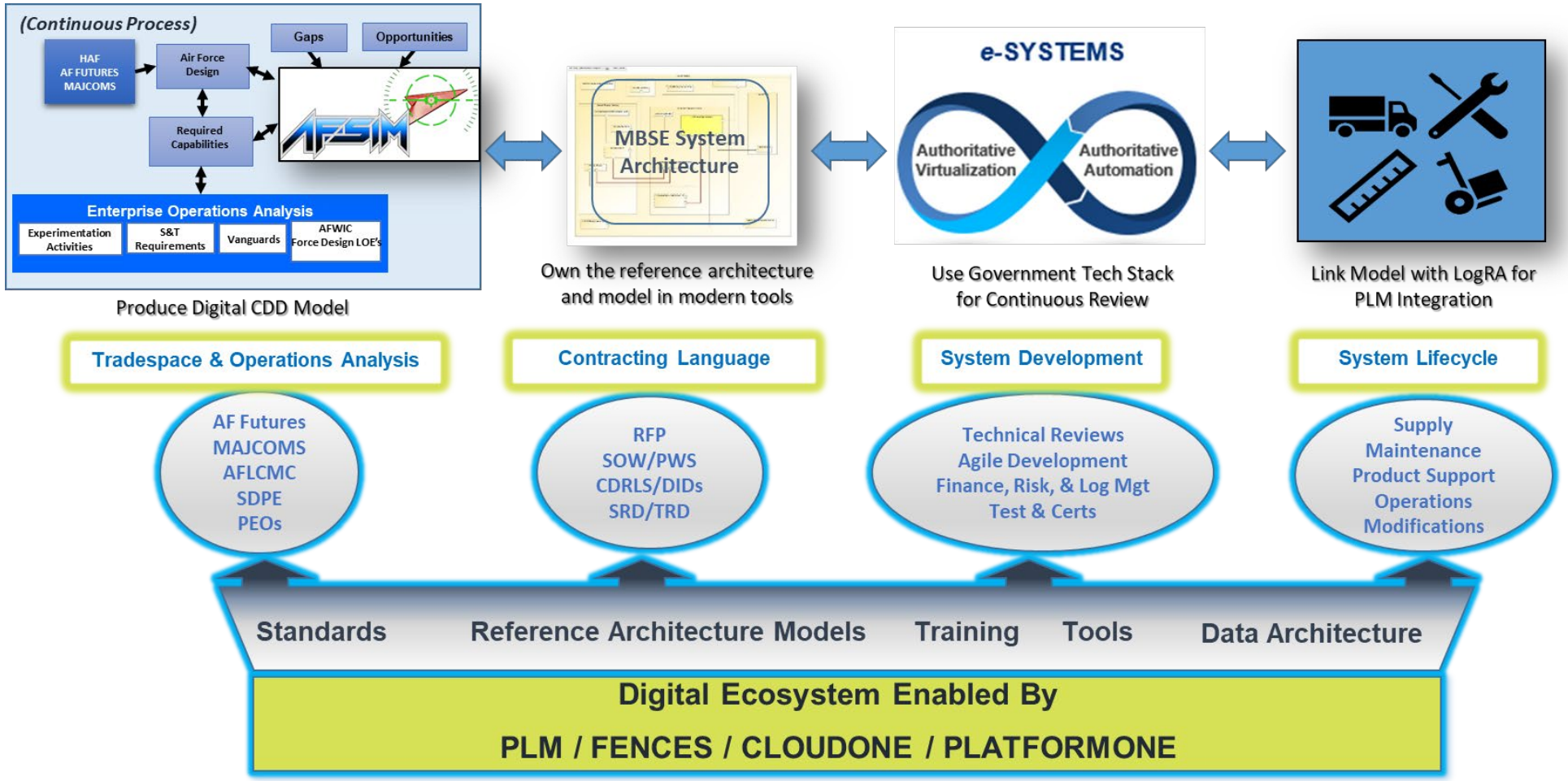
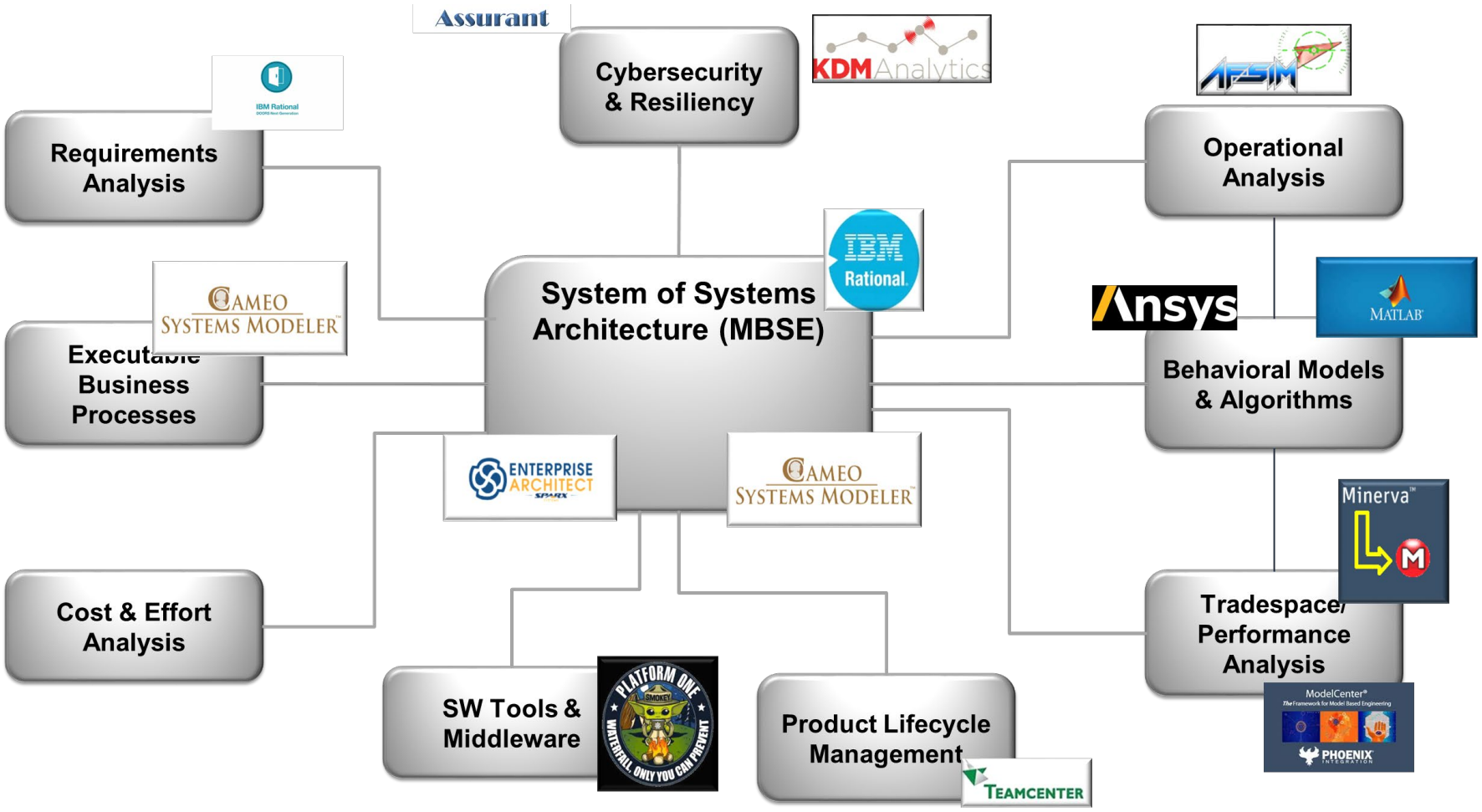
Overview

- BLUF:
  - System Model Configuration and Release Management is basically like Software Configuration and Release Management
- Key point is that Software Configuration Management (SCM) tools allow us to manage multiple configuration baselines

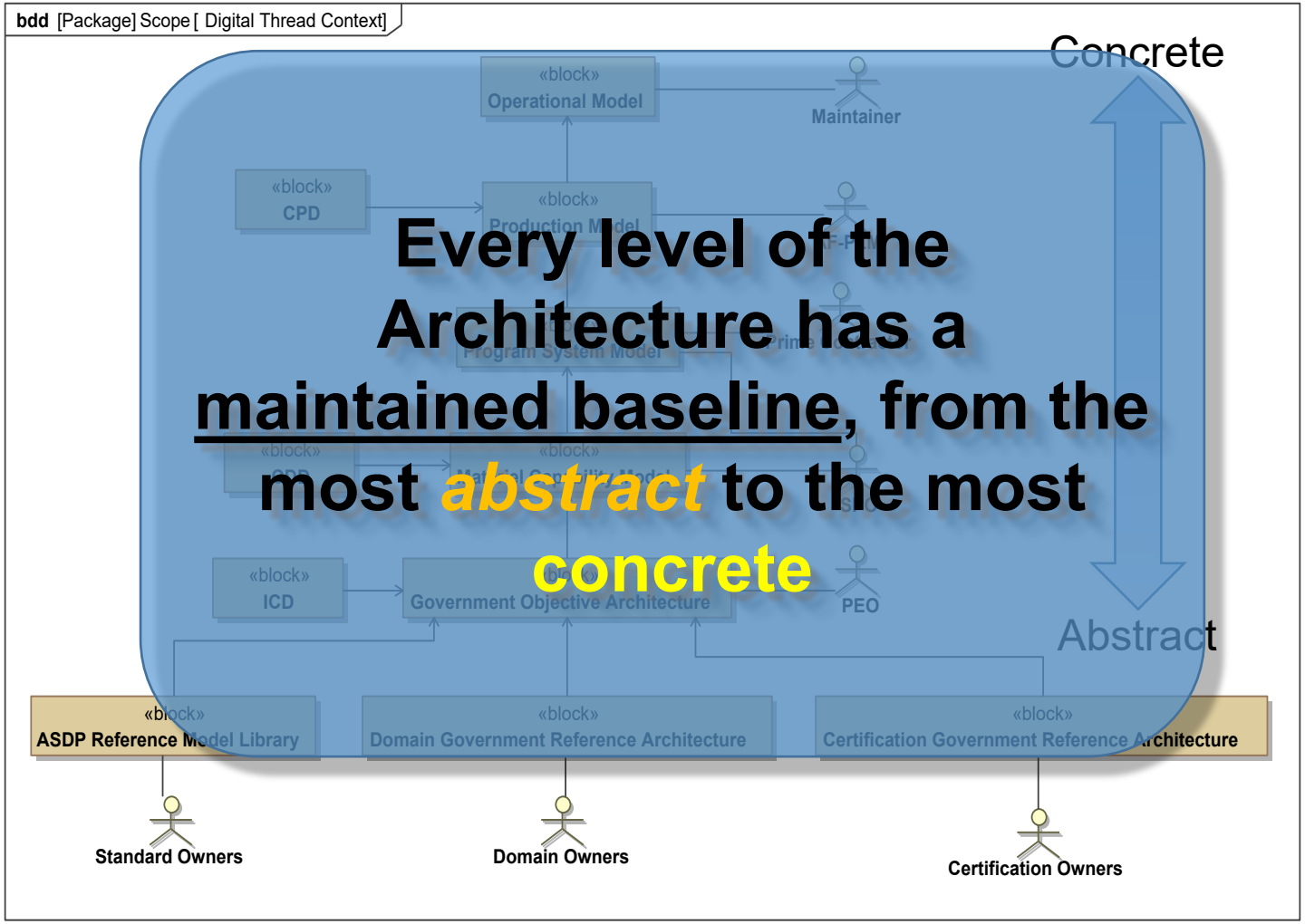
Digital Ecosystem



Architecture in Action!



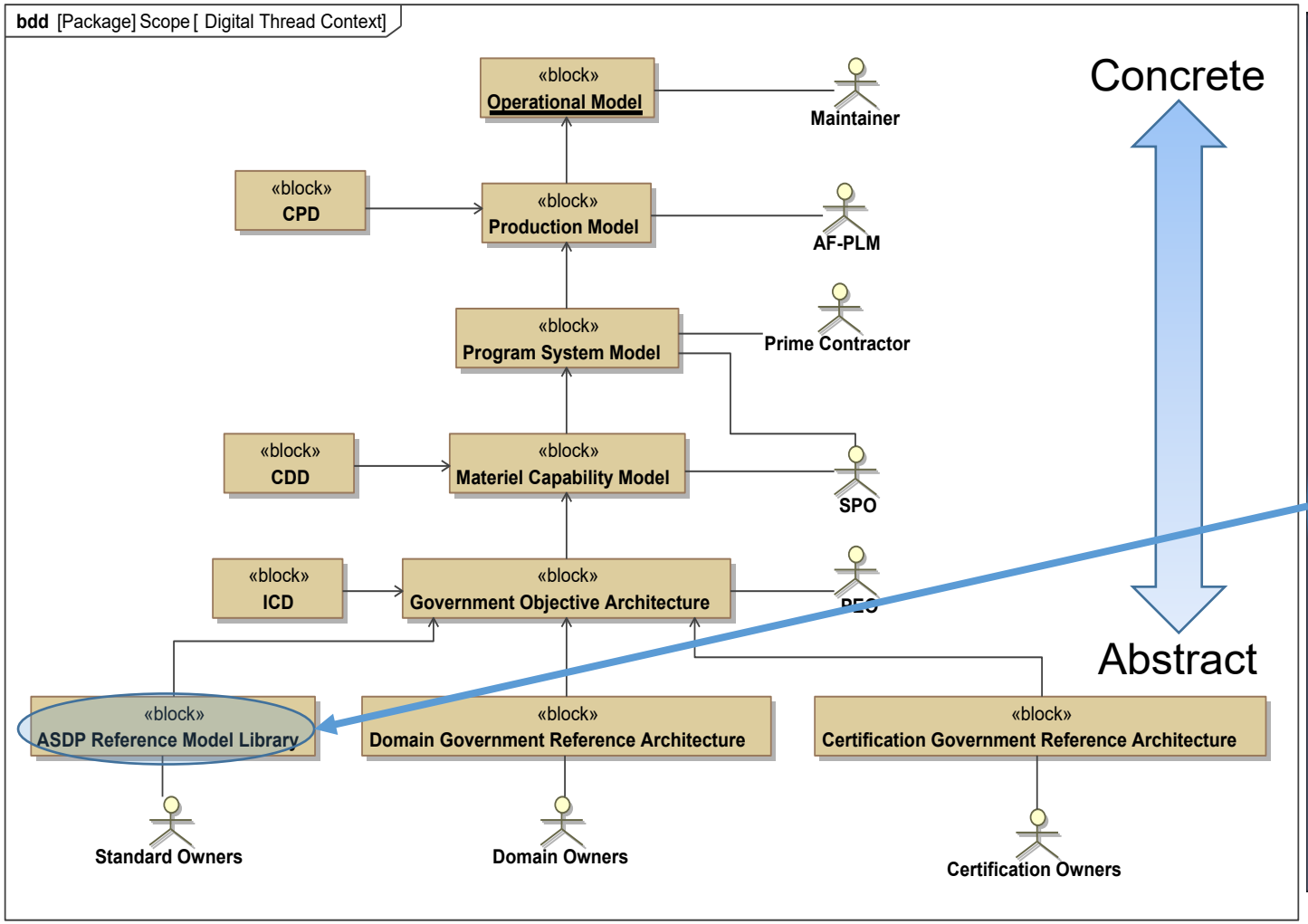
ASDP Future in the Digital Thread

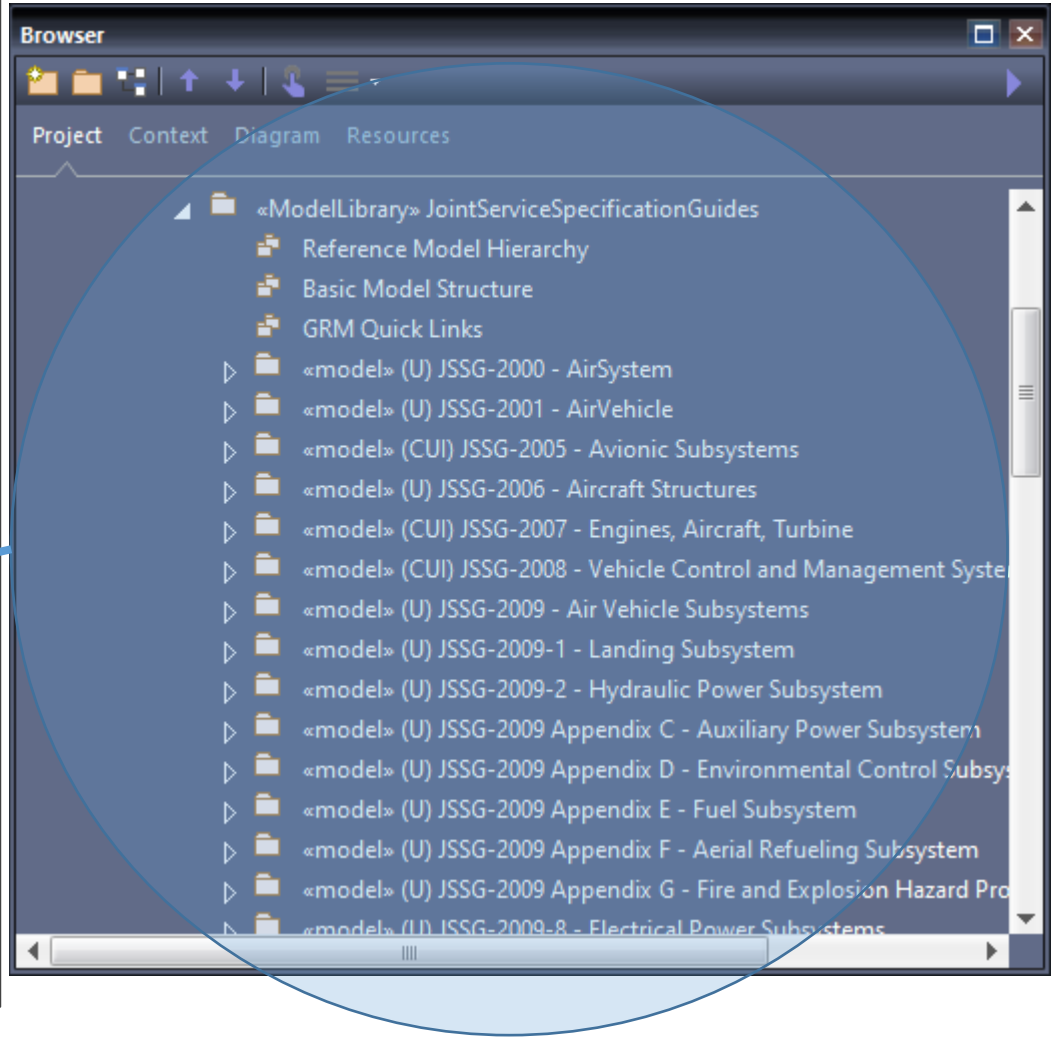


Baseline Configuration Considerations

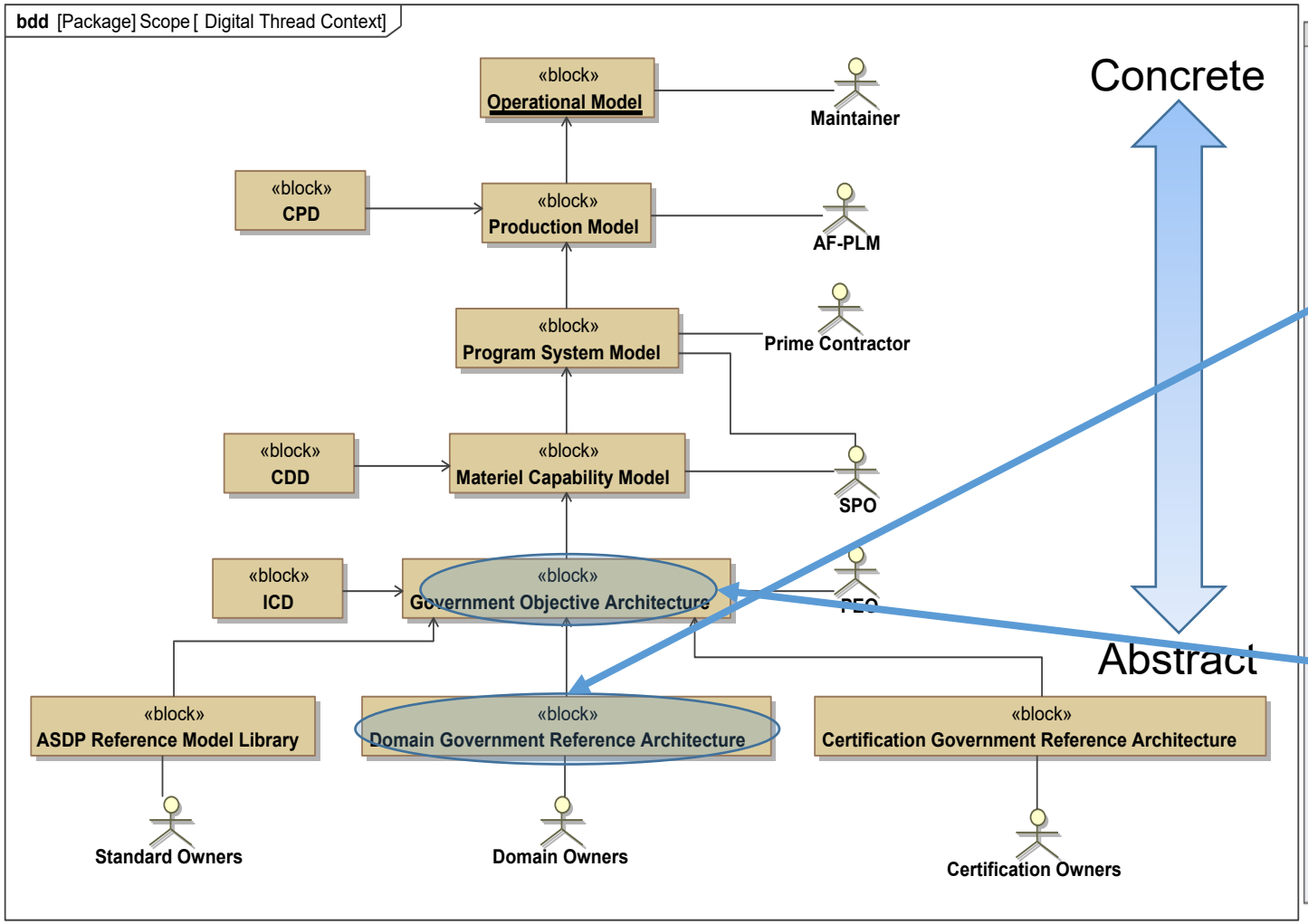
- Software attempts to merge to a single trunk release
  - Not always possible
  - Different targets need different feature sets from the trunk
    - Sometimes with modifications of the trunk that are never merged back
  - Results in multiple edition releases
- Theoretically, the only common aircraft baseline will be the abstract Air Vehicle model
  - Each level of the architecture has a release branch of its own
  - Each branch is managed separately as its own “trunk”
  - Changes to the more abstract trunk may drive changes to more concrete
- Every Air Vehicle will consist of library-based common system / subsystem elements (from the JSSGs), but pulls “Legos” from the library to define the whole
- Model libraries are separate baselines

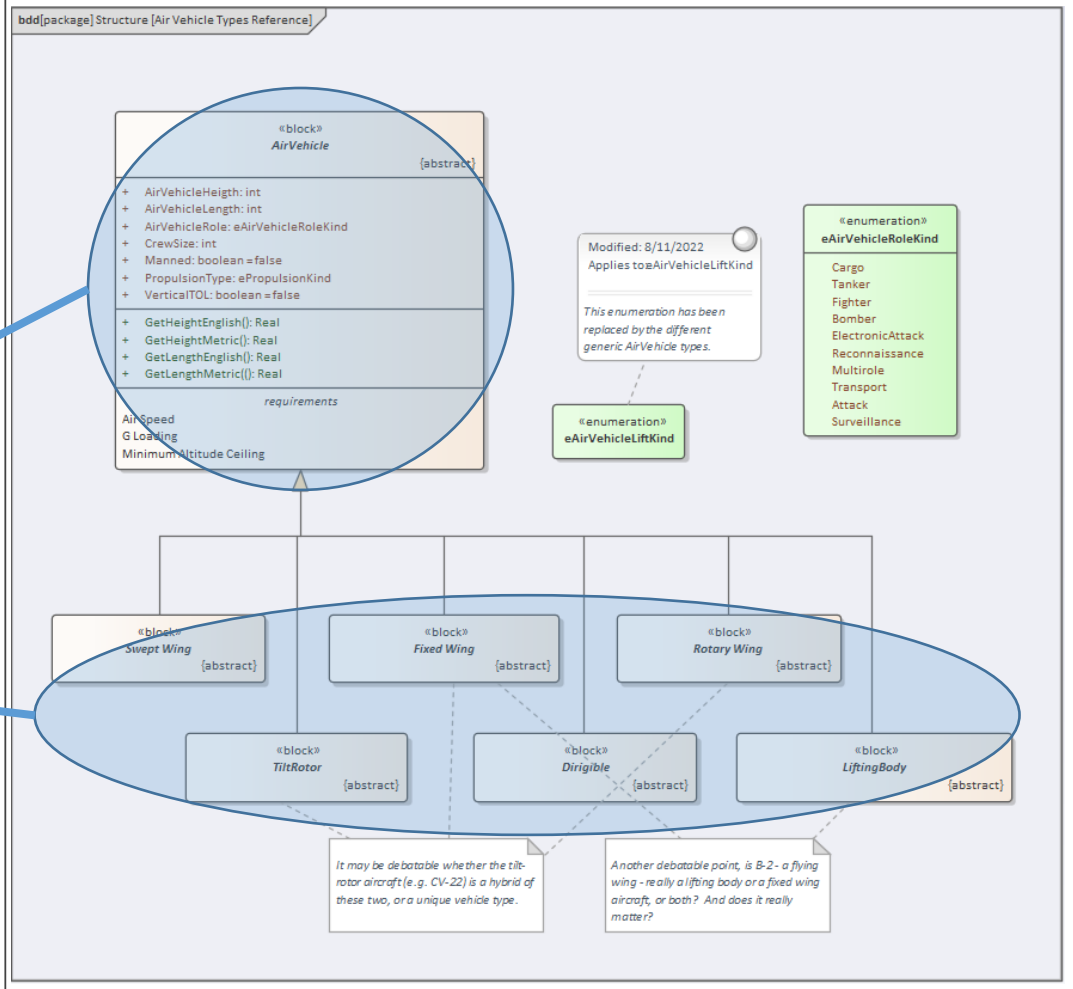
Abstract Models Managed per Level



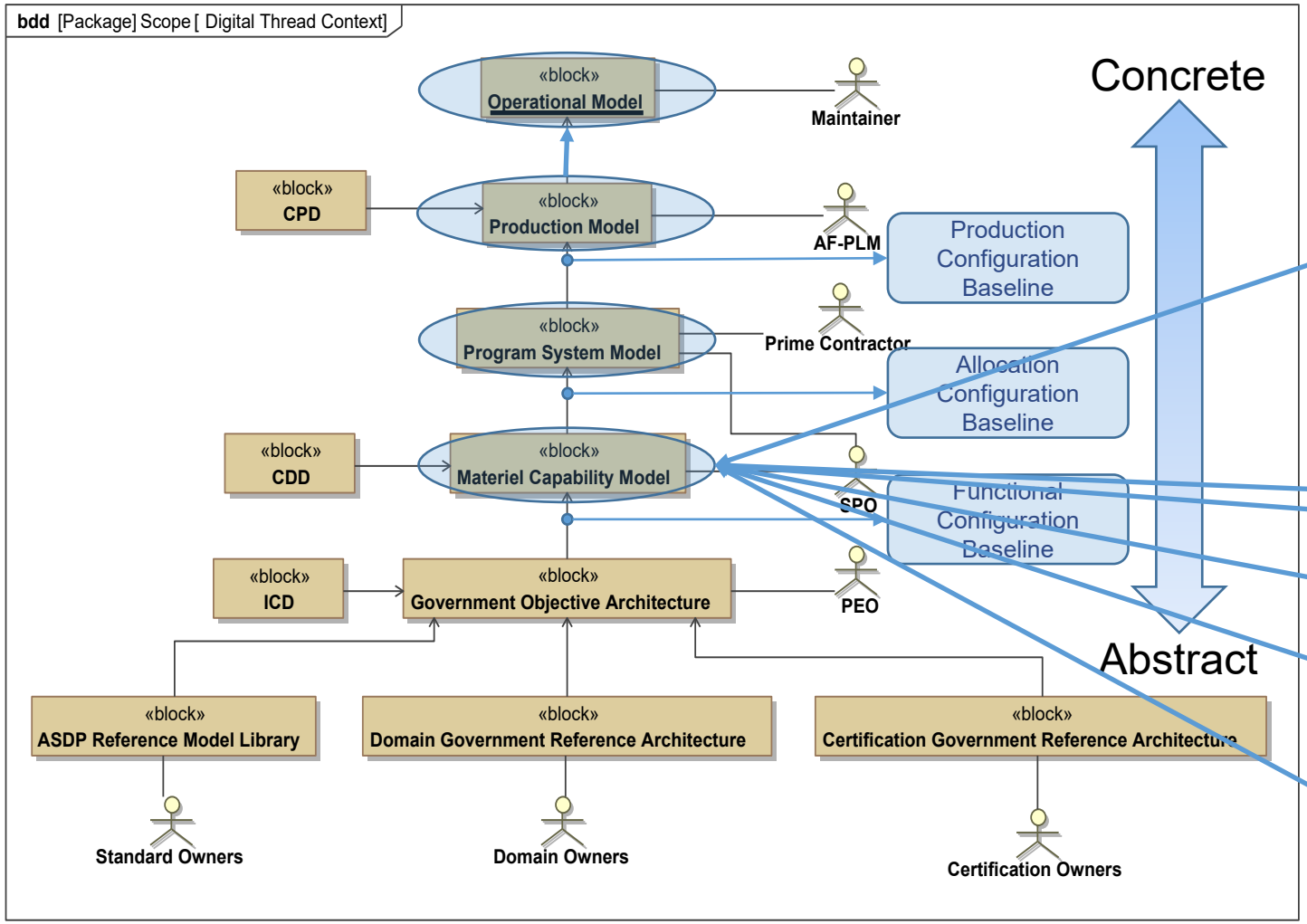


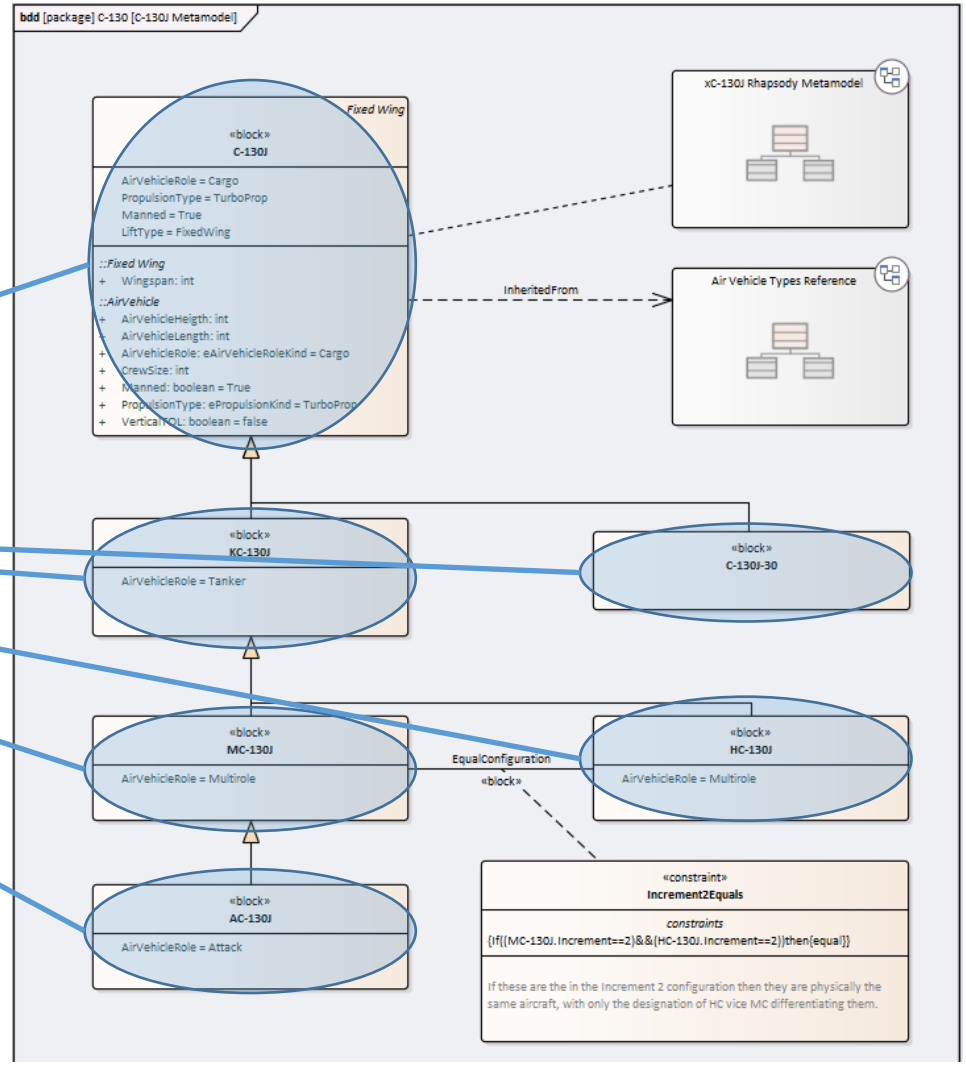
Abstract Models Managed per Level





Abstract Models Managed per Level





Summary

- **CM of MBSE Models basically equivalent to Software CM**
  - **Will be even more so with SysML v2.0**
- **Multiple levels of architecture CM is needed**
  - **Each level needs its own repository**
  - **Repositories need to be able to exchange model data**

Questions

AFLCMC… Providing the Warfighter's Edge

Changes in the Near-term Future

- SysML v2.0 is in review (with updates) for formal release
  - Target date may have slid into 2023/24
  - Based on a new language standard (not a UML profile)
    - Kernel Modeling Language (KerML)
    - KerML v1.0 is also in review for formal release
- SysML (and KerML) is text-based
  - Still has a graphical representation
  - Tools are expected to add text editing with graphical editing
- Model CM will be virtually identical to SCM
  - Both managed at the textual content level

Department of Defense Sustainability Efforts and Sustainable Technology Evaluation and Demonstration Program

2022 NDIA Systems & Mission Engineering Conference

Mr. David J. Asiello
Director, Sustainability and Acquisition
Office of the Assistant Secretary of Defense for Energy, Installations, and Environment (OASD(EI&E))
03 November 2022

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Agenda

- **Department of Defense (DoD) Sustainability**
  - Executive Order (E.O.) 14057 Goals
  - Sustainability Plan and Initiatives
- **DoD Adaptive Acquisition Framework (AAF)**
  - ESOH in Acquisition and Sustainability
  - Chemical Regulatory Management
  - Energy
- **DoD Sustainable Technology Evaluation & Demonstration (STED) Program**
  - Outreach and Communications
  - DoD Industry Sustainability Collaboration

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DoD Sustainability

- To successfully execute the DoD mission, our Military Departments must have the energy, land, air, and water resources necessary to train and operate in a world where there is increasing competition for resources.
- The Department pursues sustainability opportunities based on data that make the most compelling case in terms of mission, productivity, and long-term cost performance.

DoD's Sustainability Vision

To maintain the ability to operate into the future without decline either in mission or in the natural and man-made systems that support it.

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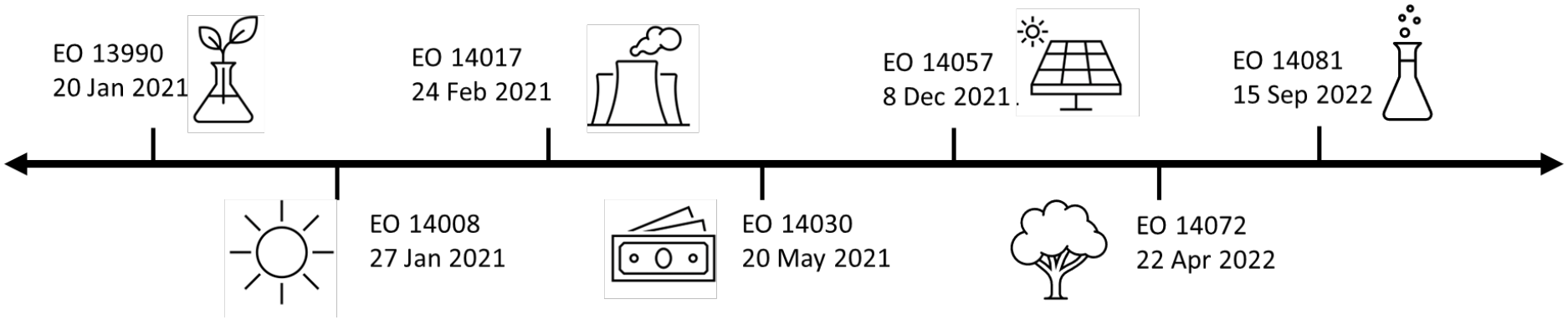
Sustainability Requirements Span EOs



EO 13990

- Incorporate Social Cost of Greenhouse Gases (SC-GHG) in areas of decision-making, budgeting, and procurement.
- Limit exposure to dangerous chemicals and pesticides;, including to low-income and communities of color.

EO 14008

- Orders climate considerations to be an essential element of United States national security policy.
- Climate crisis requires significant short-term GHG reductions and net-zero emissions by mid-century or before.

EO 14030

- Requires suppliers to (1) disclose greenhouse gas emissions and (2) disclose climate-related financial risk and (3) set science-based reduction targets.
- Orders agencies to consider the SC-GHG in procurement decisions and, where appropriate and feasible, give preference to bids and proposals from suppliers with a lower SC-GHG.

EO 14017

- Agencies required to assess climate risks to the availability, production, or transportation of critical/essential goods.

EO 14057

- Federal Government to lead by example in order to achieve a carbon pollution-free electricity sector by 2035 and net-zero emissions economy-wide by no later than 2050.
- Secure a transition to clean, zero-emission technologies and transform procurement and operations

EO 14072

- Develop policies to institutionalize climate-smart management and conservation strategies of forests on Federal lands

EO 14081

- Harness Biotechnology and Biomanufacturing R&D sustainably and increased biobased procurement

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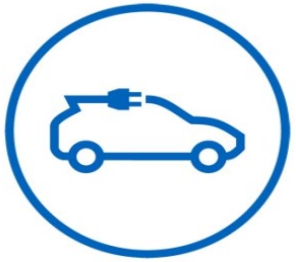
EO 14057 Goals

100% Carbon Pollution-Free Electricity by 2030, including 50% on a 24/7 basis



100% Zero-Emission Vehicle Acquisitions by 2035, including 100% light-duty acquisitions by 2027

Net-Zero Emissions Buildings by 2045, including a 50% reduction by 2032

Net-Zero Emissions Procurement by 2050

Net-Zero Emissions Operations by 2050, including a 65% reduction by 2030

Climate Resilient Infrastructure and Operations

Develop a Climate- and Sustainability-Focused Workforce

Advance Environmental Justice and Equity-Focused Operations

Accelerate Progress through Domestic and International Partnerships

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DoD Sustainability Initiatives

- **Greenhouse Reduction Planning**
  - DoD GHG Reduction Plan
  - Request for Information (RFI) and Sources Sought for DoD acquiring support for DoD Greenhouse Gas (GHG) accounting of emissions disclosures
- **Carbon Pollution-Free Electricity (CFE)**
  - Implementation Pilot Projects
  - CFE Strategic Plan
- **Sustainable Acquisitions**
  - Adaptive Acquisition Framework
  - Update to Sustainability Analysis Guide (SAG)
- **Zero Emission Vehicles (ZEV)**
  - ZEV Strategic Plan
  - Infrastructure led capacity planning
- **Net-Zero Installations**
  - Sustainable Installation Strategic Plan
  - Update Unified Facilities Criteria (UFCs)
- **Net-Zero Procurement**
  - 2 Federal Acquisition Regulations (FAR) Cases:
  - Disclosure of Greenhouse Gas Emissions and Climate-Related Financial Risk
  - Minimizing the Risk of Climate Change in Federal Acquisitions
- **Climate Resilient Infrastructure**
  - Climate Adaptation Plan
- **Environmental Justice**
  - Department-Wide Environmental Justice Strategy

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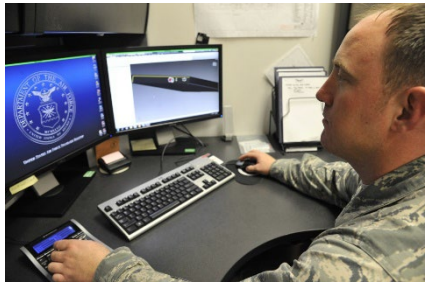
DoD AAF



*The AAF process encompasses the **design, engineering, testing, deployment, sustainment, and disposal** of weapon systems.*

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Purpose of Environment, Safety, and Occupational Health (ESOH) in Acquisition

Prevent loss of life or serious injury to personnel

Avoid damage to equipment or facilities

Support the warfighter and DoD's mission

Prevent harm to the environment and surrounding community

Avoid system failures & malfunctions (mishaps), which impact mission readiness

ESOH and Sustainability Inherent in AAF Process

- **ESOH risk and requirements management and sustainability is integral in systems/specialty engineering and product support processes for the life cycle of the weapon system.**
  - Engineering analyses inform on ESOH and supportability analyses and risk mitigation strategies.
  - A successful program meets sustainment performance requirements and continues to seek cost reductions.
- **SAG provides a full description of how to incorporate sustainability considerations in support of acquisition requirements.**
- **SAG includes traditional "internal" life cycle costs in addition to often-overlooked "external" costs.**
  - Includes the SC-GHG
- **An update to the SAG is in process to align with new DoD policies.**

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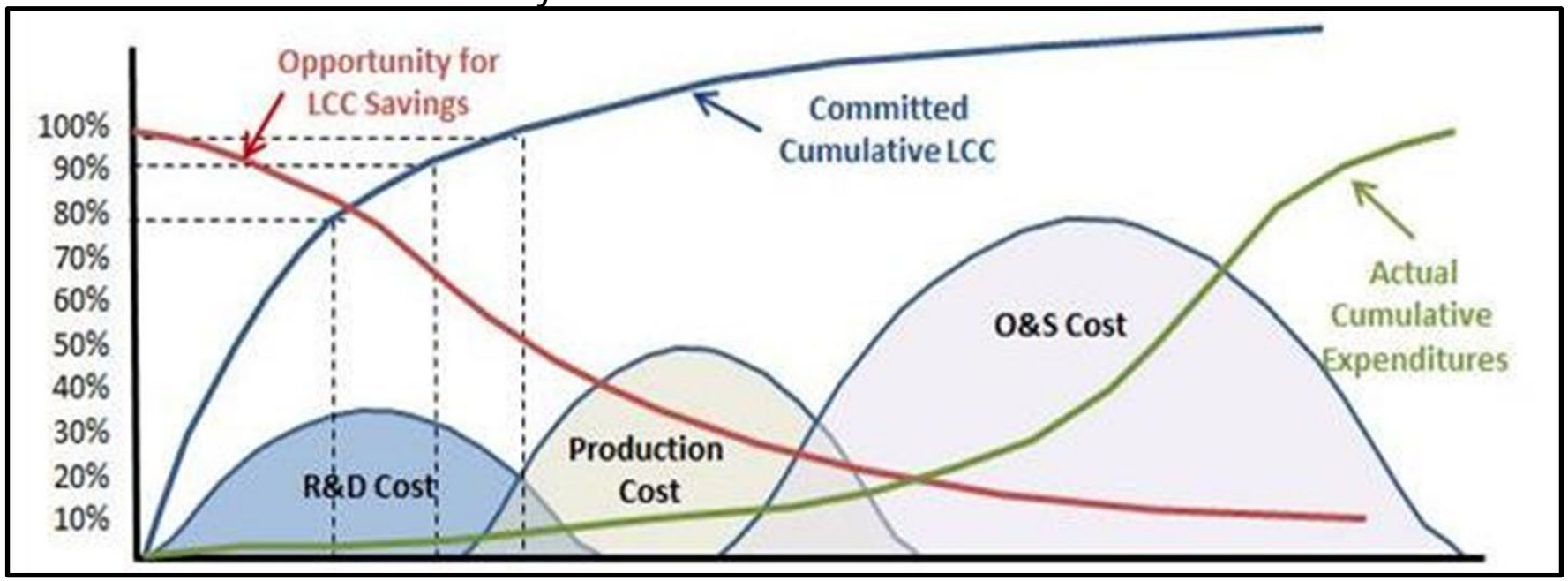
ESOH and Sustainability Inherent in AAF Process

- This graphic reflects the percentage of the total life cycle costs captured as a function of acquisition phases.
- Smart design choices achieve cost savings, as well as less ESOH statutory compliance and operational/mission/sustainability readiness constraints.



Life Cycle Costs (LCC):
- 80-90% of LCC committed during Research and Development R&D)
- 60-80% of LCC incurred during Operations and Support (O&S)14

Note: Based on a National Aerospace and Safety Administration Study

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Chemical Regulatory Management

Assure availability of natural and man-made resources to enable weapon system and platform capabilities that enhance warfighter lethality.

Availability of vital chemicals & materials needed for production, performance, and sustainment of weapon systems are increasingly at risk.

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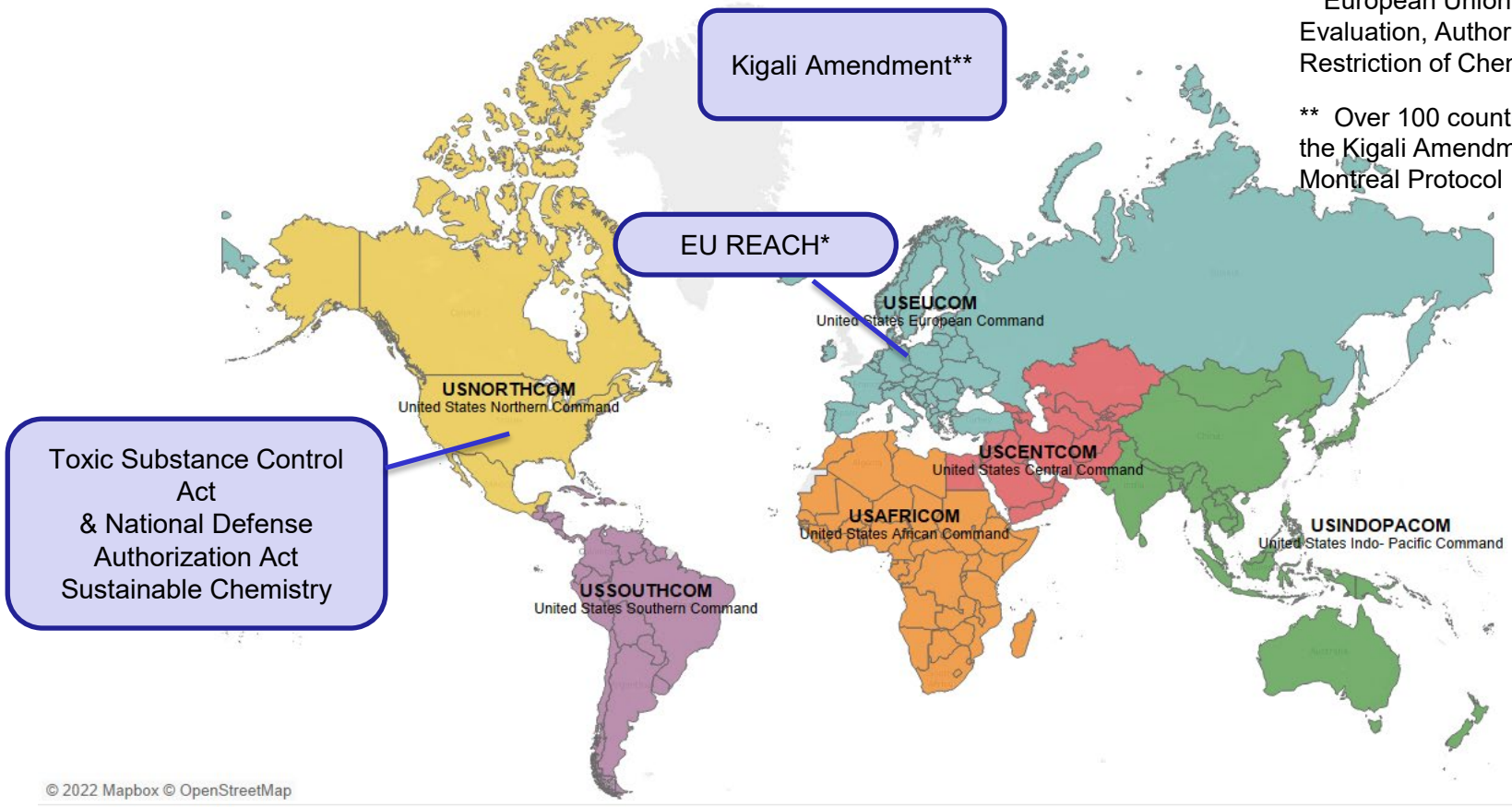
Global Chemical Management Regulations



* European Union Registration, Evaluation, Authorisation and Restriction of Chemicals

** Over 100 countries have ratified the Kigali Amendment to the Montreal Protocol

A sustainable approach is needed to address increasing regulations that limit DoD's ability to operate/maintain weapon systems globally from restricted access to mission critical chemicals.

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Regulatory Example – TSCA/REACH

- **Impacts to F-35 Performance and Maintenance**
  - Chemicals in materials highly regulated under TSCA/REACH resulting in potential availability/usage impacts and need to find viable alternative materials.

Photo credit: Lockheed Martin Photo by Chad Bellay
https://www.f35.com/media/photos-detail/f-35-fires-first-aim-9x-missile

- **1-Methyl-2-pyrrolidone CAS 872-50-4**
  - Urethane Topcoat Coating Throughout Aircraft
  - Stripper on Radome
- **Dibutyl phthalate (DPB)**
  - Ejection Seat Cartridges
- **Formaldehyde (Methylene glycol) 50-00-0**
  - Hazardous Materials Management Program Restricted
  - Composite Structures: Adhesive, Film
  - Fuel Tank Sealant
  - Polysulfide Sealant Throughout Aircraft
  - Engine Residual From Dry Film Lubricant, Epoxy Compound
  - Found In Sixteen Safety Data Sheets Used By United States Air Force Maintainers

Source: F-35 EHS Lead, Materials and Processes Principal Engineer, Lockheed Martin Aerospace

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Regulatory Example – American Innovation and Manufacturing (AIM) Act

- **AIM Act Overview:**
  - Enacted by Congress in 2020
  - Phases down Hydrofluorocarbon (HFC) consumption and production by 85% across the United States by 2036 based on global warming potential
  - Includes distribution of ‘allowances’ for production and consumption

HFC PHASEDOWN
American Innovation & Manufacturing (AIM) Act
A U.S. Environmental Protection Agency Program

- **Mission Critical Military End Use (MCMEU) Allowances**
  - DoD partnered with United States Environmental Protection Agency to distribute MCMEU allowances
  - DoD conducts an annual inventory of uses across the Department and the defense industrial base to determine/justify quantity of allowances

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Energy in AAF Process

- **Energy is a key performance parameter that must be considered as part of the weapon system design and in sustainment.**
  - Demand is increasing for fuel and power by air, sea, and land forces.
  - Operational risks increasing with logistics/sustainment targeted by adversaries.
- **The Deputy Secretary of Defense directed DoD in April 2022 to increase energy supportability and reduce energy demand across all capability solutions.**
- **An initial review of energy demand and supportability conducted in Major Capability Acquisition, Middle Tier of Acquisition, and Technology Development programs.**
  - Evaluation of approximately 60 acquisition programs
  - Complete review by end of Calendar Year 2022

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Energy in AAF Process (Cont.)

- **Initial Insights of Review to Date:**
  - Systemic approached needed
  - Difficulty in addressing energy in requirements and acquisition (e.g., demand and supportability not consistently assessed)
  - Life cycle approach needed (e.g., establish energy requirements and continue to shape downstream capabilities to include feedback loops across processes)
  - Embedding energy demand reduction and supportability analytics capability and capacity problematic
  - Revamp/adaptation of policies, guidance, and reporting needed

Energy performance is an important component in advancing capabilities to achieve the national defense mission and reducing emissions.

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DoD Sustainable Procurement

- DoD spends more than $439 billion (Fiscal Year 2020) on goods and services; the most of any Federal agency

- Both Congress and the President have directed Federal agencies to use their purchasing power to expand market offerings and standardize the use of sustainable products and services

- Can meet this requirement while also supporting and enhancing the mission

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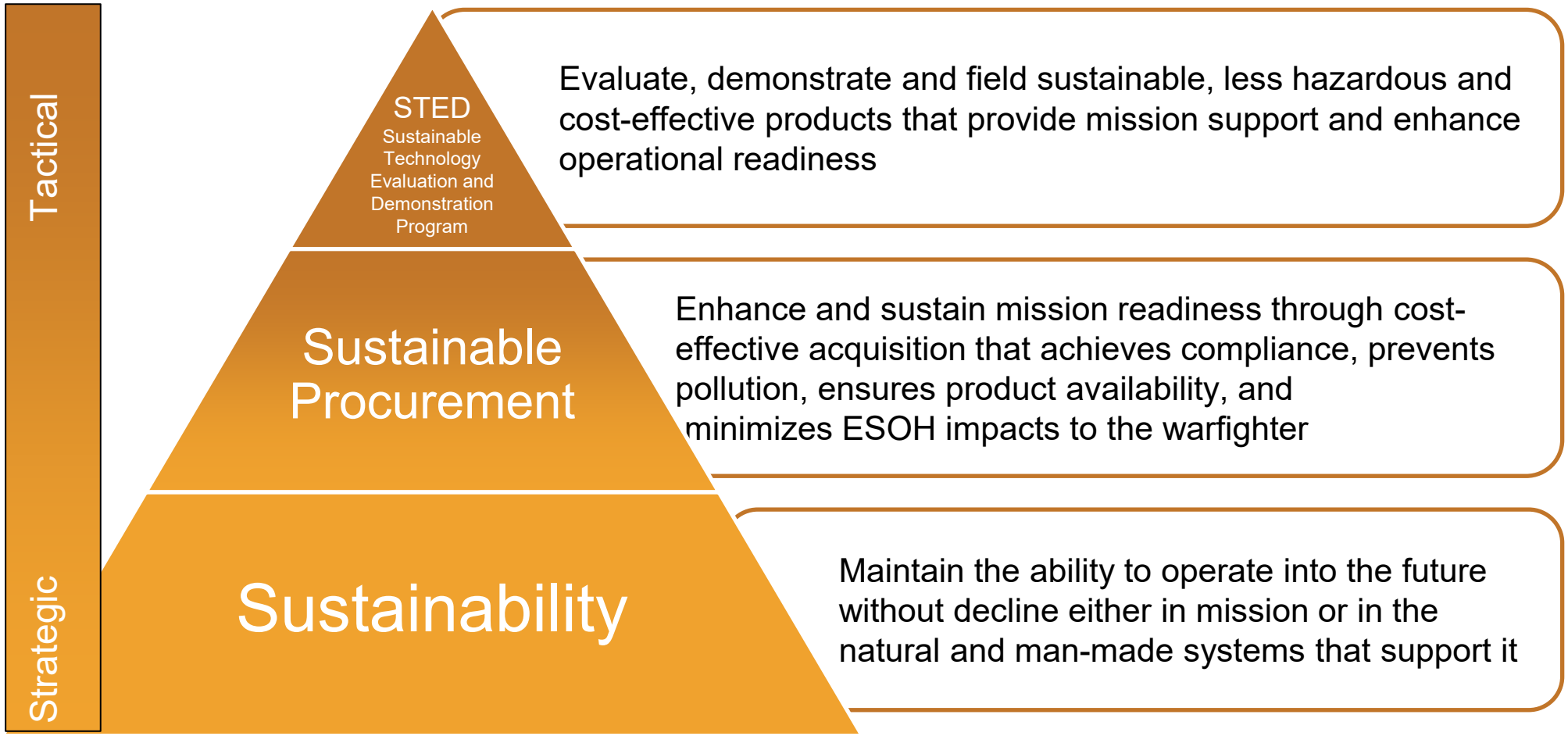
DoD Sustainable Procurement (Cont.)

- Initiatives include:



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DoD STED Program

- **Established To:**
  - Identify and demonstrate sustainable alternatives to government requirements with end users at DoD installations
  - Validate performance and cost effectiveness
  - Increase awareness and use of sustainable alternatives across the Federal Government
- **Benefits:**
  - Mission performance
  - Price versus Cost over life cycle – better value
  - Material availability
  - Reduced health and environmental impacts

Biobased Hydraulic Fluid Demonstration
MCMWTC

Biobased Sorbent Demonstration
MCAGCC 29 Palms

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DoD STED Program Demonstrations

Ongoing Demonstrations

- Biobased Sorbents
- Biobased Cleaner, Lubricant and Preservative (CLP) for Weapons
- Biobased Rifle Bore Cleaners
- Biobased Brake Cleaners
- Biobased Multipurpose Lubricants
- Biobased Corrosion Inhibitors
- Hand-Held Laser Depainting
- Biobased Tires
- Biobased Dust Suppressants
- Portable On-Demand Hypochlorous Acid Disinfectant Cleaners
- Energy-Efficient Building Access Controls
- Energy Efficient Doors
- LED Chem Light Alternatives
- Safer Choice Sidewalk Deicers
- PFAS Free Disposable Food Service Ware

Completed Demonstrations

- Biobased Motor Oils
- Biobased Greases
- Biobased Traffic and Road Marking Paints

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Biobased CLP Demonstration

Technology Description

Biobased Cleaner, Lubricant, and Preservative (CLP) for weapons and weapons systems qualified to MIL-PRF-63460 Type B and listed on Qualified Products List (QPL).

Potential Impact

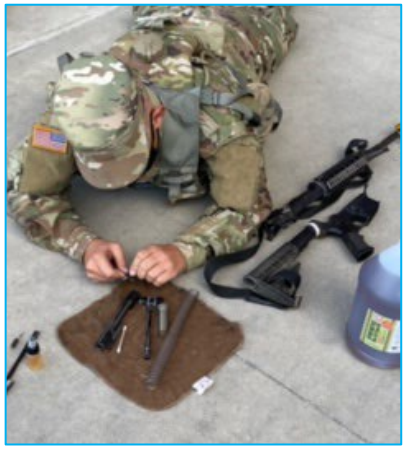
- Weapons stay lubricated longer and maintain rate of fire with less CLP required per application - reduces amount of CLP used and frequency of lubrication by 35%.
- Improve carbon removal and decrease buildup - reduces cleaning time by 30%.
- Reduce waste generation from cleaning processes by 30%.
- Reduce smoke – tactical advantage and operator health benefit.
- Low odor – improved cleaning room environment and operator health benefit.
- Increase confidence in weapon reliability.

Benefits

- Improves cleaning and operation.
- Replaces petroleum-based CLP currently used at installations.
- U.S. Department of Agriculture (USDA) BioPreferred Certified Product manufactured in USA.

Demonstration Sites

- Ft. Jackson
- Ft. Benning
- ANAD
- JBLM
- Edwards AFB
- NASA WSTF
- NASA AFRC



Ft. Jackson Basic Combat Training (BCT)

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Outreach & Communications: Installation Sustainability Expos

- **Expos bring sustainable product manufacturers/vendors to Installations and educate stakeholders about the STED Program**
- **Benefits:**
  - Identify installation needs and requirements, expand relationships and stimulate future sustainable technology demonstrations
  - Connect installation personnel to sustainable technologies, unique to STED
  - Build partnerships with regional agencies and surrounding communities
  - Train installation personnel on sustainable procurement requirements and how sustainable products/services support the mission

Mojave Desert Region DoD Sustainability Expo and Workshop – July 2022

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Summary

- **DoD sustainability initiatives strive to:**
  - Ensure resilience and mission capabilities
  - Improve operational performance
  - Enhance environmental security
- **ESOH and Sustainability in DoD acquisition process critical to:**
  - Reduce personnel exposure risks
  - Ensure availability of chemicals/materials to operate/maintain weapons systems
  - Meet energy demands in operational challenged environments
- **The DoD STED Program:**
  - Validates that sustainable technologies can meet DoD performance requirements in the field
  - Provides viable sustainable alternative opportunities to end users, increasing use across the Department and Federal Agencies
  - Supports Federal Acquisition Regulations, E.O.s, and high priority Administration goals

"When we operate more sustainably, we become more logistically agile and ready to respond to crises."

SECDEF Statement for the Leaders Summit on Climate, 22 April 2021

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Contacts

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DoD Sustainability and DoD STED Program

Questions?

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National Defense Industrial Association Systems and Mission Engineering Conference

November 2022

Data Centricity: Multi-Directional Flow of Specialty Engineering Data Throughout the Life Cycle

Mr. R. Chris DeLuca

Director Specialty Engineering

Office of the Executive Director, Systems Engineering and Architecture

Office of the Under Secretary of Defense for Research and Engineering

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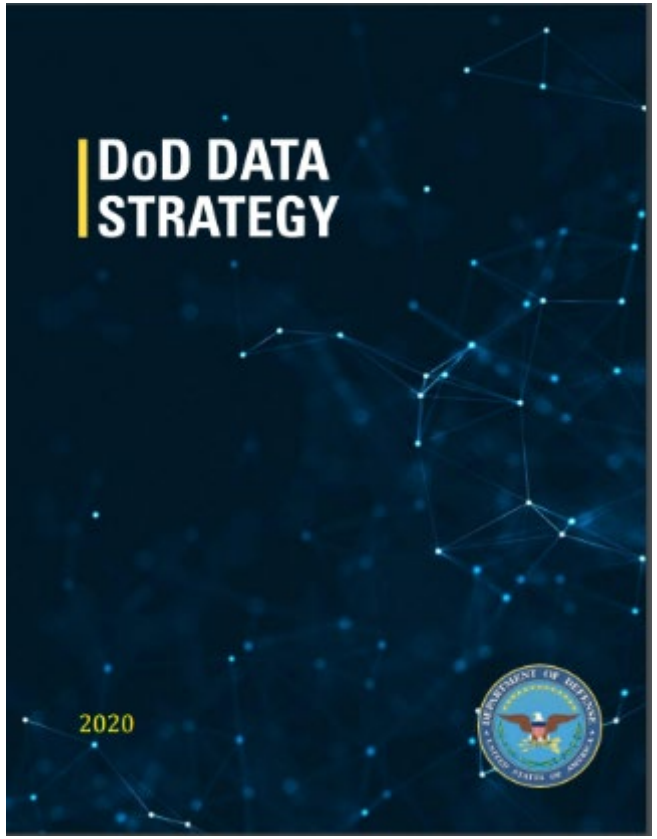
DoD Is a Data-Centric Organization



David L. Norquist, Deputy Secretary of Defense
2020

- **"Unleashing data to advance the National Defense Strategy"**
- **Guiding Principle #6 – "Data for Artificial Intelligence Training – Data sets for A.I. training and algorithmic models will increasingly become the DoD's most valuable digital assets"**
- **"As DoD modernizes and integrates AI technologies into joint warfighting, generating DoD-wide visibility of and access to these digital assets will be vital in an era of algorithmic warfare"**

"We have a very large AI challenge ahead of us but in order to do this, we have to get the data right"
Craig Martell, Pentagon CDAO, 2022 Intelligence & National Security Summit (C4ISRNET September 15)

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Increasing Complexity and Challenges

Source: 2022 PSM Workshop, RDML Dion English, SC, USN

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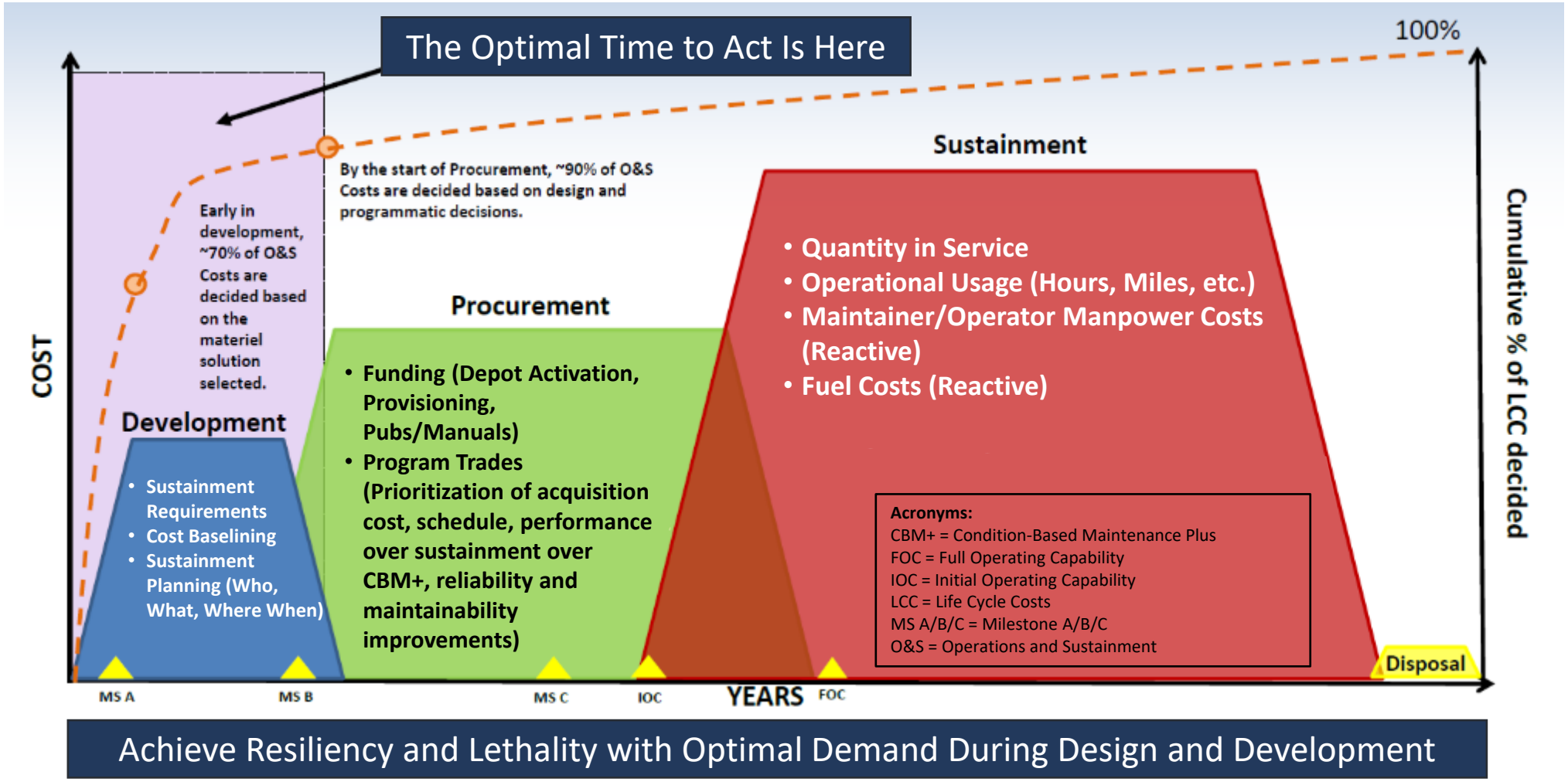
“Bake In” Data During System Design



Achieve Resiliency and Lethality with Optimal Demand During Design and Development

Source: 2022 PSM Workshop, Principal Deputy Assistant Secretary of Defense (Sustainment)

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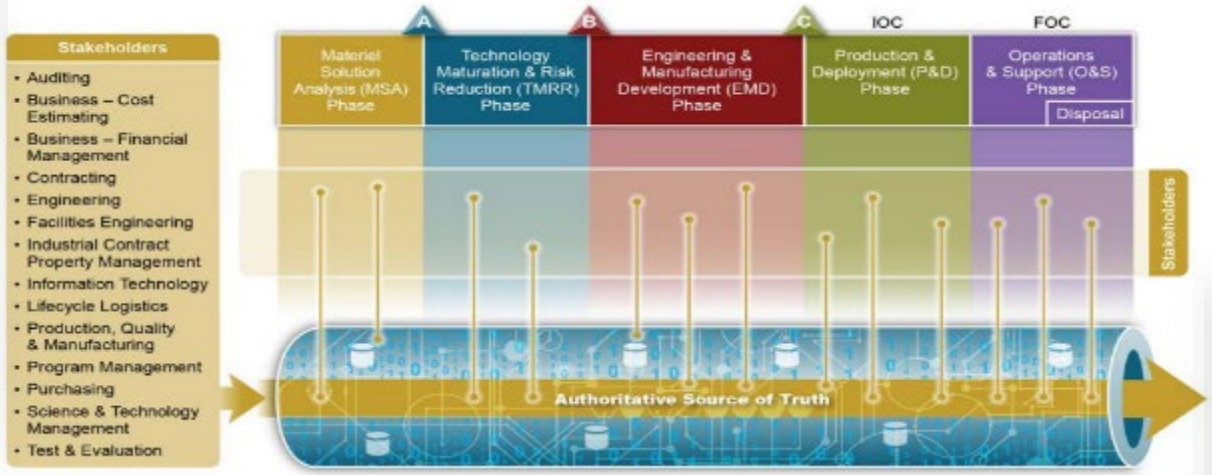
Lesson Learned: Ecosystem Needed

U.S. Air Force photo by Jill Pickett
HIGH MACH, Vol 67, No 12



Authoritative Source of Truth, Digital Engineering Strategy

Photo By: Army Spc. Kayla Anstey, "Digital Transformation, AI Important in Keeping Battlefield Edge" June 9, 2022
960cyber.afrc.af.mil/News

"Warfighters at all echelons require tested, secure, seamless access to data across networks, supporting infrastructure, and weapon systems out to the tactical edge"
DoD Data Strategy, 2020

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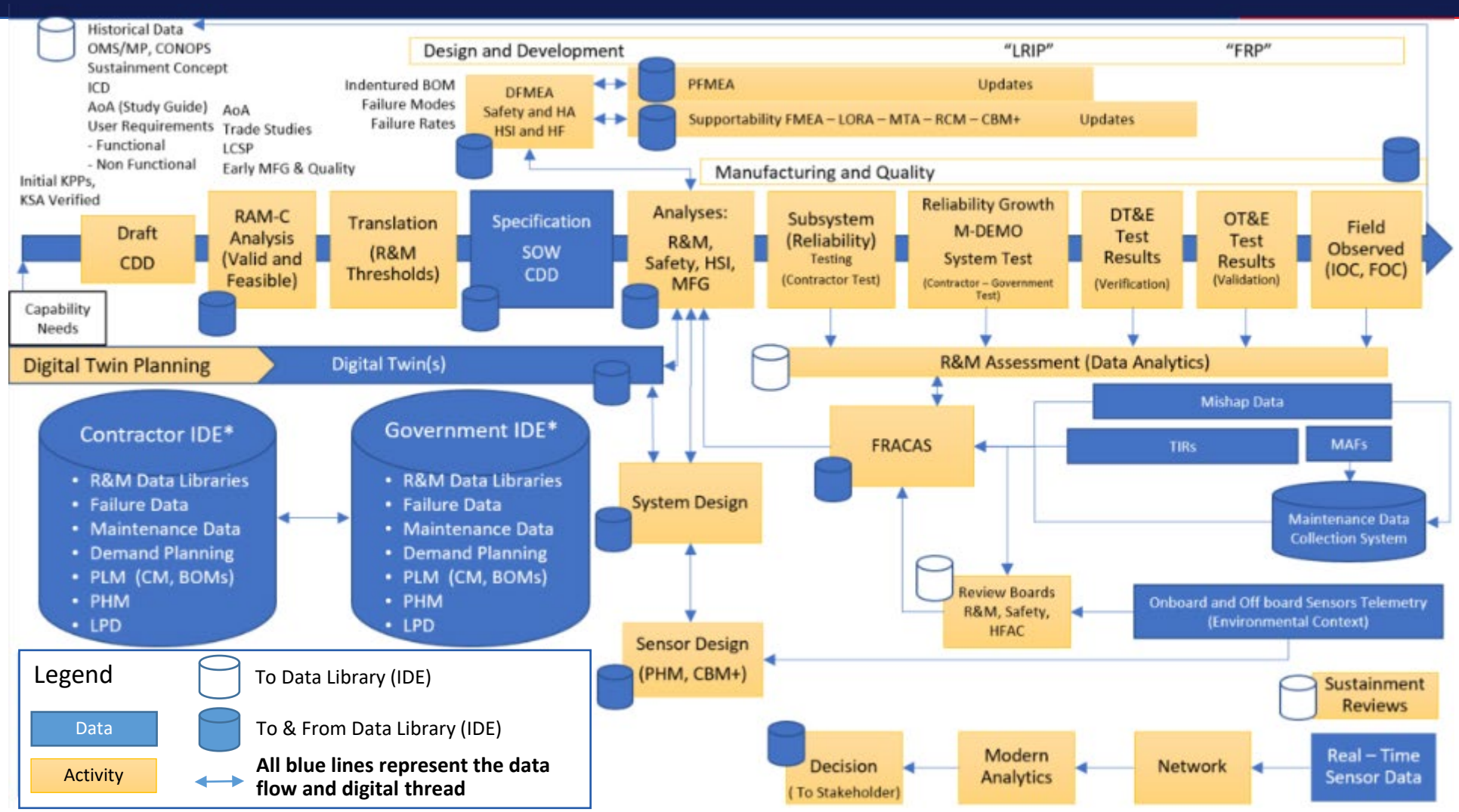
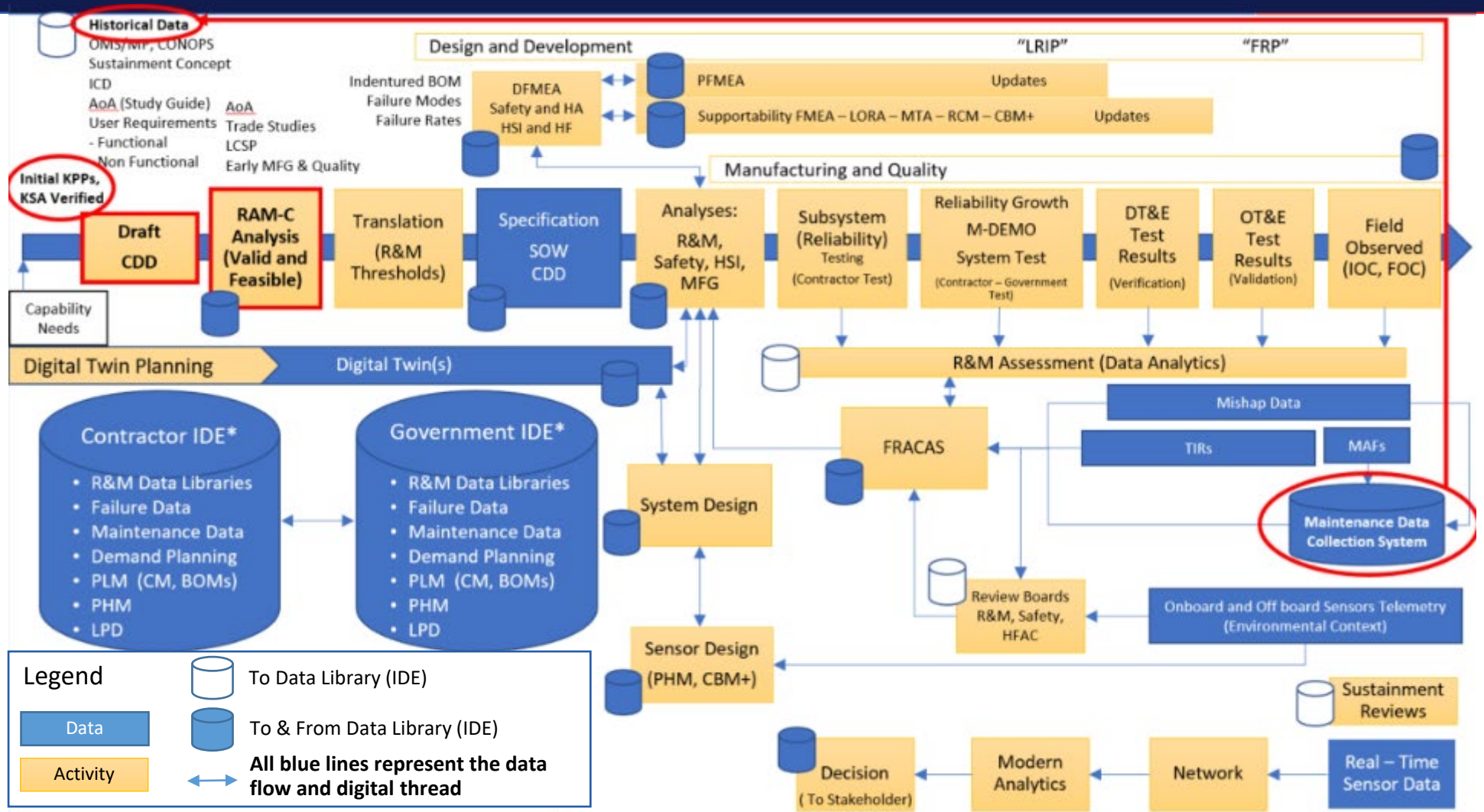
Engineering Data in a DE Ecosystem



***Contractually agreed to content, views, access, and delivery of data.**

Early Application in Engineering Data



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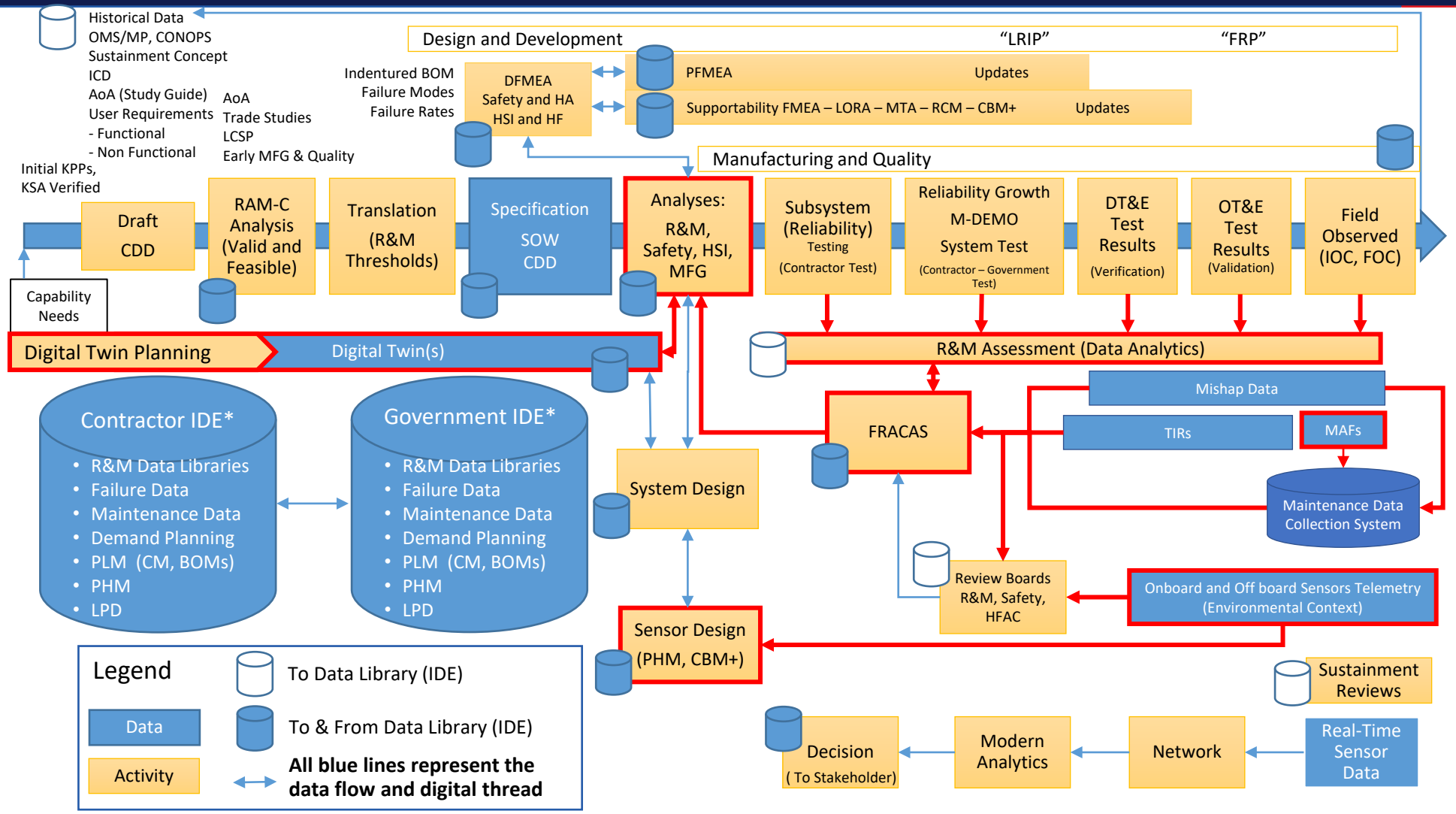
Failure Reporting Analysis and Corrective Action System (FRACAS) Feedback to the Digital Twin



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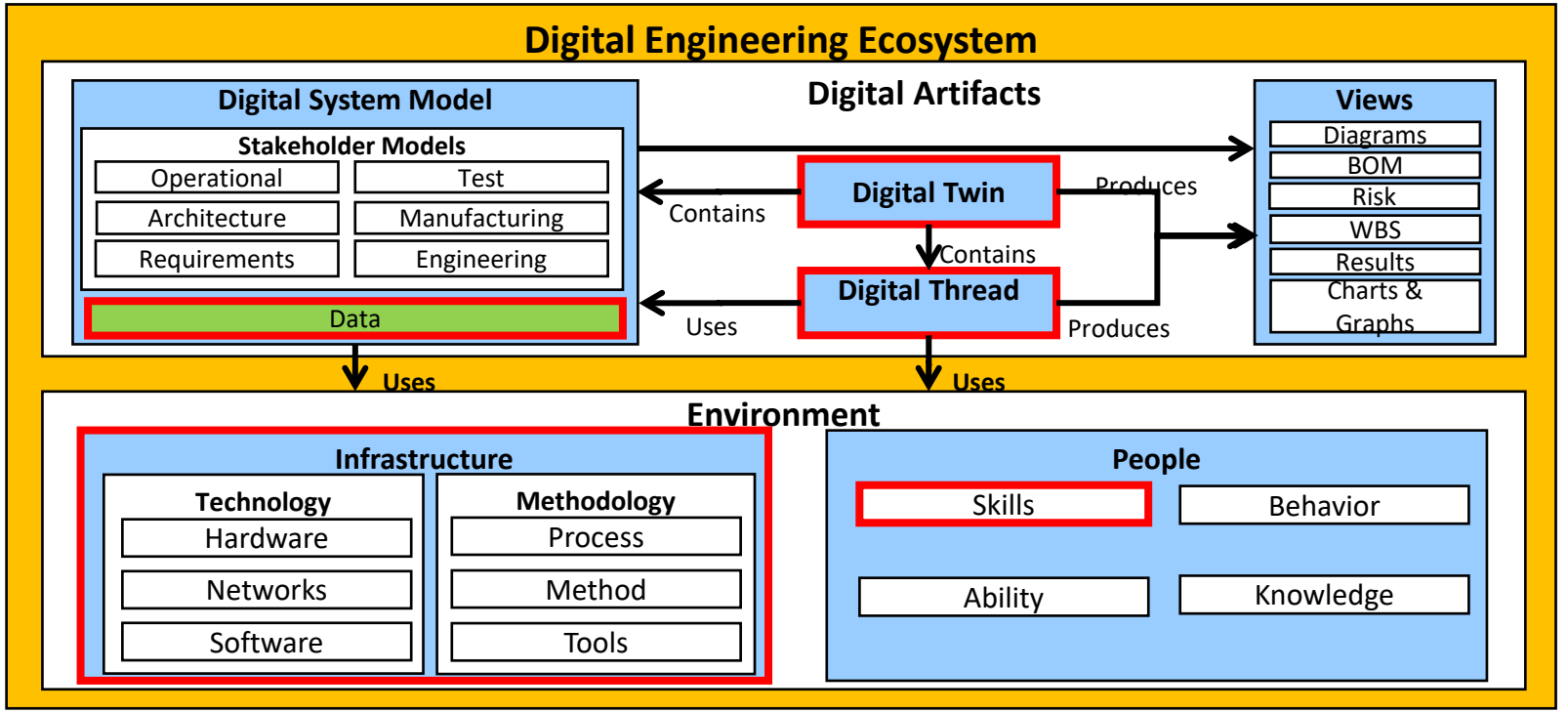
Digital Engineering Ecosystem



- Implementing digital twins and the digital thread requires a DE Ecosystem
- Infrastructure includes: Compute & Storage, HVAC, DevSec Op Tools, AI/ML/DT Tools, Simulation Tools, MLS/CDS Security, Authority to Operate (ATO) accreditation, Budget
- Skill sets include: IT, IA, Data Engineers, Data Scientists, Sys Admins, High Performance Compute, SW Developers, Scrum Masters, Security ISSO, System Engineers, HW Designers, Specialty Engineers

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Its All About the Data

… AI, Machine Learning, NLP … to be continued

Photo By: Marine Corps Staff Sgt. Jacob Osborne, "DoD Incorporating AI Ethics into Systems Engineering" January 21, 2021 Defense.gov/News

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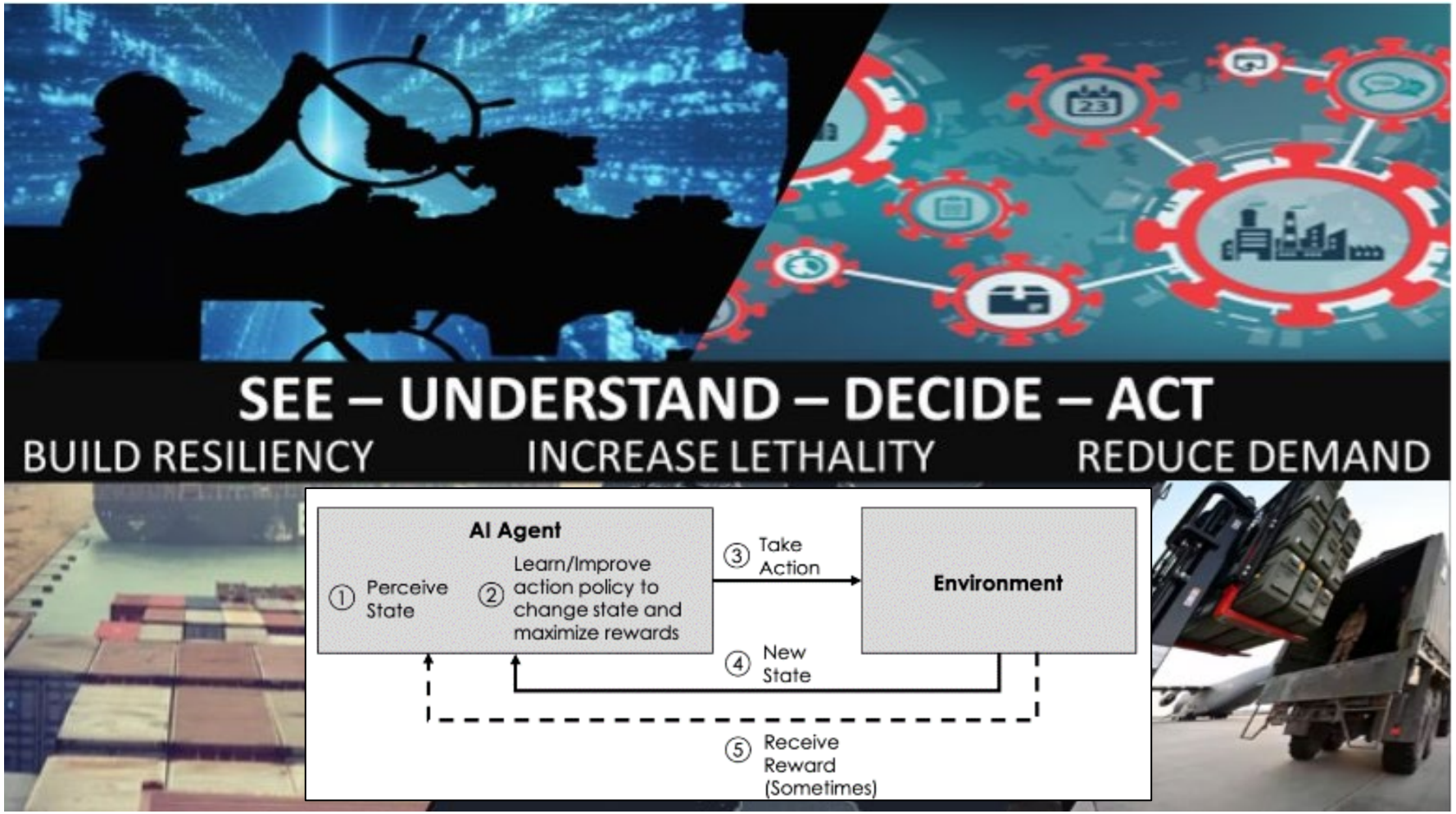
Increasing Complexity and Challenges



Source: 2022 PSM Workshop, RDML Dion English, SC, USN
Source: Understanding AI Technology, April 2020 (Figure 5)

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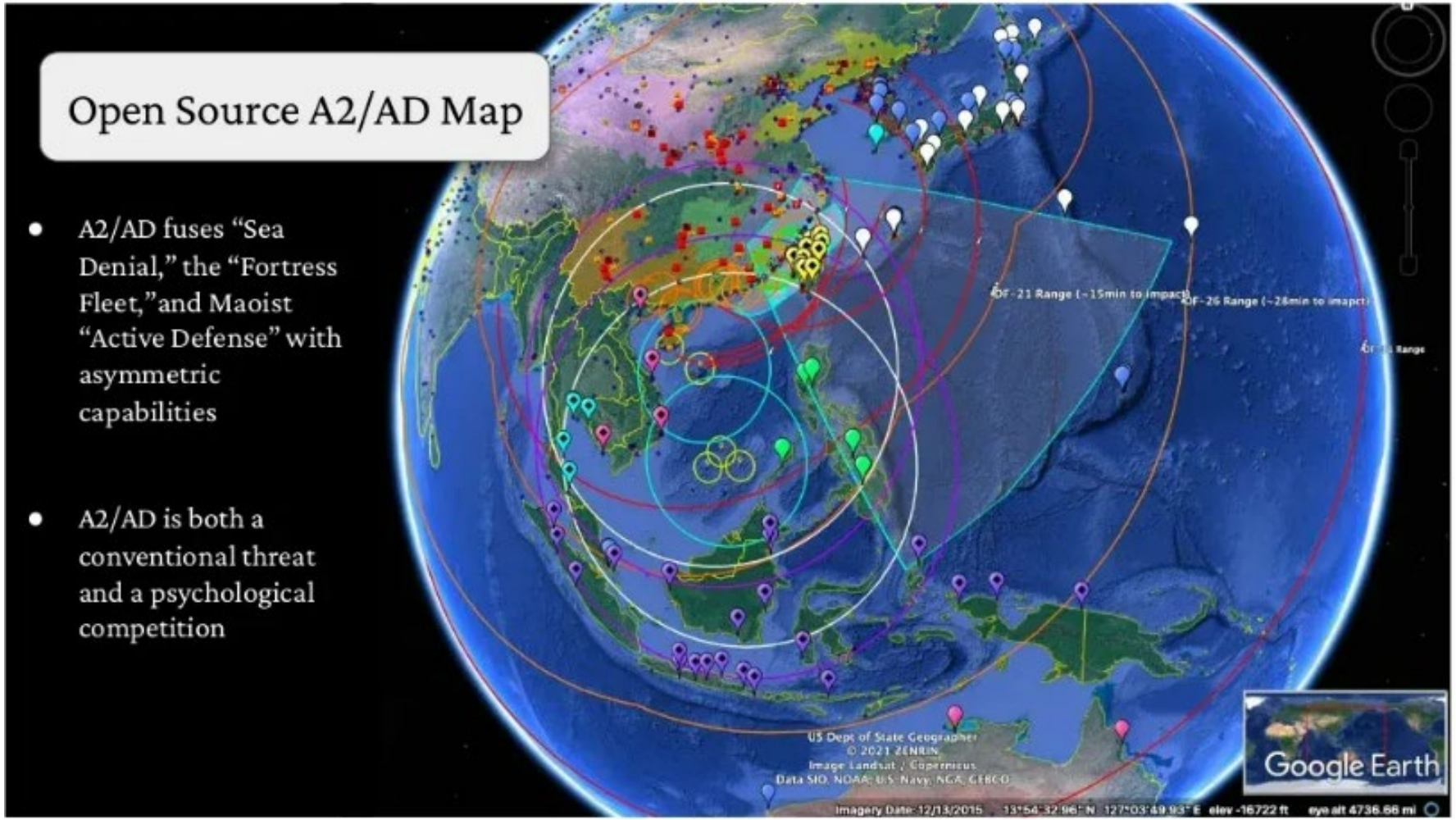

Attributed to The Stanford Project Agrippa 2021
Source: 2022 PSM Workshop, RDML Dion English, SC, USN

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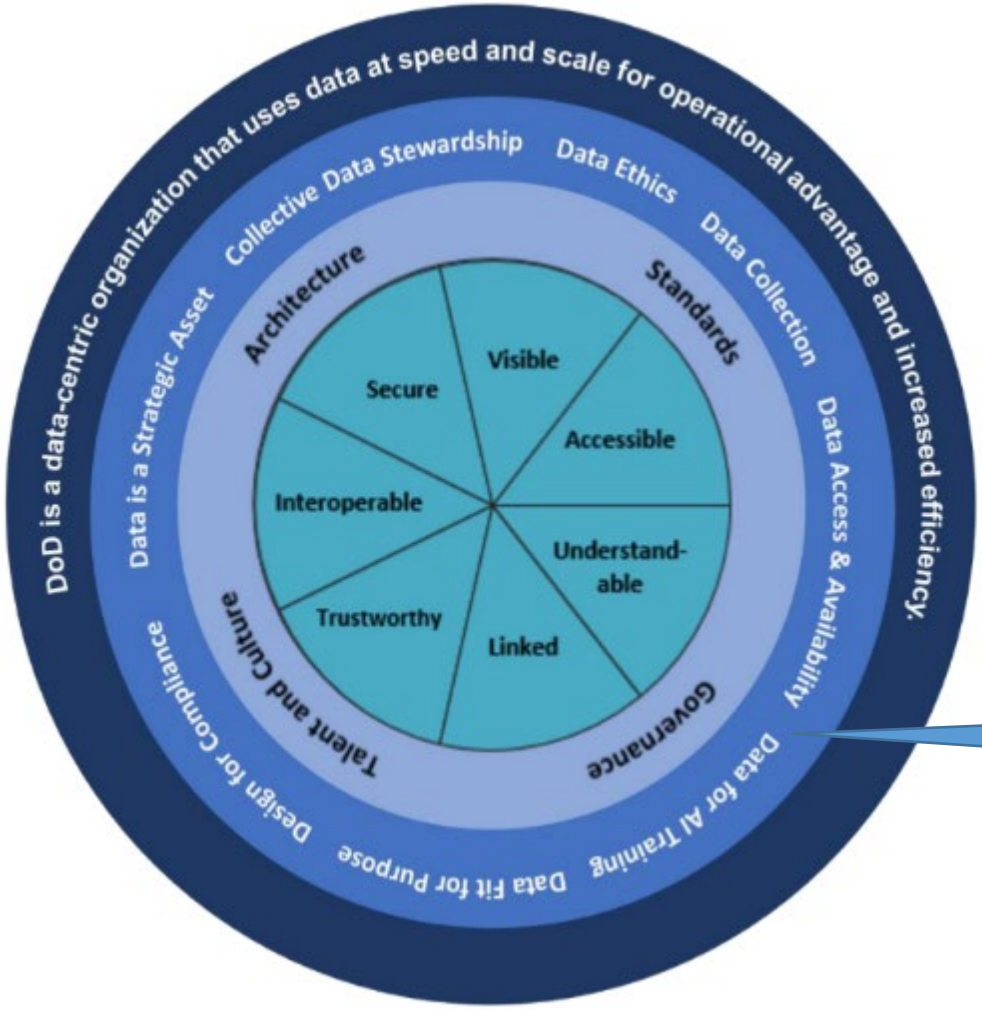
DoD Data Strategy Framework



Vision Statement
Guiding Principles
Essential Capabilities
Goals

Guiding Principle #6:
Data for AI Training

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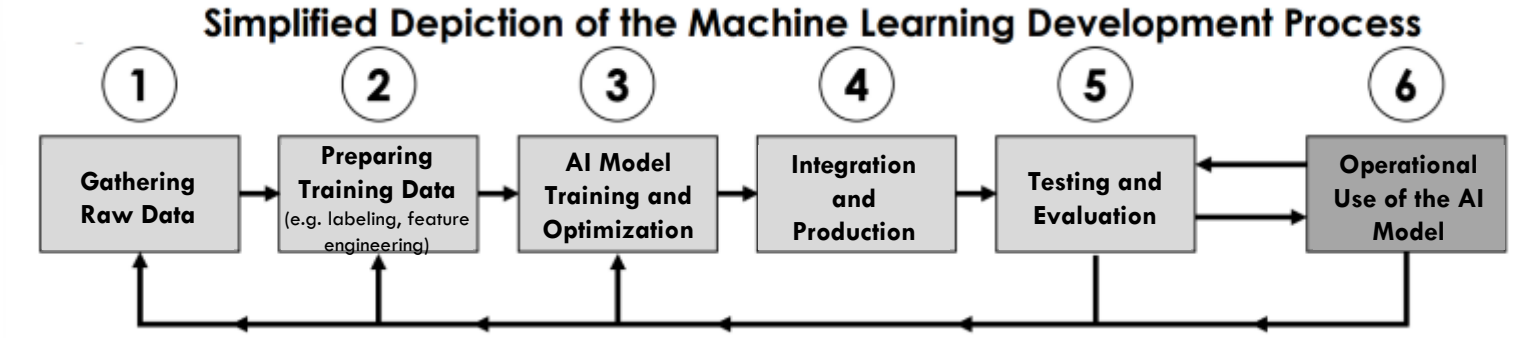
Condition-Based Maintenance Plus (CBM+)

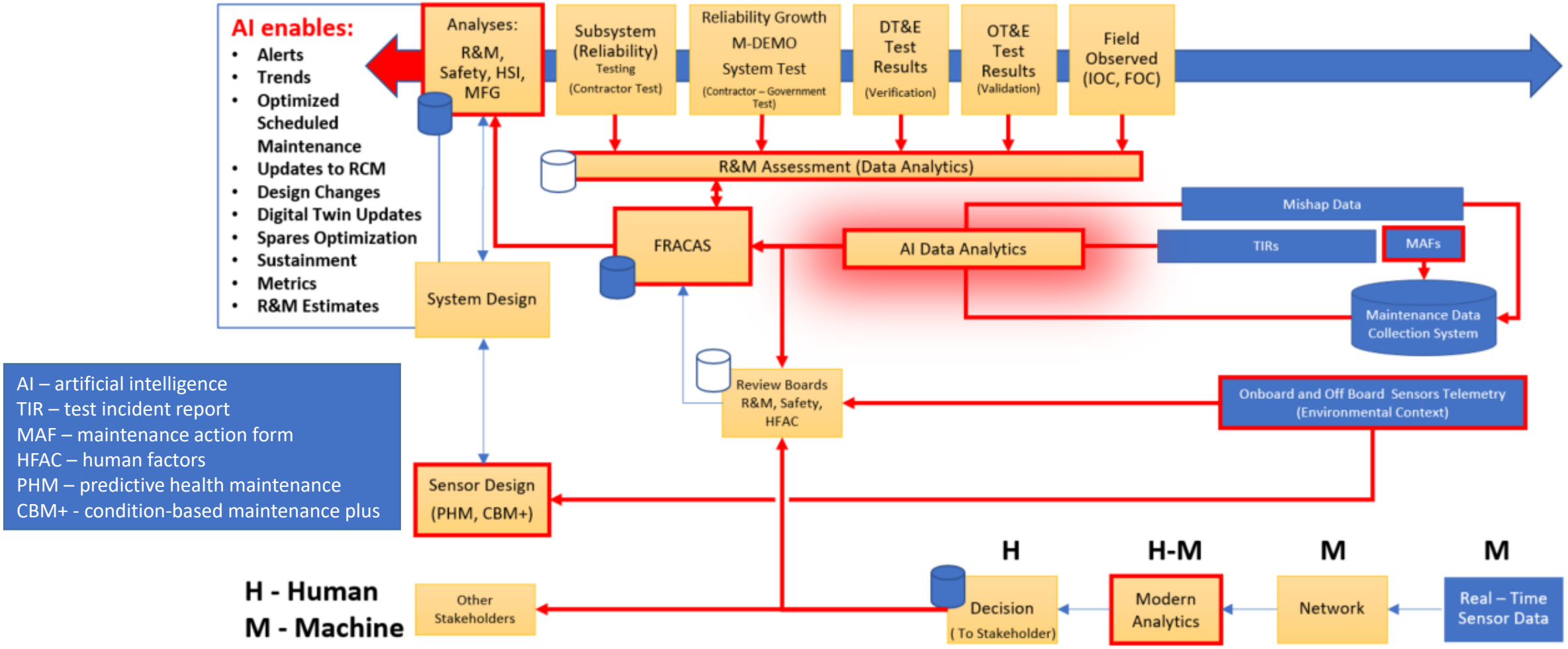
Photo By: R. Nial Bradshaw
"Face of Defense: Youngest Maintainer Launches Youngest Jet at Red Flag," February 22, 2017

Source: Office of the Under Secretary of Defense for Acquisition and Sustainment



Source: Understanding AI Technology, April 2020 (Figure 5)

AI Application in FRACAS Data



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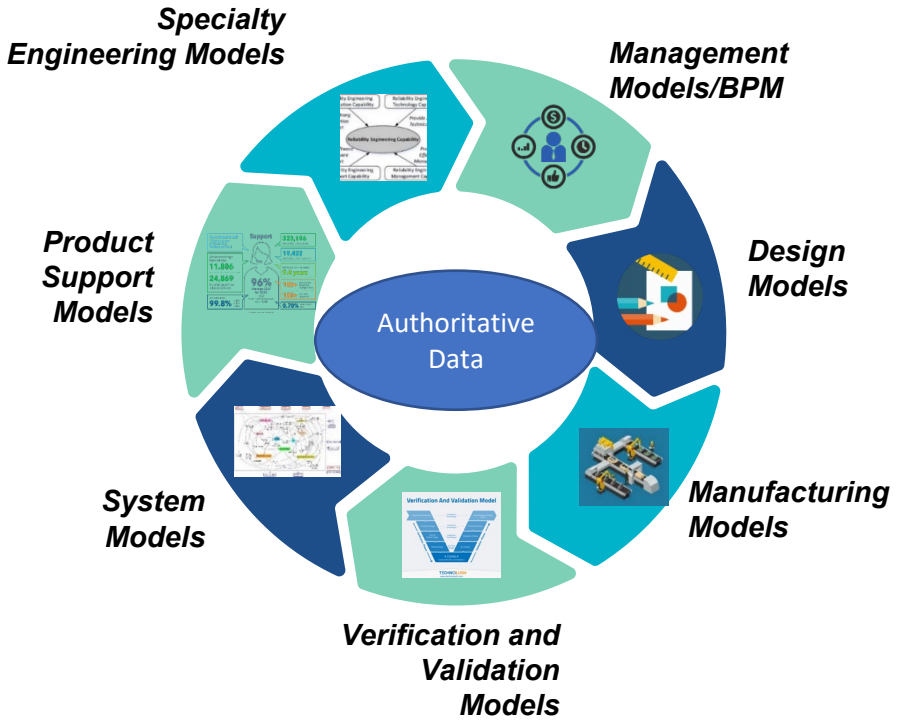
Digital Twin Models & Infrastructure



- An up-front Infrastructure is needed before embarking on AI, Digital Engineering and Digital Twins
- Infrastructure includes: Compute & Storage, HVAC, DevSec Op Tools, AI/ML/DT Tools, Simulation Tools, MLS/CDS Security, Authority to Operate (ATO) accreditation, Budget
- Skill sets include: IT, IA, Data Engineers, Data Scientists, Sys Admins, High Performance Compute, SW Developers, Scrum Masters, Security ISSO, System Engineers, HW Designers, Specialty Engineers

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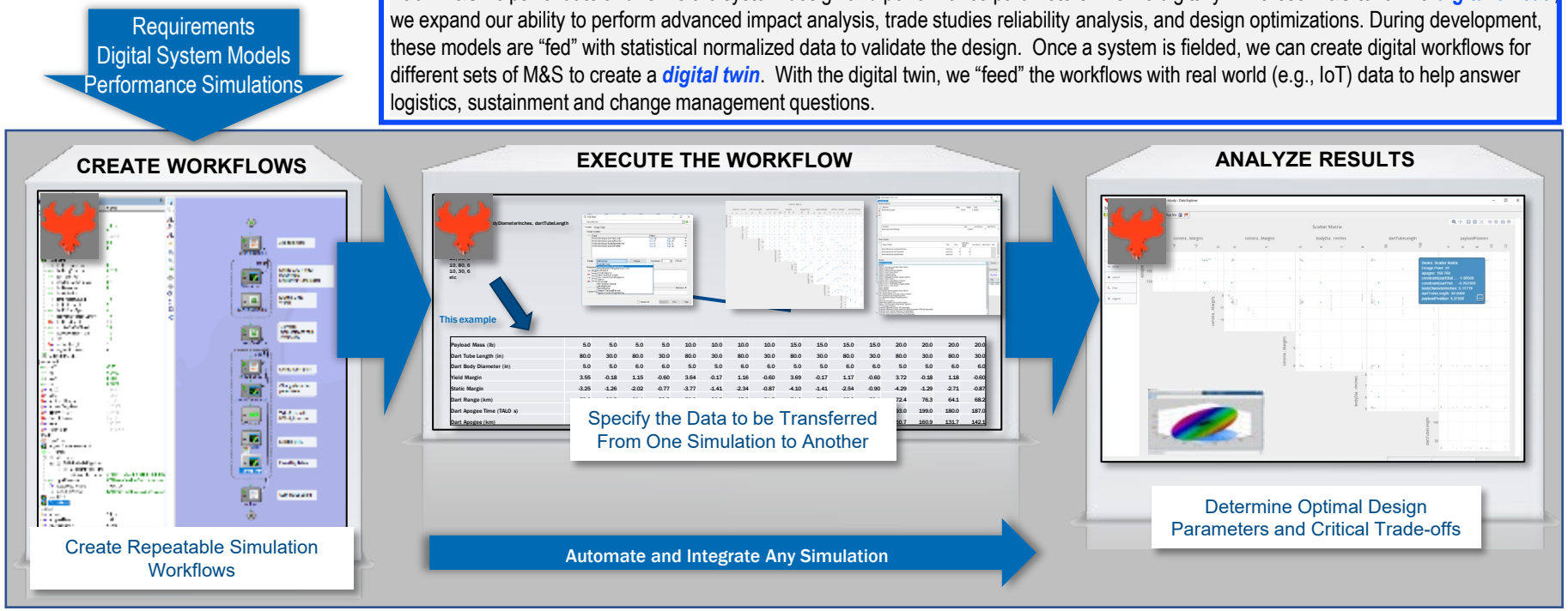
Digital Thread-to-Digital Twin Framework

Each M&S helps validate and refine the system design and performance parameters. As we digitally link these M&S to form a ***digital thread***, we expand our ability to perform advanced impact analysis, trade studies reliability analysis, and design optimizations. During development, these models are "fed" with statistical normalized data to validate the design. Once a system is fielded, we can create digital workflows for different sets of M&S to create a ***digital twin***. With the digital twin, we "feed" the workflows with real world (e.g., IoT) data to help answer logistics, sustainment and change management questions.



- For any given system there are multiple digital twins "answering" different lifecycle questions
- Digital Twin Framework allows us to efficiently create digital twins for those high-risk high-consequence system characteristics to best evolve the system based on real world data

Outcome: Enhanced Predictive Maintenance

DoD image VIRIN:195294-P-UOR35-506.jpg, available at https://www.defense.gov/observe/photo-gallery/igphoto/2001135702/

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Its All About the Data – Enhanced by AI

Photo By: Army Spc. Kayla Anstey, “Digital Transformation, AI Important in Keeping Battlefield Edge” June 9, 2022 960cyber.afrc.af.mil/News

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Contact

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osd.r-e.comm@mail.mil | Attn: Specialty Engineering
https://www.cto.mil

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NAVAL ORDNANCE SAFETY & SECURITY ACTIVITY

NAVSEA
NAVAL SEA SYSTEMS COMMAND
Ordnance Safety & Security Activity

3 November 2022

#24622 - Implementation Guide: Model-Based Systems Engineering (MBSE) for System Safety

Mr. Trung Hoang – NOSSA, N32D
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Background – MBSE for System Safety

- System Safety is the application of engineering and management principles, criteria, and techniques to achieve acceptable safety risk within the constraints of operation effectiveness and suitability, time and cost throughout all phases of the system life-cycle.
  - Identify Hazards
  - Assess and Mitigate associated safety risk
  - Track, Control, Accept, and document safety risks
- Safety Community shall embrace Digital Engineering tools utilized by Engineering to facilitate safety assessments and risk characterization to efficiently support a rapid and accelerated program while maintaining the established safety principles that ensure the development and delivery of a safe systems.
  - Allows System Safety to be part of the DEVSECOP cycle
  - Enable streamline process, documentation and analyses
  - Tracking of safety risks, mitigations and verifications throughout the life cycle
  - Provide a single source of truth for all aspects of a system

Goals of MBSE - System Safety Implementation Guide

- Provide guidance to Program Managers to incorporate system safety programs into their MBSE driven programs
- Provide guidance to System, Software, and MBSE engineers on processes and tasks necessary to integrate system safety into program using MBSE
- Provide guidance to System Safety Engineering on how to execute their MIL-STD-882E tasks and applicable Level of Rigor (LOR) tasks in an MBSE environment
- Provide guidance to Review boards and stakeholders on providing, reviewing, and assessing Objective Quality Evidences from MBSE based programs
- Provide basic MBSE System Safety metamodel to highlight the architecture, rules, constraints, and models that are applicable and useful for safety practitioners

NOSSA

MBSE SSIG History

- MBSE analyses derived from WSESRB SOAR Workshop

- POA&M for MBSE analyses
- Draft MBSE analyses White Paper

- Established Joint MBSE Working Group (bi-weekly)
  - NOSSA
  - OUSD (Specialty Engineering)
  - Army (Huntsville)
  - NSWCDD Safety

- Scope focus on MBSE SSIG
- NAVAIR joined MBSE WG
- MBSE SSIG will included two end products
  - System Safety Implementation Guide
  - System Safety Metamodel (sandbox)

- Development of the sandbox (on going)
- Air Force Joined MBSE WG
- Splinter Group Established to support the demand workloads

- Provide MBSE SSIG Status
- Path forward into FY23

MBSE Working Group Overview

- Joint DoD MBSE analyses effort initiated by Joint Weapon Safety Working Group (JWSWG) in September 2021, MBSE Working Group established in November 2021
  - Members include System Safety, MBSE, Systems Engineering SMEs
  - Representatives from OSD, Navy, Army, Air Force
    - Membership is currently DoD and DoD Contractors
    - Will expand membership to include Industry representatives
    - ~50 members (as of November 2022)
- Two (2) recurring meetings
  - Bi-weekly MBSE Working Group
  - Weekly MBSE Splinter Working Group

Joint DoD Effort to meet Digital Engineering Requirement

NOSSA

Implementation (High Level) Overview

- Establish Ground Rules and Expectations
  - Maintain requirements of MIL-STD-882E
  - Understand the processes and methodologies of System Safety Program Plans
    - Prepare safety artifact formats and templates
- Communication
  - Need to communicate system safety needs/wants to MBSE developers
    - System Safety analysis process, methodology, and templates
  - System Safety needs to have a general understanding of the MBSE tools and SysML
- Collaboration
  - System Safety needs to collaborate with MBSE to understand the basics of the System model in the digital engineering tool
  - System Safety needs to interact with MBSE, Systems Engineering, Software Engineering , and other Stakeholders in order understand system information that is available
  - System Safety is "data hungry" and requires data to fully assess the system(s) under analysis
    - E.g., OV-1 diagram, Functional Block Diagram, Interface Block Diagrams, Requirements, Design Architecture, Schematics, etc.

Communication and Collaboration

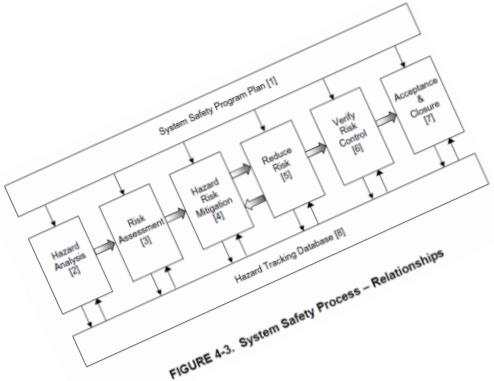


FIGURE 4-3. System Safety Process – Relationships

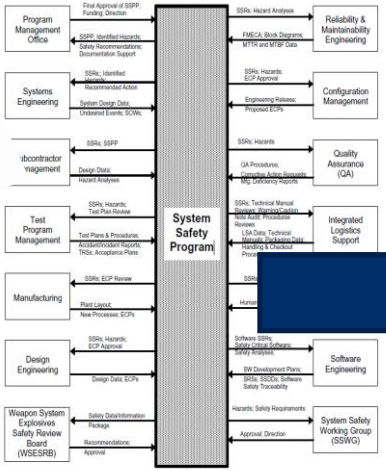


FIGURE 4-5. Major SSP Interfaces and Data Exchange

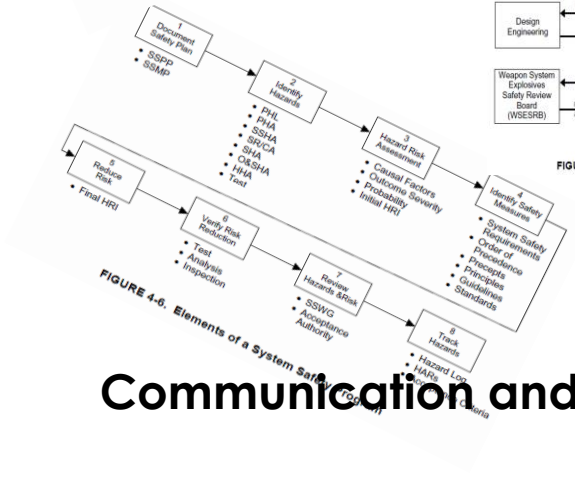
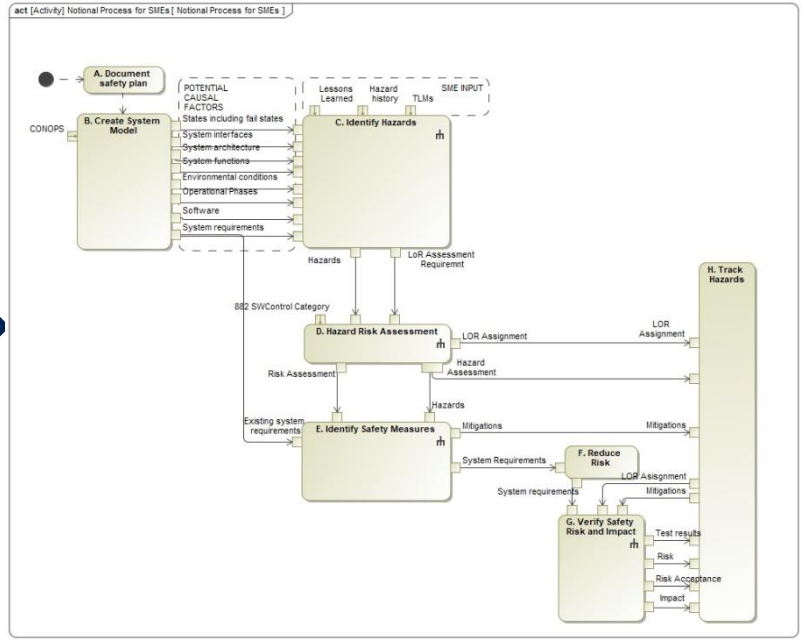
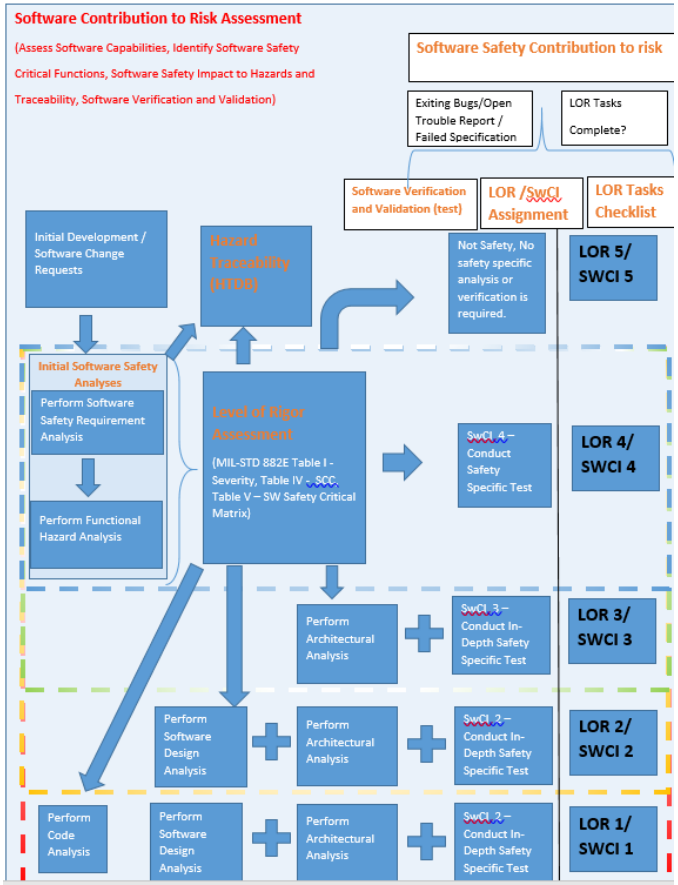


FIGURE 4-6. Elements of a System Safety Program



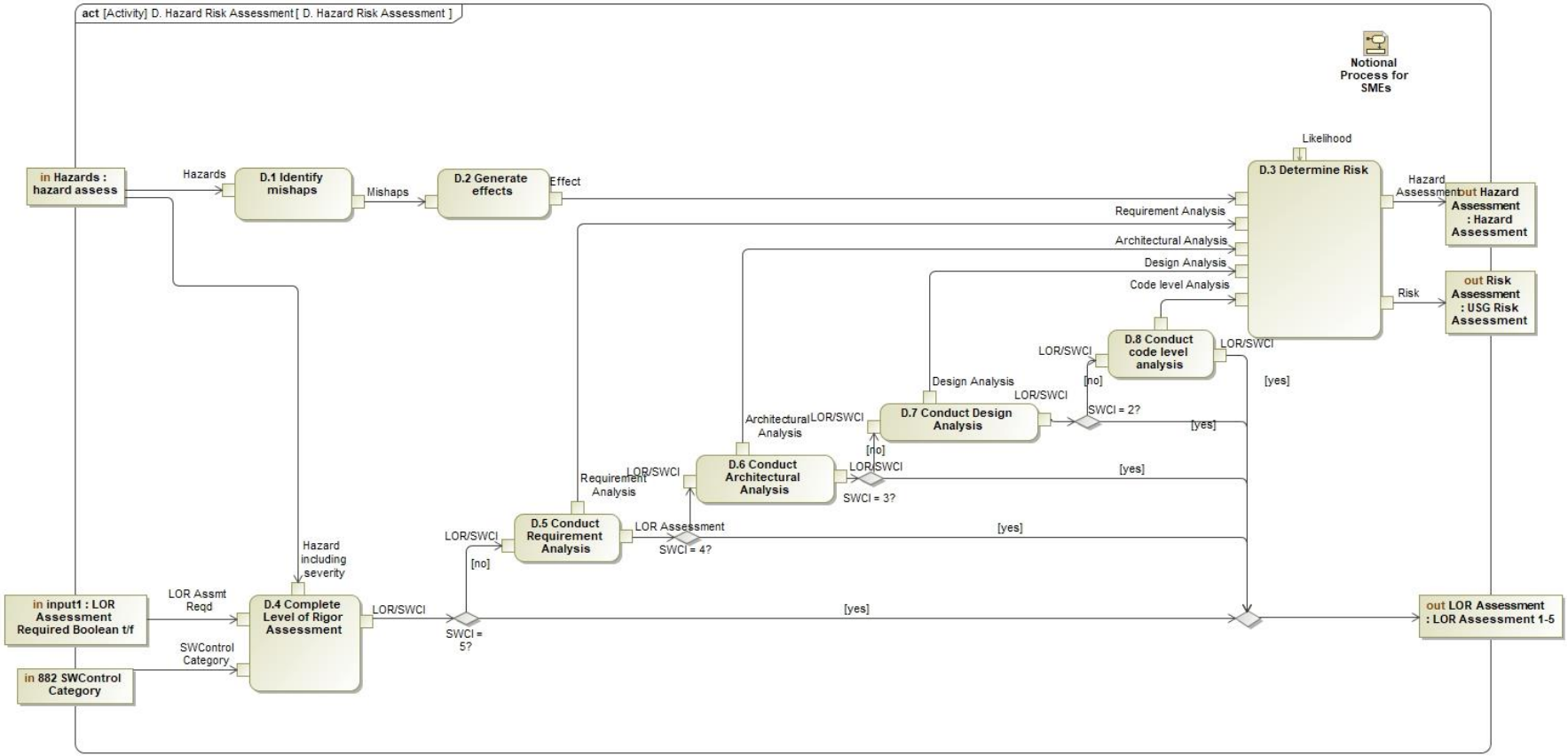
Communication and Collaboration are key to success throughout the program's lifecycle

Example – Software Level of Rigor Process

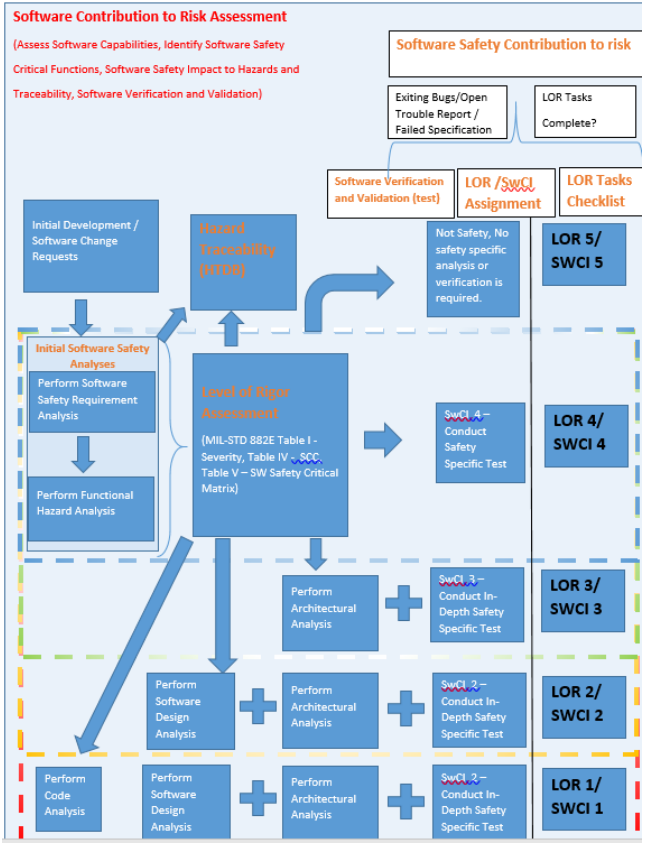


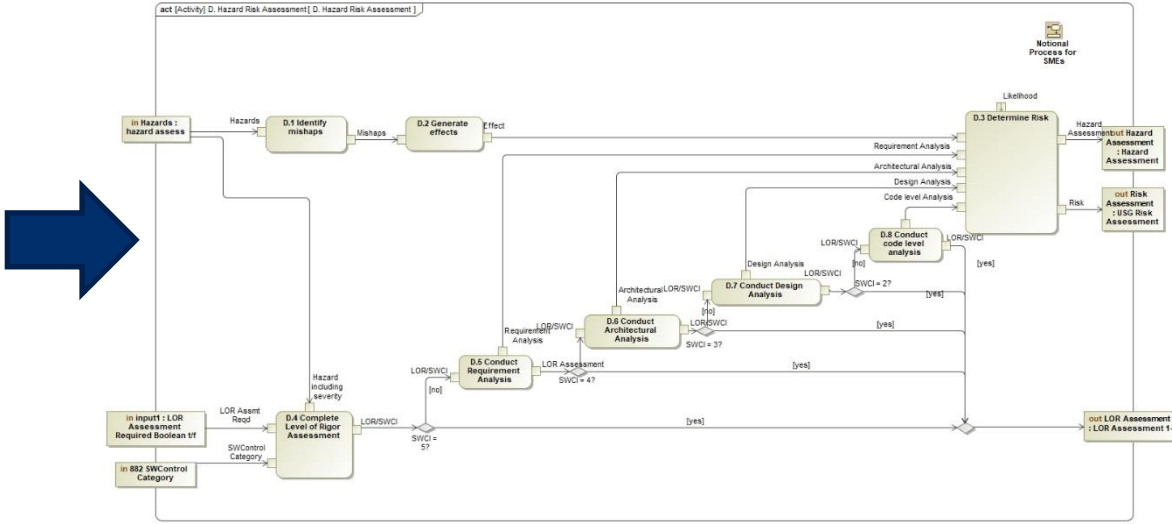
- Software Safety Level of Rigor (LOR) provides a depth and breadth of software analysis and verification activities necessary to provide a sufficient level of confidence for software's contribution to risk
  - Use as a Objective Qualitative Evidence (OQE) to support safety case or rationale
  - Demonstrate the software safety process to independent review boards, other program engineering activities, and/or stakeholders from a System Safety perspective

Example – Software Level of Rigor Process



Example – Software Level of Rigor Process





- Safety Process is within MBSE Model
- Enhancement can be made to incorporate integration features with Software Engineering Team to allow a **single source of truth**
- Could serve as LOR OQE to provide to the Review Board to substantiate adequate completion of LOR

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Challenges and Lessons Learned (so far)

- Maintaining System Safety perspective of "out-of-the-box" thinking for thorough safety analyses and risk characterization
  - MBSE provides a design perspective, limited operational perspective
- Communication between MBSE and System Safety
  - Need to cross reference of terminology between MBSE vs. System Safety vernacular
- Maintaining Configuration Management (CM) of models
  - Best to work in Teamwork Cloud environment to maintain CM
  - Safety Analyses are typically a snapshot in time, need to determine CM for organic, real-time data
- Determine if safety data will be fully digitized via Dashboard or exported to document file(s) (e.g., MSWord, Excel)
  - Need to have system safety dashboard ("Start Here") to ensure external stakeholders can easily navigate models (containment trees, diagram trees, structure trees)
- Ability for all users to adapt and evolve from entrenched processes
  - Need to develop best practices for reviewing System Design information in DE environment
  - System Safety needs to learn from MBSE and Systems Engineering SMEs, and MBSE SMEs need to learn from System Safety
  - Instead of having separate hazards analyses such as a PHA, SRHA, FHA, SHA, SSHA, HHA, and O&SHA, have a single real-time Hazard Analysis that assesses all attributes of the 882E tasks in the digital engineering environment to gain efficiencies while not sacrificing system safety analysis rigor
- Need to know desired outputs from other engineering activities in order to be effective in MBSE environment
  - Integration between engineering activities and MBSE developers
  - Cross-engineering traceability between hazards, mitigations, system requirements, tests, verification, etc.

Challenges are being identified and understood
Our goal is to address these challenges in the Implementation Guide

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Activities

- Phase 1 (Near-term)
  - Integrate into mock-up model to validate safety model and methodologies
    - Ensure safety attributes can be documented and tracked in model
    - FHA Template/Worksheet can be exported and viewed by third party reviewer
    - Interface Data can be cross-referenced with the model
  - Using Safety Sandbox to conduct "partial" Functional Hazard Analysis (FHA)
  - Developing System Safety Dashboard (landing page)
  - Complete Draft MBSE System Safety Implementation Guide (SSIG) to document lessons-learned, challenges, and recommendations for successful System Safety Program execution in MBSE environment
  - Draft MBSE SSIG to be reviewed and vetted through JWSWG

- Phase 2 (Future)
  - Expand Safety Sandbox to include more safety analysis tasks and Hazard Tracking System (HTS)
  - Collaborate with Warfare Centers to create plans for Workforce Development and training
  - Promulgate current MBSE SSIG for guidance to DoD and Industry

Summary & Conclusion

- MBSE Implementation Guide is a joint effort from all services and will be released under DOD documentation
- The objective of the Implementation Guide is to ease the system safety adaptation/transition to MBSE
- Both MBSE Implementation Guidance documentation and sand box model will be made available for all stakeholders once released
- New members (MBSE developers) are welcome to support the working groups
  - To include expanding MBSE Working Group Membership to Industry representatives to leverage best practices / lessons learned

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Questions/Answers

Sustainability Analysis in the Adaptive Acquisition Framework

2022 NDIA Systems & Mission Engineering Conference

Mr. Michael S. Bruckner and Ms. Emma Williams,
Noblis support to
Office of the Assistant Secretary of Defense for
Energy, Installations, and Environment (OASD(EI&E))
03 November 2022

Distribution A: Approved for Public Release. Distribution is Unlimited

Outline

- **Acknowledgements and Introduction**
- **Background and Policy**
- **Resources and Methodology**
- **Application in RDT&E**

Acknowledgements

Dr. Patricia Underwood, ODASD(E&ER)

Mr. David Asiello, ODASD(E&ER)

Dr. Robin Nissan, SERDP-ESTCP

Dr. Wes Ingwersen, EPA/ORD

Mr. Michael Bruckner, Noblis

Dr. Kelly Scanlon, IPC

Mr. Scot Bryant, Noblis

Dr. Andrew Henderson, ERG

Ms. Emma Williams, Noblis

Dr. Shannon Lloyd, Concordia University

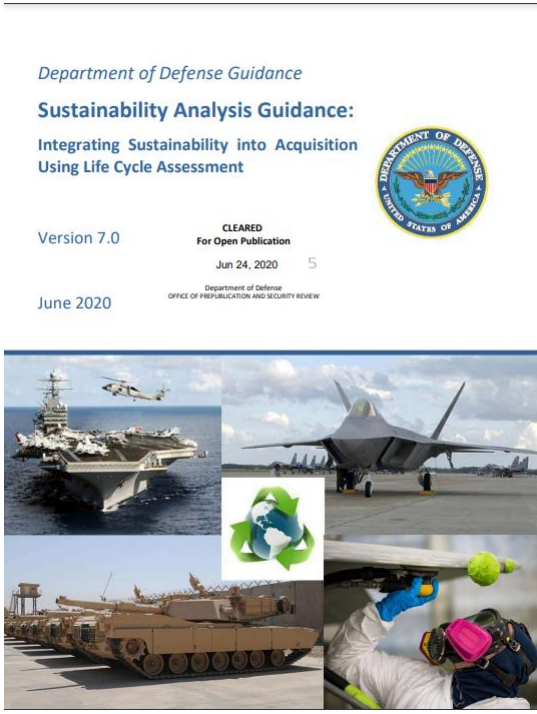
Sustainability Analysis Introduction

- **Sustainability Analysis facilitates incorporation of sustainability considerations in Defense Acquisitions**

- **Sustainability Analysis quantifies life cycle costs, emissions, and environmental impacts of design decisions.**
  - Can be used to identify the most sustainable alternative among those that meet performance requirements.
  - Quantifies emissions (e.g., GHGs) and usage of energy, water, waste, chemicals
  - Users include weapon system managers, product support managers, RDT&E Programs

- **Sustainability Analysis resources include:**
  - Sustainability Analysis Guide (SAG)
  - Supply Chain Emissions Factors (i.e., DoD Scoring Factors)
  - Example analyses available for public use
  - Short Course materials (e.g., Short Course at SERDP-ESTCP Symposium)

- **The SAG provides a description of how to meet sustainability requirements within Adaptive Acquisition Framework.**



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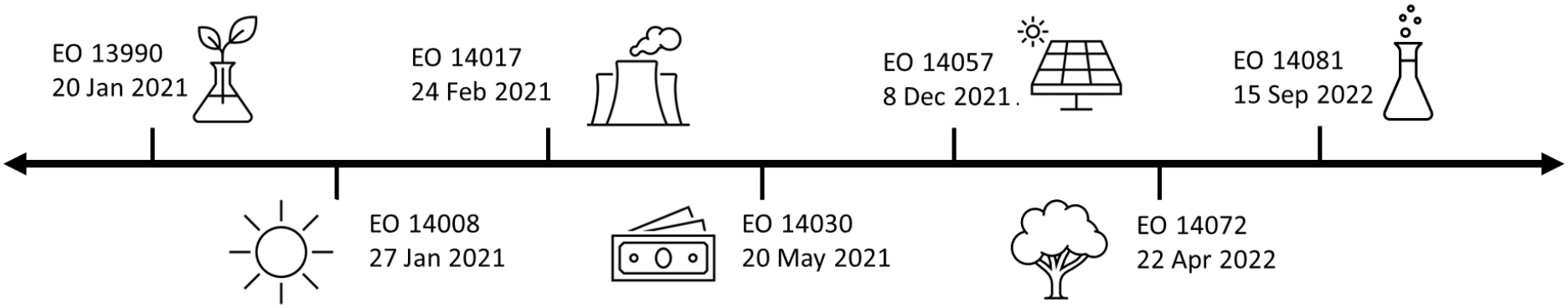
Sustainability Requirements Span Executive Orders (EO)



EO 13990

- Incorporate Social Cost of Greenhouse Gases (SC-GHG) in areas of decision-making, budgeting, and procurement.
- Limit exposure to dangerous chemicals and pesticides;, including to low-income and communities of color.

EO 14008

- Orders climate considerations to be an essential element of United States national security policy.
- Climate crisis requires significant short-term GHG reductions and net-zero emissions by mid-century or before.

EO 14030

- Requires suppliers to (1) disclose greenhouse gas emissions and (2) disclose climate-related financial risk and (3) set science-based reduction targets.
- Orders agencies to consider the SC-GHG in procurement decisions and, where appropriate and feasible, give preference to bids and proposals from suppliers with a lower SC-GHG.

EO 14017

- Agencies required to assess climate risks to the availability, production, or transportation of critical/essential goods.

EO 14057

- Federal Government to lead by example in order to achieve a carbon pollution-free electricity sector by 2035 and net-zero emissions economy-wide by no later than 2050.
- Secure a transition to clean, zero-emission technologies and transform procurement and operations

EO 14072

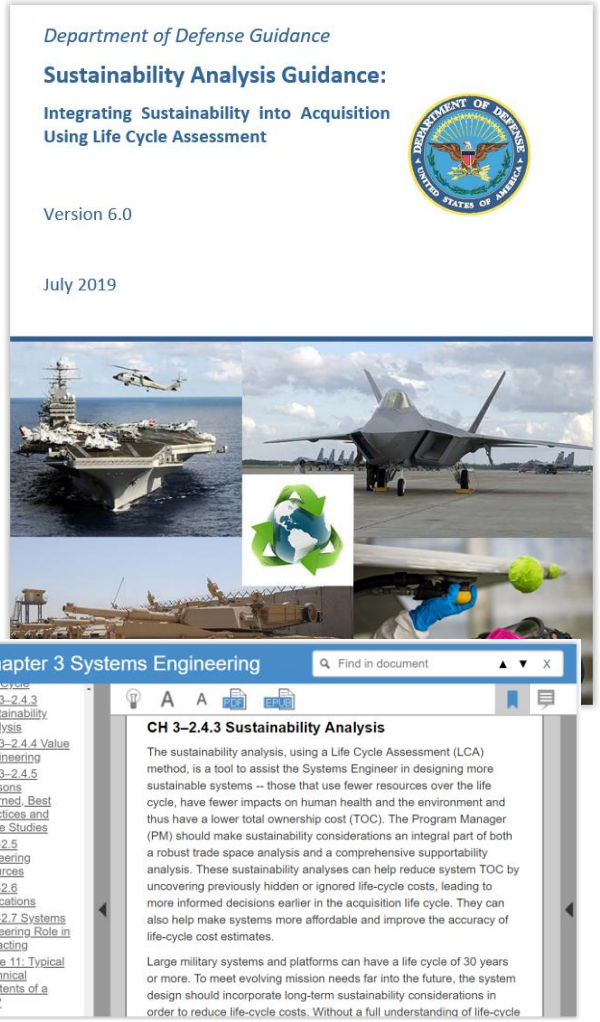
- Develop policies to institutionalize climate-smart management and conservation strategies of forests on Federal lands

EO 14081

- Harness Biotechnology and Biomanufacturing R&D sustainably and increased biobased procurement

The Adaptive Acquisition Framework includes Sustainability Considerations

- **Environment, safety, and occupational health (ESOH) must be considered during the acquisition process and for the duration of a system's life cycle.**
  - "DoDI 5000.02 requires … appropriate measures be taken to reduce O&S costs by influencing system design early in development…. since the opportunities to reduce O&S costs decline significantly as the system design evolves." (Operating and Support Cost-Estimating Guide; CAPE 2014)
- **Sustainability Analysis Guide (SAG) provides a full description of how to incorporate sustainability consideration in support of acquisition requirements.**
- **SAG includes traditional "internal" life cycle costs in addition to often-overlooked "external" costs.**
  - Includes the Social Cost of Greenhouse Gases (SC-GHG)
- **The SAG is in the process of being updated in accordance with new policy**



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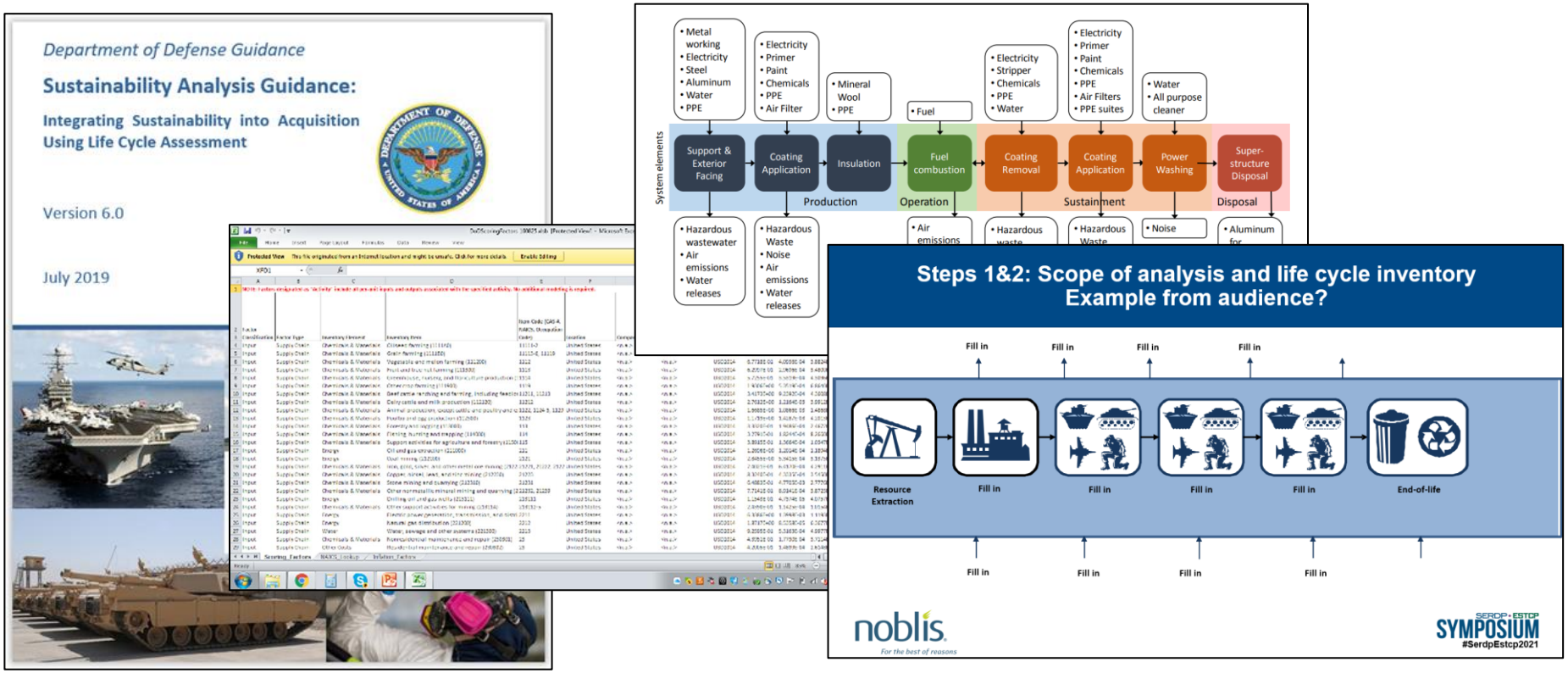
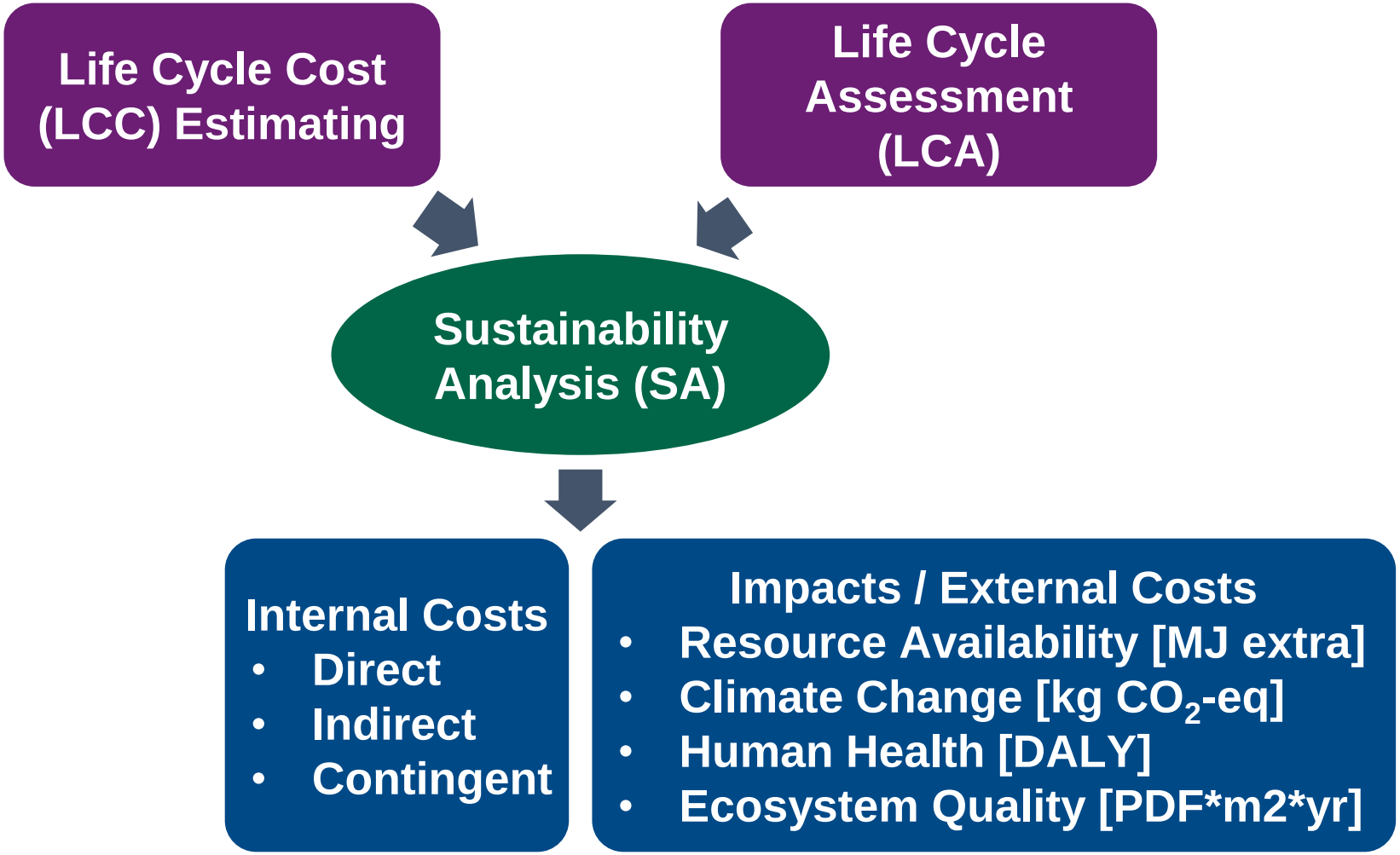
Sustainability Analysis Resources

- **Sustainability Analysis Guide**
- **Supply Chain Emissions Factors**
  - (i.e., DoD Scoring Factors)
- **Example analyses**
- **Short Course materials**



Link to guide and resources: https://denix.osd.mil/esohacq/home/

Sustainability Analysis Guide Methodology



Example Inputs and Outputs

Inputs, Outputs, and Impacts

Inputs & Outputs

Required:
- Energy
- Chemicals and Materials
- Water
- Land
- Releases & Waste
- Procured Goods
- Procured Services

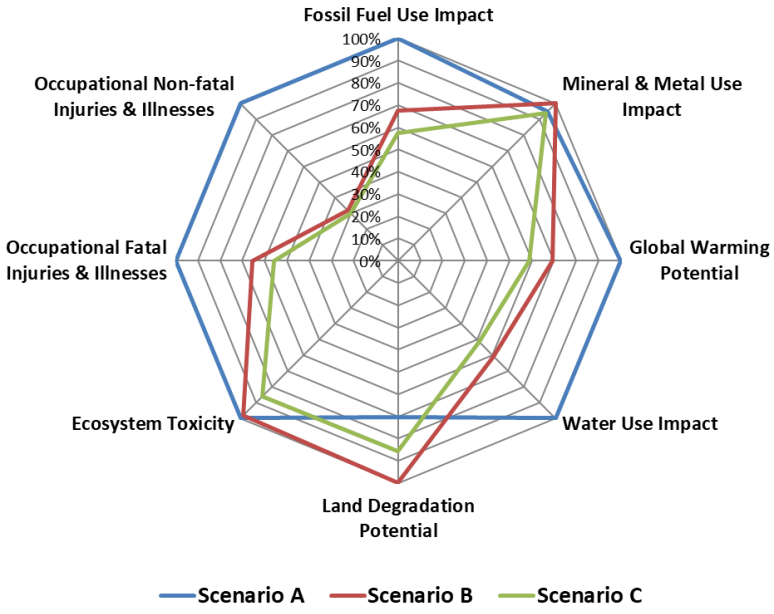
Midpoint Impacts

Required:
- Climate change
- Ecosystem toxicity
- Water use
- Fossil energy use
- Land use
- Mineral use

Endpoint Impacts

Required:
- Climate change
- Human health
- Ecosystem quality
- Resource availability

Example Results from LED Lighting for Littoral Combat Ships



Sustainability Analysis quantifies emissions (to air and water) and usage of energy, water, waste, chemicals. Emissions and energy are translated to impacts (e.g., global warming potential, ecosystem quality).

DoD Supply Chain Emissions Factors

- **Support estimates of supply chain emissions**
  - Support tool that accompanies SAG
  - Scoring factors translate product spend data to emissions and environmental impacts
  - Estimates include Scope 3 GHG emissions
- **Support estimates of supply chain (Scope 3) GHG emissions**
- **Uses defense specific model**
  - Defense Input Output (DIO) model
  - Aligns with EPA USEEIO model, incorporating the latest available information from BEA, TRI, US GHG Inventory, NEI, etc.
  - Model is currently in the process of being updated.
- **Estimates Social Cost of Greenhouse Gases (SC-GHG)**
  - Scoring factors calculate CO2-eq and SC-GHG.
  - Factors need to be updated to align with new SC-GHG values.
- **Estimates other environmental impacts (e.g., Ecosystem Quality)**
- **Available at https://www.denix.osd.mil/esohacq/index.html**

Supply Chain Emissions Factors Example

Estimate emissions and SC-GHG by spend data and NAICS code

Inventory Element	Inventory Item	Item Code (CAS #, NAICS, Occupation Code)	Location	Climate change *kg CO2-eq*	SC-GHG USD2014
Chemicals & Materials	Turned product and screw, nut, and bolt manufacturing (3	33272	United States	4.9590E-01	8.0454E-02
Chemicals & Materials	Coating, engraving, heat treating and allied activities (33	3328	United States	7.6120E-01	1.0618E-01
Chemicals & Materials	Valve and fittings other than plumbing (33291A)	332911-2, 332919	United States	3.8079E-01	7.0321E-02
Chemicals & Materials	Plumbing fixture fitting and trim manufacturing (332913)	332913	United States	3.4646E-01	8.0682E-02
Chemicals & Materials	Ball and roller bearing manufacturing (332991)	332991	United States	4.2769E-01	5.7778E-02

Estimate emissions and for defense specific activities by mass-based unit

Inventory Element	Inventory Item	Item Code (CAS #, NAICS, Occupation Code)	Location	Inventory Item Unit	Climate change *kg CO2-eq*	SC-GHG USD2014
Energy	Electricity use, average generation mix	<n.a.>	South Carolina, U.S.	MJ	1.2987E-01	2.0315E-02
Energy	Electricity use, average generation mix	<n.a.>	South Dakota, U.S.	MJ	1.1739E-01	2.1484E-02
Energy	Electricity use, average generation mix	<n.a.>	Tennessee, U.S.	MJ	1.6533E-01	2.2161E-02
Energy	Electricity use, average generation mix	<n.a.>	Texas, U.S.	MJ	1.8444E-01	2.4500E-02
Energy	Diesel combustion in light utility vehicle	<n.a.>	Global / Unspecified	L	3.2083E+00	4.8942E-01
Energy	Diesel combustion in locomotive	<n.a.>	Global / Unspecified	L	3.2702E+00	5.3791E-01

The Emissions Factors are available to estimate emissions or impact of design decisions during acquisitions

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Example Requirement: Strategic Environmental Research and Development Program (SERDP) Statements of Need (SON)

Example: Development of Advanced Coating System (WPSON-20-C1)

- Objective: **New, innovative advanced protective coatings and systems**
  - Improved protective properties
  - Require few resources
  - Easier to use
  - Environmentally sustainability
- **The "new" system must be able to meet performance requirements** …
  - Operational protective properties
  - Less complex application techniques
  - Ability to selectively strip or apply coatings
- … and, it **must be more sustainable** …
  - Reduced life cycle costs and impacts associated with human health and the environment
  - Energy efficient
  - Improved chemistry
- … **when compared with current and legacy systems**.

Example requirement: Hydrofluorocarbon (HFC) alternative SON

- HFCs are high global warming potential (GWP)
  - AIM Act requires a phase down of usage based on global warming potential (GWP) values
  - Identified as critical to the United States reaching its Paris Agreement GHG goals
  - Integrated in weapon systems subsystems

- SERDP and ESTCP released a SON for low GWP-HFC alternatives
  - “The objective of this SON is to identify, develop and test lower-GWP alternatives to refrigerants in use by the Department of Defense”
  - Pre-proposals are due the first week of January.

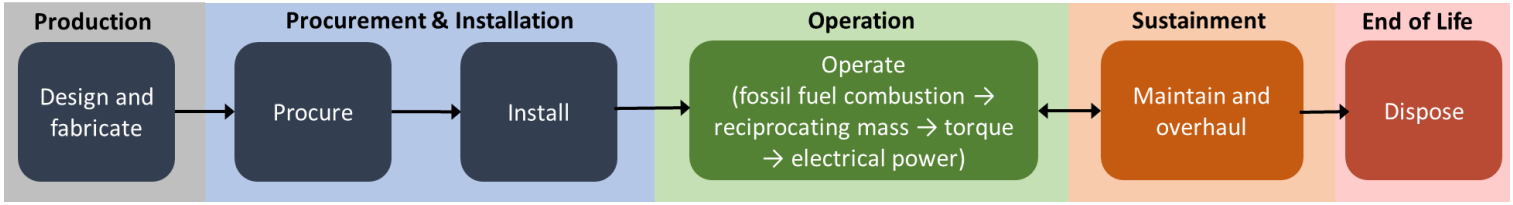
Sustainability Analysis can be used to quantify life cycle GHG emissions reductions and costs.

Example Applications across DoD

- Chromium plating alternatives for weapons systems components in the Navy
- LED Lighting on a littoral combat ship
- Additive vs. traditional manufacturing for aviation fuel nozzles
- Back-up and renewable power scenarios at Fort Hood, TX
- **Alternative engine designs for T-AGS(X) Naval Oceanographic Vessel**
- Sustainable alternative to C-4 Demolition Brick
- PFAS-free alternative firefighting foam replacement

Example Alternative engine designs for T-AGS(X) Naval Oceanographic Vessel

- Pilot Project Scope
  - Compare seven diesel engine combinations (ECs) (including baseline) with two air emissions compliance tiers, in accordance with OPNAVINST 5090.1.
    - Baseline: Shipboard EC with EPA Tier 3 (T3) emissions control



  - Assess return on investment (ROI) and cost savings, and minimized trade-off penalties imposed on fuel consumption, range, payload, availability, useful life, and LCC.

- Partnership

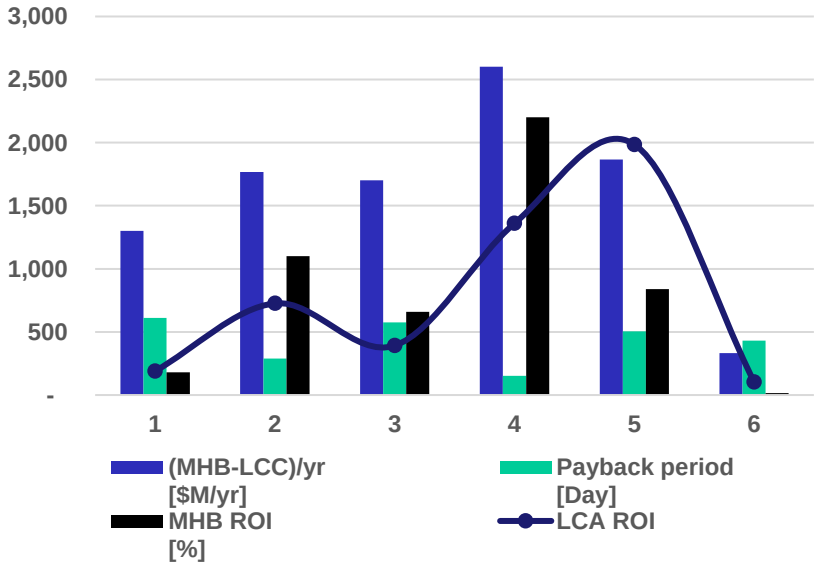
NAVSEA NAVAL SEA SYSTEMS COMMAND

NAVSEA WARFARE CENTERS Philadelphia

Example Alternative engine designs for T-AGS(X) Naval Oceanographic Vessel

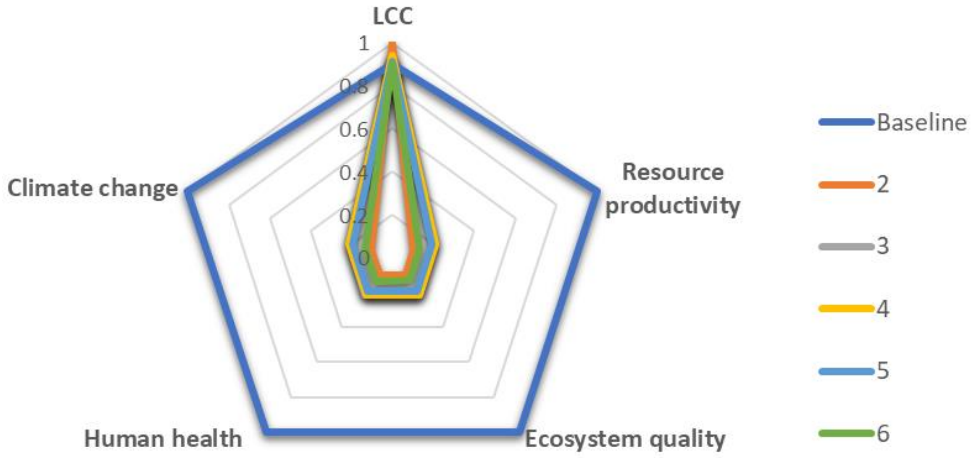
Monetized Health Benefit (MHB) and LCC Results

- Costs included installation design, procurement, installation, operation, and maintenance and overhaul.
- Annual savings (MHB - LCC) are 330 - 2,600 $K/yr.
- Payback period is 5 - 20 months.
- MHB ROI is 10 - 2,200%.



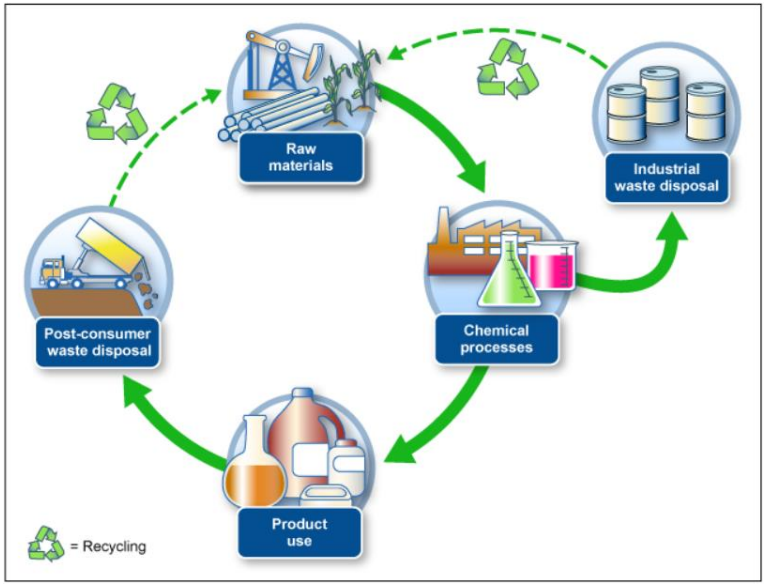
Endpoint Impacts and LCC Results

- Normalized all systems (baseline and alternatives) to the worst-performing system.
- Decreased internal costs and potential environmental liability for the Navy when the following alternatives are selected (EC 4 , 2, 5, 3, 1, and 6, in descending ROI order).



Next Steps

- DoD SAG will be updated to align with new policy and requirements
- Supply chain emissions factors will be updated with increased resolution for defense sector
- Development of DoD-relevant pilot studies
- Short course at 2022 SERDP-ESTCP symposium
- Development of toolkit for RDT&E application



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Questions?

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Mission Drivers

- **Mission Performance**
  - Improved performance – recent technology enhancements
  - Improved logistics – shorter tail, less material into the field
- **Price versus Cost over Life Cycle – Better Value**
  - Use and dispose of less, longer life cycle, increase affordability
- **Material Availability**
  - Made from domestically sourced materials offering increased supply chain security
  - Reduced dependency on fossil fuels
  - Reduced impact on non-renewable resources
- **Reduced Health and Environmental Impacts**
  - Reduced exposure to hazardous materials – lower liability
  - Lower impact on personnel, operations and training lands

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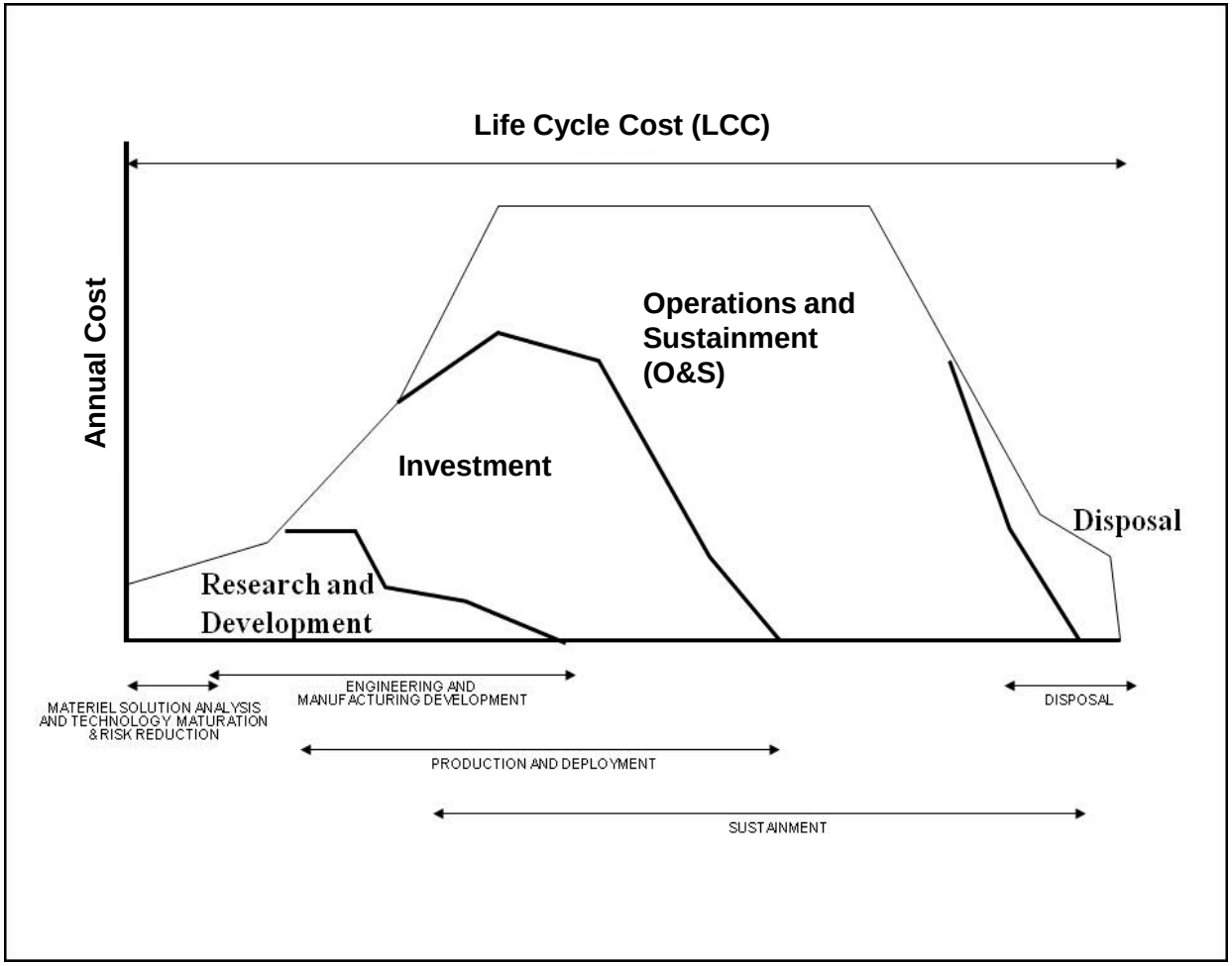
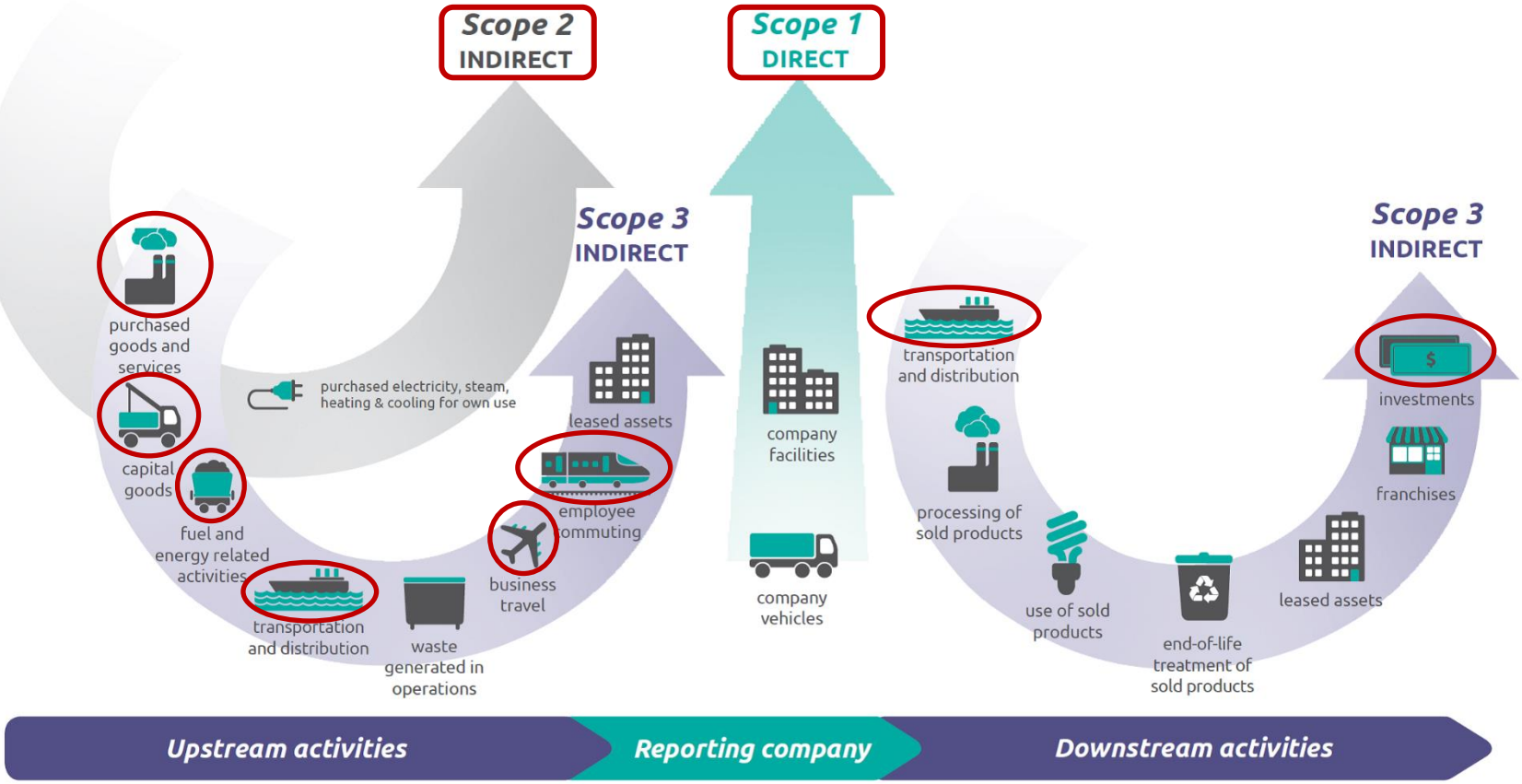
Systems Engineering and Defense Acquisitions



- ~80-90% of LCC committed during R&D
- 60-80% of LCC incurred during O&S

Systems engineering approaches, including sustainability analysis, are needed from cradle to grave

GHG emissions captured as part of sustainability analysis



Hybrid Digital Twin Technology for Predictive Maintenance

November 3, 2022

Dr. Reni Raju
Director, Business Development

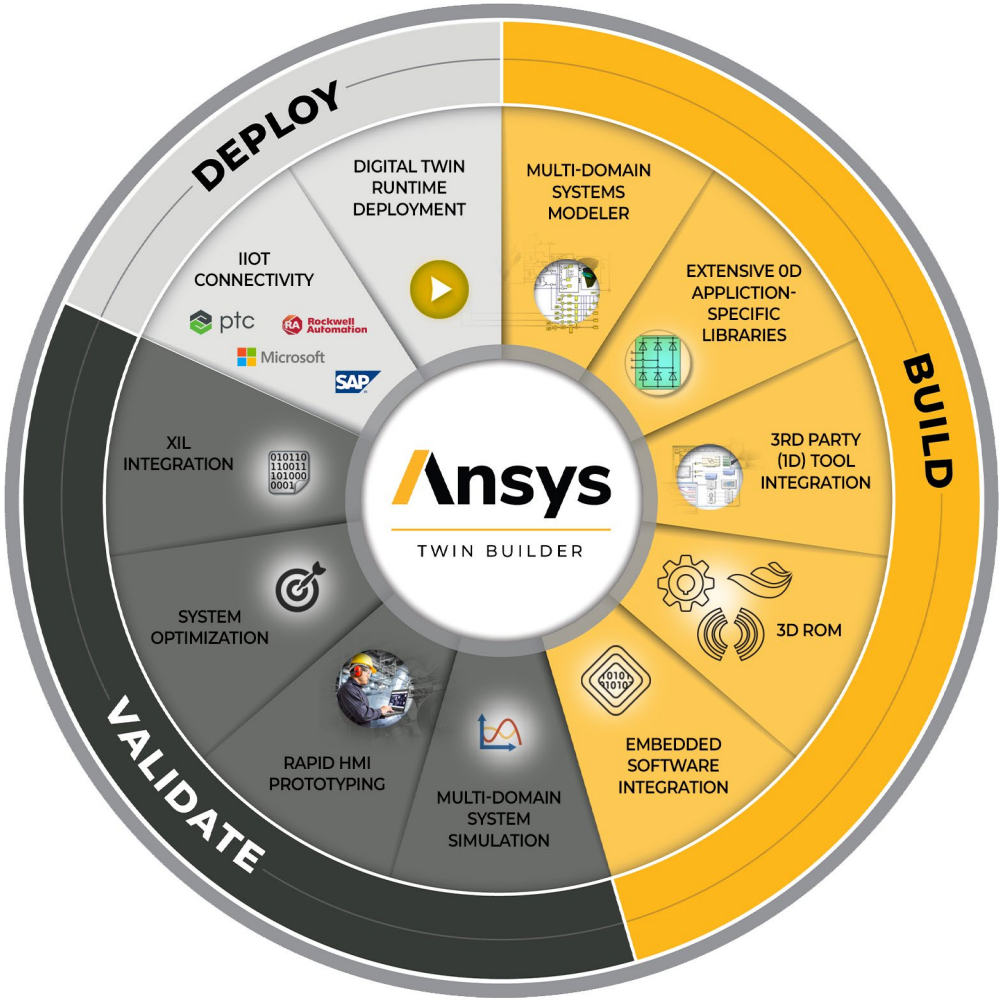
Dr. Matt Adams
Lead Product Specialist, Digital Twin

Approved for public release

Ansys

Overview

- Intro
- Digital Twin Challenges
- Hybrid Solution
- Hybrid Analytics Capabilities



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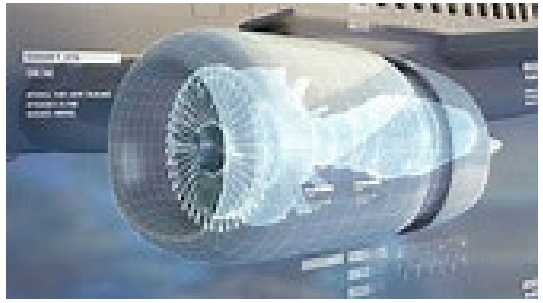
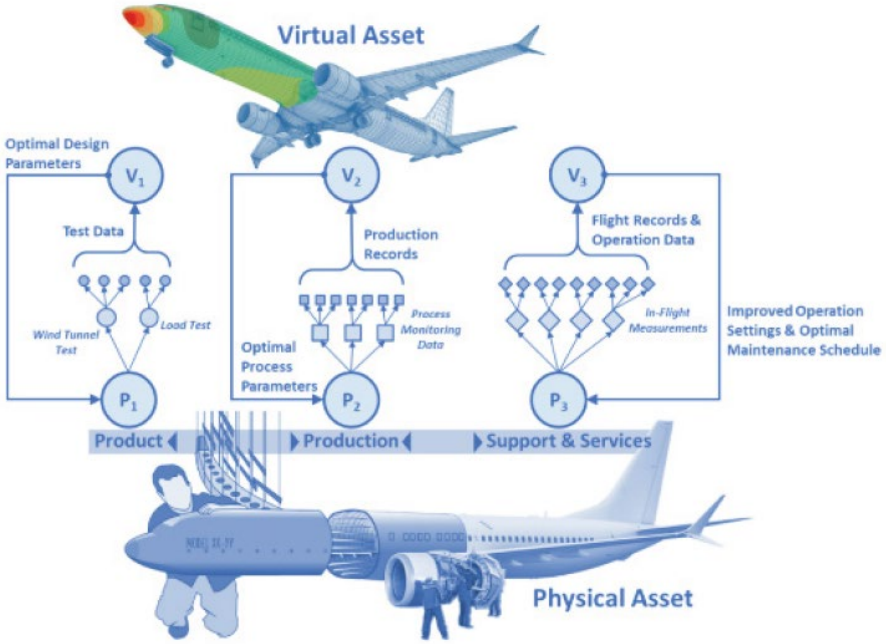
Digital Twins

A Digital Twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity.

A Digital Twin is a **Virtual Representation** of a **<u>connected</u> Physical Asset**





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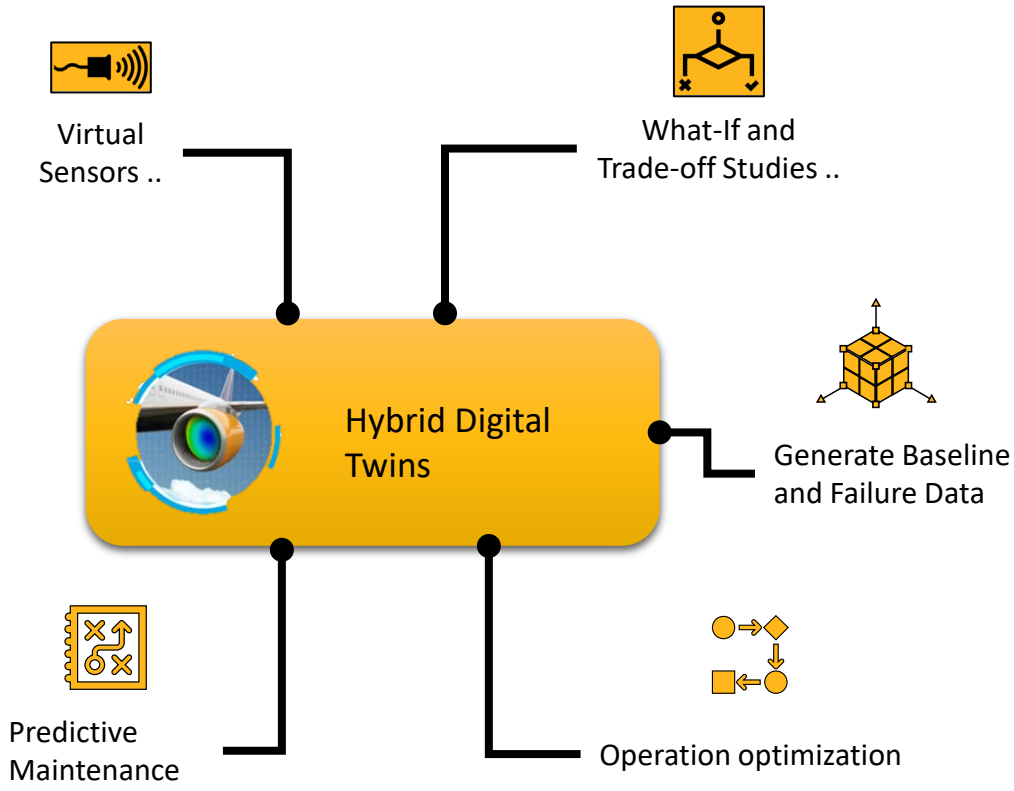
Value of Digital Twins

Detect, prevent, predict, and optimize through real time analytics to deliver business value

Virtual Commissioning, Trouble Shooting and System Configuration

Predictive and Prescriptive Maintenance

Production Optimization and Yield-as-a-service



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Challenges in Creating a Digital Twin

Accuracy

Adhere as closely as possible to physical behavior

Adaptability

Adapt to changing environments and conditions

Flexibility

Model multiple scenarios without overfitting to any one

Scalability

Rapidly build and deploy adaptable Digital Twins

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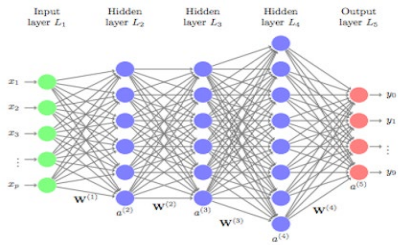
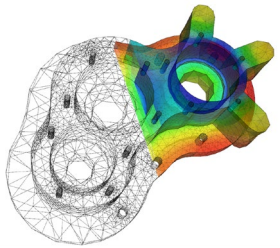
Digital Twin Challenge: Accuracy, Time & Cost



Data-Driven Modeling

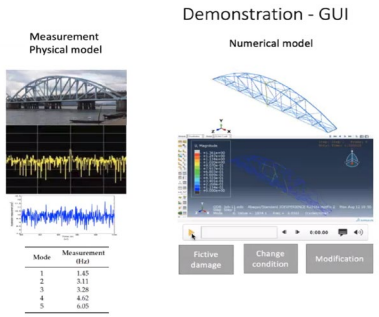


Design & simulation information not readily available / usable

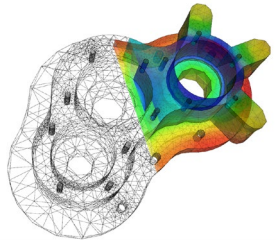
Model Development

Large volumes of process data required for training

Insufficient accuracy, limited by observed data



Simulation-Based Modeling



Difficult to accurately model the as-operated performance of equipment

Model Development

Lacking ability to incorporate available data into models

Long, expensive time scales to develop & deploy

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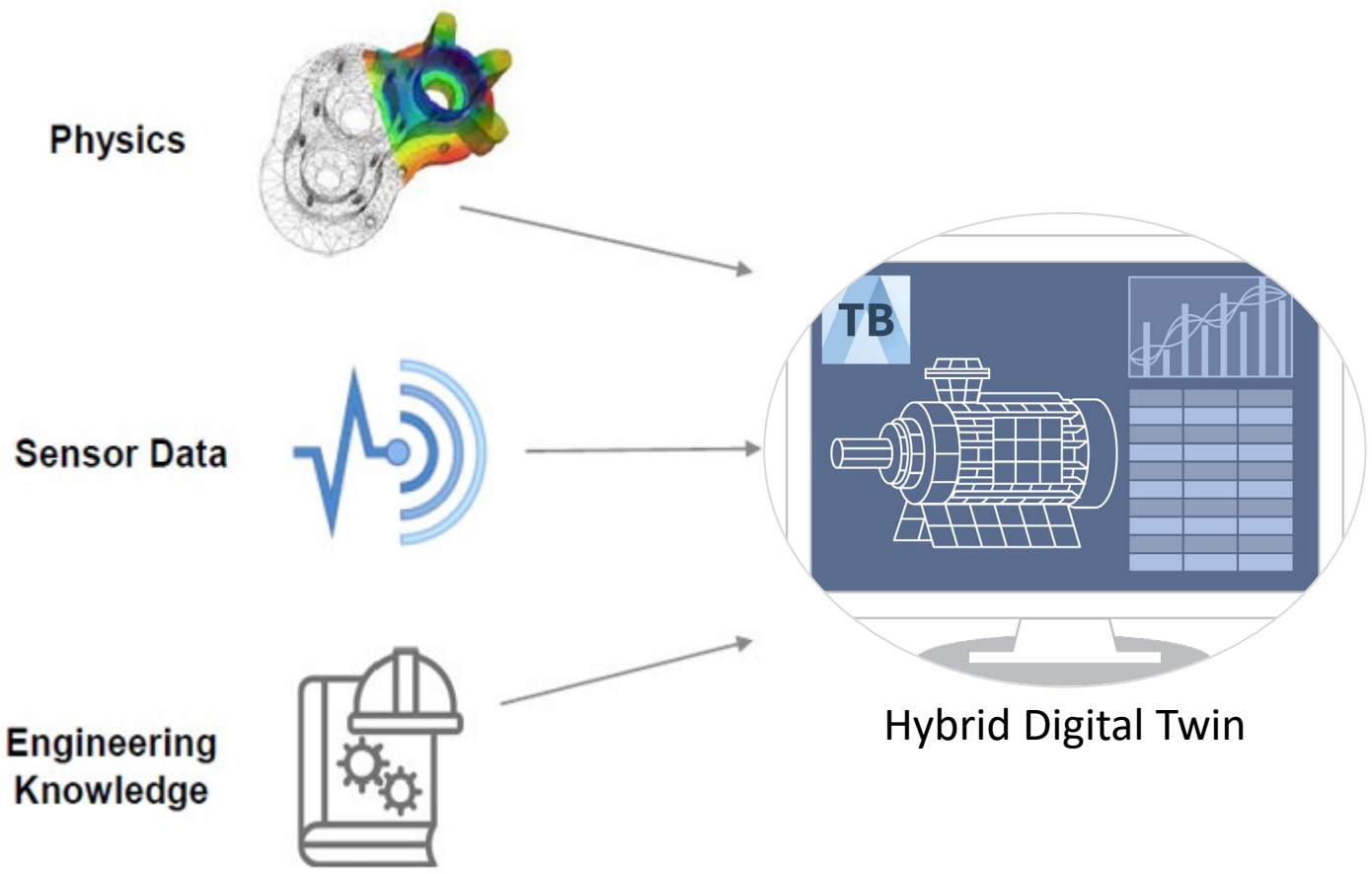
Solution = Hybrid Digital Twin



- Combine the best of both approaches
- Use all available information from engineering, physics, and data
- Integrate into a Hybrid Digital Twin

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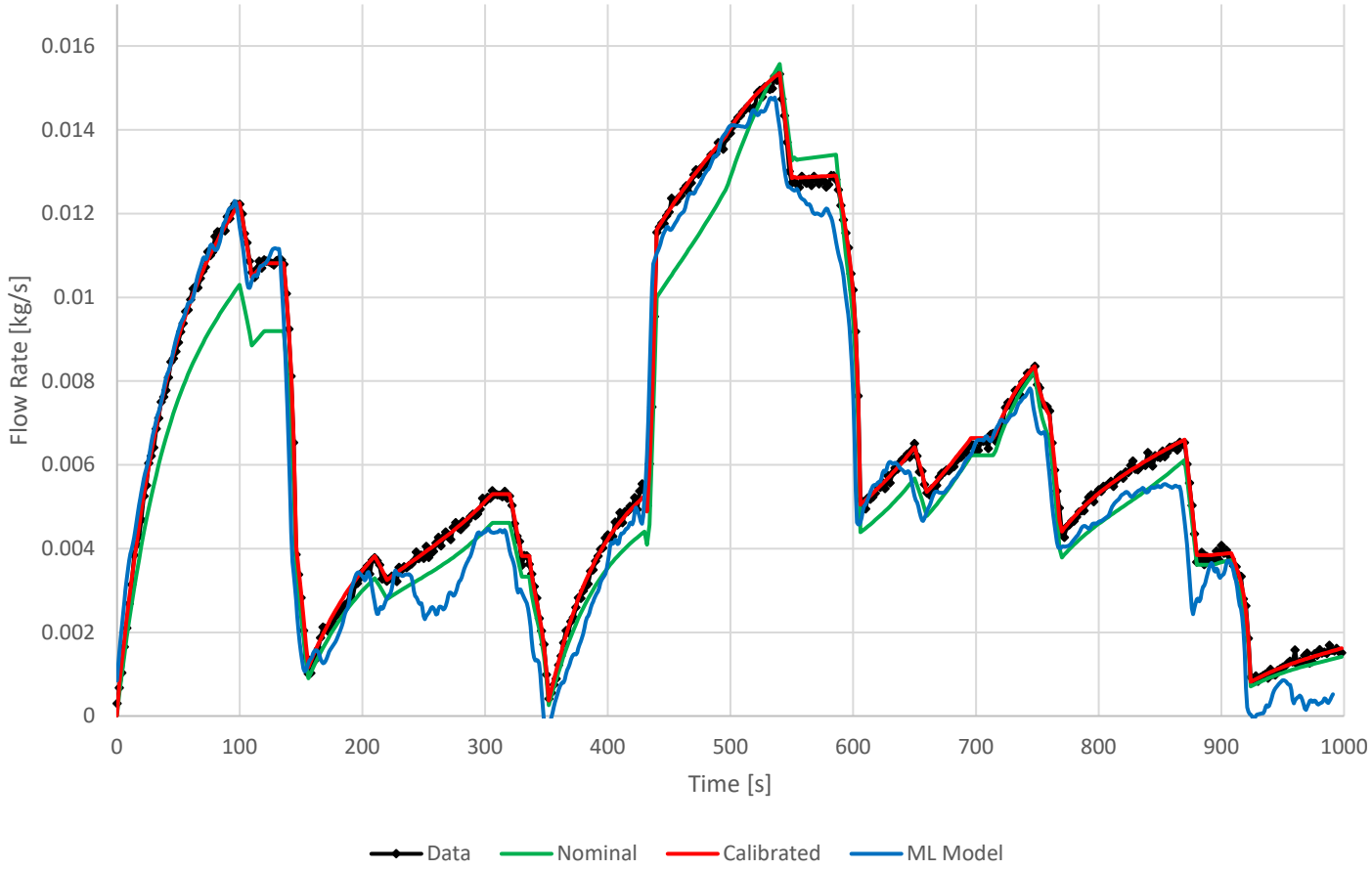
The Hybrid Approach

- Data and Simulation approaches each make reasonable predictions, but also both face limitations

- Using the same data and the same physics model, the Hybrid Approach resents a better, more efficient solution.



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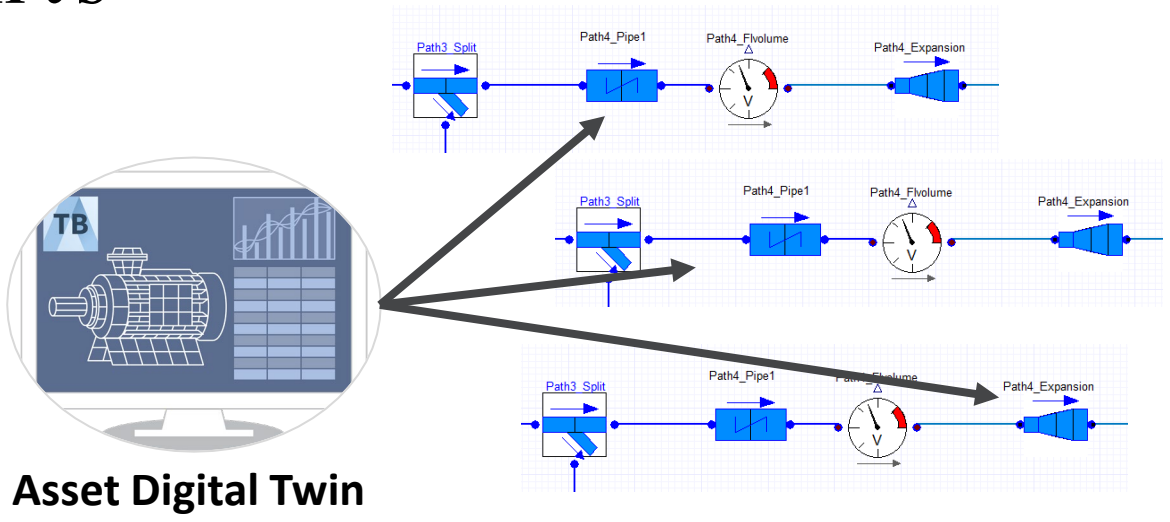
Use Case – Fleet Deployments

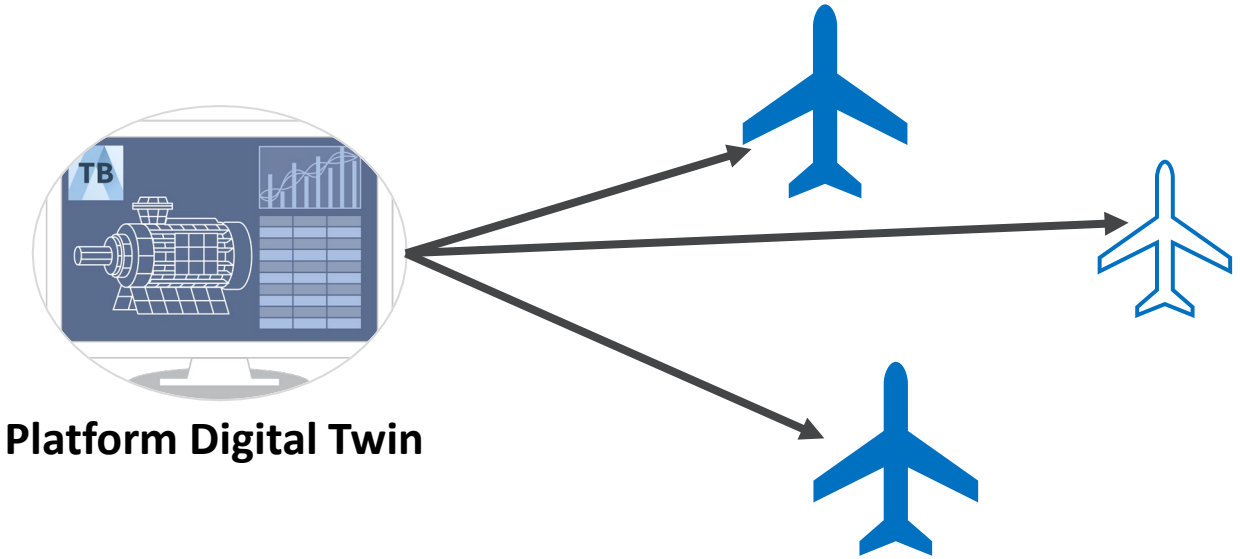
Challenges

- Deploy the same Digital Twin to multiple assets in a fleet
- Adapt the twin behavior to each asset as it evolves independently of others in the fleet



Solution

- Use data from each asset to update and adjust the twin to match the asset's unique behavior and environment



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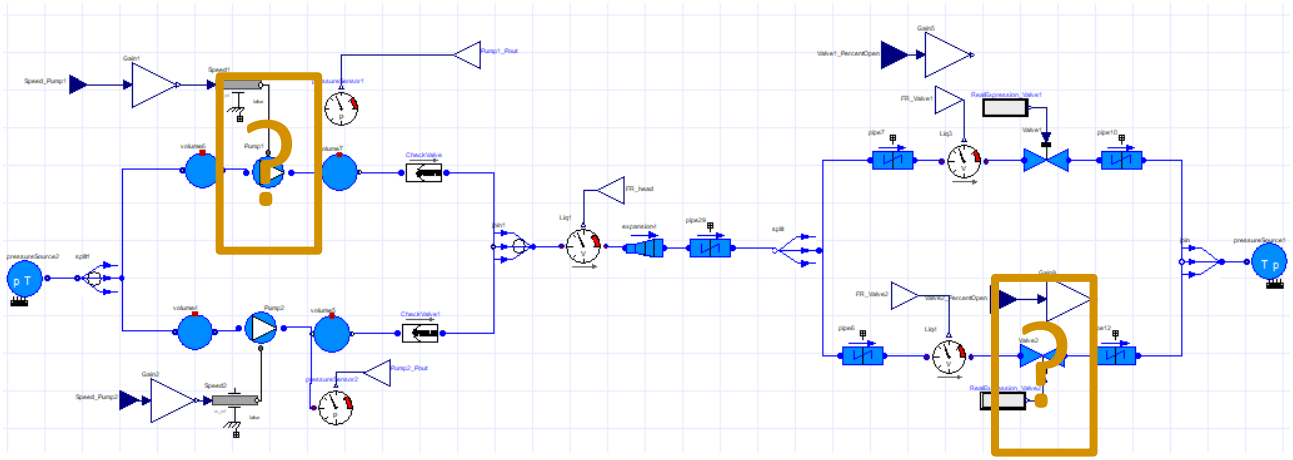
Use Case – Brownfield Deployments

Challenges

- Operators have incomplete information for their system
  - Missing specs or drawings
  - OEM protected IP
- Asset behavior may have changed over time



Solution

- Learn missing behavior/information my enhancing a model with data

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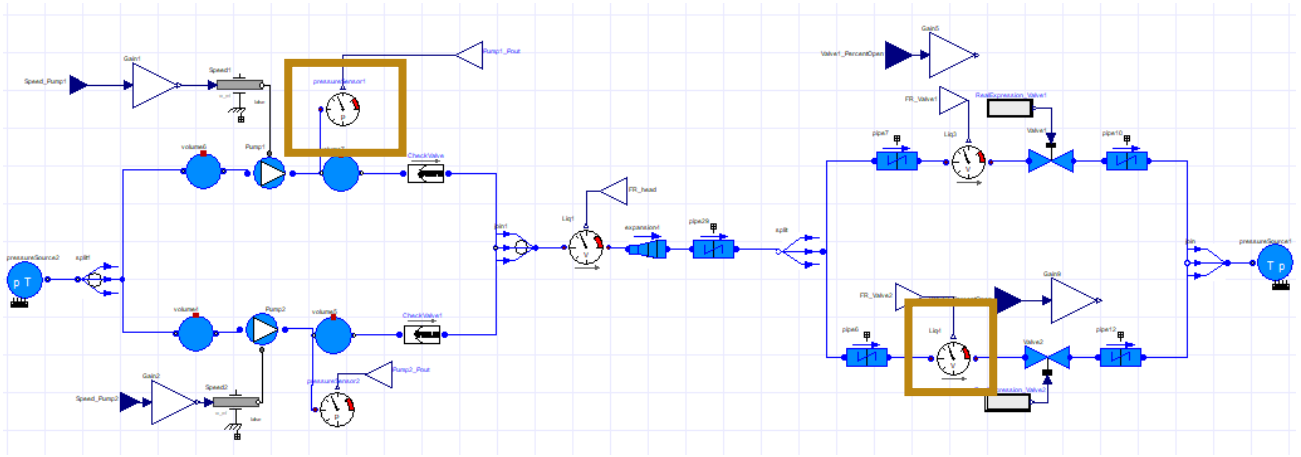
Use Case – Greenfield Deployments

Challenges

- Physical sensors are expensive



Solution

- Decrease cost by replacing physical sensors with virtual sensors
- Optimize where to place sensors

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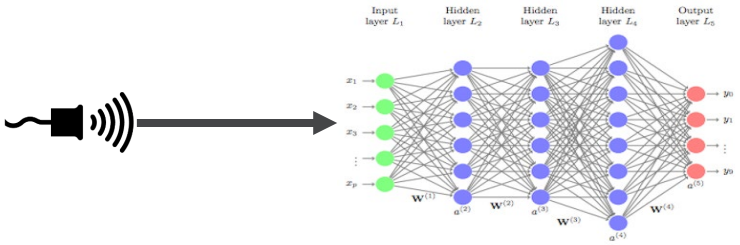
Use Case – Virtual Sensors

Challenges

- Missing information for data models
- Inability to collect with physical sensors either due to cost or because there is not sensor for desired information



Solution

- Virtual sensors provide missing information
- Validate Digital Twin with some physics sensors and predict other missing quantities

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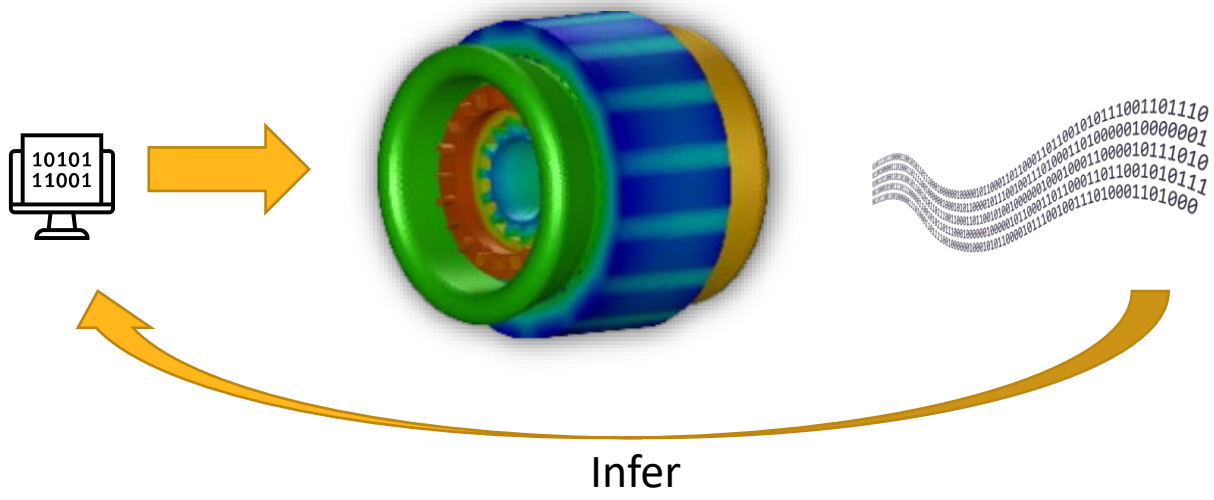
Use Case – Inverse Problem

Challenges

- Understand how to change operation when asset behavior doesn't match desired outcomes

Solution

- Use data and a Hybrid Digital Twin to infer what inputs or operating conditions would lead to the desired behavior



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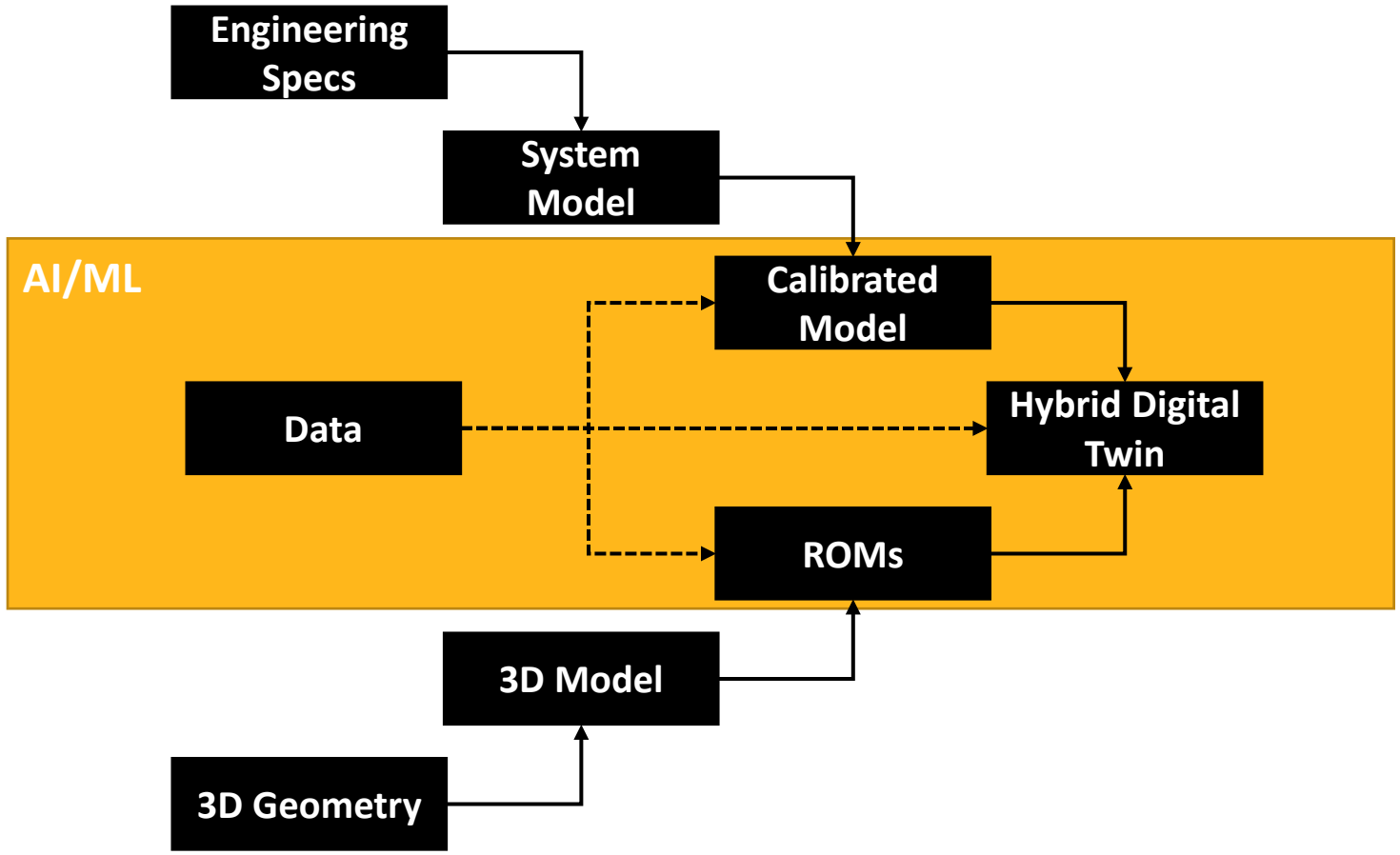
Building a Hybrid Digital Twin – Two Approaches

Top Down

- Accuracy is achieved through model calibration based on experimental data
- Real-time simulation achieved through light-weight system models



Bottom Up

- Accuracy is based on high-fidelity modeling of full physics equation and accurate geometry
- Real-time simulation achieved through ROMs

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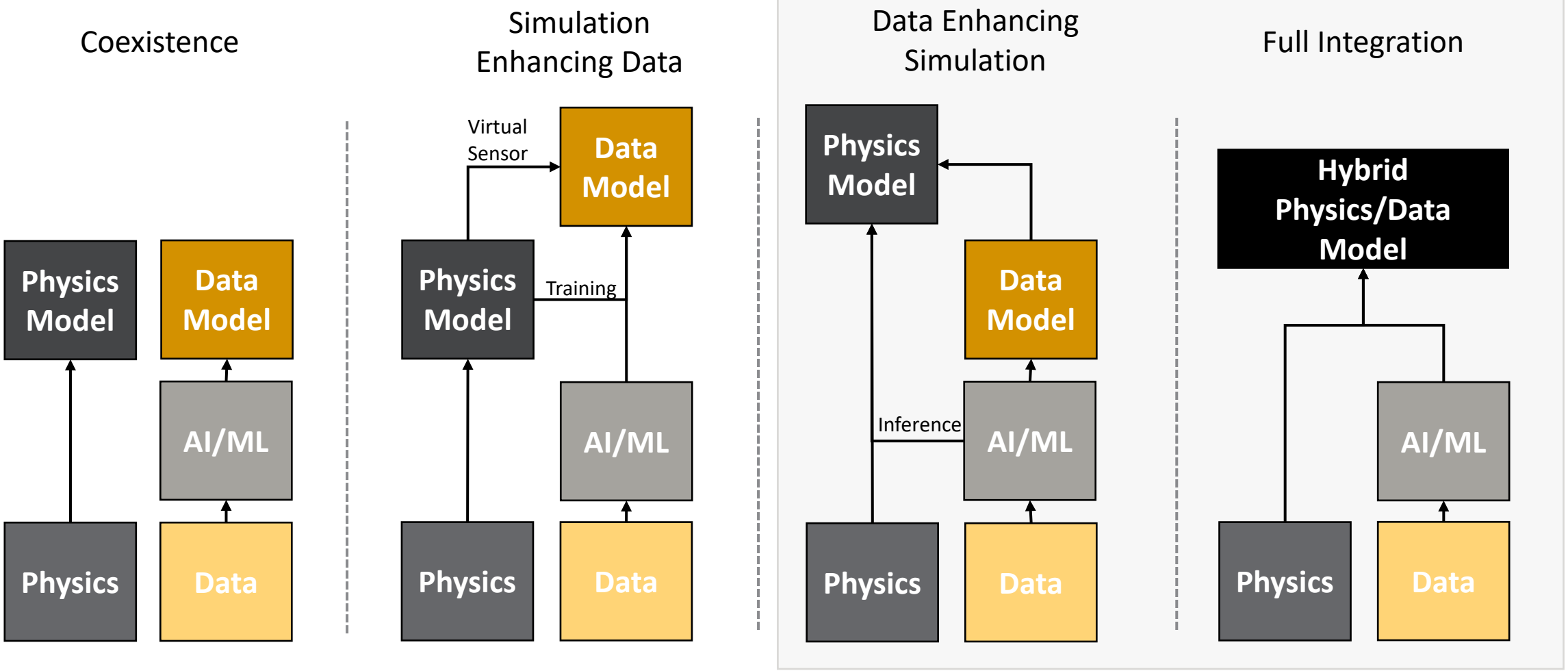
The Hybrid Framework



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Digital Twin Solution Architecture

1. Hybrid Calibration → Most accurate Twin
2. Best in class ROM capabilities → Easy Reuse
3. Unique runtime model → Easy Scalability
4. Open architecture → Faster adoption

Twin Builder

Existing System Libraries

System Model

ROM

Solver

ROM Extraction Capabilities

Dynamic

Static

LTI/LPV

Twin Model for cloud/edge deployment

FMU for simulation workflows

Deployer Services

Python integration, Pre-built agents, DTDL Export, Linux compilation

Hybrid Analytics

Fusion Hybrid Calibration Data Integration, Auto-calibration, …

Twin Deployer

FMI/FMU

Validated Ansys Physics

Test Data, 3rd Party Software

Digital Twin Partners

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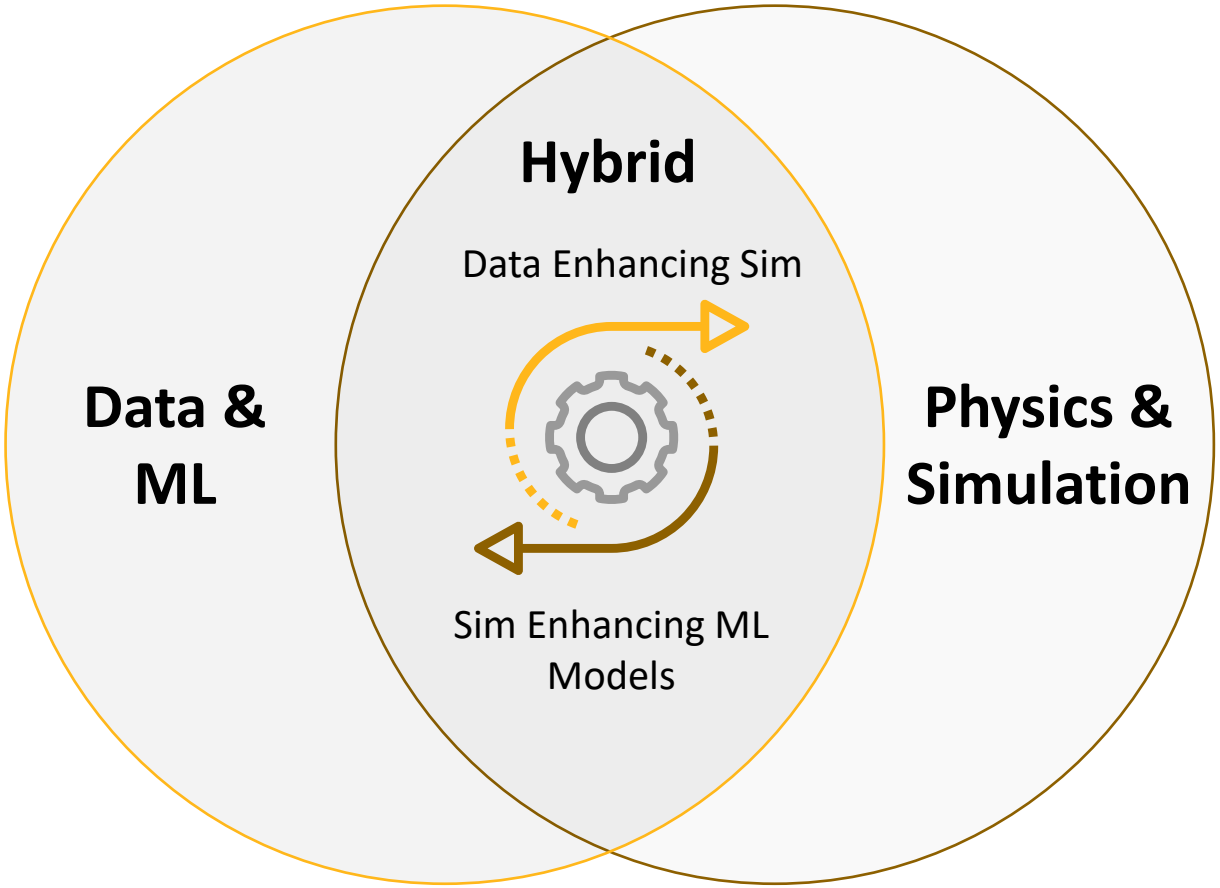
Hybrid Analytics



Hybrid Analytics is a toolset for combining data and physics modeling using machine learning techniques

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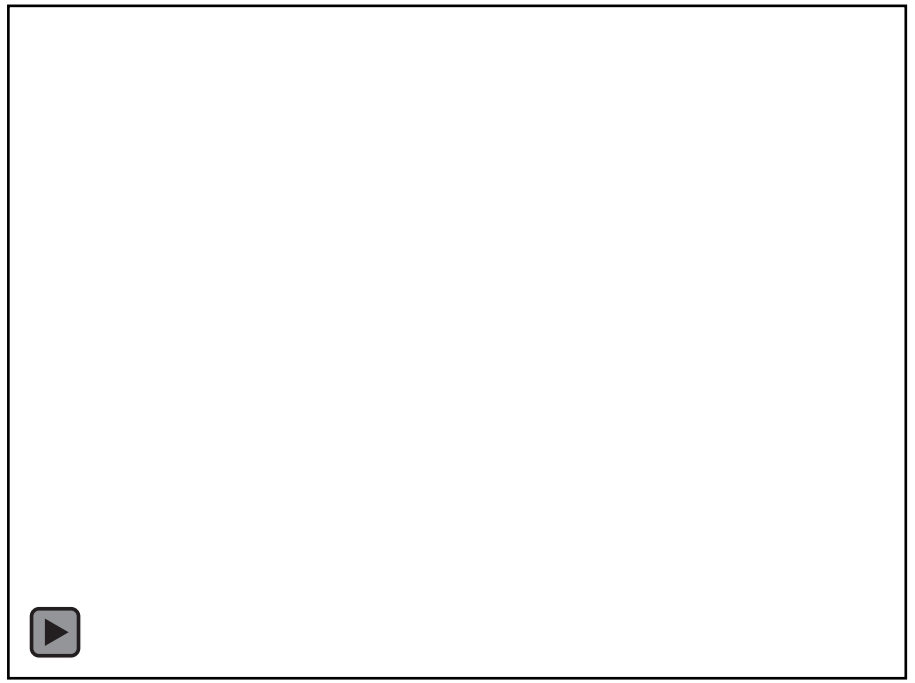
Hybrid Analytics – Combining Data and Physics

Unparalleled Accuracy

Robust Algorithms to cover diverse use cases

Uncertainty Quantification for confidence in fit

Easy Online recalibration



~ **80% accuracy** - Purely ML-based analytics

~ **90% accuracy** - Physics-Based Simulation Digital Twin

~ **98% accuracy - Hybrid Digital Twin**

(ML-based analytics combination with the physics-based approach)

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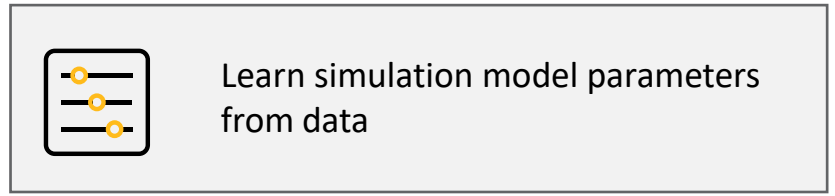
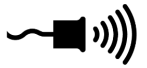
Hybrid Analytics – Calibration

What is Hybrid Calibration?

- Parameter Estimation
- Uncertainty Quantification on parameters
- Uncertainty Propagation to outputs
- Key use-case is virtual sensors



Parameter Estimation



Create virtual sensors to “measure” missing data

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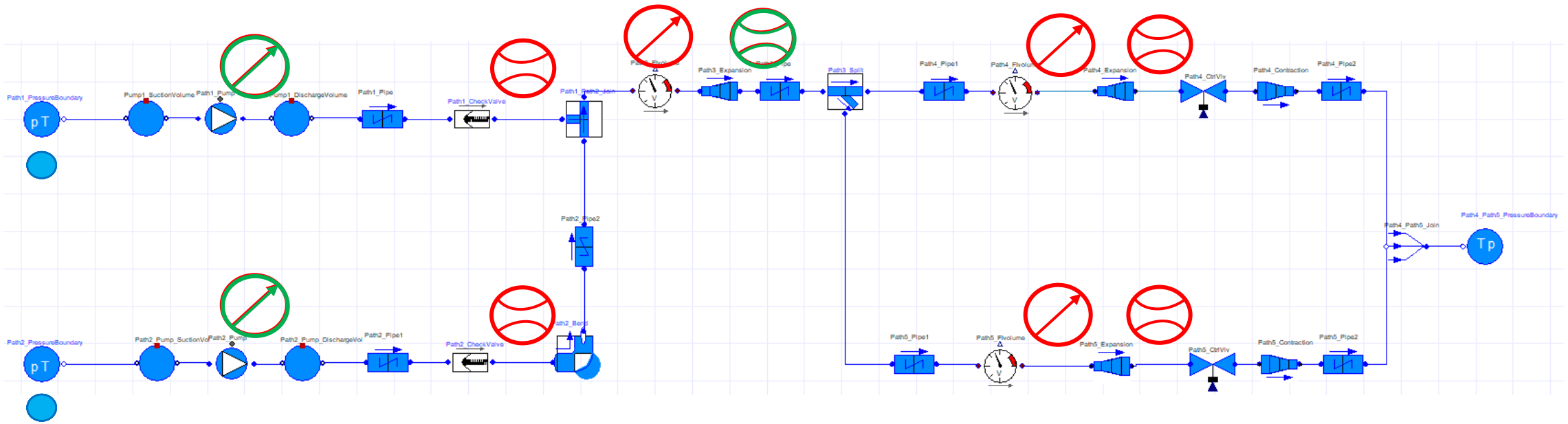
Model Diagram

Challenge: Determine the flow and pressure on each branch with a minimal number of physical sensors



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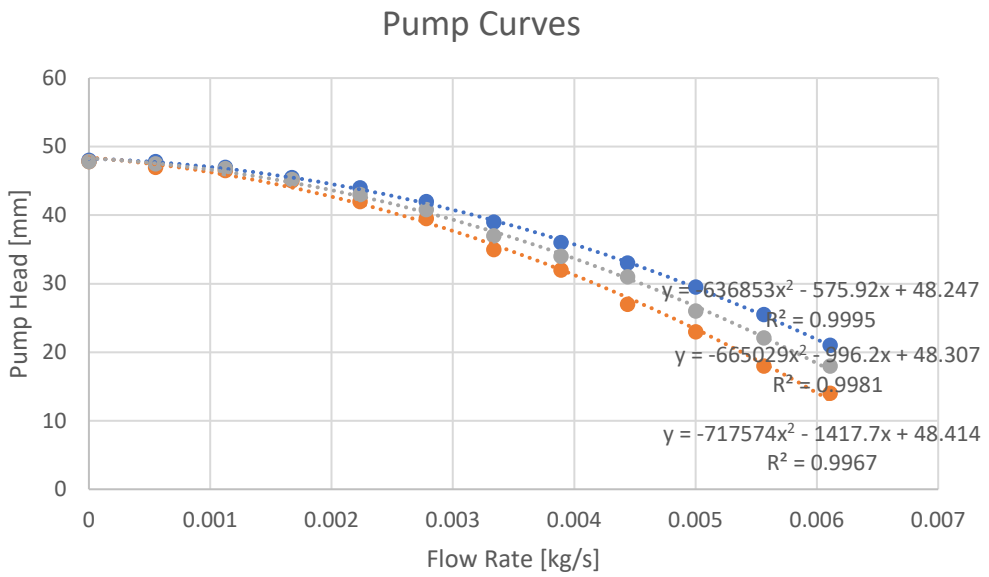
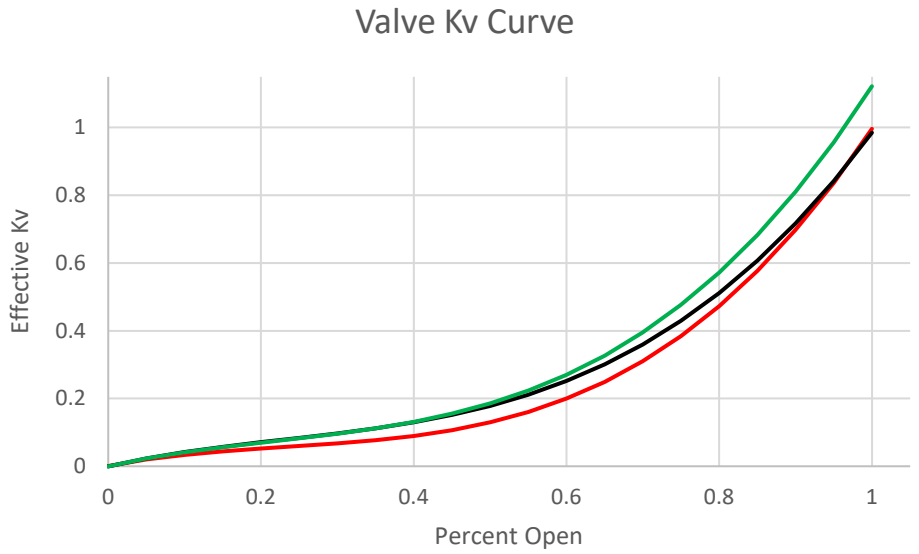
Component Models and Parameters





$$H = b_0 + b_1 q + b_3 q^2$$

Three polynomial coefficients as parameters

$$K_v = a_0 + a_1 D + a_2 D^2 + a_3 D^3$$

Four polynomial coefficients as parameters

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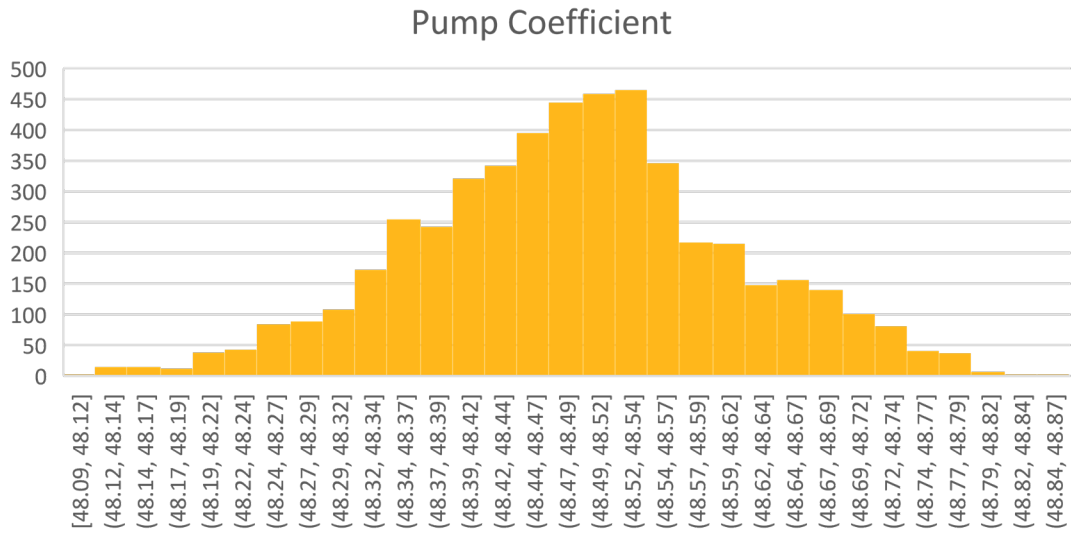
Results – Model Parameter Distributions

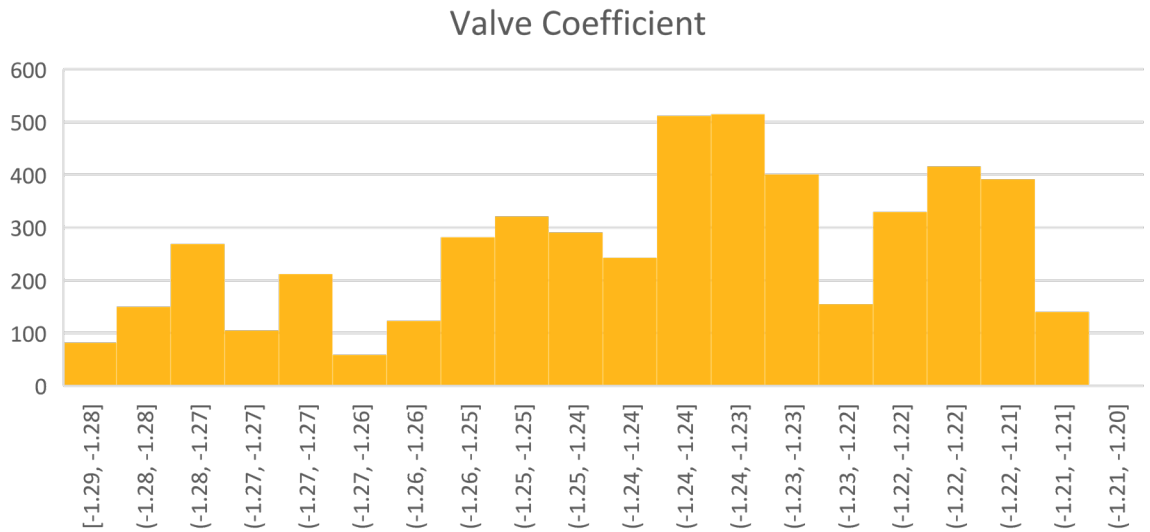
Pump Coefficient b_0

- Peaked distribution shows confidence in prediction
- Range gives uncertainty on measurement



Valve Coefficient a_2

- Dispersed distribution shows that system behavior is insensitive to this parameter
- The parameter can take a wide range of values without significantly affecting the system behavior



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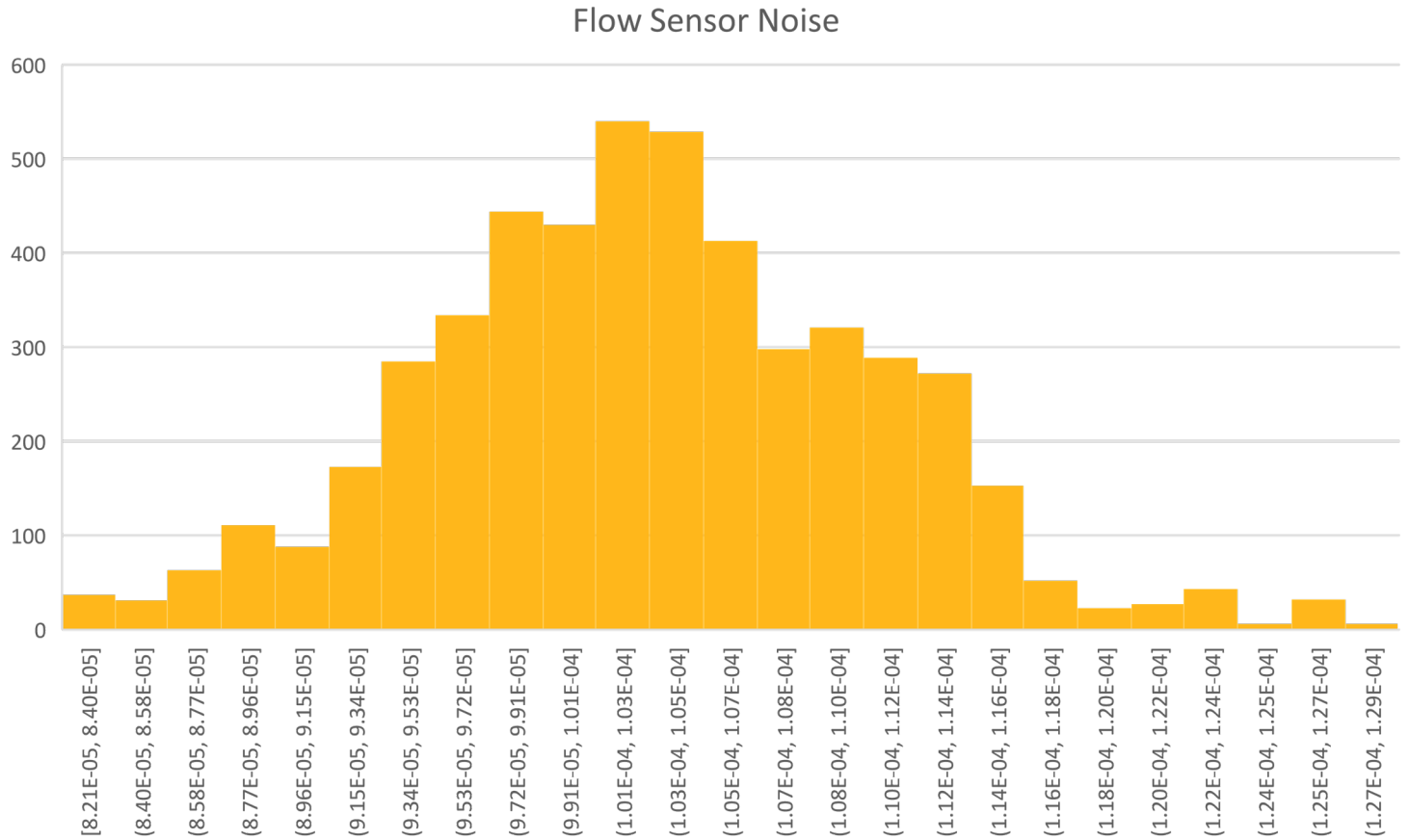
Results – Noise Parameter Distributions

- Manufacturer Spec = 0.1 g/s
- Most Probable = 0.102 g/s

- Accurate virtual sensor value and uncertainty

- Simultaneously fit physical model and noise



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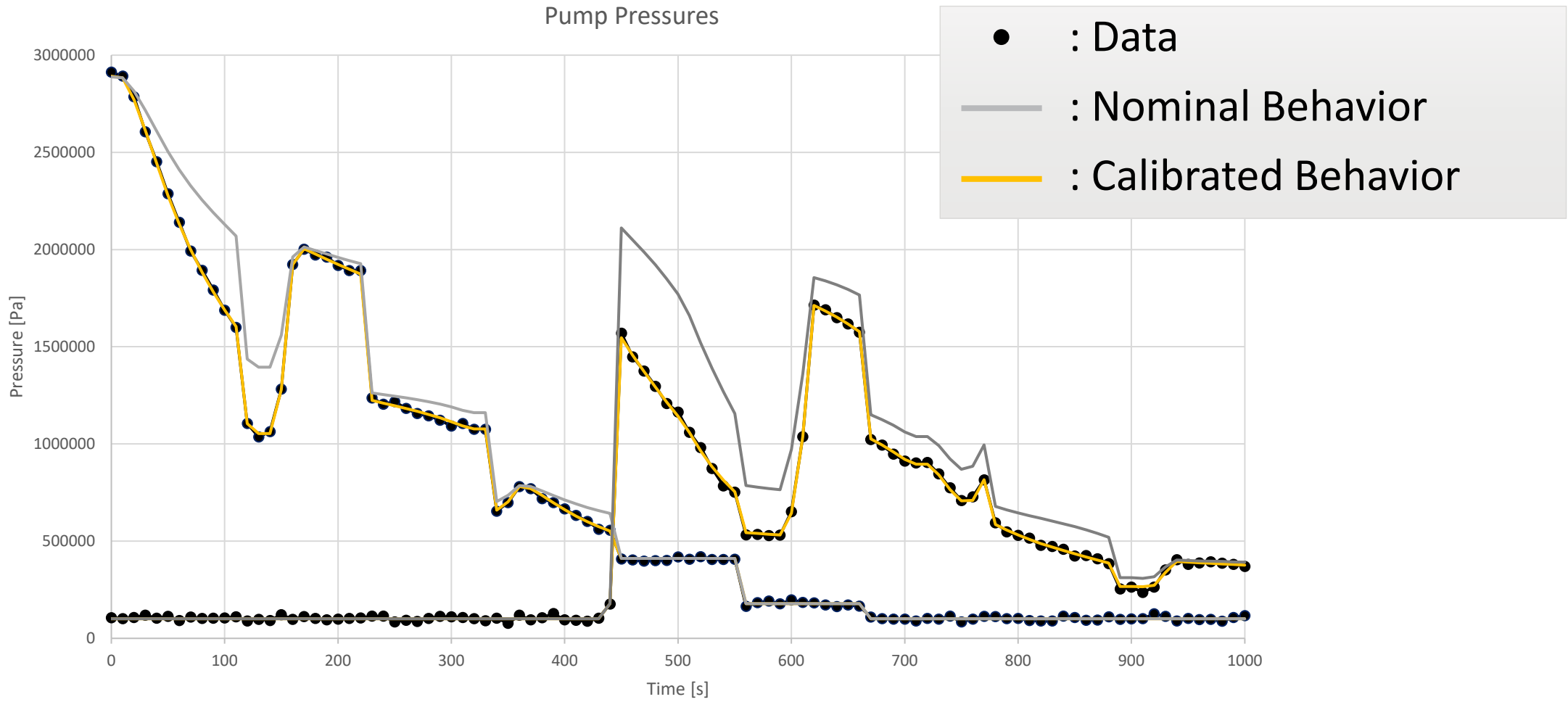
Results – Before and After For Physical Sensors



- Updated behavior matches performance much better than nominal manufacturer specs

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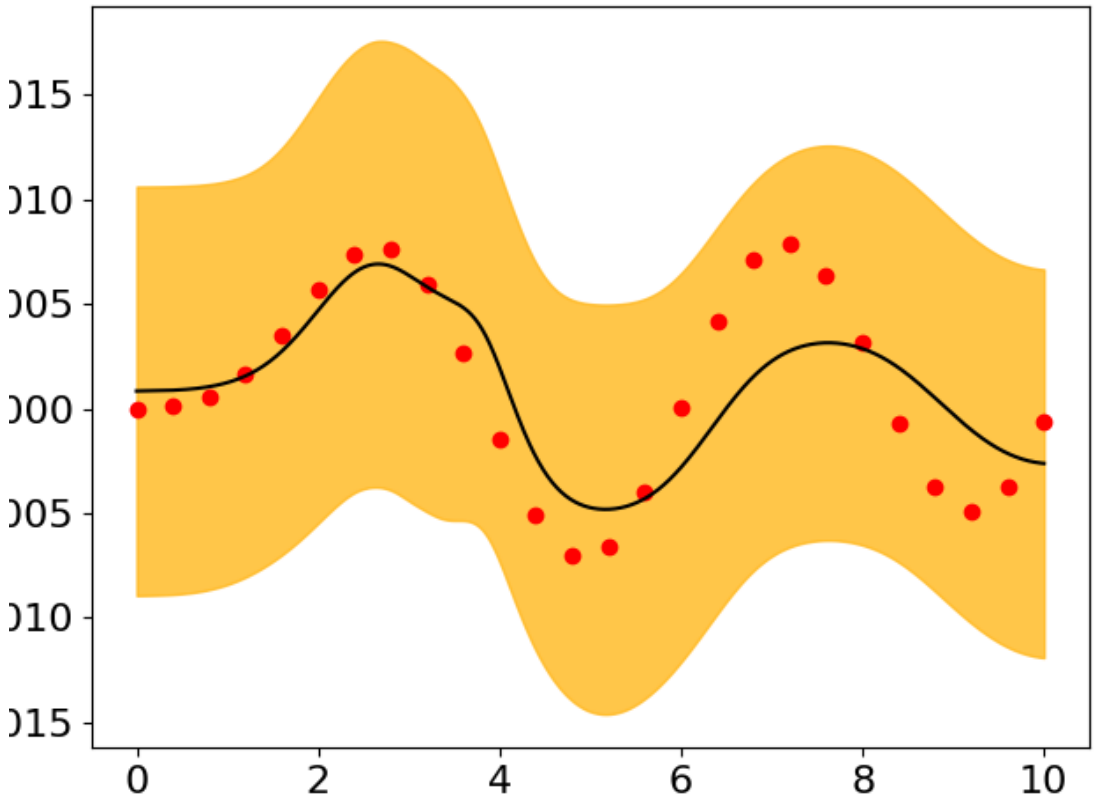
Hybrid Analytics – Fusion Modeling

Fusion Models

- Multiple machine learning techniques for creating models from data sources
- For some use cases:
  - Automatically search over available techniques and choose the best model
  - Return uncertainty of fit



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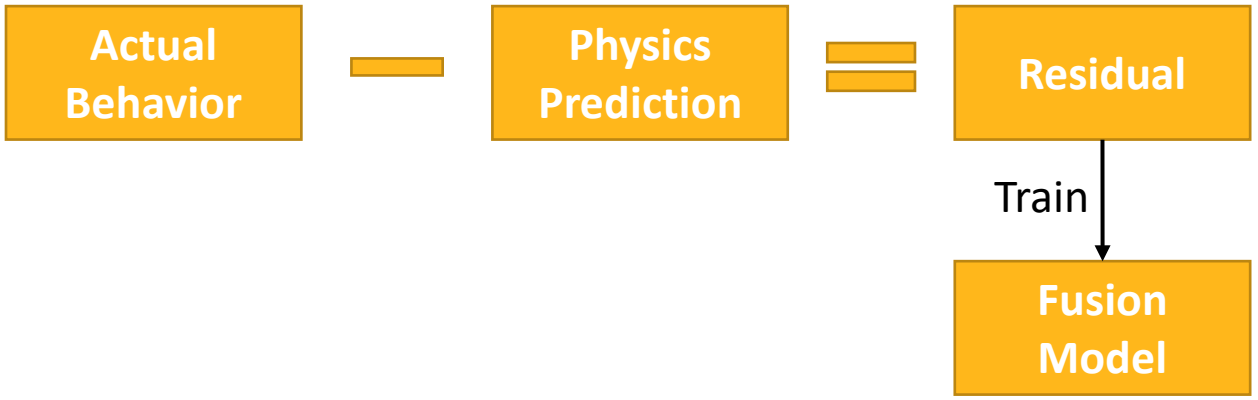
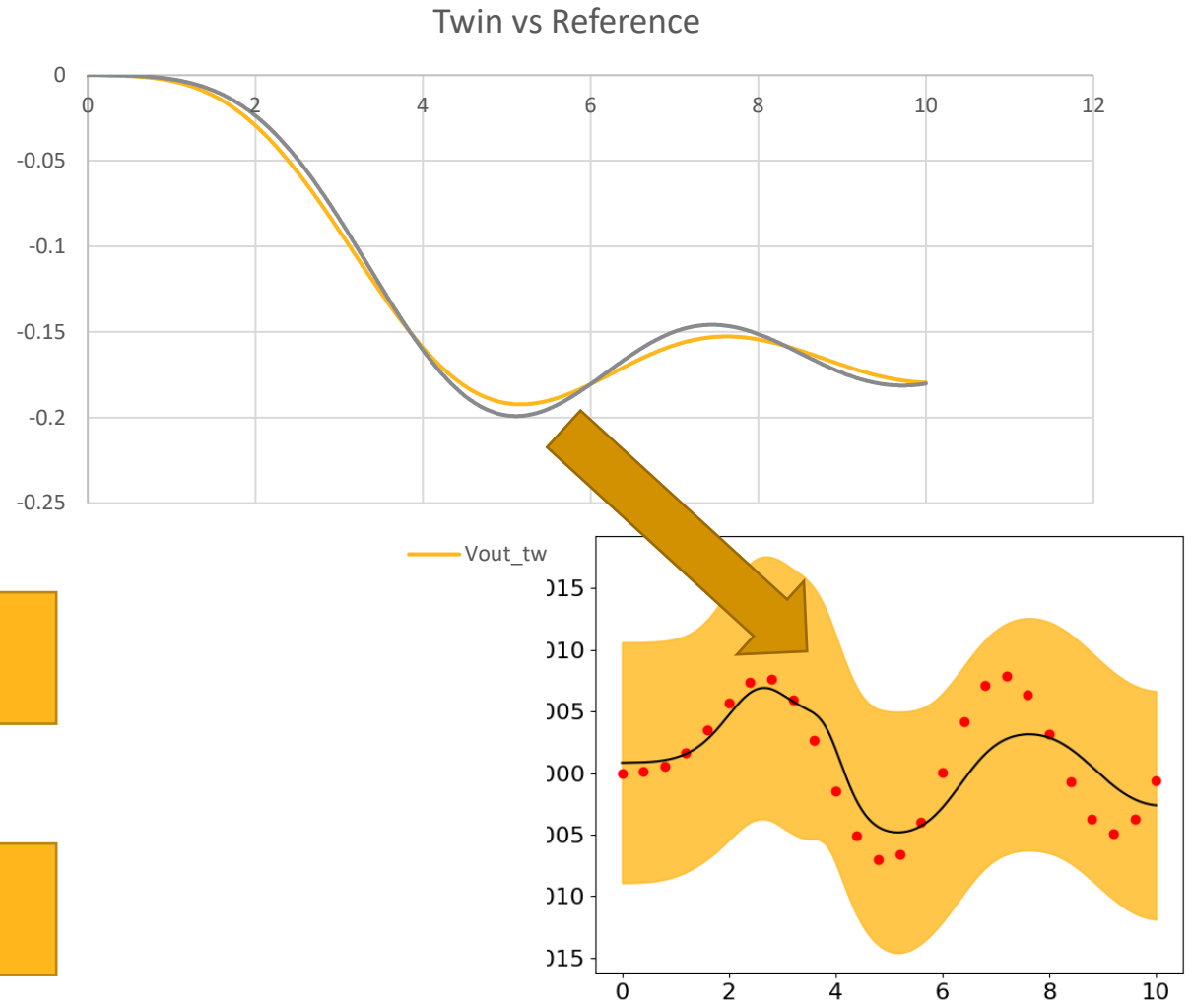
Fusion Use Case: Residual Modeling

- Often even the best simulations don't perfectly match sensor data
- Instead of training a full data model, use the most accurate physics model available and train an ML model of the residual
- The results of the physics model + the residual model correction give a better outcome.





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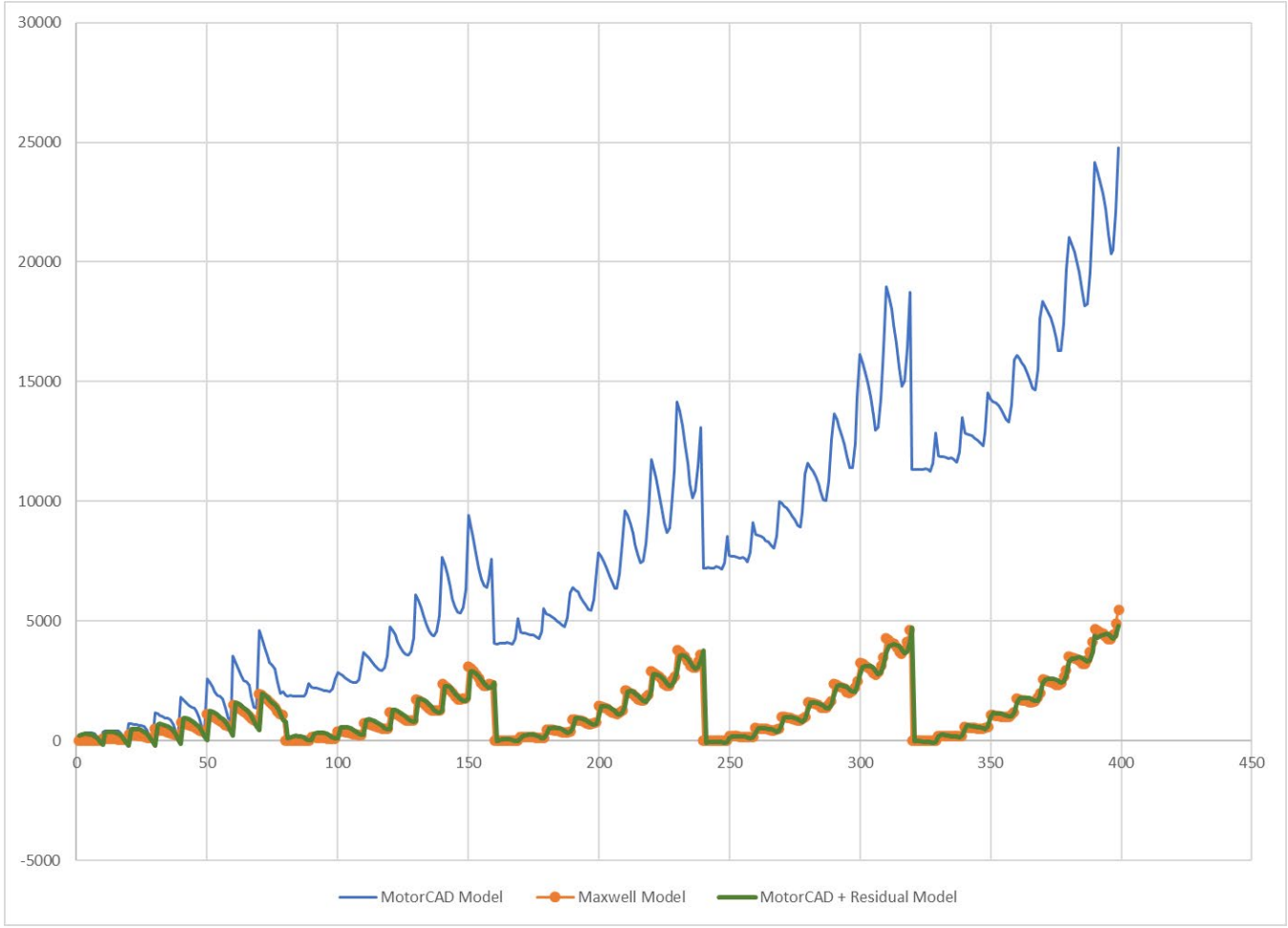
Fusion Use Case: Approximating 3D Models

- 3D simulations can be costly
- Lower fidelity 1D models are an approximation to 3D simulations
- Build a multifidelity regression model to fill in gaps in 3D model by fitting the difference between the higher fidelity and lower fidelity models

- For the case shown at the left, a Maxwell model gives much higher results than a MotorCAD model
- But, the MotorCAD model plus a trained fusion model performs about the same as the full Maxwell model



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Summary

- Hybrid Digital Twins solve challenges inherent in creating Digital Twins.
- The Hybrid Analytics toolset combines data and physics modeling together to create the best possible Hybrid Digital Twins.
- Hybrid Digital Twins ingest field data to adapt to changing environmental conditions.

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Ansys

National Defense Industrial Association Systems and Mission Engineering Conference

November 2022

Department-Wide Software Science and Technology Strategy

Mr. Allan Dianic

Director, Software Engineering

Office of the Executive Director, Systems Engineering and Architecture

Office of the Under Secretary of Defense for Research and Engineering

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Overview

- History and Background
  - NDAA 2020, Section 255, Department-Wide Software S&T Strategy
  - Drafting and Approval
- Content and Approach
- Strategy Rollout

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History and Background: NDAA 2020, Section 255 Department-Wide Software S&T Strategy

- NDAA 2020 Section 255 (enacted December 19, 2019) established two major requirements for DoD:
  - Section 255 (a) Appoint a senior official to guide DoD in software in six areas
  - Section 255 (b) Develop a DoD-wide Software Science and Technology (S&T) Strategy under guidance from the designated senior official

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Research Areas

1. Research and development activities on new technologies for the creation of highly secure, scalable, reliable, time-sensitive, and mission-critical software;

2. Research and development activities on new approaches and tools to software development and deployment, testing, integration, and next generation software management tools to support the rapid insertion of such software into defense systems;

3. Foundational scientific research activities to support advances in software;

4. Technical workforce and infrastructure to support defense science and technology and software needs and mission requirements;

5. Providing capabilities, including technologies, systems, and technical expertise to support improved acquisition of software reliant business and warfighting systems; and

6. Providing capabilities, including technologies, systems, and technical expertise to support defense operational missions which are reliant on software.

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History and Background: NDAA 2020, Section 255 Department-Wide Software S&T Strategy

Approach

- Establish standing working group for Services, OSD, and industry for ongoing interchange
- Align with research labs and FFRDC to guide
- Conduct software-focused prototyping to advance and mature research in software intensive capabilities and to enhance transition/adoption
- Coordinate across major prototyping efforts to align foundational capabilities for joint use

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SSG Composition

- Senior Steering Group
  - OUSD(R&E) Sponsor
  - OUSD(R&E)
  - OUSD(A&S)
  - DoD CIO
  - DOT&E
  - U.S. Army
  - U.S. Air Force
  - U.S. Navy

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Software S&T Strategy Document (approved November 2021)

Department of Defense Software Science and Technology Strategy

In response to National Defense Authorization Act for Fiscal Year 2020 (P.L. 116-92) Section 255

November 2021

Department of Defense (DoD) Software Strategy Coordinator

Office of the Under Secretary of Defense for Research and Engineering

Washington, D.C.

The estimated cost of this report or study for the Department of Defense is approximately $159,000 in Fiscal Years 2020 - 2021. This includes $125,000 in expenses and $34,000 in DoD labor.

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Content & Approach – Software S&T Strategy Key Points

	STRATEGIC VISION - DELIVER RESILIENT SOFTWARE CAPABILITIES AT THE SPEED OF RELEVANCE			
Goals	**2.1 SHIFT ENGINEERING AND DEVELOPMENT LEFT**	**2.2 ADOPT AN INTEGRATED FRAMEWORK OF SHARED RESOURCES**	**2.3 TRANSFORM THE SOFTWARE WORKFORCE**	**2.4 ALIGN SOFTWARE S&T WITH ACQUISITION**
Focus Areas	• Advance DevSecOps • Enhance resilience through speed • Create and curate high fidelity HWIL/SWIL, and M&S • Enhance engineering rigor and employ pervasive automation and self-service • Ensure a high level of assurance • Mitigate technical debt	• Research highly secure, resilient, cloud-native architectures • Leverage modern ecosystems, technologies, tools and processes • Focus on data acquisition, data science and event streaming • Accelerate delivery and adoption of AI/ML • Create federated repositories of reusable and shared resources • Invest in low-code, no-code and robotic process automation	• Connect the S&T and Engineering workforce • Train and invest in data science, AI/ML, and software engineering • Cultivate a leading S&T and software engineering workforce • Enable continuous learning to keep pace with the commercial sector • Elastically scale the software development workforce	• Bridge the gap between S&T and Acquisition • Embrace the mindset that software is never done • Advocate a strategic outlook toward software S&T investments • Invest in leap forward tech to leverage industry best practices • Streamline the planning, funding, requirements, and contracting process
NDAA Sec(b)	FY2020 NDAA Section 255 (b) 1 to 6. Including Strategies for: 3.1 Types of Software Related Activities within the Science and Technology Portfolio of the Department 3.2 Investment in New Approaches to Software Development, Deployment, and Next Generation Management Tools 3.3 Research to Innovate the Software Development Engineering, and Testing Process for Safety and Mission Critical Systems 3.4 Status of Implementing Recommendations on Software 3.5 Supporting the Acquisition, Technology Development, Testing, Assurance, and Certification 3.6 The Transition of Relevant Capabilities and Technologies to Programs			

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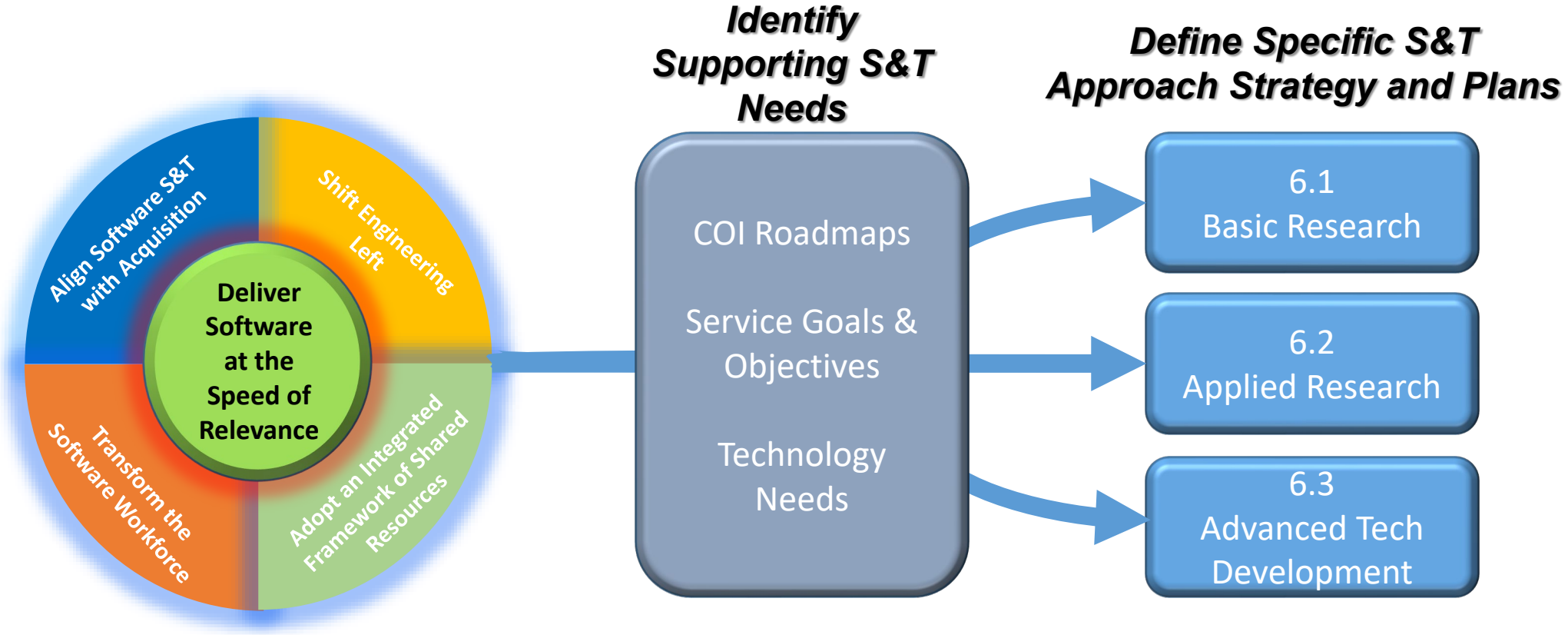
Strategy Link to Research Planning

- Coordinate across S&T activities
- Align strategy goals with research threads



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Preliminary COI Engagement

- Communities of Interest (COIs) were established as a mechanism to encourage multi-agency coordination and collaboration in cross-cutting technology focus areas with broad multiple Component investment.
- COIs provide a forum for coordinating S&T strategies across the Department, sharing new ideas, technical directions, and technology opportunities.
- Software cuts across many COIs.

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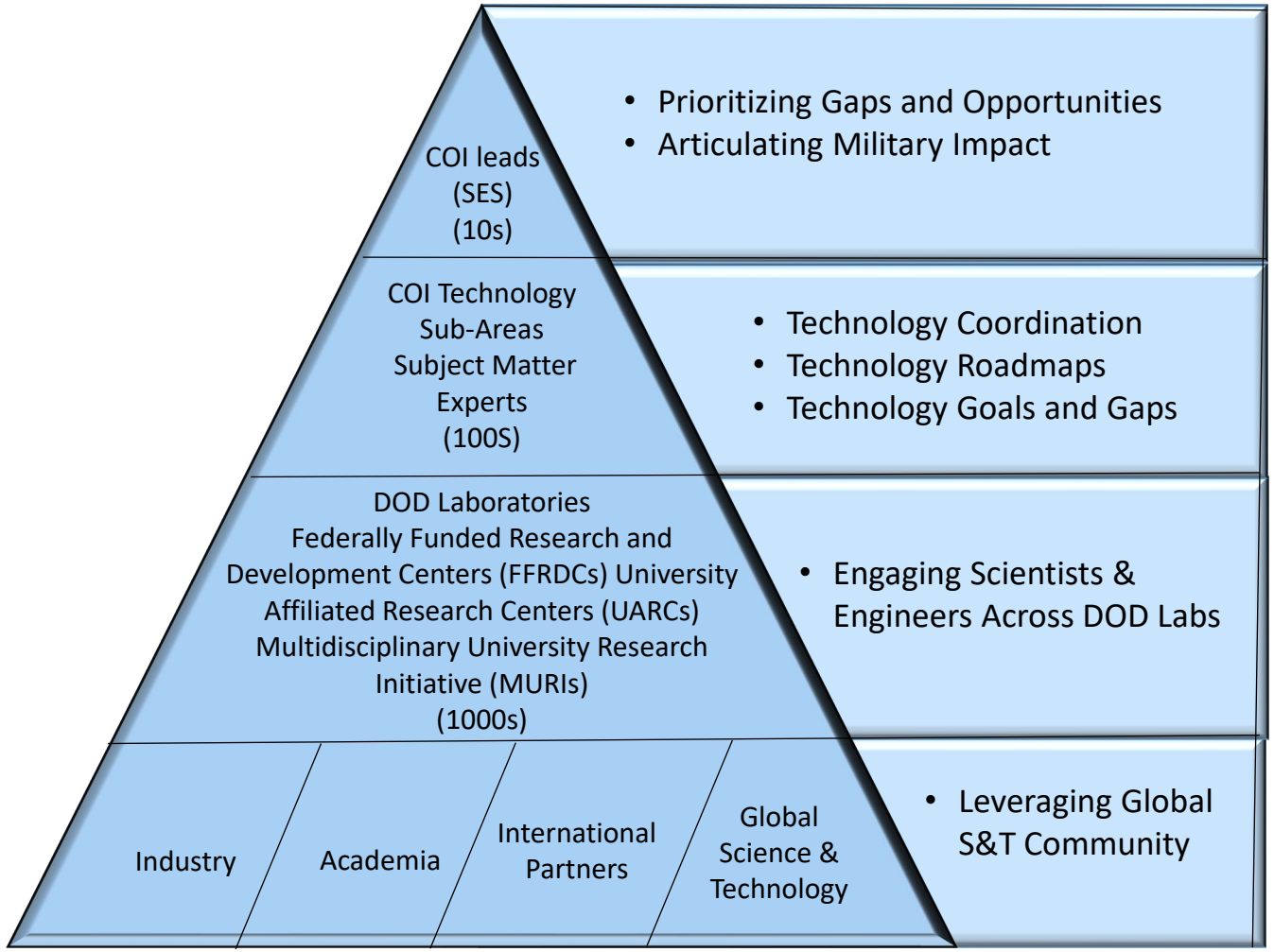
Preliminary COI Engagement



Overview of Portfolio
Topic Breakdown, scope, Approximate Investment across sub-topic

Major Goals
What are the Technical Challenges, Opportunities and desired outcome?

How do these align worth operational capability needs?
What is the potential impact?

COI Portfolio Reviews

Investment Plans
Laydown of current and planned project
Transition Opportunities
Key performers. Critical capabilities and facilities

What are the Priority Gaps?

Portfolio Health Assessment
What are the concerns, risks and mitigation?

What are the highlights and strengths?

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Addressing Software S&T Needs for DoD Systems

DoD must leverage commercial and academic research to keep pace with industry and adversaries.

DoD must also address its critical software needs with research for its unique system challenges.

DoD infrastructure challenges: secure, legacy, embedded, heterogeneous

NDAA 220 Section 255

20 SEC. 255. DEPARTMENT-WIDE SOFTWARE SCIENCE AND
21 TECHNOLOGY STRATEGY.
22 (a) DESIGNATION OF SENIOR OFFICIAL.—Not later
23 than 180 days after the date of the enactment of this Act,
24 the Secretary of Defense, acting through the Under Sec-
25 retary of Defense for Research and Engineering and in

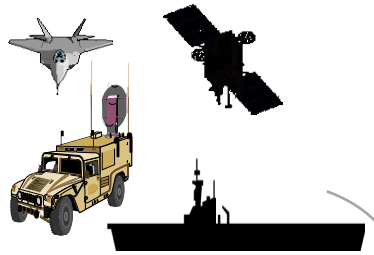
Software S&T Research

DoD Labs
FFRDCS/UARCS

Commercial Industry/Academia

- DevOps
- Artificial Intelligence
- Homogeneous Cloud
- Open Source

Secure
Legacy
Embedded
Heterogeneous



DoD System Examples

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DoD Research Software Challenges (Examples)

- **Security:** DoD software systems have life-critical dependencies to mission operators and are subject to advanced threats from nation-state actors intended to impact weapons and strategic systems
- **Legacy:** The DoD has a very large and costly legacy software and hardware platform inventory to maintain and upgrade with substantial costs to changes in infrastructure across most DoD mission areas
- **Embedded:** Many DoD software platforms are legacy embedded weapons, air, space, ground, and sea infrastructure that need new approaches for adopting modern continuous integration practices and advanced methods of test and evaluation
- **Heterogeneous:** Unlike many homogeneous cloud software/hardware platforms, the DoD must integrate across highly heterogeneous systems, particularly in the context of command, control, and communications infrastructures

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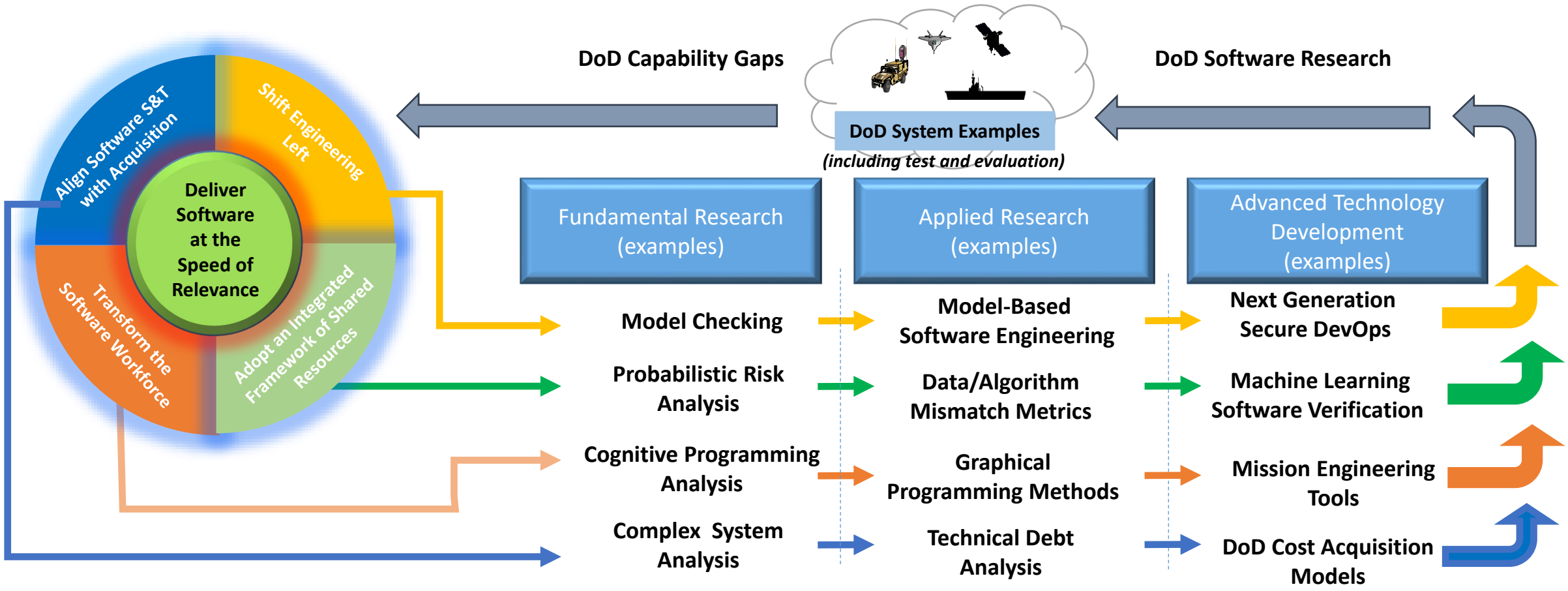
Research Strategy

Software S&T Strategy addresses technology needs for DoD systems by leveraging and incorporating commercial, academic, and DoD research in system development and test and evaluation



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Research Strategy (Examples)

- Shift Engineering Left: Develop software and system models to plan for complex system integration issues
  - Fundamental Research: Develop methods to improve the accuracy and scale of model checking for software to model system security and performance
  - Applied Research: Develop advanced models of embedded, cloud, and information services to enable integration of large-scale defense software
  - Advanced Technology Development: Develop advanced tool frameworks to constitute missions on top of resilient and reusable information services

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Research Strategy (Examples)

- Adopt a Common Automated Foundation: Automate the software lifecycle to reduce cost and complexity as well as manage automated methods for machine learning
  - Fundamental Research: Improve methods of probabilistic risk analysis to establish performance standards for matching data and machine learning algorithms
  - Applied Research: Characterize how mismatch occurs between data and algorithms in machine learning to enhance data and algorithm security
  - Advanced Technology Development: Enable a routine method of characterizing the performance and security of automated software, data, and machine learning software

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Research Strategy (Examples)

- Transform the Software Workforce: Develop tools to automate and simplify software integration and analysis for mission operators
  - Fundamental Research: Develop automated methods to analyze the cognitive performance of software and mission developers in system planning and use
  - Applied Research: Develop methods of graphical programming so software mission developers can quickly analyze and correct security flaws in software and infrastructure
  - Advanced Technology Development: Develop and train a workforce to leverage emerging mission engineering tools for cloud and information services

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Research Strategy (Examples)

- Align Software S&T With Acquisition: Develop methods and tools to assess cost and complexity of large-scale DoD software integration with rigorous data analysis
  - Fundamental Research: Develop analytics to characterize key complex software system integration flaws from program and empirical system data
  - Applied Research: Develop methods to translate software system flaws into technical debt and cost metrics for system design trade-offs in the acquisition process
  - Advanced Technology Development: Develop acquisition models that can be used to characterize the procurement and sustainment cost of DoD software systems

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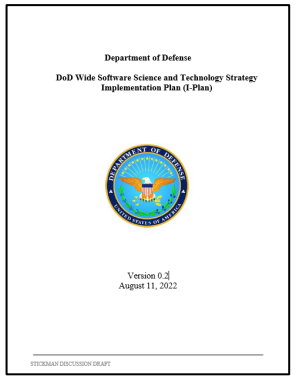
Implementation

Implementation Plan


Department of Defense

DoD Wide Software Science and Technology Strategy Implementation Plan (I-Plan)

Version 0.2
August 11, 2022

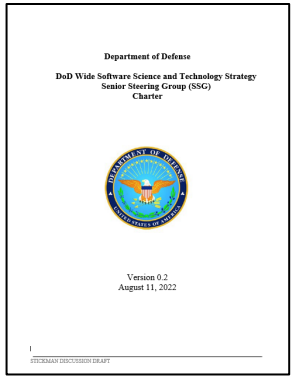
STICKMAN DISCUSSION DRAFT

- Initial activities
- Link to strategies

- ❑ Ensure SSG membership has correct representation
- ❑ Define action teams
- ❑ Define internal and external relationships

- ❑ SG 1: Shift Left
- ❑ SG 2: Integrated Framework of Shared Resources
- ❑ SG 3: Transform the S&T Workforce
- ❑ SG 4: Align Acquisition with SW S&T

SSG Charter


Department of Defense

DoD Wide Software Science and Technology Strategy Senior Steering Group (SSG) Charter

Version 0.2
August 11, 2022

STICKMAN DISCUSSION DRAFT

- Alignment
- Scope

- ❑ Threads linking SW S&T Strategic Goals to SW Mod goals/objectives
- ❑ S&T Communities of Interest (CoI)

- ❑ Align 6.1-6.3 planning with SW Mod SSG
- ❑ Link between related working groups
- ❑ Functions and responsibilities
- ❑ Membership

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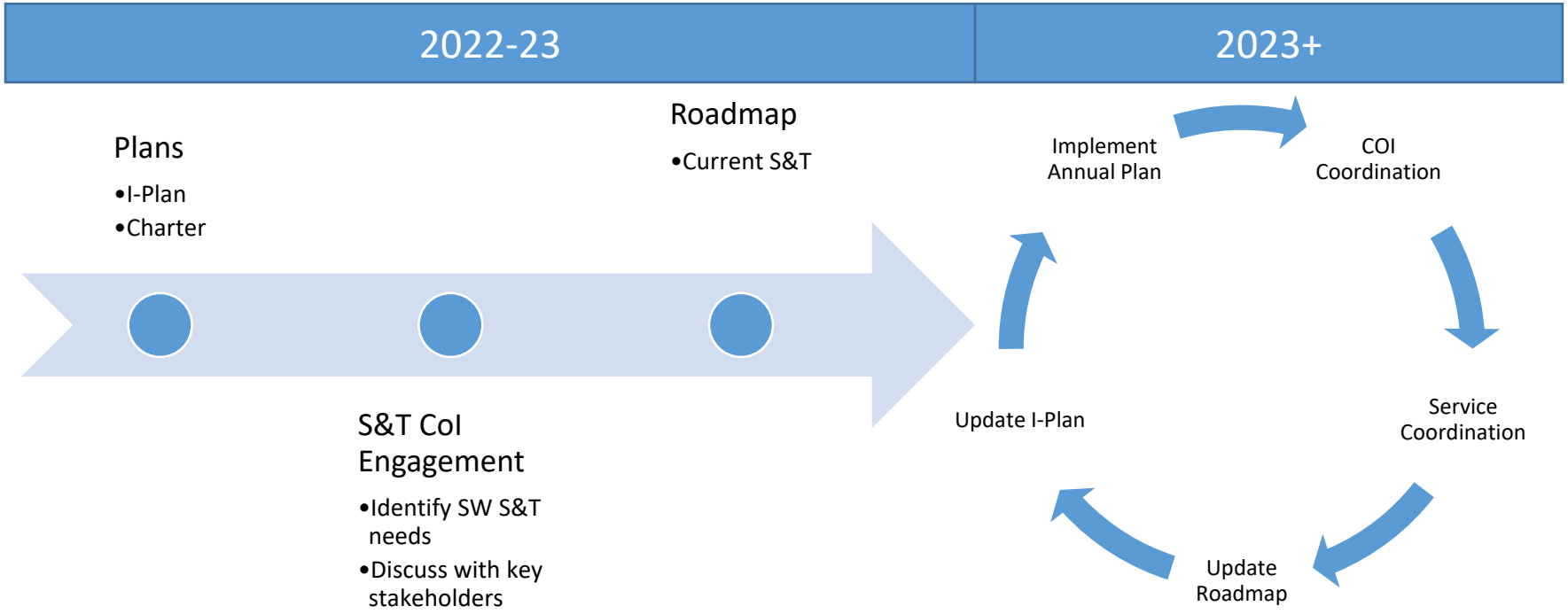
Strategy Rollout Timeline



- Complete initiation of strategy planning/integration cycle
- Establish process relationships
- Enter annual execution cycle

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Conclusion

- Questions and discussion

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https://ac.cto.mil/engineering

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Practical Software and Systems Measurement (PSM) Digital Engineering Measurement Framework

Version 1.0c
June 21, 2022

A collaboration among industry, government and academia

Developed and Published by Members of:

Practical Software & Systems Measurement

Systems Engineering Research Center

Aerospace Industries Association

National Defense Industrial Association

International Council on Systems Engineering

Department of Defense Research & Engineering

The Aerospace Corporation

Digital Engineering Measurement Framework

Unclassified: Distribution Statement A: Approved for Public Release; Distribution is Unlimited

Digital Engineering Measurement Framework - Project Overview and Timeline

2020

AIA EMC Project Plan

- Refined list of DE metrics serving as Key Performance Indicators for program execution, and model health
- Detailed descriptions of each metric, traceable to SE metrics, quality, & requirements volatility

Established collaborative WG (9/14/20)

(PSM, NDIA, INCOSE, AIA, SERC, Aerospace, OUSD R&E, …)

Objectives

- Define industry consensus measurement framework for DE, MBSE
- Align measures with business information needs for project execution and organizational performance improvement.

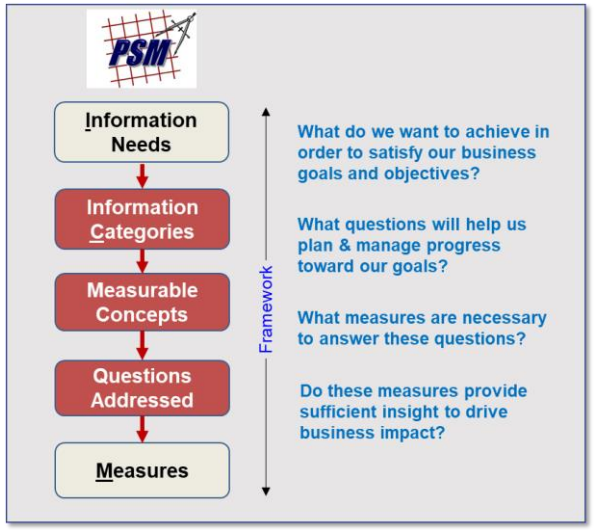
Leverage partner resources and assets

- Practical Software and Systems Measurement (PSM) Continuous Iterative Development Measurement Framework
- SERC / INCOSE / NDIA MBSE Maturity Survey
- SERC DE metrics research (SERC-2020-SR-003, SERC-2020-TR-002)
- Systems Engineering Leading Indicators Guide
- DoD Digital Engineering Strategy

2021

Follow PSM process to define DE measurement framework

- Aligned with ISO/IEC/IEEE 15939 measurement process standard



Team product development

- Front matter (concepts, terms, …)
- Information Needs (ICM Table)
- Measurement specifications

2022

Initial framework draft for review (Jan 2022)
V1.0 Publication release (May 2022)

Practical Software and Systems Measurement (PSM) Digital Engineering Measurement Framework

Version 1.0c
June 21, 2022

Developed and Published by Members of:

Practical Software & Systems Measurement (PSM) · Systems Engineering Research Center · Aerospace Industries Association (AIA) · National Defense Industrial Association (NDIA) · International Council on Systems Engineering (INCOSE) · Department of Defense Research & Engineering · The Aerospace Corporation (AEROSPACE)

Initial Measurement Specifications

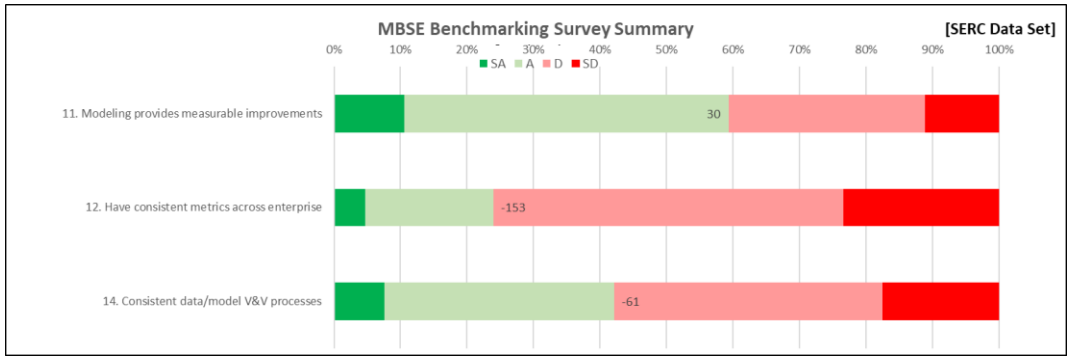
- Architecture Completeness and Volatility
- Model Traceability
- Product Size
- DE Anomalies
- Adaptability and Rework
- Product Automation
- Deployment Lead Time
- Runtime Performance

http://www.psmsc.com/DEMeasurement.asp

Lack of effective DE/MBSE measures has been an inhibitor to digital transformation

Substantiated by DoD SERC research

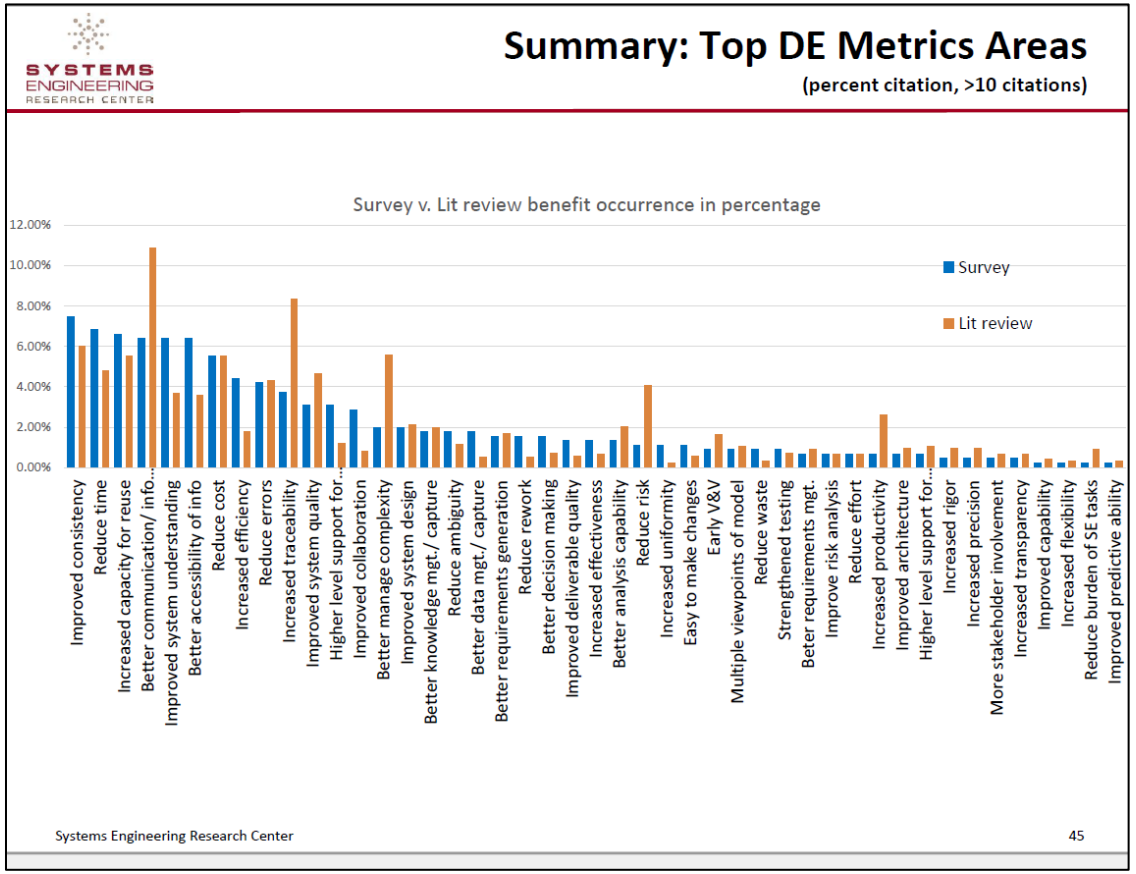
Benchmarking the Benefits and Current Maturity of Model-Based Systems Engineering across the Enterprise (SERC-2020-SR-001)



Category	Question title	SERC MBSE Questionnaire	Survey Score	SA	A	D	SD	Chart	Calculated Score
Model Metrics	11. Modeling provides measurable improvements	Modeling activities in our organization provide measurable improvements within and across projects.	30	18	83	50	19		30
	12. Have consistent metrics across enterprise	We have consistent metrics across our program(s)/enterprise that include our modeling activities.	-153	8	33	90	40		-153

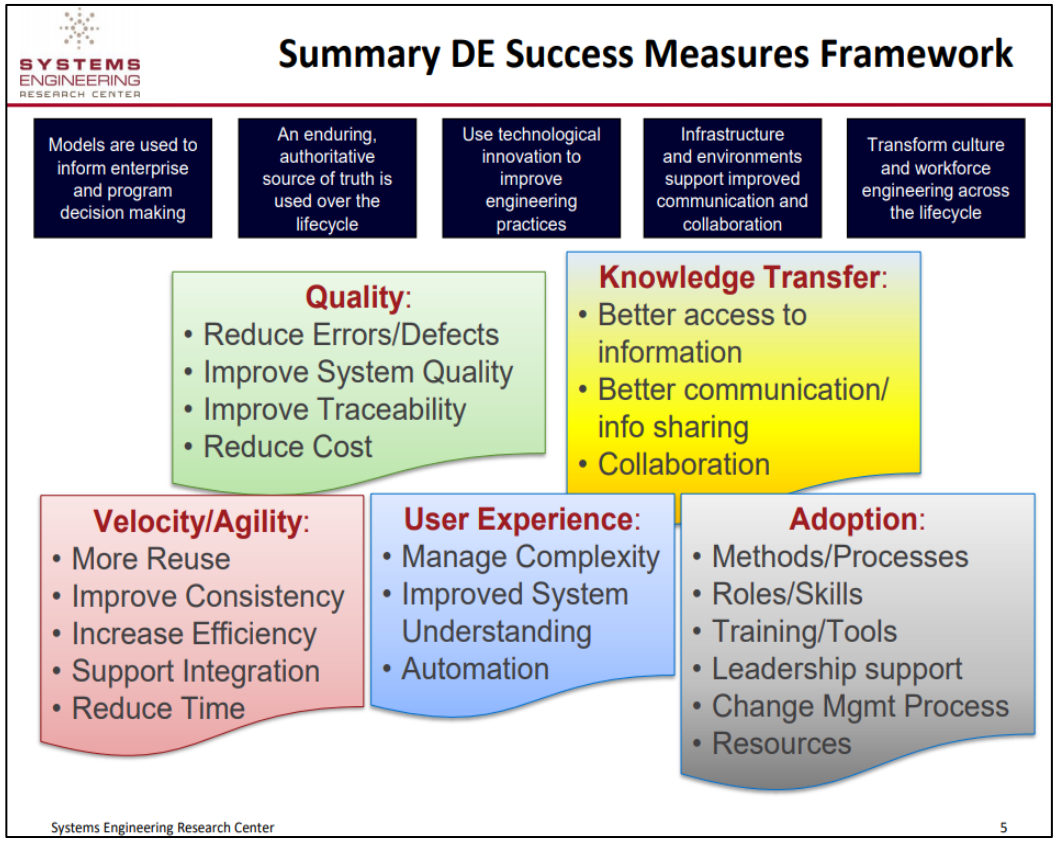
https://sercuarc.org/results-of-the-serc-incose-ndia-mbse-maturity-survey-are-in/

Summary Report Task Order WRT-1001: Digital Engineering Metrics Supporting Technical Report (SERC-2020-SR-003)
Task Order WRT-1001: Digital Engineering Metrics Technical Report (SERC-2020-TR-002)



Success Measures and Benefits of Digital Engineering Transformation

Research from DoD SERC and Virginia Tech helped inform the DE Measurement Framework



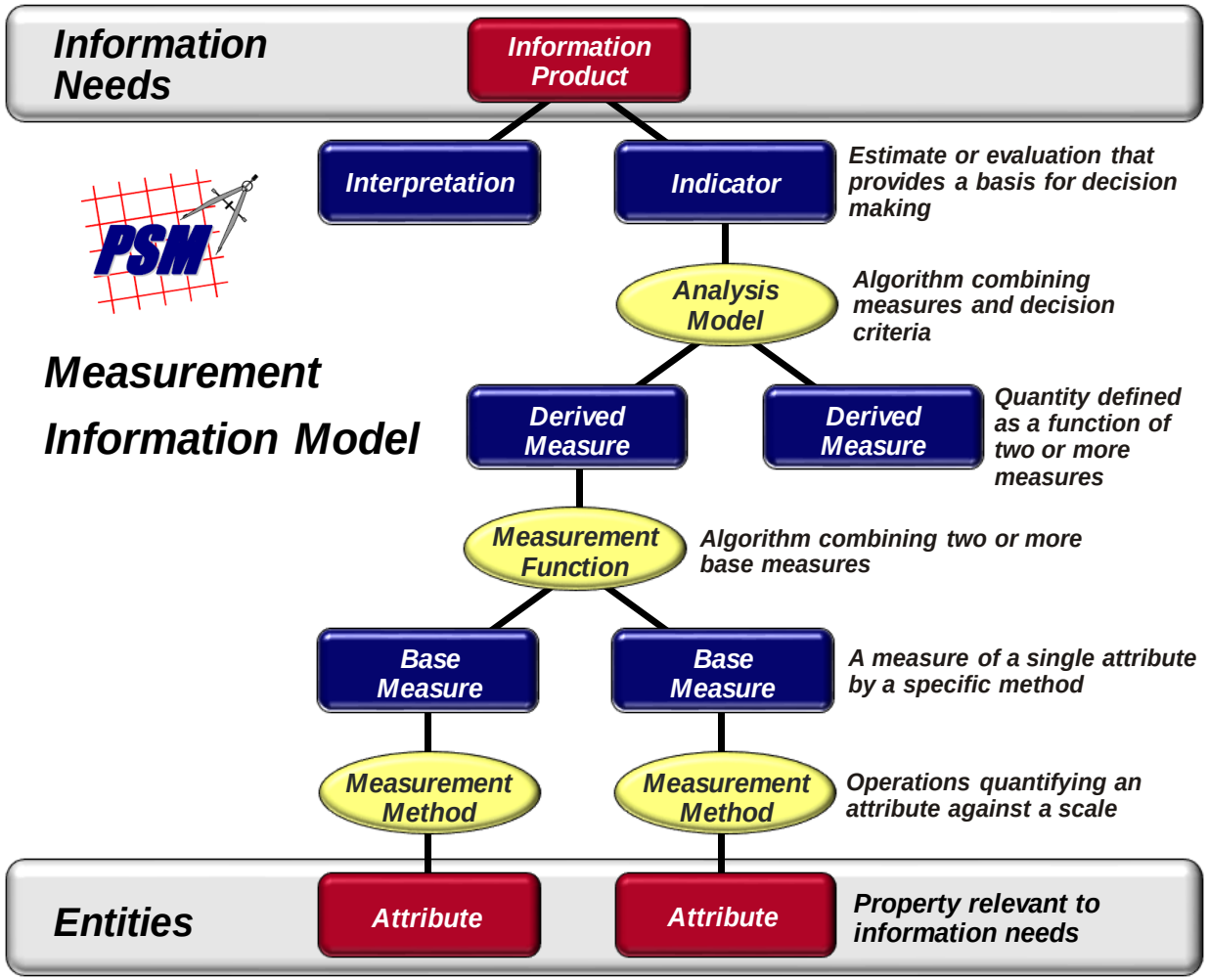
Primary Benefits	Description	Secondary Benefits and Measures
Higher level support for automation	Use of tools and methods that automate previously manual tasks and decisions	8.6 Product Automation 8.7 Deployment Lead Time
Early Verification and Validation (V&V)	Moving tasks into earlier developmental phases that would have required effort in later phases	8.4 DE Anomalies 8.5 Adaptability and Rework 8.7 Deployment Lead Time
Reusability	Reusing existing data, models, and knowledge in new development	8.4 DE Anomalies 8.5 Adaptability and Rework 8.7 Deployment Lead Time
Increased Traceability	Formally linking requirements, design, test, etc. via models	8.7 Deployment Lead Time 8.8 Runtime Performance
Strengthened Testing	Using data and models to increase test coverage in any phase	8.1 Architecture Completeness and Volatility 8.2 Model Traceability 8.3 Product Size
Better Accessibility of Information (ASoT)	Leveraging an Authoritative Source of Truth (ASoT) to increase access to digital data and models to increase the involvement of stakeholders in program decisions	8.7 Deployment Lead Time 8.8 Runtime Performance
Higher Level of Support for Integration	Using data and models to support integration of information and to support system integration tasks	8.6 Product Automation 8.2 Model Traceability
Multiple Model Viewpoints	Presentation of data and models in the language and context of those that need access	8.1 Architecture Completeness and Volatility 8.7 Deployment Lead Time

PSM measures are derived from business information needs

Based on objectives and issues from the project or enterprise levels

- *Objective* - a project goal or requirement
- *Issue* - an area of concern that could impact the achievement of an objective, including risks, problems, and lack of information

Measures should provide insight into project or enterprise information needs to support decision-making



See Framework for more information

PSM Practical Software and Systems Measurement, www.psmsc.com

DE Measurement Framework ICM Table (Excerpt)

Table 7-2: Information Categories, Measurable Concepts, and Measures

Information Categories	Measurable Concepts	Project Information Needs	Enterprise Information Needs	Potential Measures	Notes (Guiding Objectives)
Schedule and Progress	Architectural Completeness	How complete is the architecture? Does the architecture account for all required functions? Is the architecture sufficiently complete to proceed with design at acceptable risk?	What is the amount of schedule and design risk for each project? What is the architecture progress across projects?	Architecture Completeness and Volatility *	
Schedule and Progress	Model Coverage	What is the extent of traceability across digital model elements? What traceability gaps exist? What is our progress in completing the digital model?	What is the extent of model traceability for a set of projects? What is the modeling coverage and progress of the digital engineering capability across projects? What is the current upper limit of the digital engineering capability?	Model Traceability * Model Coverage (modeled elements)	Measurement is against only the digital model elements. Model elements are created to fulfill the functions and interfaces allocated during the architecture and design phases.
Size and Stability	Functional Size and Stability	What is the size and scope for the DE project or product? How much work must be done? How many functions and interfaces have been identified in the system architecture or design? How much is that changing? How does DE product size relate to estimates and measures of cost, schedule, productivity, or performance?	Is the current project similar in size and scope to historical projects? Is the work scope changing? Is the schedule and effort sufficient to address changes? How does DE product size relate to estimates and measures of cost, schedule, productivity, or performance?	Product Size * (Model Elements) Architecture Completeness and Volatility * Functions Identified Functional Change Requests	In development, product size can be determined by a count of model elements. Function Volatility includes the aspects of continuing to identify new functions and/or having the functional allocation continue to change. In maintenance, change requests are often used as a measure of work scope.

Example Measurement Information Model – Anomalies

Digital engineering measures and indicators are specified in a structured template aligned with the PSM Measurement Information Model

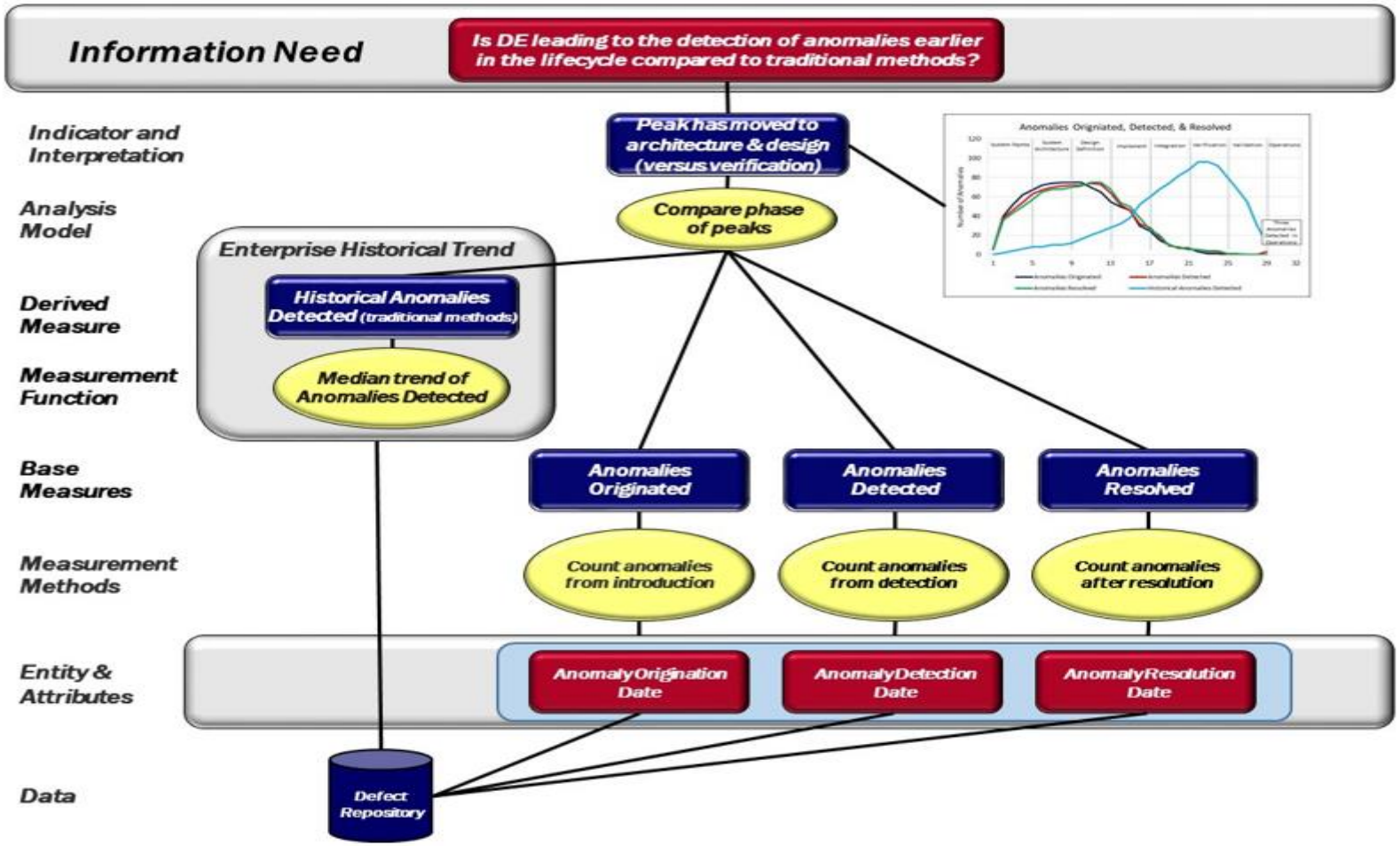


Figure 3.2-4: Mapping Data to Measures

Example Measurement Specification (Excerpts)

8.2 MODEL TRACEABILITY

Description

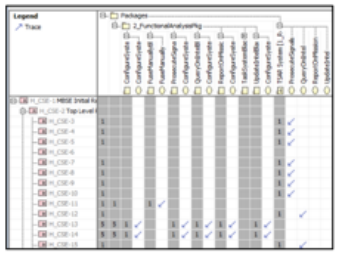
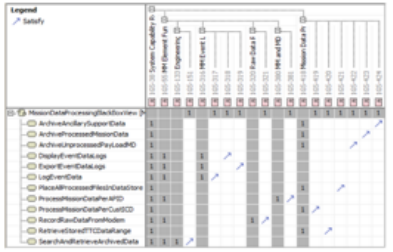
Measure Introduction	
Description	The usefulness and quality of a digital model depends on the completeness and integrity of the relationships among model elements. Traceability between elements, such as requirements allocation and flow down to architectural, design, and implementation components, assures that the system solution is complete and consistent. Gaps in bi-directional traceability between the artifacts of two models or might indicate where further analysis or refinement are needed. This might further apply to traceability gaps within a single model, when there is no implicit traceability between artifacts of different design stages. The prerequisites of any traceability measurement are agreed-upon, a priori guidelines and definitions, e.g., what model elements and relationships shall be traced, that apply to the specific DE model of the system. *Note:* While traceability might be applied to any model elements of interest that shall be defined a priori, functional architecture completeness always explicitly focuses on functions, requirements, and the associated hierarchy. Traceability reports and analyses might be facilitated by digital modeling tools. The traceability concepts and indicators in this specification are representative examples of more general traceability mappings and reports across the development life cycle, such as: • Traceability between stakeholder needs, system requirements, and allocated or derived requirements at each level of the system hierarchy • Traceability and flow down of requirements to the logical or physical solution domain (e.g., design, implementation, integration, verification, validation) • Allocation and traceability of performance measures or parameters, such as Measures of Effectiveness (MOEs) or Key Performance Parameters (KPPs) • Traceability of system interfaces
Relevant Terminology	Model Element: Modeling constructs used to capture the structure, behavior, and relationships among system model components (See 2.2.2 Model Element) Source Element: The *a priori* base model elements defined per DE model from which other model elements shall be derived from or allocated to, e.g., a stakeholder needs. Destination Element: The model elements defined per DE model that shall be derived from or allocated to the Source Elements. Traceability Gap: One or more model elements defined per DE model that shall be traced, but that have not yet been derived or allocated to Source Elements. Note: For enhanced traceability concepts refer to the advanced topic discussion.

Definitions

Measures (Base, Derived)

Information Need and Measure Description	
Information Need	What is the extent of achieved traceability coverage from Source Elements, e.g., requirements, down to the logical or physical solution domain? What is our progress in completing the digital model? What traceability gaps exist?
Base Measure 1	Model Elements Traced [integer] "Number of model elements in a 1... n source/destination element relationship(s) as defined in an agreed upon, *a priori* guideline.
Base Measure 2	Model Elements Not Traced [integer] Number of model elements not in any 1... n source/destination *element relationship as* defined in an agreed upon, *a priori* guideline.
Derived Measure 1	Total Model Elements = Model Elements Traced + Model Elements Not Traced [integer] Total number of model elements *Note:* As defined in an agreed upon, a priori guideline (See Base Measure 1 and Base Measure 2).

Indicator(s) and Interpretation

Indicator Specification	
Indicator Description and Sample	Model Traceability can be depicted using visual or tabular summaries of the relationships among model elements. The specific indicators may depend on the model elements for which traceability is being measured, and the built-in reports and analyses provided by the digital modeling tool. For example, traceability among model elements might be implemented by showing requirements derivation and model traceability coverage of stakeholder needs into system and component requirements. Representative example indicators used to assess traceability dependencies among selectable model elements (e.g., requirements, use cases, activities, logical architecture and design, physical design, interfaces, parameters, measures of performance) are depicted in Figure 8.2-1. Here, mostly 2-dimensional matrices containing model specific model elements of interest are utilized. Alternatively, the relationship between model elements might be depicted as flow down. With respect to Figure 8.2-1 (bottom left), a specific use case is linked to related actions via an activity diagram.  Traceability Between Model Elements (Dependency Matrix)  Relationships to Problem or Solution Domain («*satisfy*» or «*refine*» Matrix)

Analysis Guidance

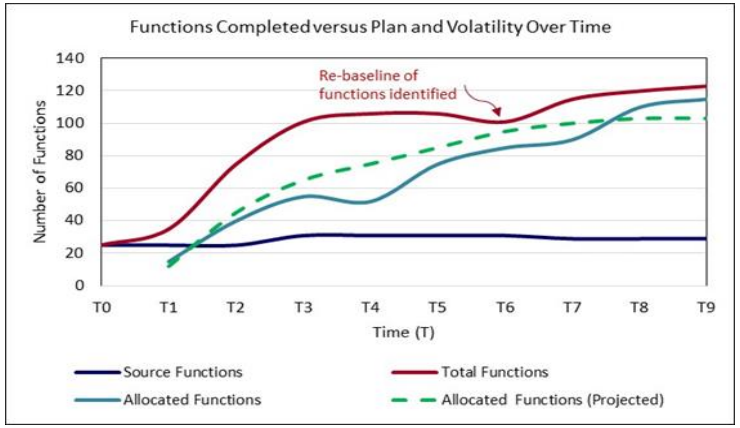
Analysis Model	Projects and organizations shall define the objectives, constraints, and criteria for establishing traceability among applicable model elements. This is typically guided by a model schema, metamodel, or blueprint that constrains traceability to meet the model's purpose. Review and analyze traceability dependencies among model elements to assess the completeness, adequacy, quality, and integrity of the digital model. The analysis may vary according to the types of specific model elements selected, but general guidelines may include: • Each source (parent) model element (Model Element 1) should be traceable to one or more allocated or derived destination (child) model elements (Model Element 2). • Each destination (child) model element (Model Element 2) should be derived from, or refine, a parent requirement or model element (Model Element 1). • Determine if the set of linked dependencies are, in aggregate, sufficient to adequately implement the parent requirement or model element.
Decision Criteria	In case a desired model traceability coverage (Derived Measure 2), e.g., 70%, of model elements of interest has not been met, the team shall specifically address these gaps. To validate whether the system meets stakeholder needs, at minimum, the system requirements should be traceable to these stakeholder needs. Model elements that do not satisfy requirements, might be obsolete and shall be evaluated. Again, the prerequisites of any decision making are agreed-upon, a priori guidelines and definitions, e.g., what model elements and relationships shall be traced, that apply to the specific DE model of the system

Additional Information and Guidance

Additional Analysis Guidance
Implementation Considerations
Information Category
Measurable Concept
Relevant Entities
Attributes
Data Collection Procedure
Data Analysis Procedure

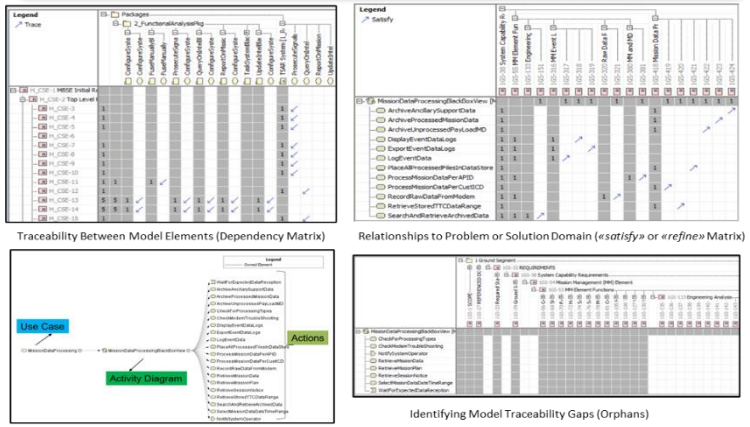
Digital Engineering Measurement Framework – Example Indicators

Architecture Completeness and Volatility



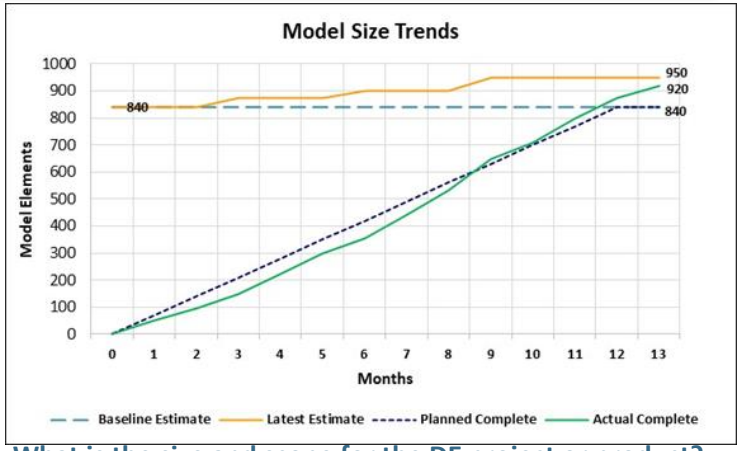
Is the architecture complete to proceed with design?

Model Traceability



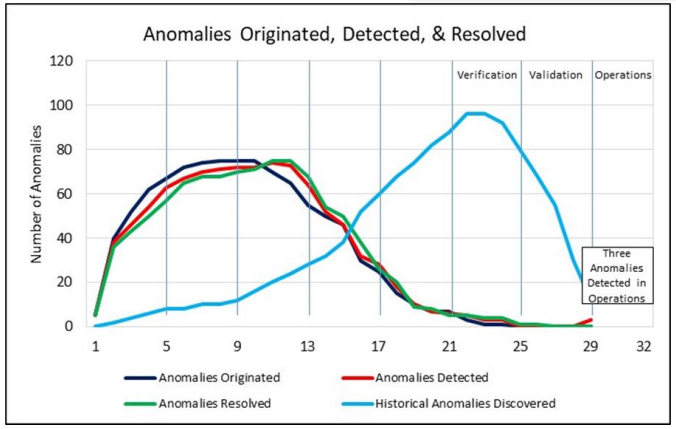
What is the traceability and coverage of model elements?

Product Size (Model Elements)

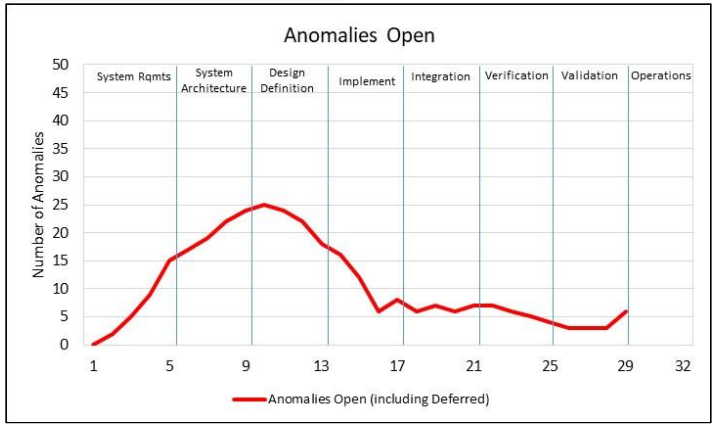


What is the size and scope for the DE project or product?

DE Anomalies

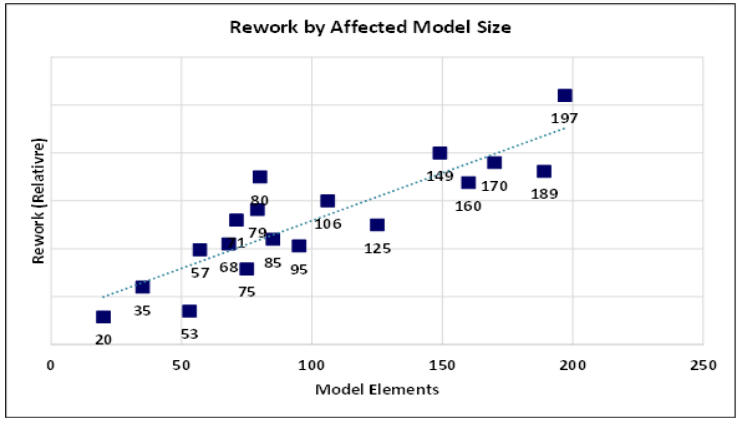


Are we finding and removing anomalies earlier using DE?



Is product quality adequate to be used in subsequent phases?

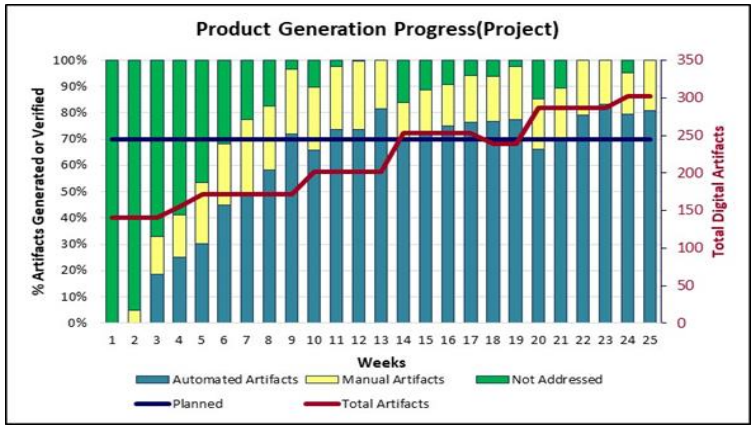
Adaptability and Rework



How much rework is for planned and unplanned changes?

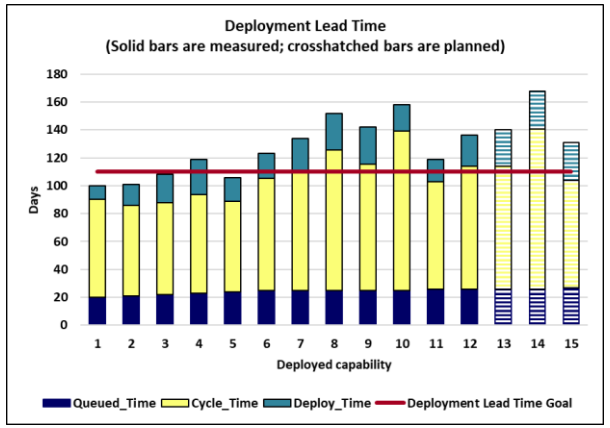
Digital Engineering Measurement Framework – Example Indicators

Product Automation



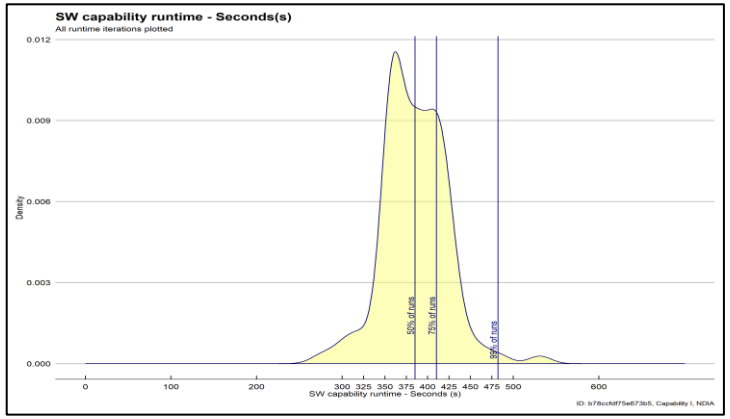
What percentage of artifacts are automatically model-generated?

Deployment Lead Time



How long does it take to deploy an identified capability?

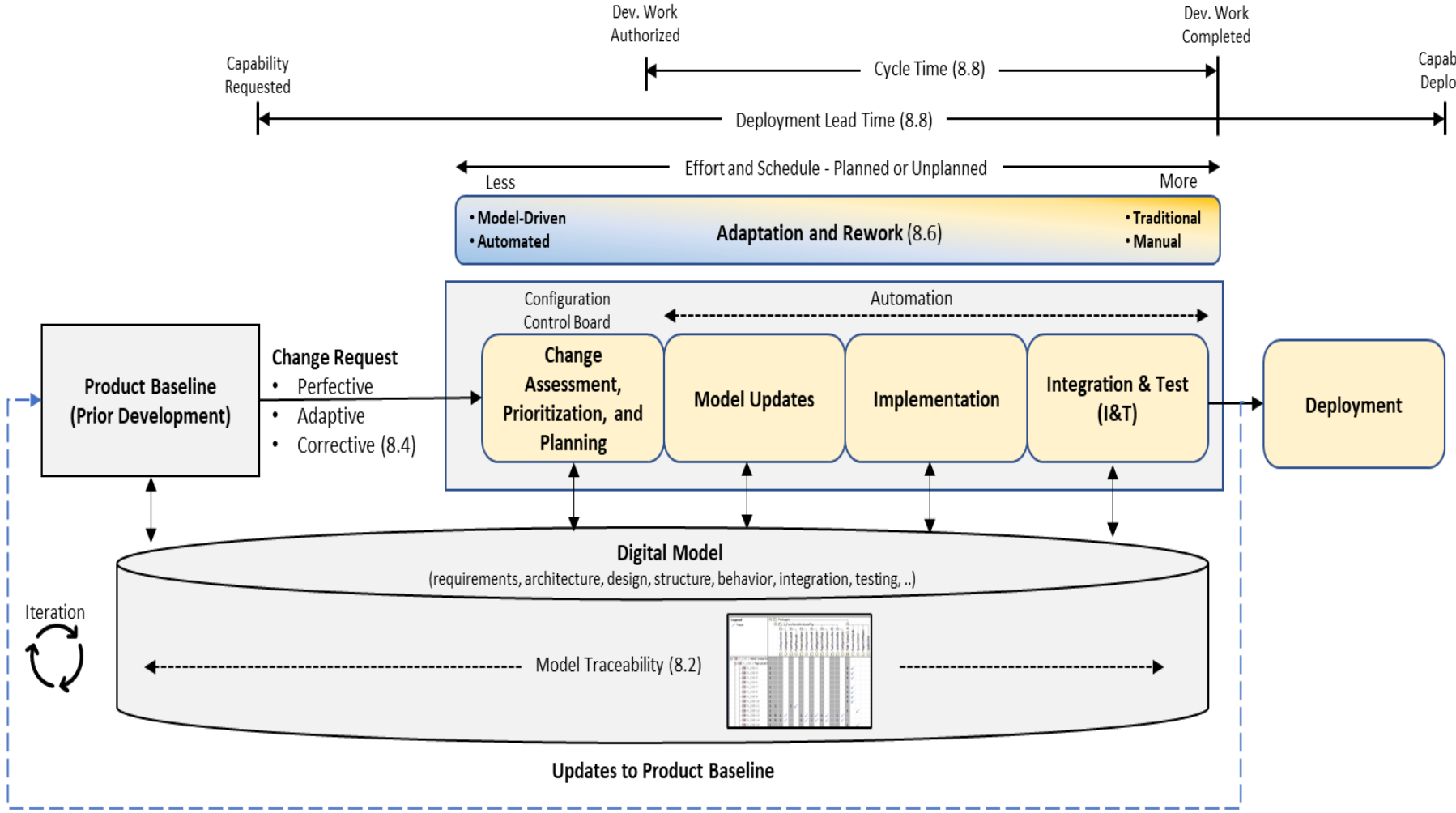
Runtime Performance



What is the likelihood performance will meet operational needs?

Excerpts only from DE measurement specifications. Some specs have multiple sample indicators. See framework Section 8 - Measurement Specifications for details.

Tying it all together – DE measurement framework concept



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Chris Schreiber	Lockheed Martin Corporation NDIA Systems Engineering Division
Paul Solomon	Retired
Brian Tenney	Lockheed Martin Corporation
Sundar Thyagarajan	L3Harris Technologies
Steven Turek	United States Air Force
Timothy Walden	Lockheed Martin Corporation
John Wood	Naval Information Warfare Command

Much appreciation to the many individuals and organizations that supported development of the V1.0 Digital Engineering Measurement Framework!

Where do we go from here?

- *DE measures for the enterprise*
- *Measure breadth of usability and user experience with digital tools*
- *Measure return on investment*
- *Measure additional productivity indicators related to velocity and agility*
- *Measure additional indicators that isolate new value to the enterprise through DE, in areas such as quality and knowledge transfer*
- *Measure enterprise and personnel process adoption*
- *Measure usability and user experience with digital tools*
- *Supportability and maintainability measures (impact assessment agility)*
- *Measures for security*
- *Identify typical digital artifacts*
- *Specify leading indicators*

Summary – Digital Engineering Measurement Framework v1.0a

- Lack of common measures and established best practices have inhibited digital transformation
- The v1.0a release of the DE Measurement Framework establishes an initial consensus from our partners as a starting point to advance a discussion across industry – some measures are conceptual

This initial DE measurement framework proposed by our team of representative stakeholder experts is intended to help projects and enterprises establish an initial path toward a measurably effective transition and implementation of digital engineering methods. It is but the first steps along this path, it will be a long and challenging but rewarding journey, and our industry will learn, iterate, and evolve as we go. We hope enterprises across a variety of application domains will find this initial measurement guidance useful to assess the effectiveness of their respective digital engineering transformation initiatives.

- Help us improve it! Participate in reviews, provide comments and suggestions, pilot the measures proposed, and participate in the future evolution of this framework
- Contact our team leads to get further involved

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CODEMMANDOS

Empowering Agile/DevSecOps Citizen Developers with No-code & Scripting

Brandon Froberg
Erik Olson

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CODEMMANDOS

Motivation

Loathe Coding is a software development mentality to “get rid of a problem”…

a person loathes a problem SO MUCH …

they learn to code, go out of their way to figure out, or seek out new methods which solve their issue

CODEMMANDOS

Motivation

Vision

Empower unit and staff assigned Airmen to solve their own problems through software development

Execution

It's NOT a Software Factory…

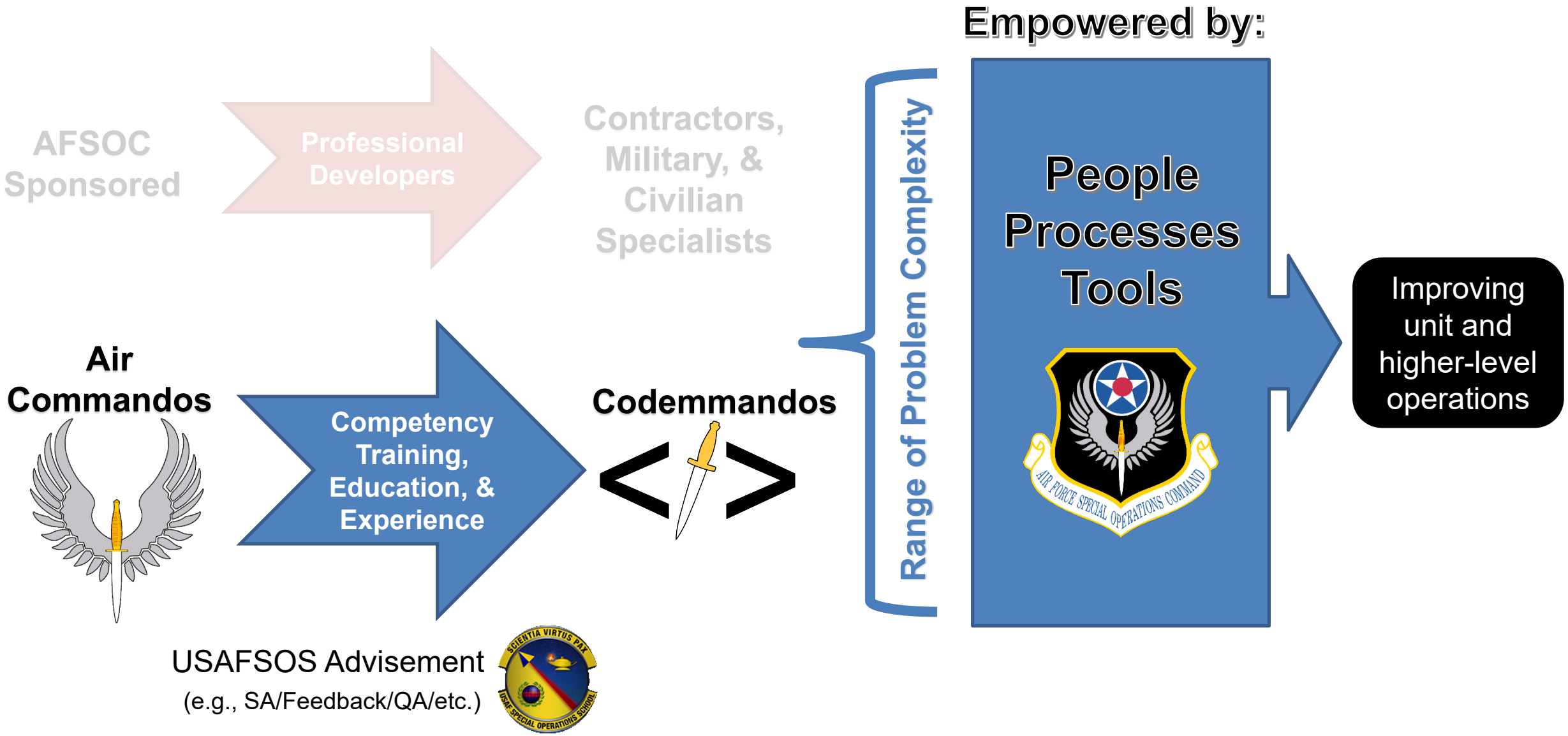
It is a Software Auto-Hobby Shop

Create citizen developers & a cadre of unit-level SMEs to:

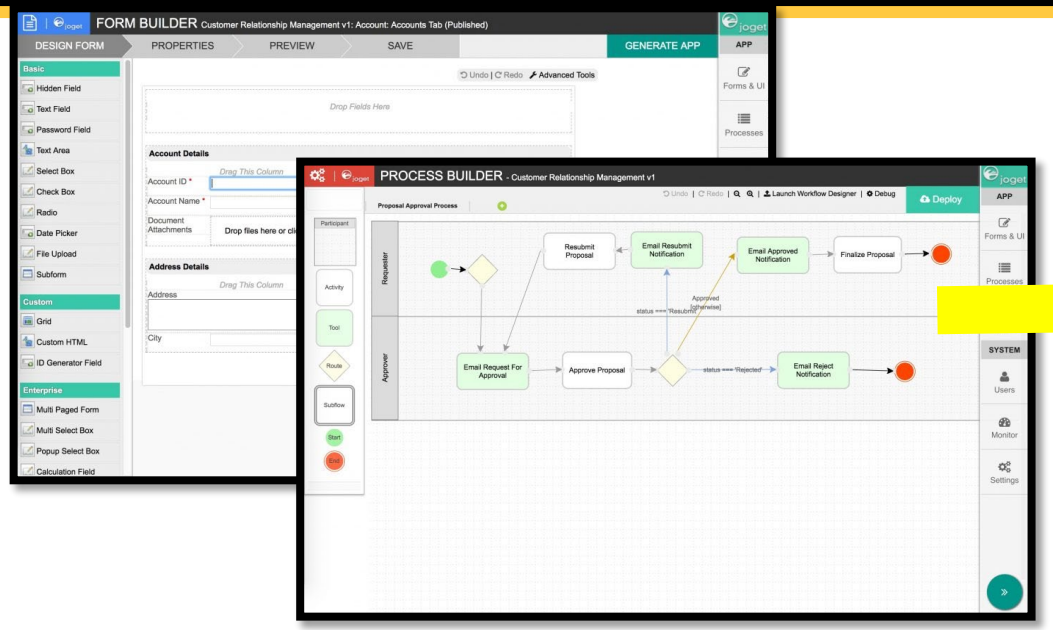
- **Develop fast and approved software (e.g., no-code apps + scripts)**
- **Using low-cost tools**
- **Solve unit-level problems**

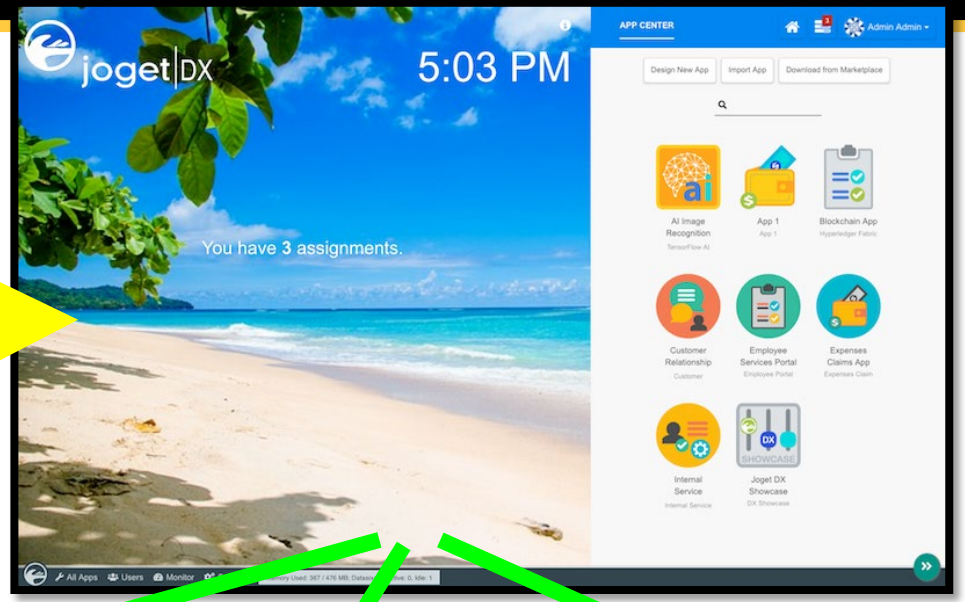
Img source [1]

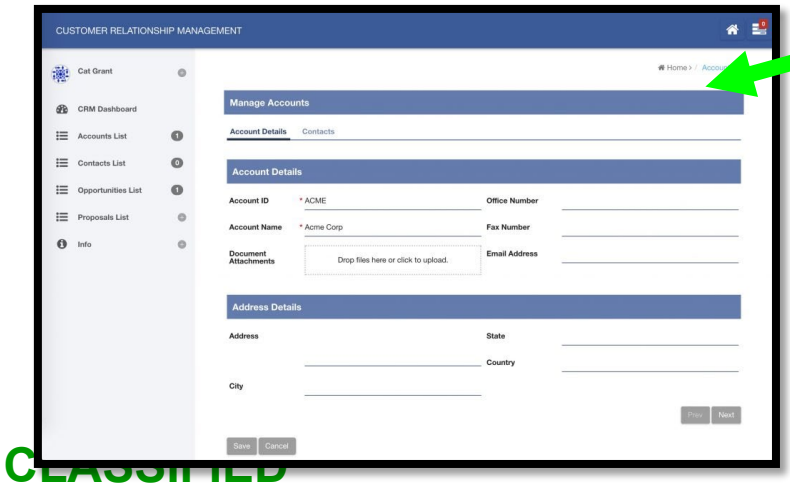
The Codemmandos Initiative (OV-1)

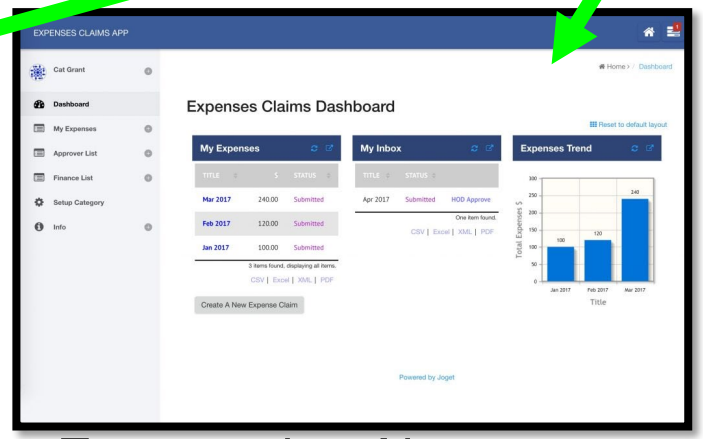


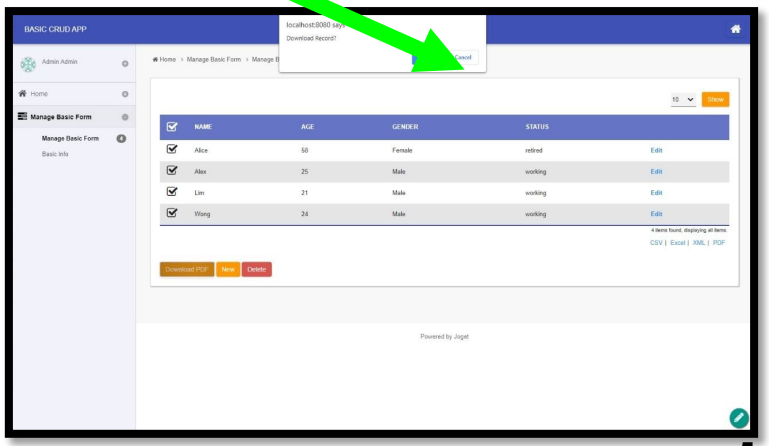
CODEMMANDOS *The Joget "No-Codemmando"*











CODEMMANDOS

Lessons Learned

- Good
  - Competency Based Learning -- AFH 36-2647 “Competency Modeling”
  - Adaptive Acquisition Framework/Software Development Process
  - DevSecOps -- “Plan-Develop-Build-Test” + Teach-One, Show-One, Do-One
- Bad
  - Manning/Support (Long term-to-Daily)
    - Make POC’s singularly focused, OR have regular “hide in a room” days
  - "Multiple Levels/Targets“ – divides attention, dilutes total work
    - Work a single task/effort, then go to a new effort
- Ugly
  - Course Execution (it was good in person)
    - Record sessions + Make it self-study
  - Tools selected (Joget and HTML Applications <HTA’s>) are niche

The effort was a 1-year approved Innovation Effort hosted by AFSOC (ended Sep 22)

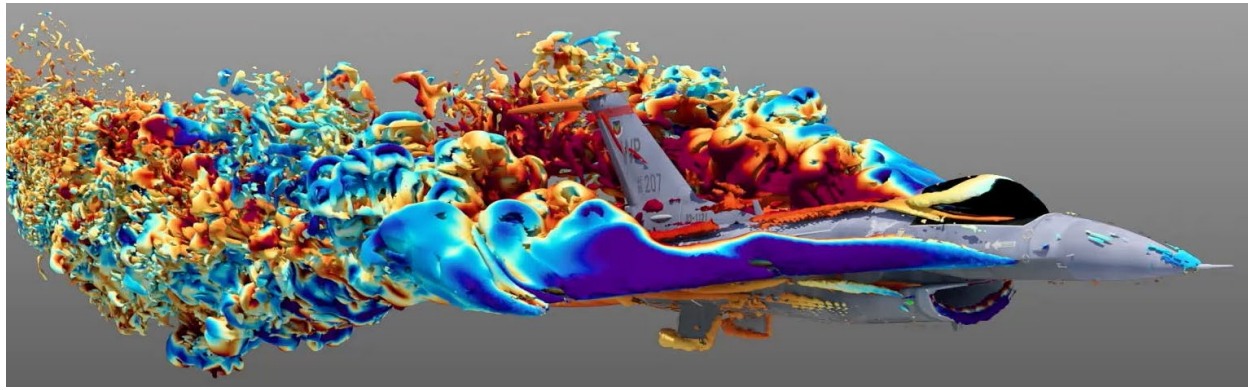
CODEMMANDOS

Future / Questions

- Future
  - Codemmandos is on indefinite pause
  - Need to identify long-term supported platforms/approaches
  - Formal Requirement to ID/ask for support

- Note: Send email for links for training resources / MS Teams / app site
  - brandon.froberg.1@us.af.mil

QUESTIONS?



Progress Towards Improving the Models in Model Based Systems Engineering with High Fidelity Physics

Dr. Scott A. Morton, Dr. David McDaniel, and Dr. Jennifer Abras

National Defense Industry Association
Systems and Mission Engineering Conference
1-3 November 2022

Presenter - Dr. Scott A. Morton, Associate Director for Software
DoD HPCMP, US Army ERDC/Information Technology Laboratory
Scott.a.Morton@usace.army.mil

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Definition: Digital Engineering vs. MBSE

- **Model-based systems engineering (MBSE) –** a formalized methodology used to support the requirements, design, analysis, verification, and validation associated with the development of complex systems *(Nataliya Shevchenko, "An Introduction to Model-Based Systems Engineering (MBSE)," Software Engineering Institute (SEI), 21 Dec 2020)*

- **Digital engineering (DE)** – an **integrated digital approach** that uses authoritative sources of systems' **data** and **models** as a **continuum across disciplines** to support life cycle activities **from concept through disposal.** *(Defense Acquisition University)*
  - Integrated digital approach → a monolithic solution that suggests there can be no R&E / A&S divide
  - Data → must be regularly managed/updated/curated at each stage of the process
  - Models → both compute and data-intensive; range from basic analysis to high-end computing (HEC)
  - Availability → accessible to anyone in the design, test, evaluation, sustainment, mission planning pipeline
  - Duration → from concept through disposal (and possibly beyond); decades to centuries
  - Extensity → continuum across disciplines; simultaneous accounting of all assets at all lifecycle stages to facilitate projection of current and future forces in a full range of scenarios, to determine gaps, to advise the characteristics of future platforms, and to build preventive maintenance plans for individual assets

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HPC Impacting Digital Engineering

Physics Based Simulation

High Fidelity Physics Simulations Primarily Used for Issue Diagnosis and Resolution or Design Downselect

- Many Single Point Calcs
- Close match with Reality
- Typically Occurs after wind tunnel tests or after flight tests (days/!M's CPU Hrs)
- Fixes can be costly since vehicle is farther in the design process
- Data computed not in a form easily reused for other needed points

Models

System Level Models Useful for Systems Engineering

- Calculations are faster than real time
- Broad applicability of model to vehicle envelope
- Can be available any time in the design cycle
- Only useful if decision level data is accurate enough
- Easily moved through the design cycle
- Continuously updated as system design changes

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Physics Based Surrogates

Physics Based Surrogates

- Based on pre-computed high fidelity simulations
- Broad applicability to vehicle flight envelope
- Faster than real time calc times

- Single or multi-physics applicability depending on pre-computed physics sims
- Can be combined with other surrogates

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Model Based Systems Engineering

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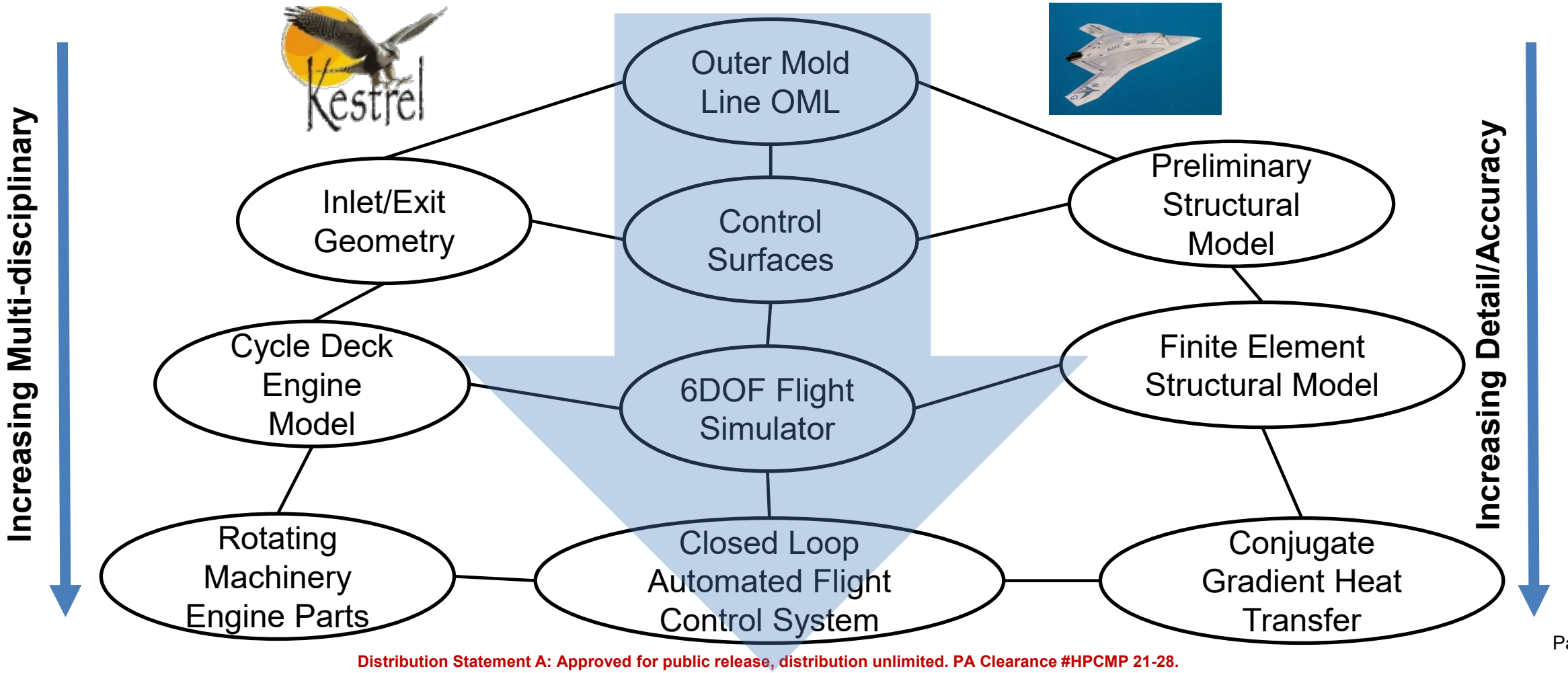
Physics Based Simulations

- During the design process we can eliminate poor design choices by increasing the fidelity of the PBAs as more information is known (objects and connection notional)



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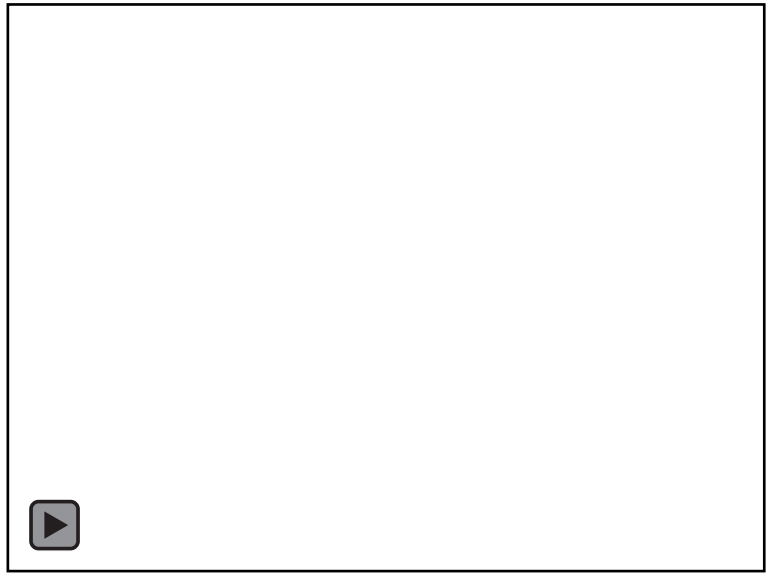
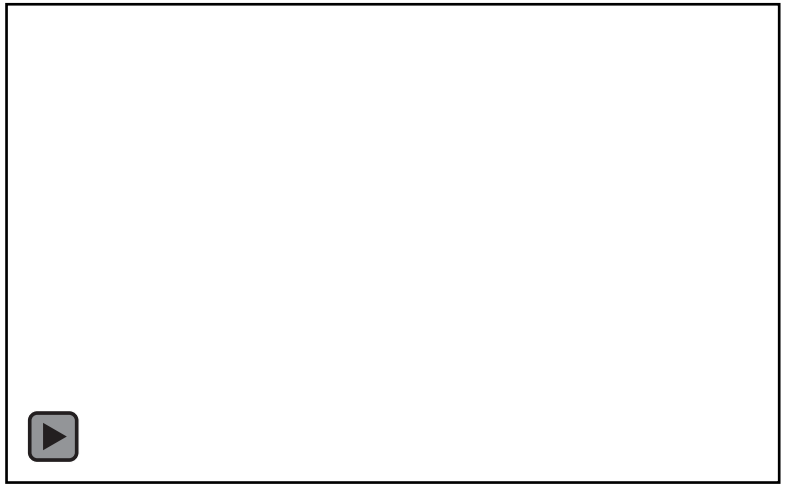
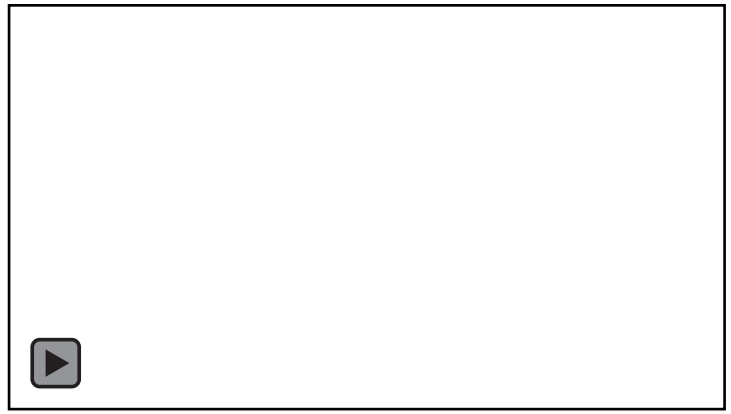
Physics-Based Simulations



Integrated Rotating Machinery



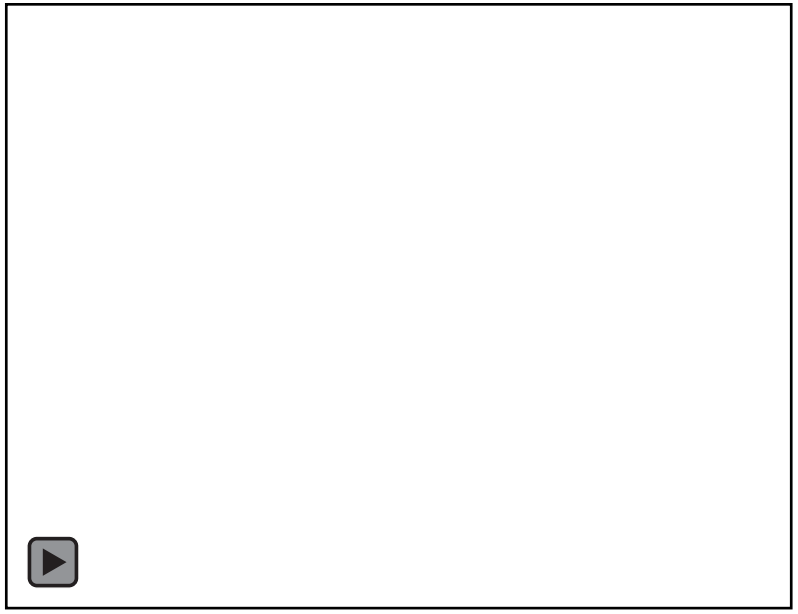
Integrated Structural Elasticity



Integrated Moving Control Surfaces

Single Point Physics-Based Surrogates

- Many methods of building Surrogates/ROMS
- Aircraft C.G. Loads using System Identification
- Distributed Loads using Proper Orthogonal Decomposition
- Machine Learning using Neural Networks



Vehicle Envelope Level Surrogates-AI/ML

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Machine Learning Methods

- **A wide variety of machine learning methods exist**
- **For the current effort the Deep Neural Network (DNN) and the Convolutional Neural Network (CNN) are the primary focus**
- **The DNN is a simpler method that learns based on point based information**
  - This is the main ML driver for the effort
- **The CNN is a more complex method that learns based on patterns in distributed information**
  - This is included as an optional feature that allows for the inclusion of more complex physics into the analysis when needed

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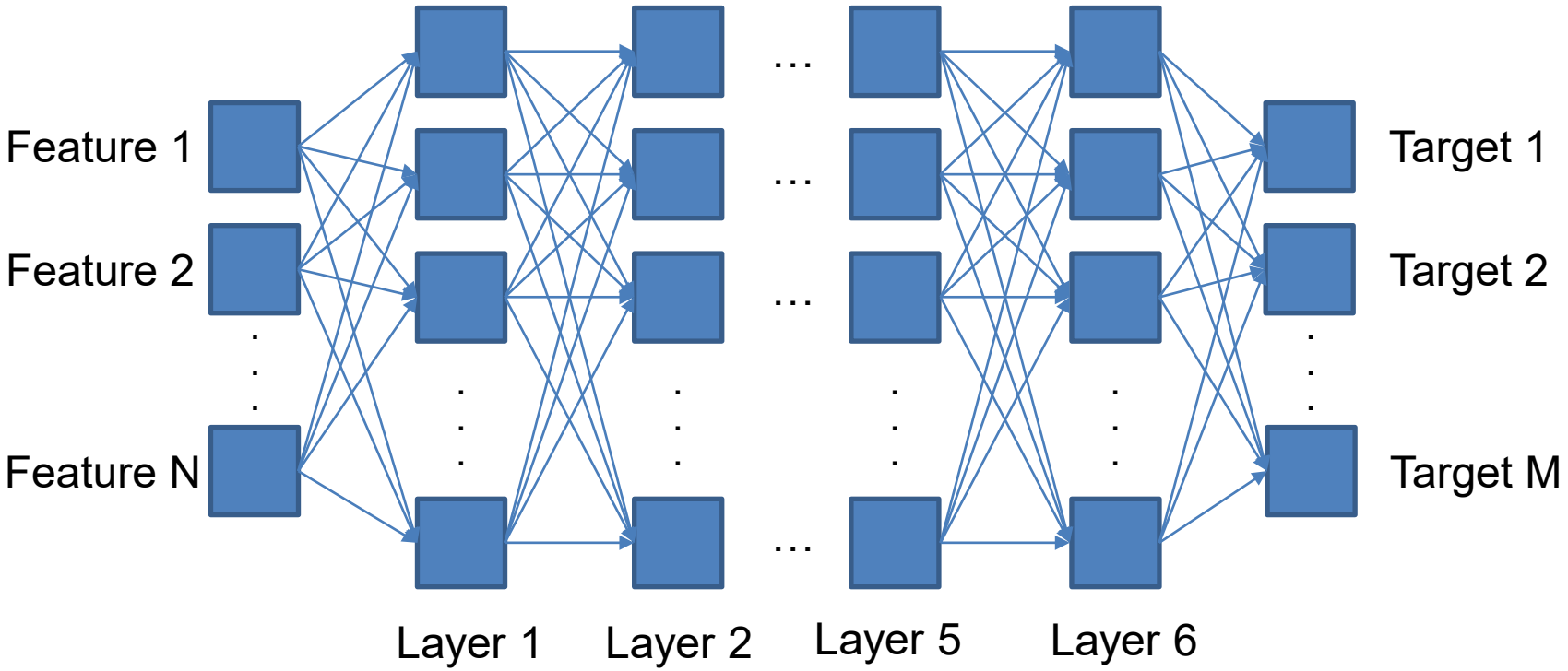
Deep Neural Network (DNN)

- The DNN is the core ML method employed for this effort
- The DNN implemented is a multi-layer perceptron regressor
- The current setup uses 6 hidden layers of 100 neurons



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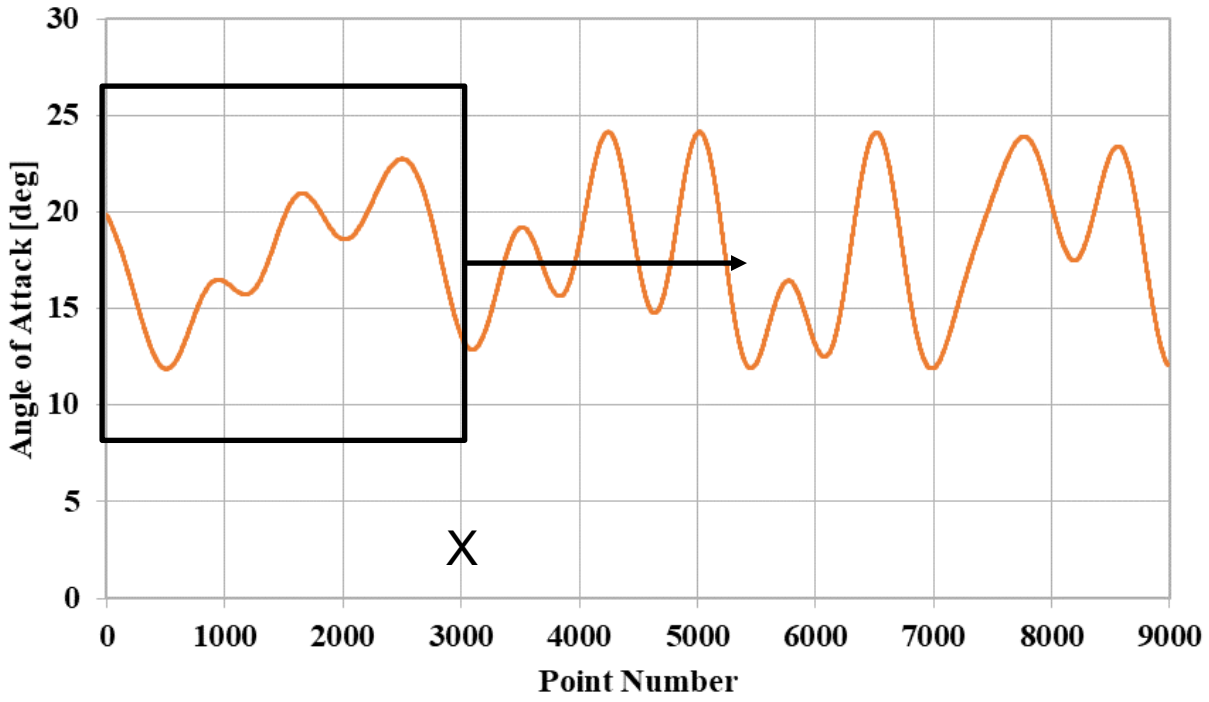
Convolutional Neural Network (CNN)

- A one-dimensional form of the CNN is employed in this effort
- The input time-history data are divided into sequences to train the model
- The target data are extracted at the next point in the sequence



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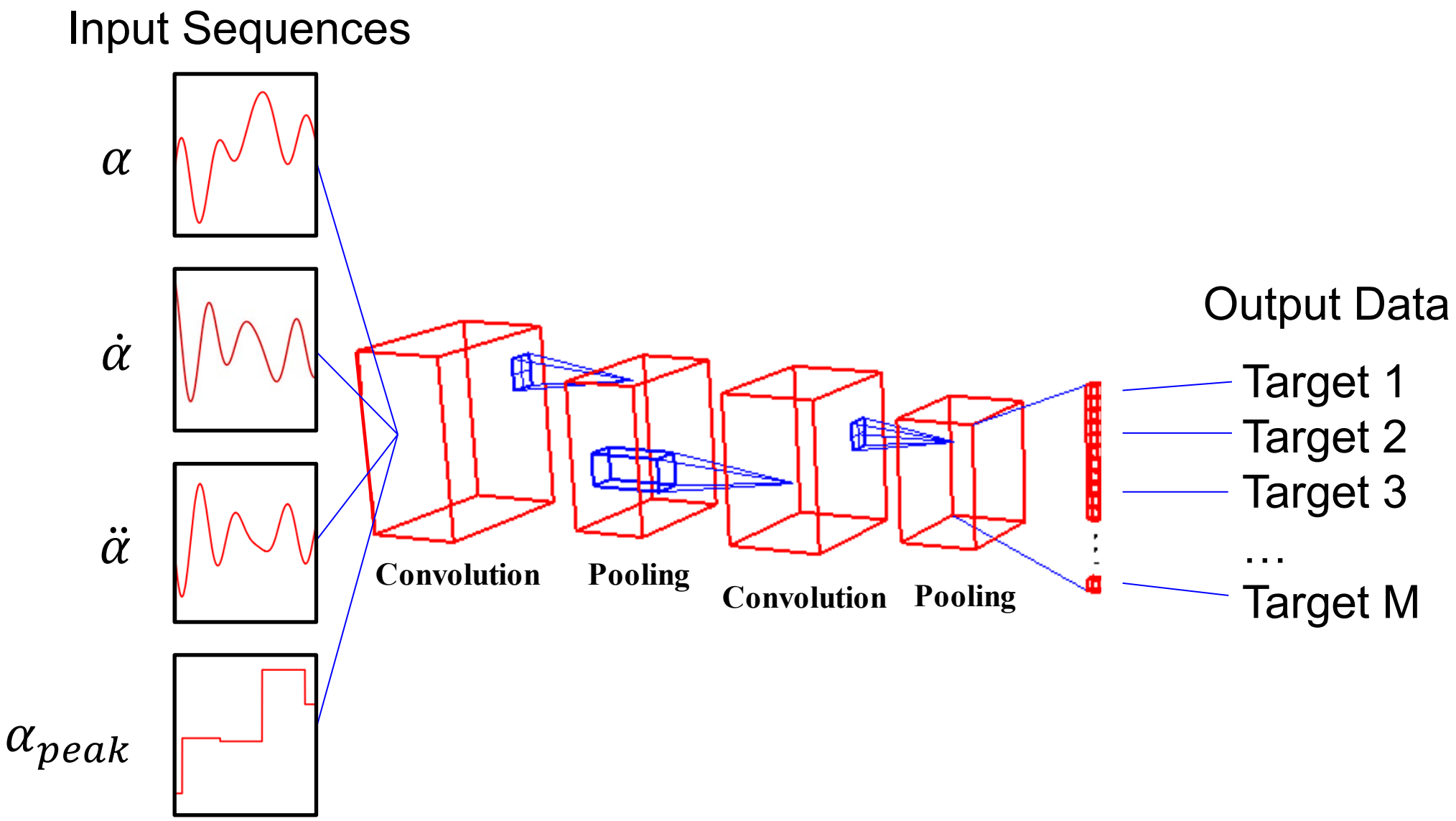
CNN Architecture Illustration



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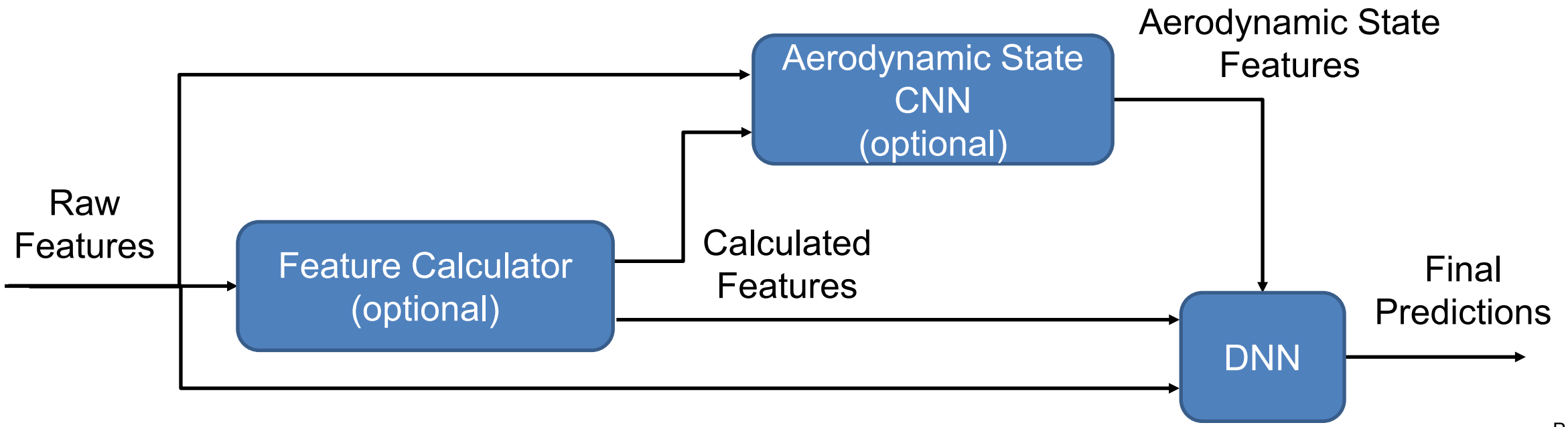
Dual Machine Learning Framework

- **The DNN and CNN are combined into a dual ML framework**
- **Inclusion of the aerodynamic state is beneficial for the prediction of loads where the contribution of more complex physics is a non-trivial factor**
  - The CNN is used to include the more complex physics behavior where needed
  - Use of the CNN is optional because for a majority of the use cases targeted the contribution of complex physics isn't a major factor in predicting sufficiently accurate integrated loads



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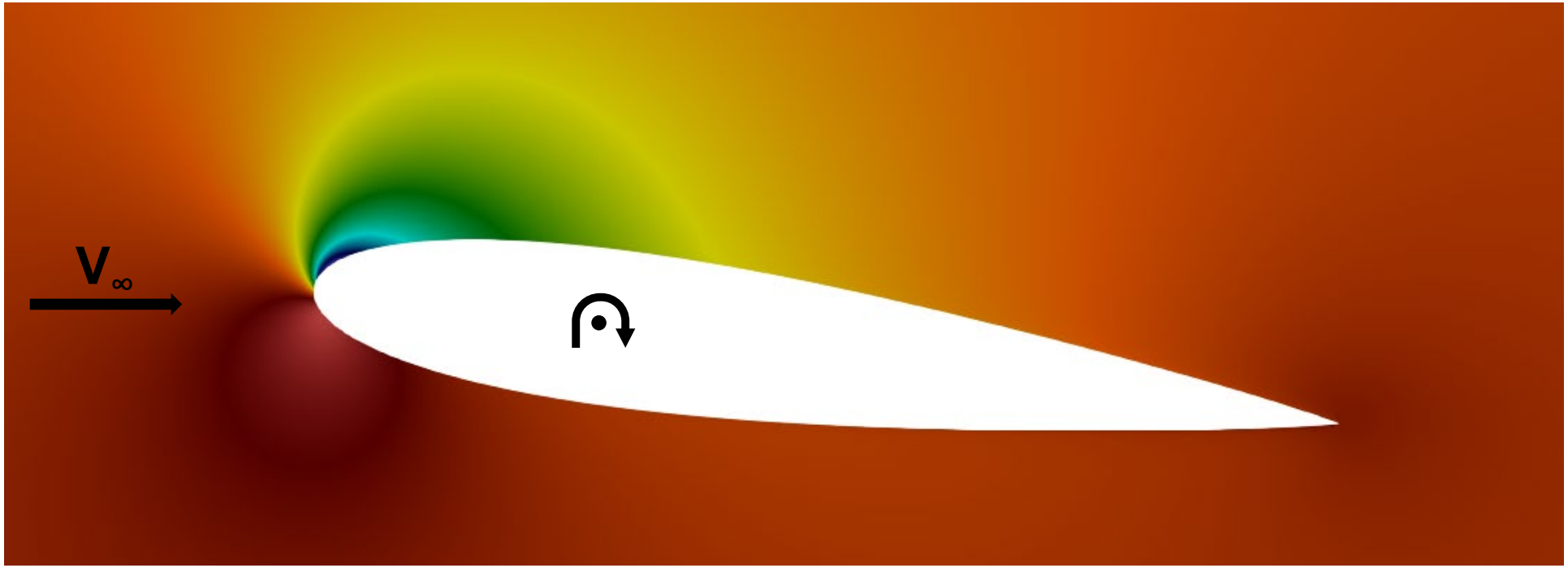
NACA0015: Problem Description

- **NACA0015 pitching airfoil about the quarter chord**
  - R. A. Piziali, “2D and 3D Oscillating Wing Aerodynamics for a Range of Angles of Attack Including Stall,” NASA-TM-4632, 1994
- **Case setup to match this report as well as to define parameter bounds for angle and frequency**
  - No comparisons to experimental data are intended



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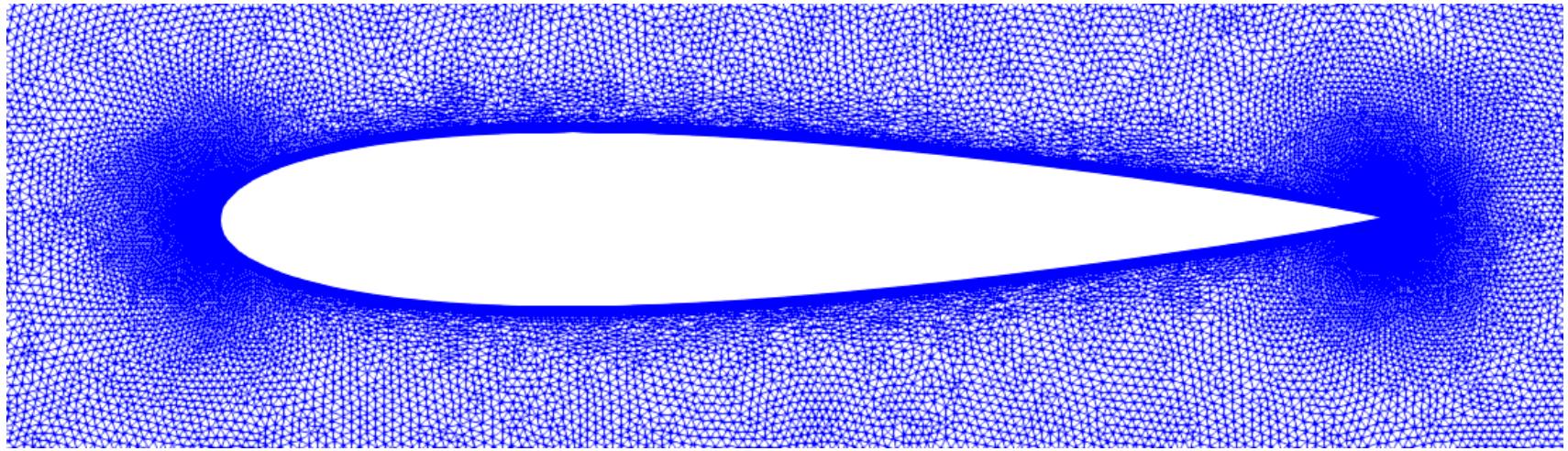
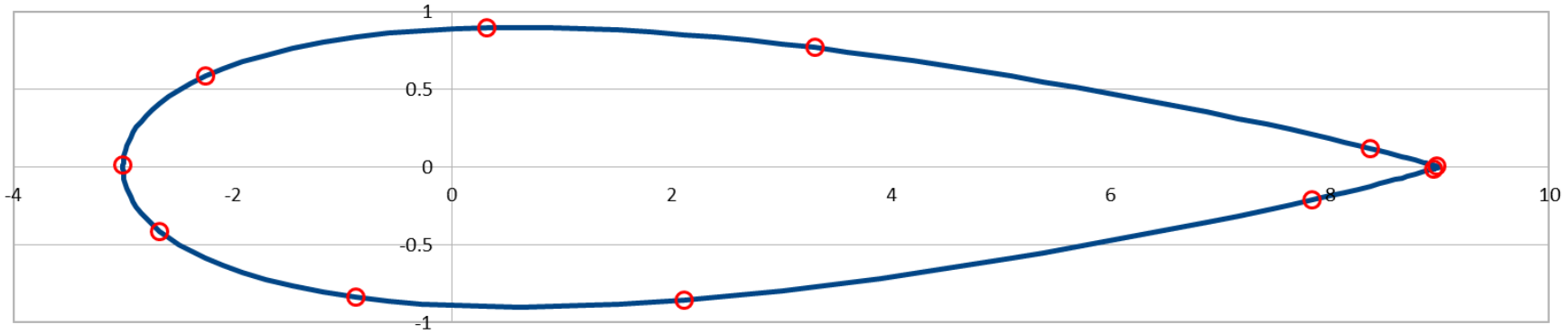
NACA0015: CFD Setup Description

- Kestrel v12.1, 44 Procs (Onyx)
- 2D Airfoil, 200 surface taps, 11 taps used for the ML study





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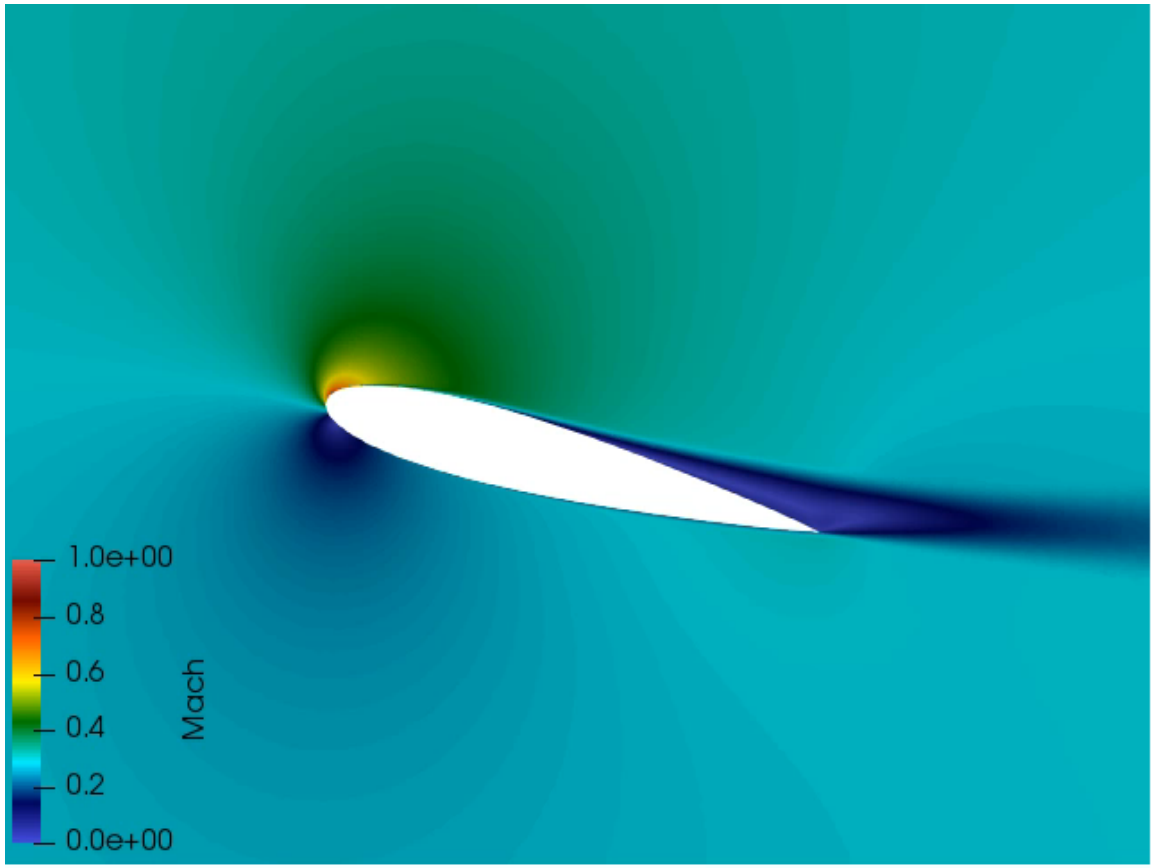
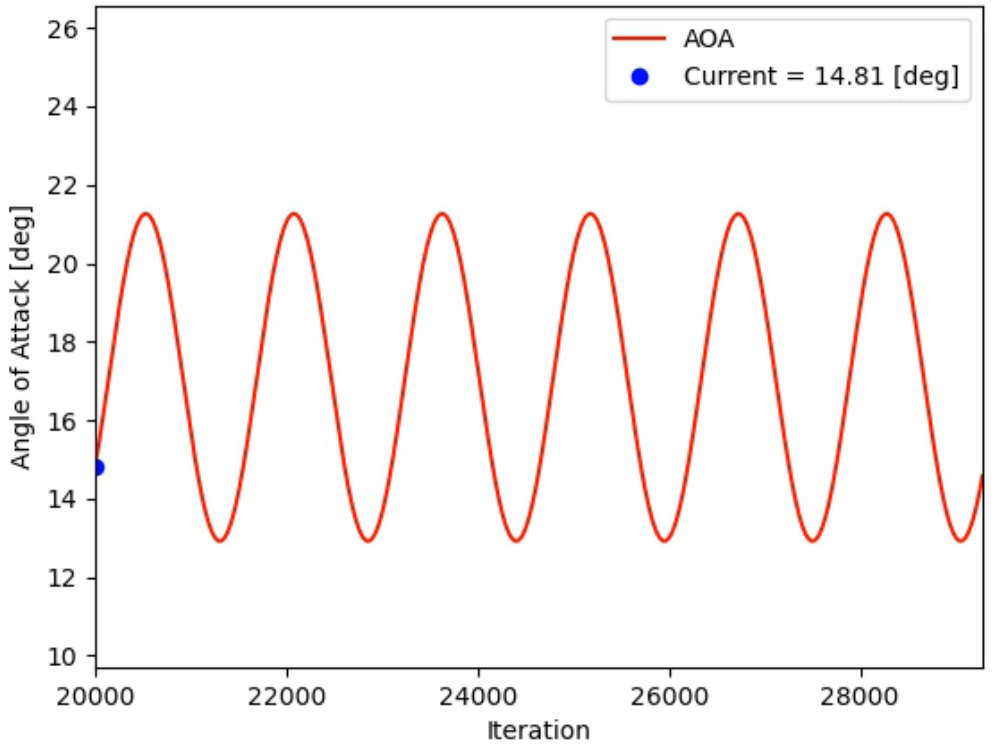
NACA0015: Simulation Illustration

- Illustrates the degrees of freedom for the setup
- Also provides an example of why predicting the aerodynamic state is sometimes needed





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NACA0015: ML Model Setup

- **Input Features**
  - Case 0: α
  - Case 5: $\alpha, \dot{\alpha}, \ddot{\alpha}, \alpha_{Peak}$

- **Output Targets**
  - CNORMAL, CAXIAL, CPITCH

- **Case 0 is trained using steady CFD data**
- **Case 5 is trained using unsteady CFD data**

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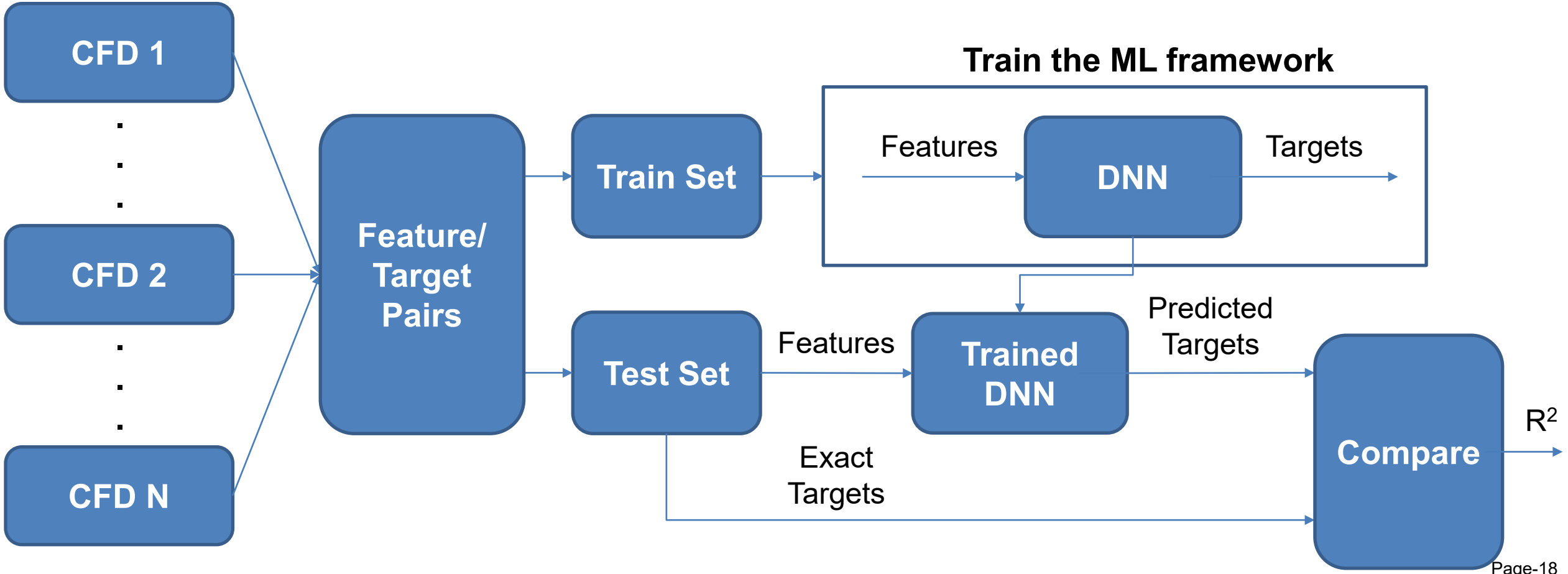
NACA0015: Training Workflow

- Time-history data sourced from multiple CFD simulations
- Each iteration of each simulation is treated as an individual example



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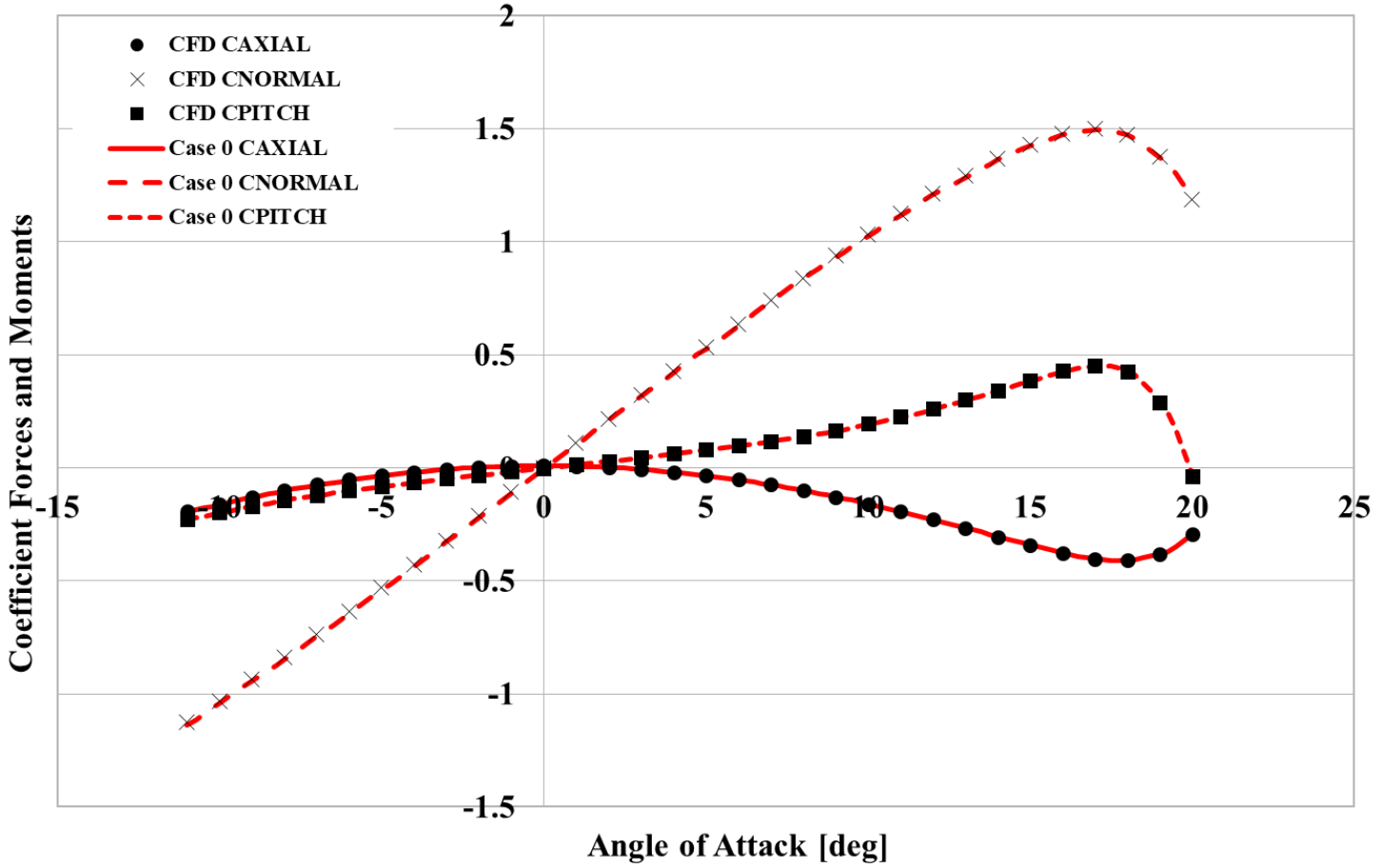
NACA0015: Steady Train and Prediction Results

- For the airfoil case the results are a good fit for Case 0 where only steady-state data are used to train the model
- In this database lookup type use case having only angle of attack as input is acceptable/preferable



NACA0015	Case 0 (α)
Test Data Score	0.9998

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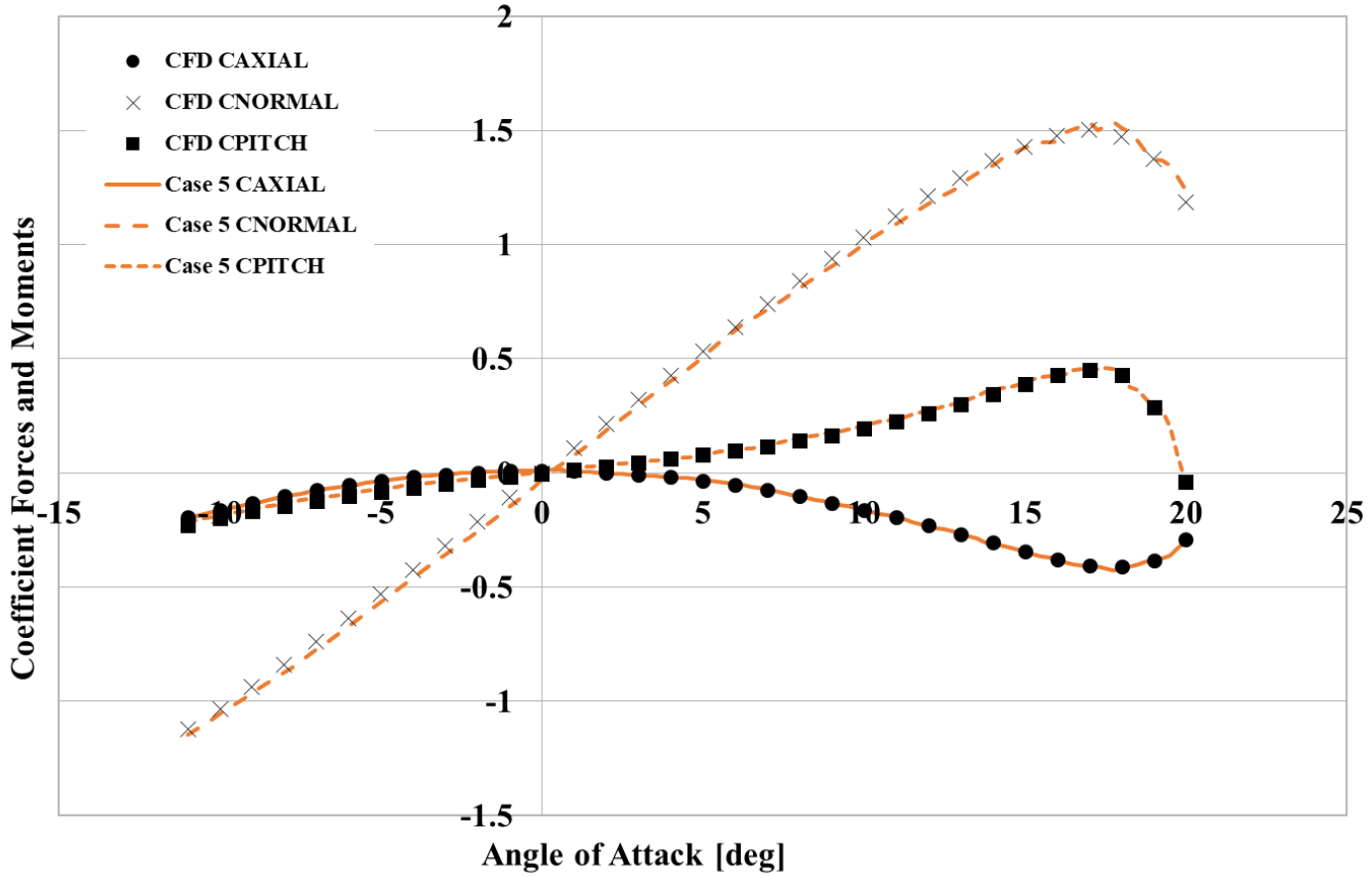
NACA0015: Results using Unsteady Train Data

- Steady predictions are still possible using the unsteady dataset
- Increasing the feature space to include rate and prior peak data is able to capture the steady angle of attack sweep



NACA0015	Case 5 $(\alpha, \dot{\alpha}, \ddot{\alpha}, \alpha_{Peak})$
Test Data Score	0.9452

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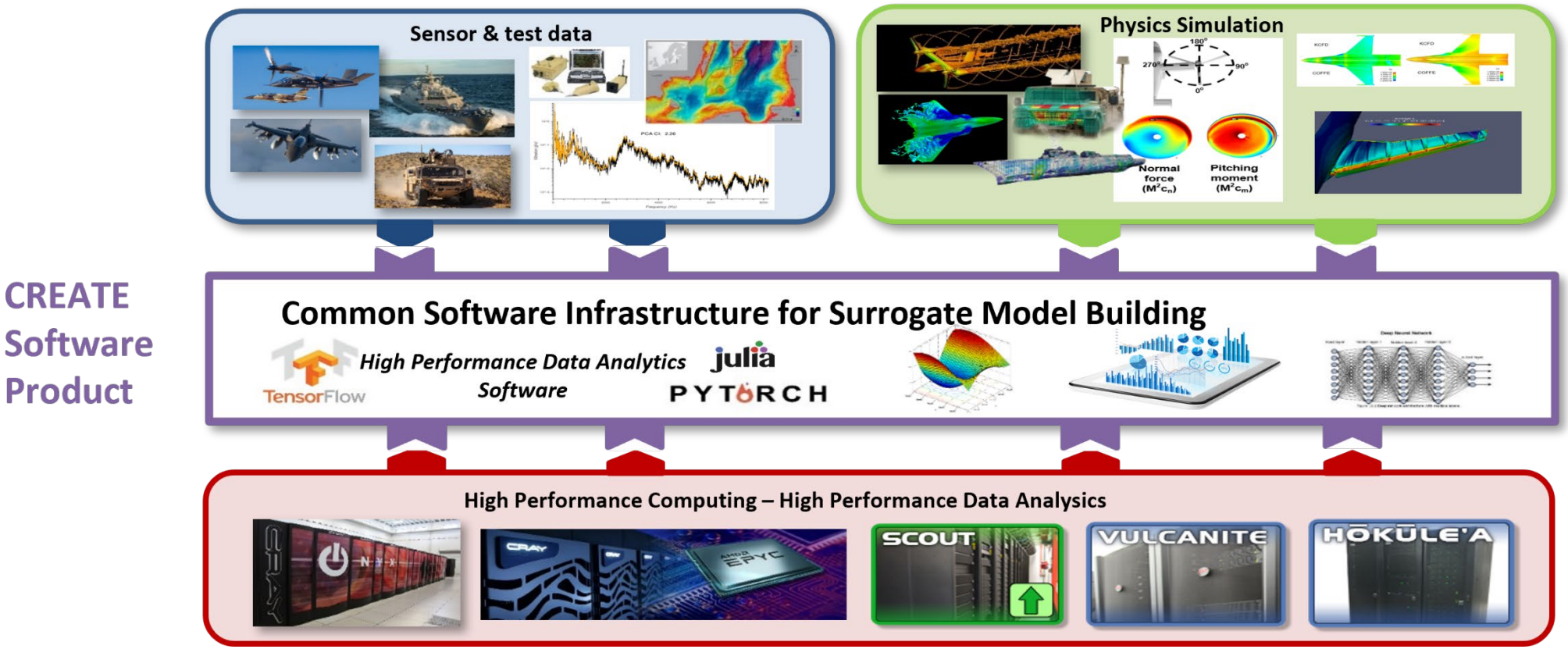
Surrogate Building Infrastructure

Software infrastructure to enable *surrogate model generation from data-driven analytics and physics-based analytics for DoD Air, Land, and Sea Vehicles

*Surrogate = approximate model used when a full-physics computational model is intractable



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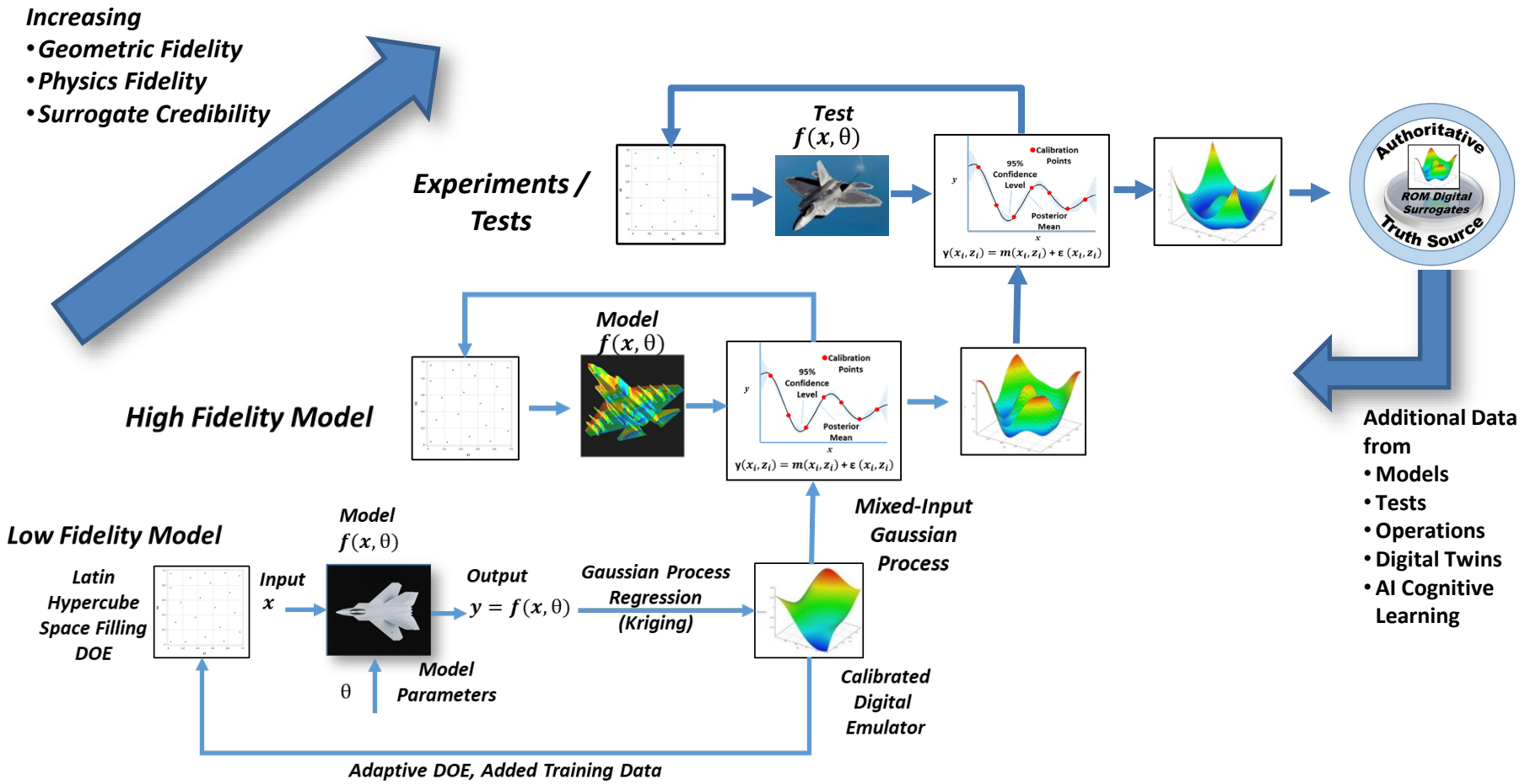
Developing an Authoritative Digital Surrogate Reduced Order Model for Aerodynamics



Edward M. Kraft, "Development and Application of a Digital Thread / Digital Twin Aerodynamic Performance Authoritative Truth Source," AIAA-2018-4003. Aviation Systems Conference, Atlanta, GA, June 25-29, 2018

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Concluding Remarks and Discussion

- The Connection between Physics Based Simulation and Useful Models for Model Based Systems Engineering have been described
- The union of Machine Learning and Digital Surrogate Training via Physics-Based virtual test is what will deliver decision support data at the speed of relevance
- A ML based surrogate model has been developed using a combination of Deep Neural Network based Machine Learning techniques
- A generalized framework that incorporates the novel ideas of aerodynamic state prediction can capture complex temporal variations
- The model has been validated for a number of 2D and 3D steady-state and unsteady cases
- Broader applicability to the aircraft system are underway to include more than just aerodynamics and across the vehicle envelope

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Acknowledgements

Material presented in this paper is a product of the CREATE (Computational Research and Engineering for Acquisition Tools and Environments) element of the U.S. Department of Defense HPC Modernization Program. In addition, the authors would like to acknowledge the support of the supercomputing resources provided by the HPCMP, in particular, the Army Engineer Research and Development Center (ERDC).

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Questions?

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Can Systems Engineering Enhance Policy Development?

HEATHER MASTAPETER
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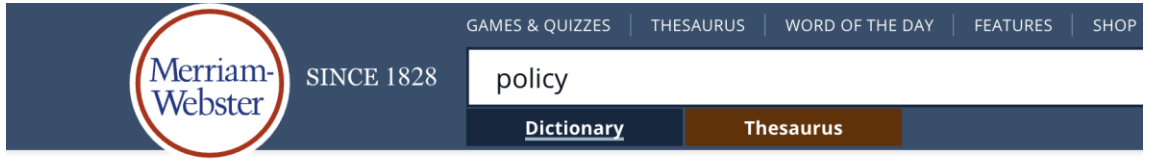
Outline

1. What Is a Policy?
2. How Can We Apply SE to Improve Policies?
3. How Can We Implement this Approach without Scaring Policy Makers?

1. WHAT IS A POLICY?

What's a Policy

- Lot's of definitions, but the "Merriam-Webster" shows the key elements
  - Definite course of action
  - High-level overall plan
- But what is it in Systems Engineering terms?



policy noun (1), often attributive

Save Word

pol·i·cy | \ ˈpä-lə-sē \

plural **policies**

Definition of *policy* (Entry 1 of 2)

1 **a** : prudence or wisdom in the management of affairs

b : management or procedure based primarily on material interest

2 **a** : a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions

b : a high-level overall plan embracing the general goals and acceptable procedures especially of a governmental body

https://www.merriam-webster.com/dictionary/policy *accessed 10/10/2022*

Policies in SE Terms

- Policies contain *requirements and constraints* for the organization
- Those requirements and constraints are *allocated or traced* to different parts of the organization
- Policies also frequently contain processes or procedures which are essentially implementation *scenarios*

Why not apply systems engineering techniques to analyze these policies to make sure they work prior to implementation?

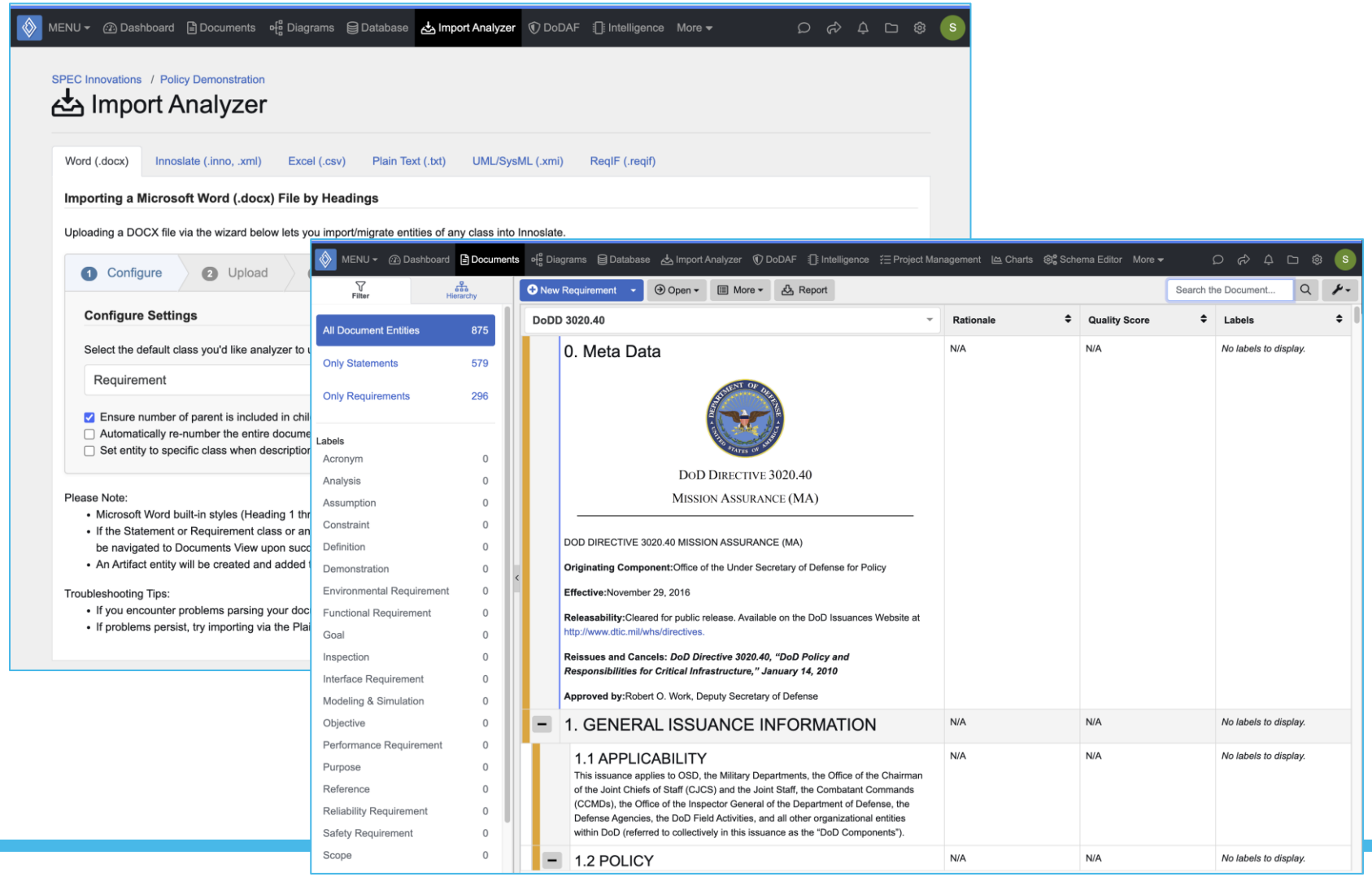
2. HOW CAN WE APPLY SE TO IMPROVE POLICIES?

Apply Requirements Analysis

- Treat the policy draft(s) as a requirements document
- Analyze for quality (clarity, completeness, etc.)
- Enhance the text using these quality criteria
- Use a “document view” for presentation to stakeholders
- Capture comments in tool and produce ”comment matrix”

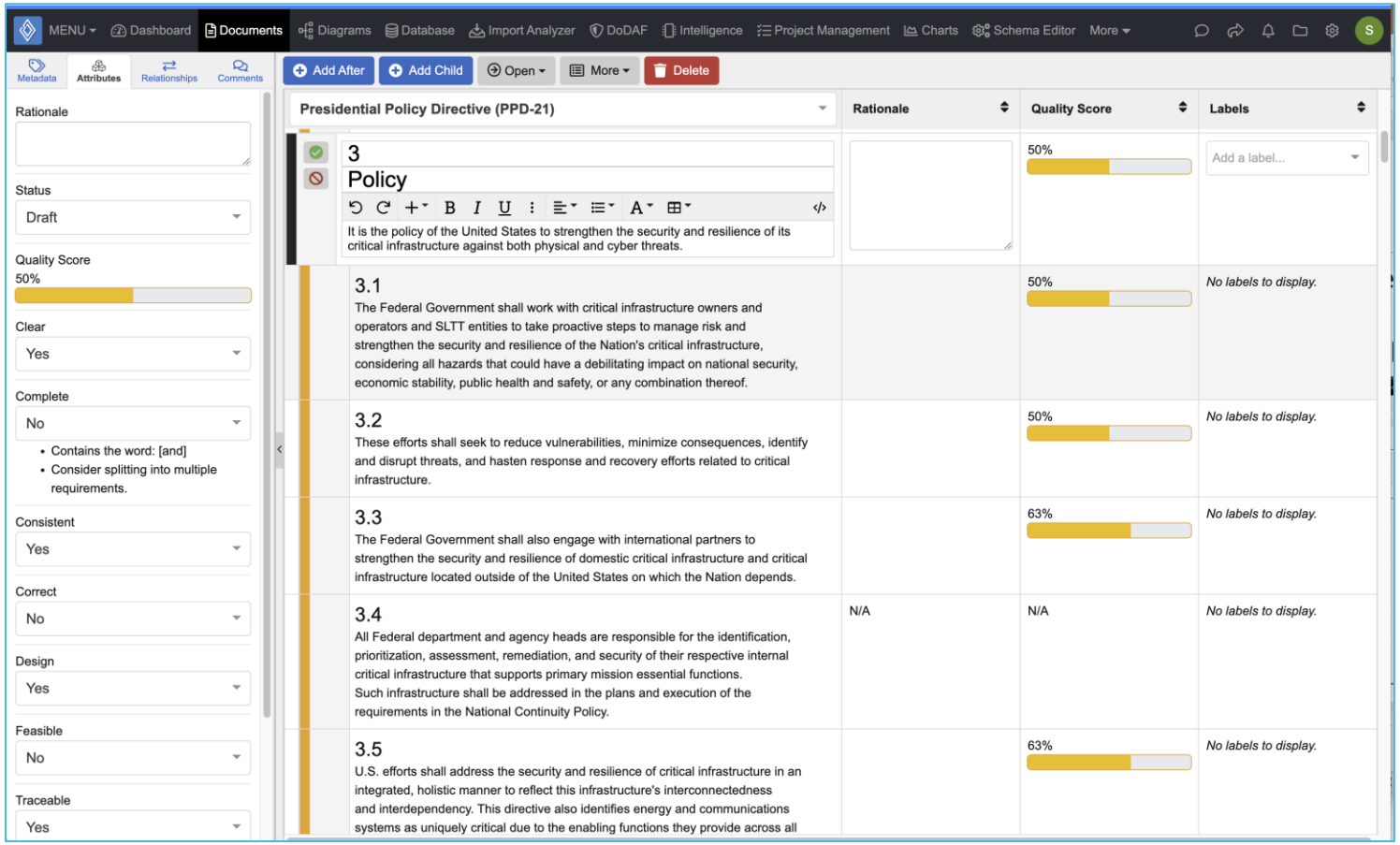
RA: Treat the policy draft(s) as a requirements document

- Import documents into a requirements analysis tool
- Break paragraphs into individual requirements for analysis
- Note many statements may not be written like a requirements, but still are requirements



RA: Analyze for quality (clarity, completeness, etc.)

- A number of the standard quality factors apply directly to policies (clear, complete, consistent, and correct)
- Others may apply, depending on the specific policy (Design, Feasible, Traceable, Verifiable)

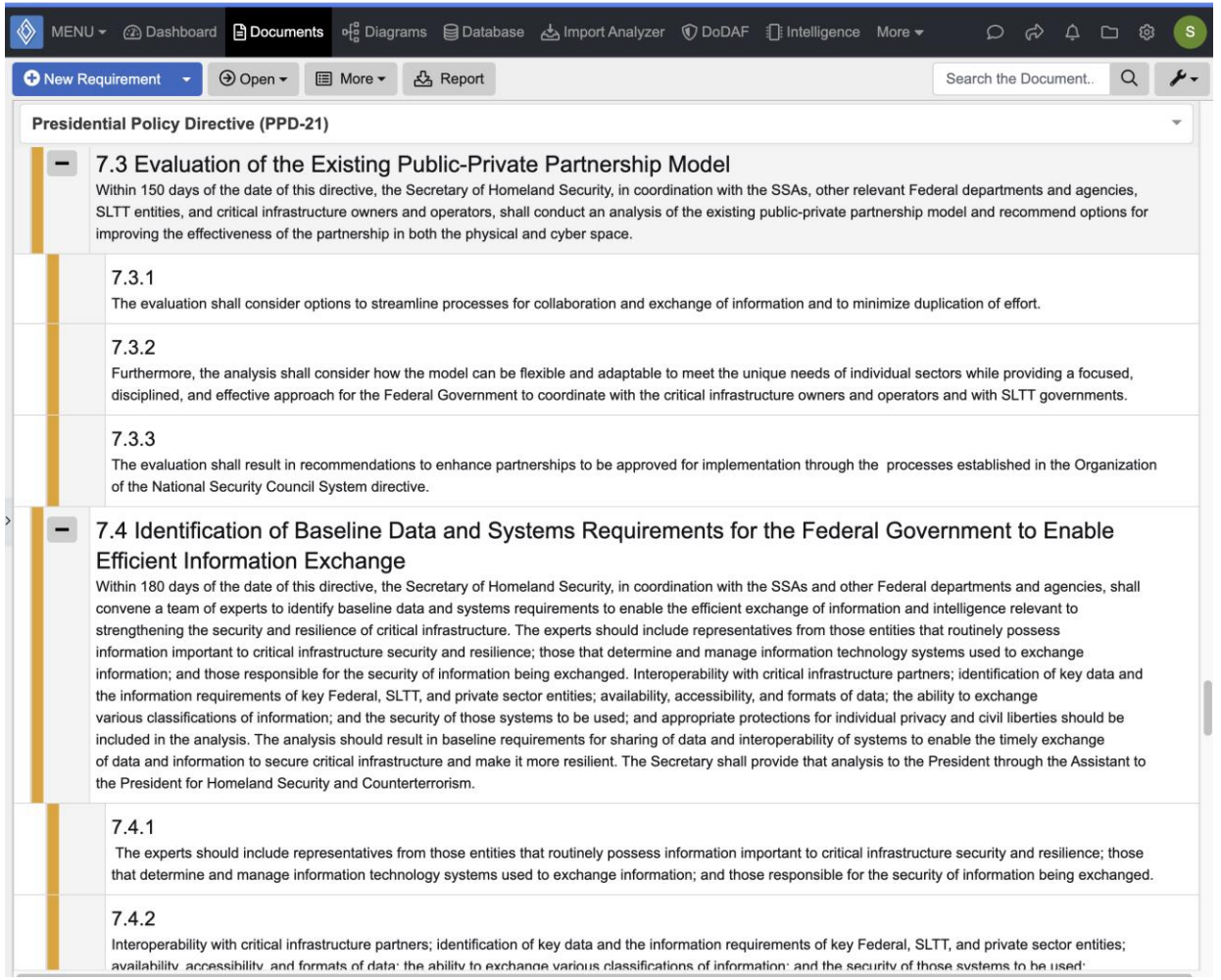


RA: Enhance the text using these quality criteria

- Enhance the grammar
- Simplify, where possible
- Break into separate requirements, if desirable

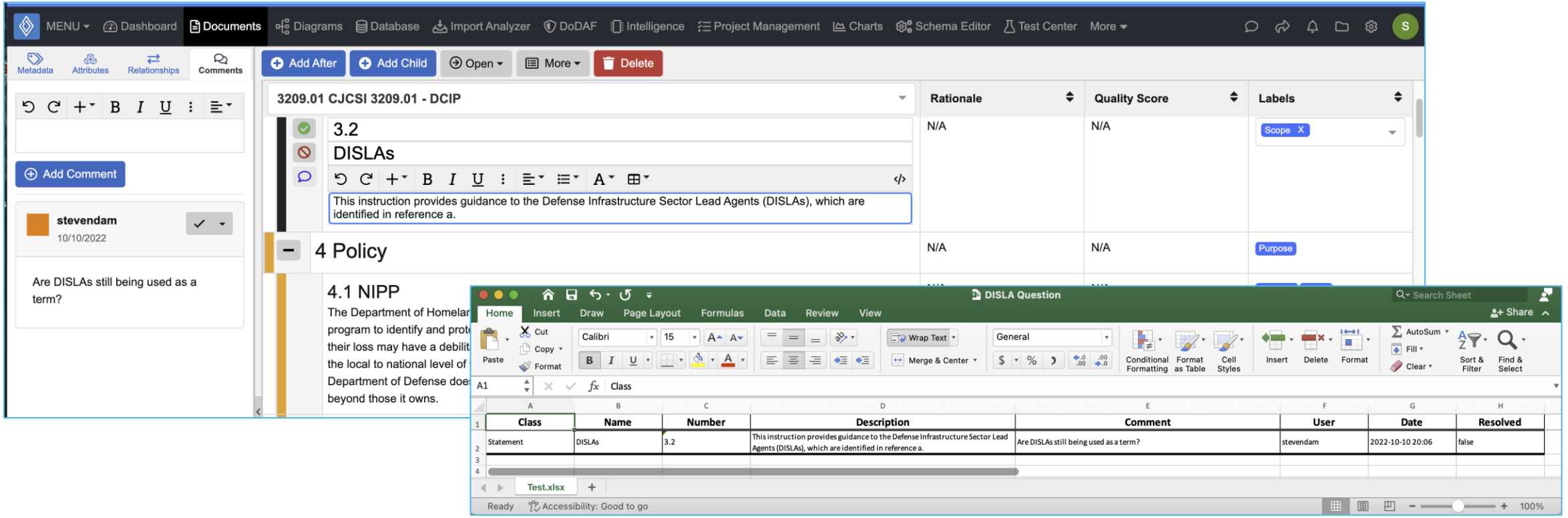
RA: Use a “document view” for presentation to stakeholders

- Hide information that may confuse a reader/viewer
  - e.g., columns with quality score, labels, other attributes
- Readers can then view it as they would a document in MS Word, but any comments and other information would be accessible at the paragraph level
- Hyperlinks can be provided to guide them to other documents



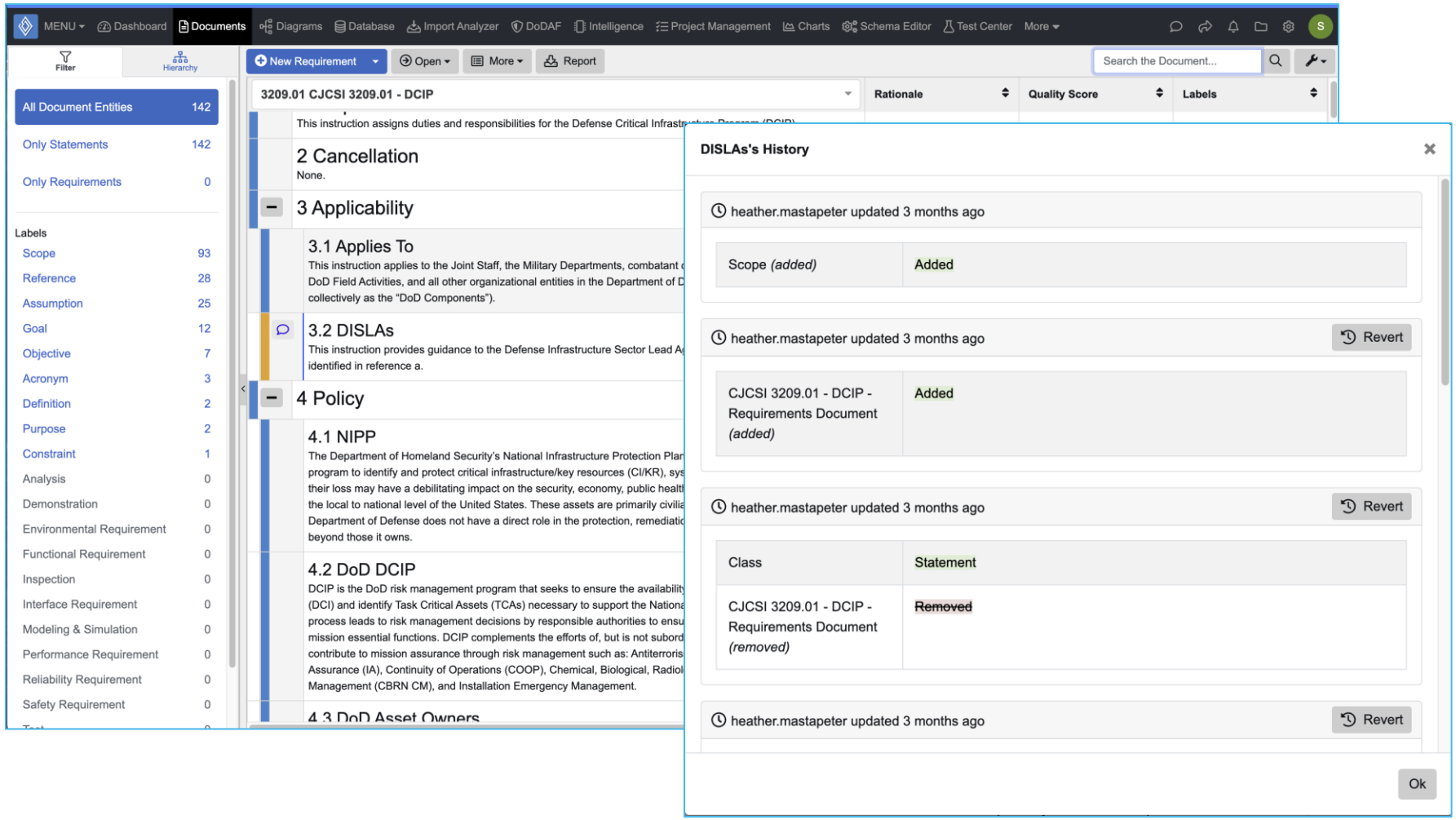
RA: Capture comments in tool and produce "comment matrix"

- Use commenting features where available
- Special reports may be desired



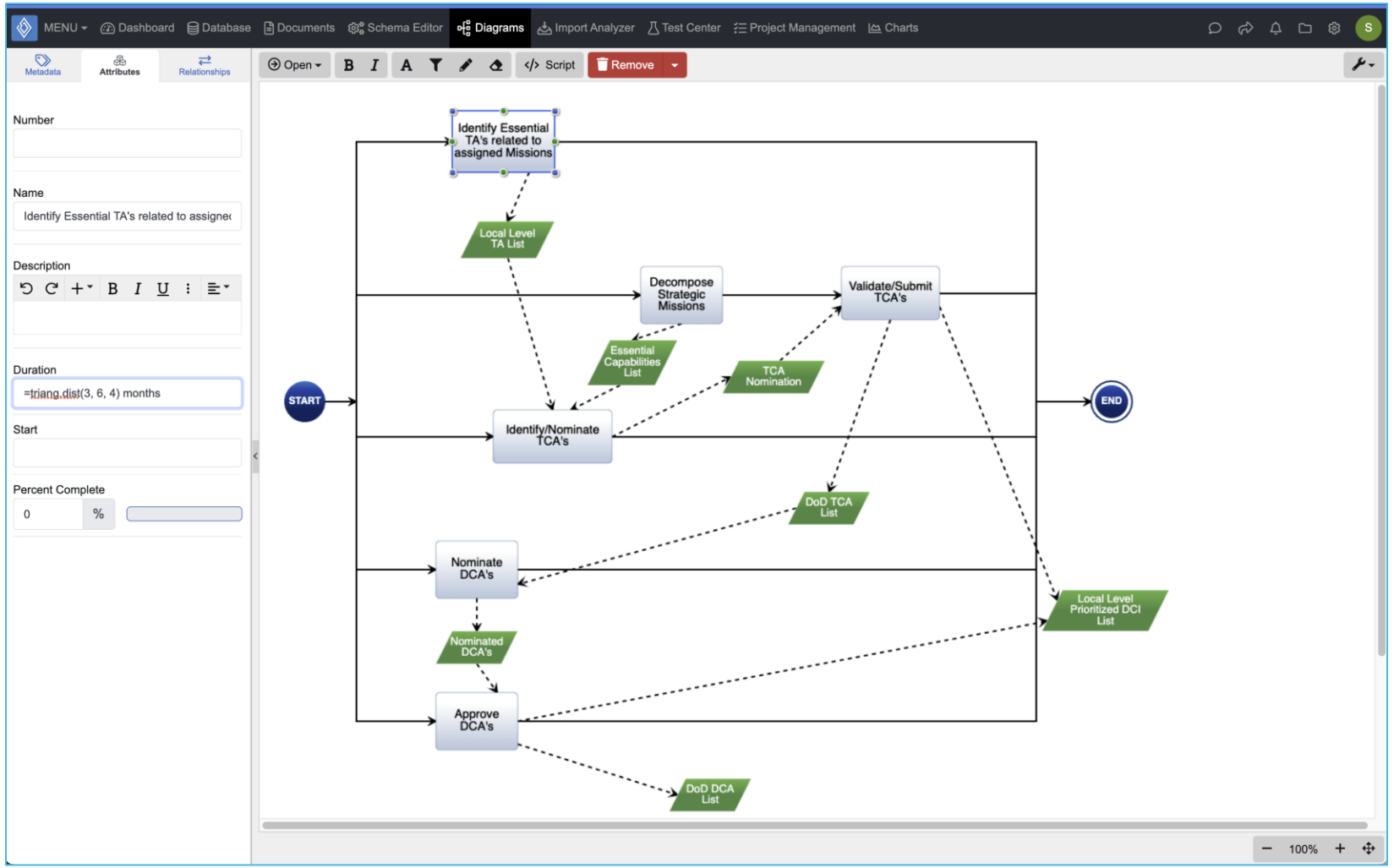
Configuration Manage Policy Documents

- Baseline
- Track change history
- Branch/fork for excursions
- Store files in database



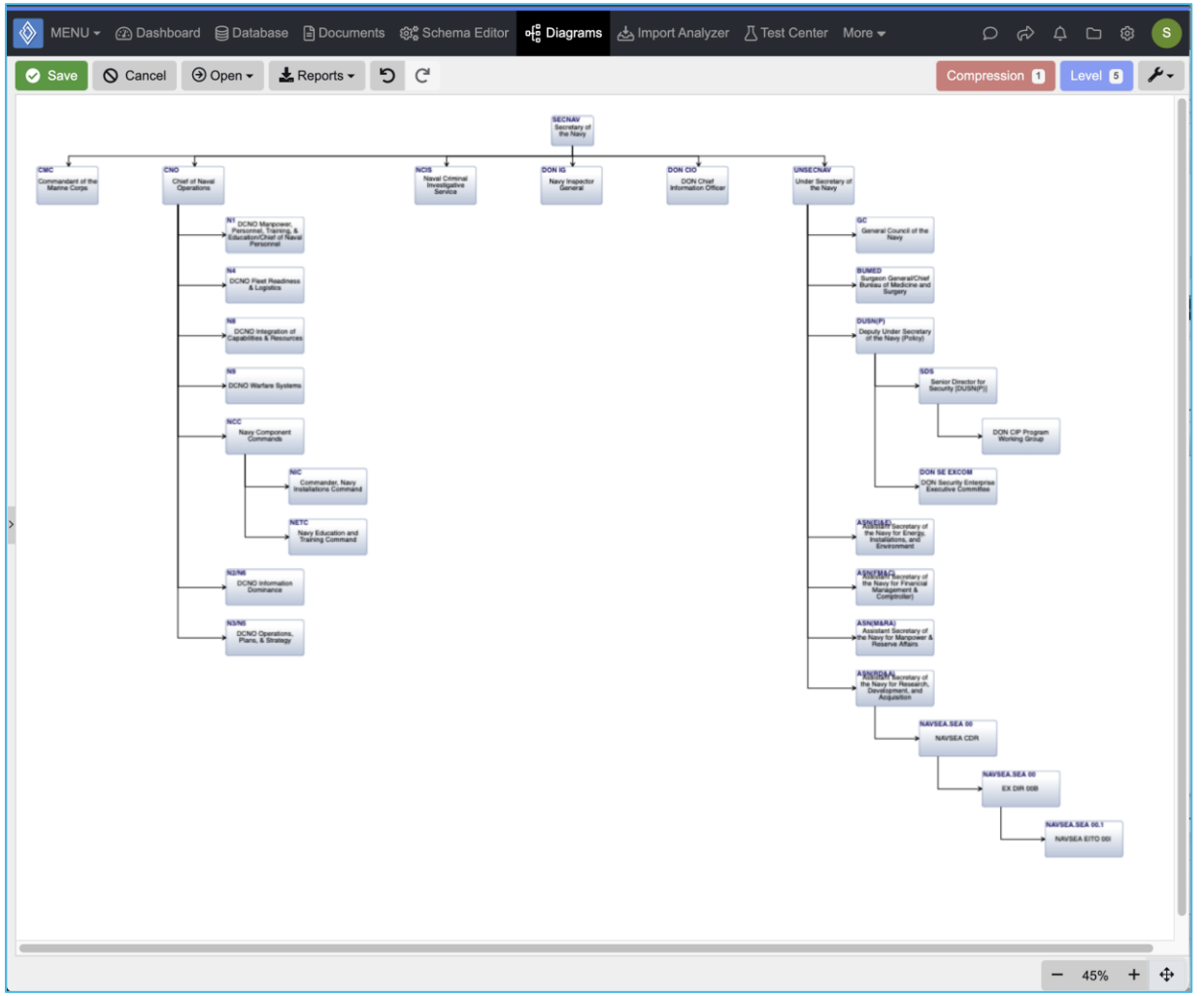
Model Processes and Procedures

- Review policies for processes and procedures
- Create a functional model
- Trace back to requirements
- Enter time distributions
- Associate costs
- Allocate to performing elements



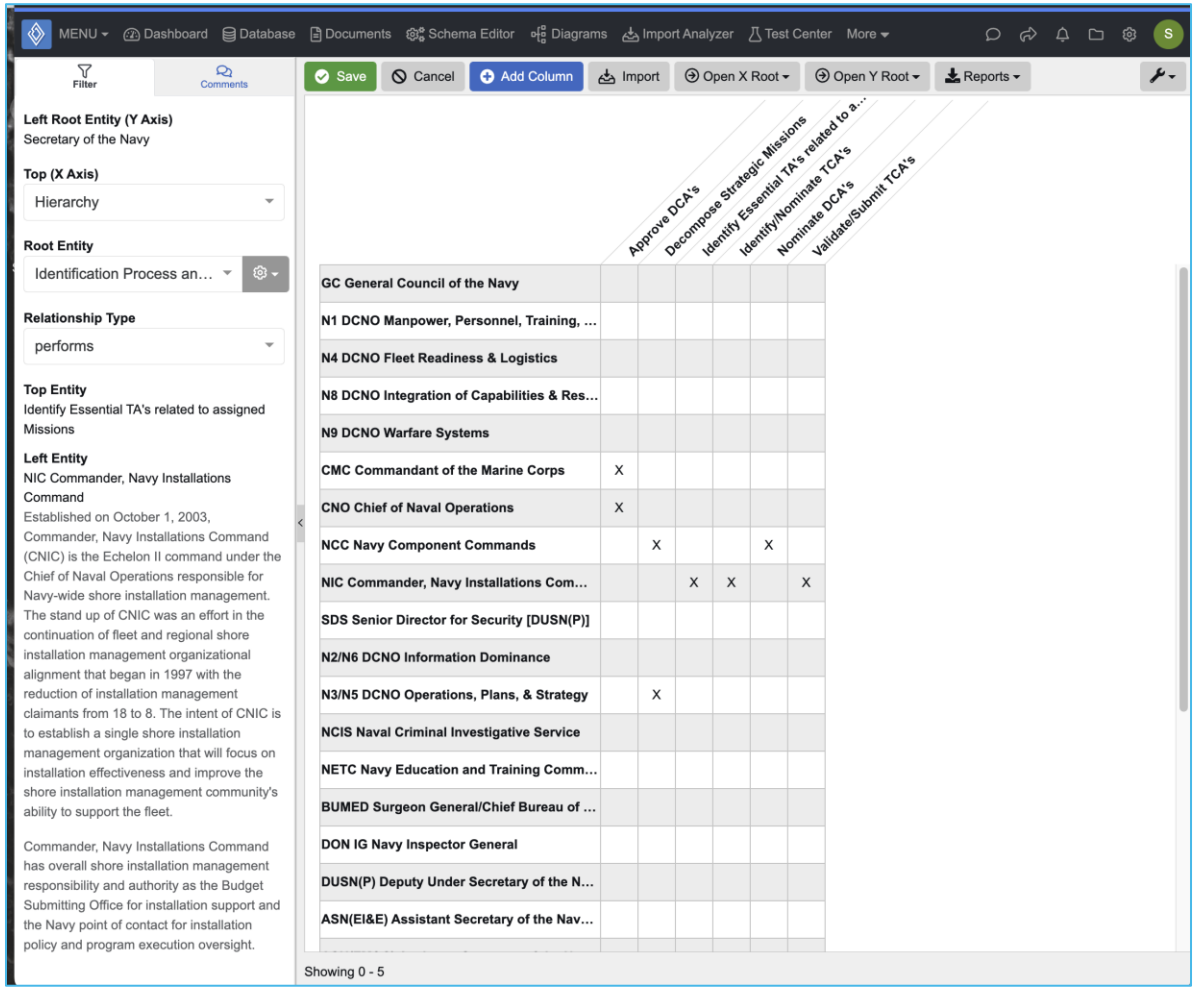
Capture Organization Information in Database

- Create hierarchy
- Allocate actions and requirements as appropriate



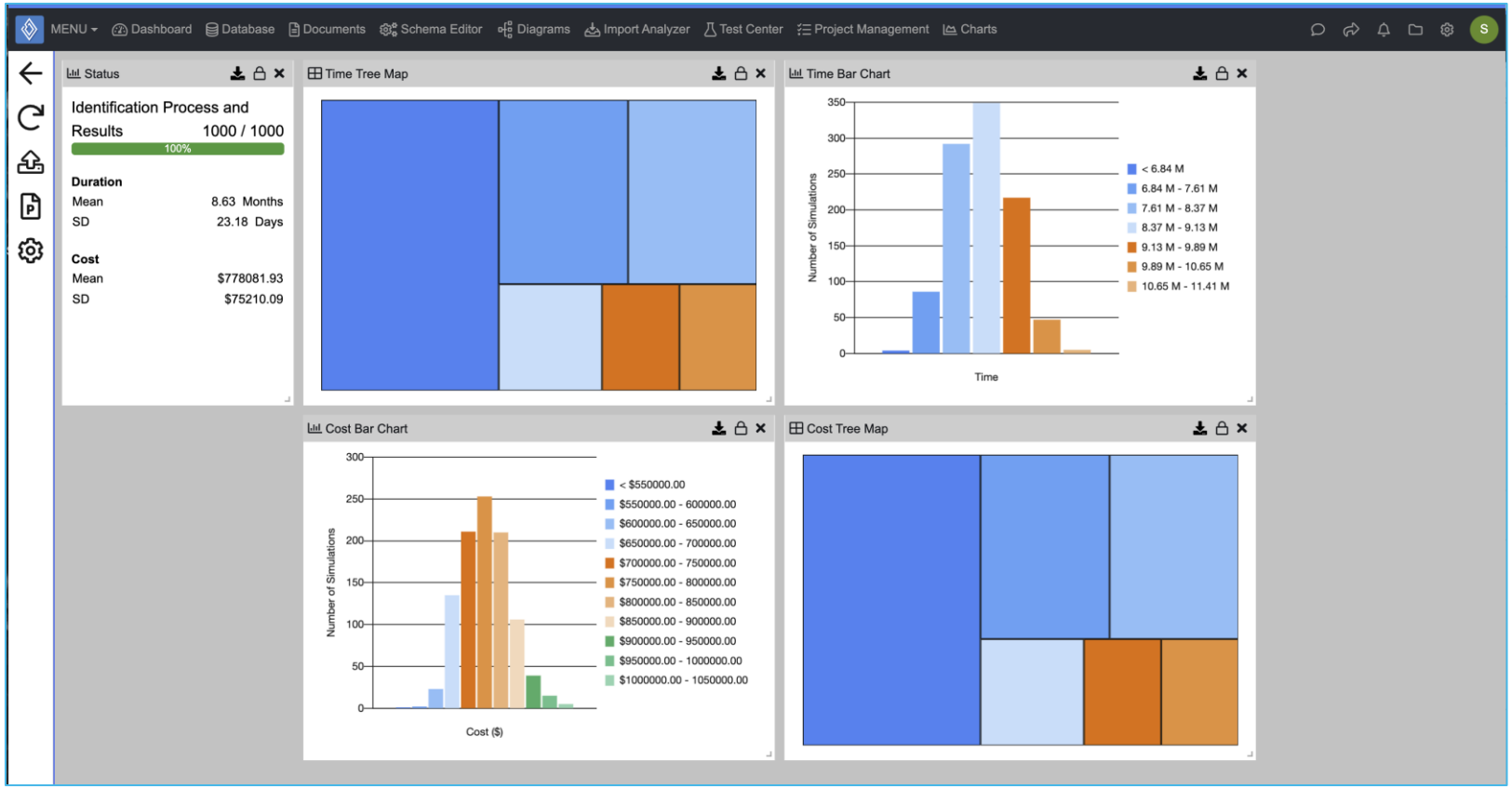
Allocate Tasks to Organizational Elements

- Create relationships between tasks and organizations, according to policies
- Use this information to determine if the correct organizations are being correctly tasked
- Suggest changes, as appropriate, and/or identify risks to the organization and mitigation strategies



Verify Processes Work through Simulation

- Uses timing and cost information for each step
- Distributions in time and cost provide a more realistic range of the process
- These distributions also provide a measure of cost and schedule risk



3. HOW CAN WE IMPLEMENT THIS APPROACH WITHOUT SCARING POLICY MAKERS?

Implementation Strategy

- Don’t tell them you are doing systems engineering
  - Most people think systems engineering only applies to hardware and software
- Perform the analysis, but only show results in a form that they will easily accept
  - No UML, SysML, IDEF0, etc. drawings
  - Simple summaries of changes (i.e., document markups and text summaries)
  - No engineering jargon!
- Wait for them to ask how you got the results
  - Then just show them the bare minimum of SE information
  - Once they buy into these, you can start show them more

Summary

- Systems engineering can dramatically improve policy development and implementation
- You must work fast in doing your analysis – use multi-purpose tools with analytics to speed up your analysis and delivery
- Only show results, not how you got there … until necessary

Implementing SysML v2 – Part 2

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Public Release Approved

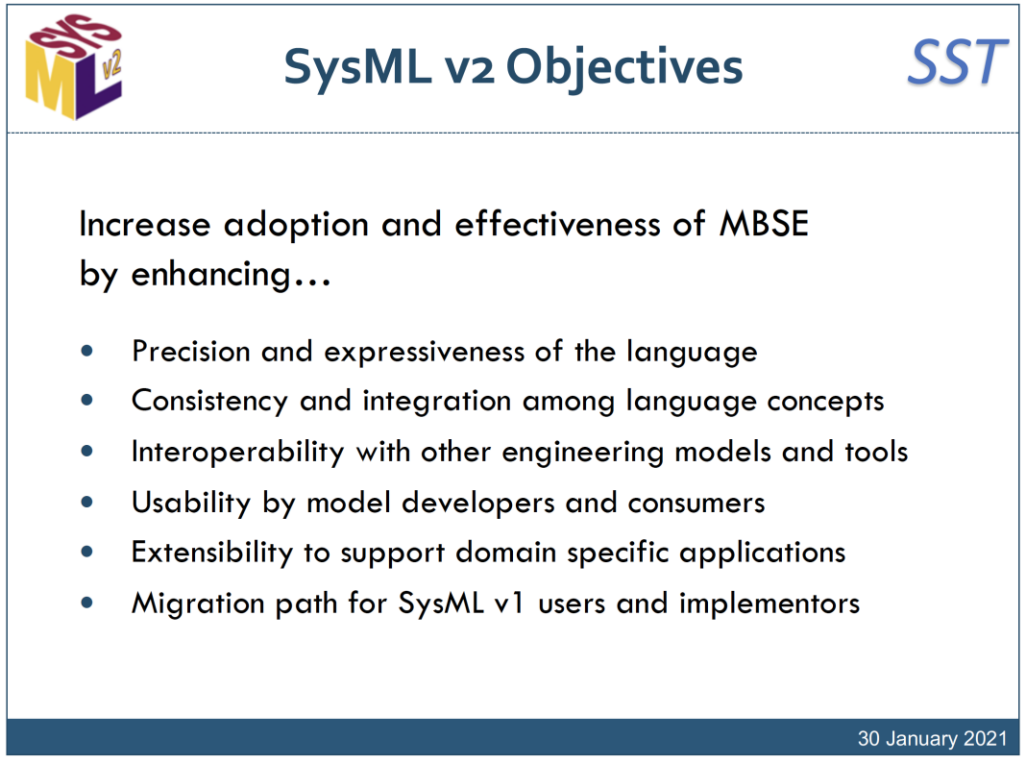
Presentation Overview

- SysML v2 Overview
  - Background and Objectives
  - What is KerML?
  - What is SysML v2?
  - Plan for SysML v2
- SysML v2 with JupyterLab Pilot Implementation
- Research in Understanding and Applying SysML 2.0
  - GMU SYST 699 Research
  - LML to SysML v2 Conversion Guide
  - LML to SysML v2 Entity/Relationship Mapping
  - LML to SysML v2 Conversion Process
- Plans for Implementing SysML v2 in Innoslate®

SysML v2 Overview

Background and Objectives

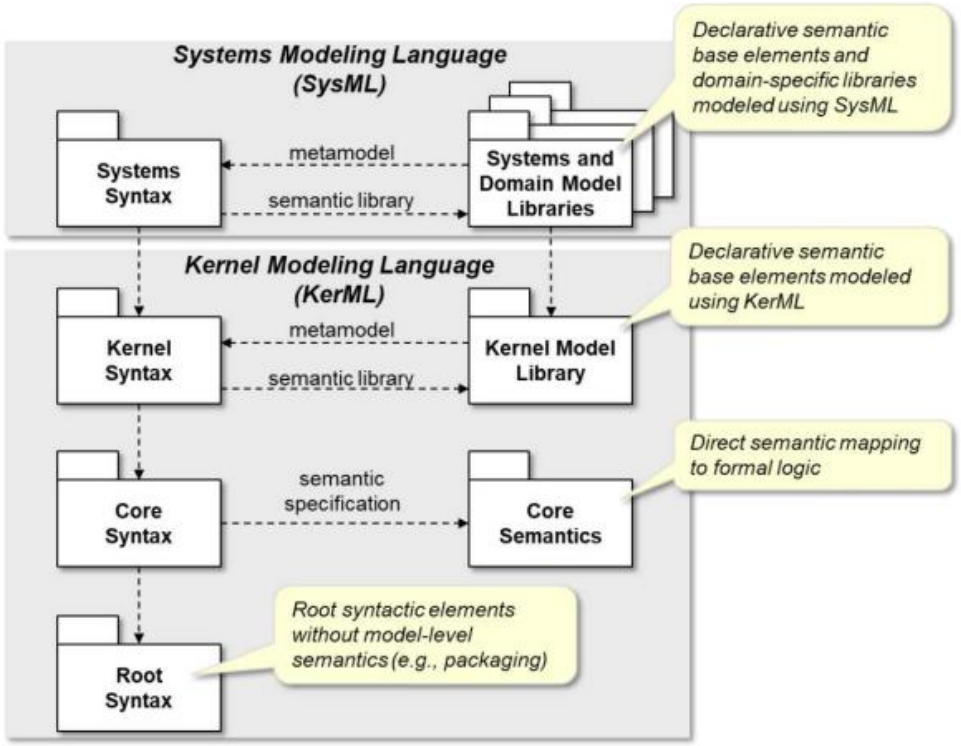
- SysML v1 was adopted in 2006 and has be used across the MBSE industry
  - Learned both strengths and weaknesses
  - Outgrew UML
- Systems Engineering Domain Special Interest Group (SE DSIG)
  - OMG working group
  - Developed requirements for the next generation of SysML
- December 2017 - OMG RFP for SysML v2 Language
- June 2018 - OMG RFP for standardized SysML v2 API and Services
- Led to the establishment of the SysML v2 Submission Team (SST)
  - Over 200 people from over 80 organizations



From presentation by Sanford Friedenthal, SysML v2 Submission Team (SST), 30 January 2021, INCOSE International Workshop

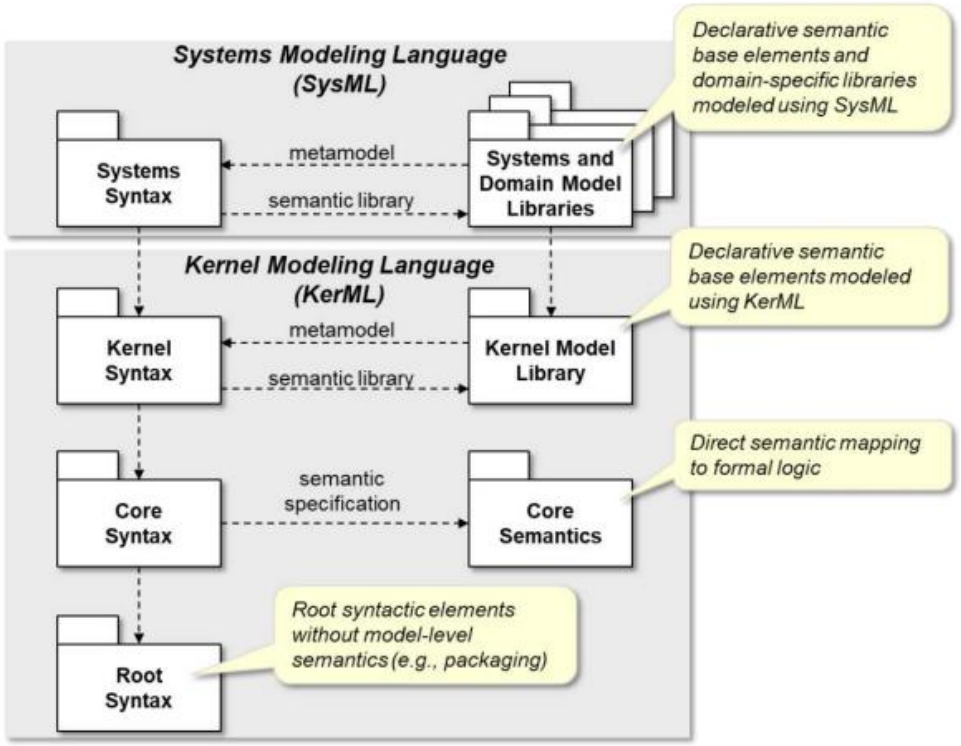
What is KerML?

- Kernel Modeling Language
- Created by the SysML v2 Submission Team (SST) to be a modeling language to create modeling languages
- Consists of three metamodel layers:
  - Root Layer - most general syntactic constructs
    - Includes elements and relationships between them, annotations of elements, and membership of elements in namespaces
  - Core Layer - most general constructs that have semantics based on classification
    - Includes type, feature, and classifiers
  - Kernel Layer - provides commonly needed modeling capabilities
    - Include classes, data types, structure, associations, connectors, behaviors, interactions, functions, expressions, feature values, multiplicities, metadata, and packages
- Foundation for SysML v2



What is SysML v2?

- Fourth metamodel layer:
  - Systems Layer - specializes the KerML to include domain-specific concepts
- Metaclasses either reuse or extend the KerML metaclasses
- Usage-Oriented
- Provides a textual notation and a graphical notation
- Graphical notation
  - Diagram types will be defined to facilitate the transition from v1 to v2
  - Will not constrain what elements can be on a particular diagram, so long as it conforms to the metamodel
- Can be extended to build domain specific extensions



Plan for SysML v2

- SST finalized the specification documents and artifacts for their September OMG meeting to submit early
- Final submission is in November
- OMG adoption and finalization to start December/January
- Beta specification to be released at the beginning of next year
- Finalization process will take until 2024
- 1.0 Specification to release early to mid 2024

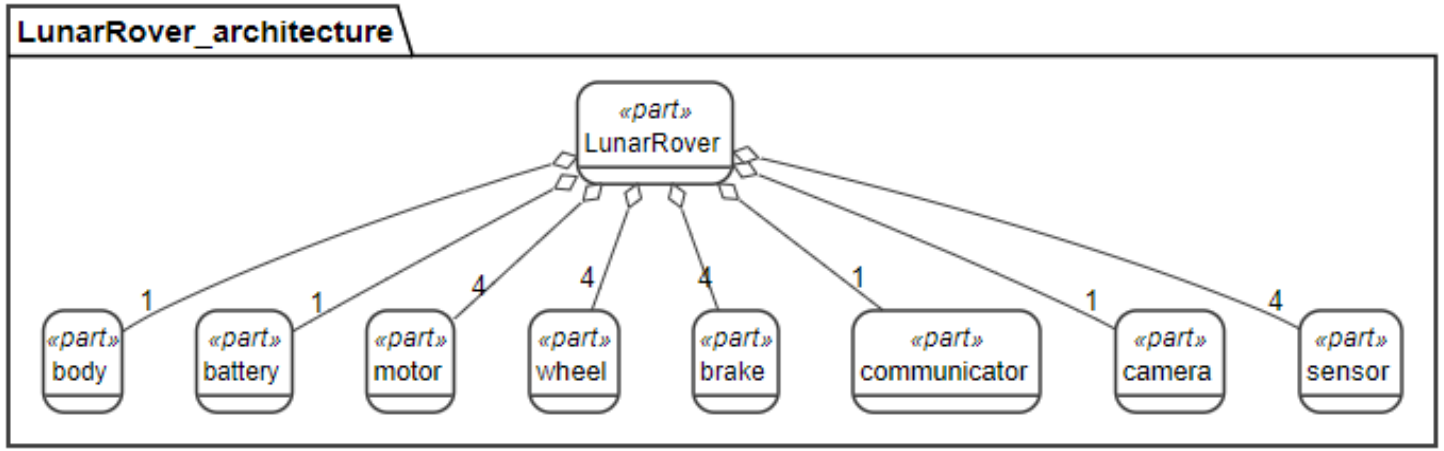
SysML v2 with JupyterLab Pilot Implementation

- Package
  - container for elements to organize a model
- Part
  - unit of structure
  - may have attributes, ports, perform actions, and exhibit states
- Decomposition

```
package LunarRover_architecture{

    part LunarRover{
        part body;
        part battery;
        part motor [4];
        part wheel [4];
        part brake [4];
        part communicator;
        part camera;
        part sensor [4];
    }
}
```

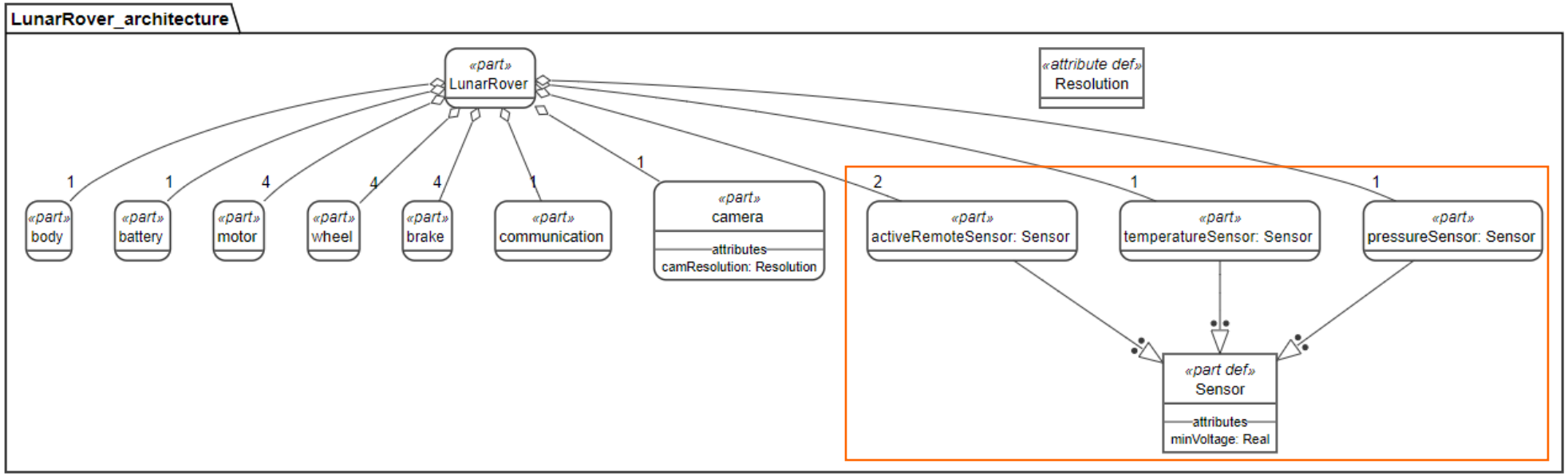
```
Comment (723263a8-a0b0-4bb2-ba61-f2daa37f8a25)
Package LunarRover_architecture (c7cb8c37-dddf-480a-a09d-9b79a4ca50ee)
```

```
%viz --view=Tree LunarRover_architecture
```



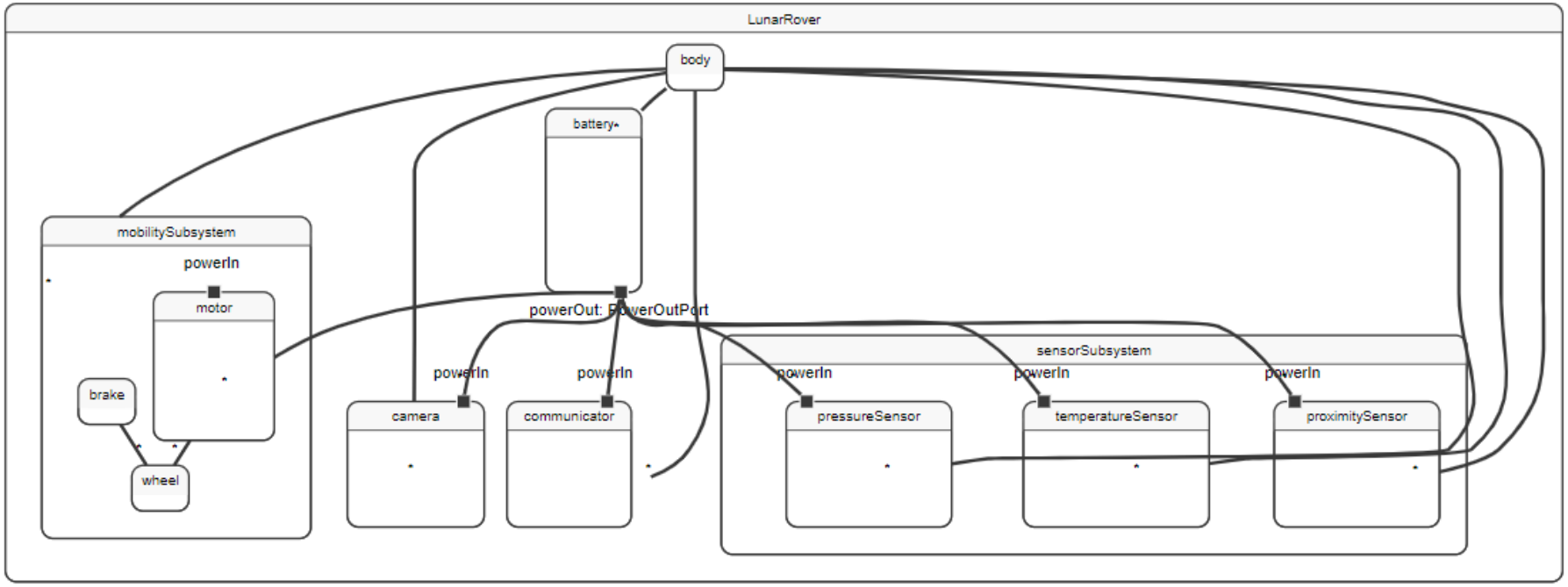
```
package LunarRover_architecture{
    import ScalarValues::*;

    attribute def Resolution{
        resolution : Integer;
    }
    part def Sensor {
        attribute minVoltage : Real;
    }

    part LunarRover{
        part body;
        part battery;
        part motor [4];
        part wheel [4];
        part brake [4];
        part communicator;
        part camera{
            attribute camResolution : Resolution;
        }
        part activeRemoteSensor : Sensor [2];
        part temperatureSensor : Sensor;
        part pressureSensor : Sensor;
    }
}
```

- Definition and Usage
  - Facilitates reuse in different context
  - Applies to all element types
  - Definition
    - Classifies or defines a type of element before its use
  - Usage
    - Usage of a definition element in a certain context
    - Must be defined by at least one definition element, default is most general definition
    - Colon connects a usage to its definition
- Import
  - Libraries and packages
- Multiplicity
  - Denoted by square brackets
  - Range or single number
- Attribute
  - Define a set of values



```
package LunarRover_architecture{

    item def Energy;
    port def PowerOutPort{
        out item powerSupply : Energy;
    }
    interface def PowerInterface{
        end PowerOut : PowerOutPort;
        end PowerIn : ~PowerOutPort;
    }

    part LunarRover{
        part mobilitySubsystem{
            part wheel [4] ;
            part brake [4] ;
            part motor [4] {
            port powerIn : ~PowerOutPort;
            }
        }
        part body;
        part battery{
            port powerOut : PowerOutPort;
        }
        part communicator{
            port powerIn : ~PowerOutPort;
        }
        part camera{
            port powerIn : ~PowerOutPort;
        }
        part sensorSubsystem{
            part proximitySensor [2]{
                port powerIn : ~PowerOutPort;
            }
            part temperatureSensor{
                port powerIn : ~PowerOutPort;
            }
            part pressureSensor{
                port powerIn : ~PowerOutPort;
            }
        }
```

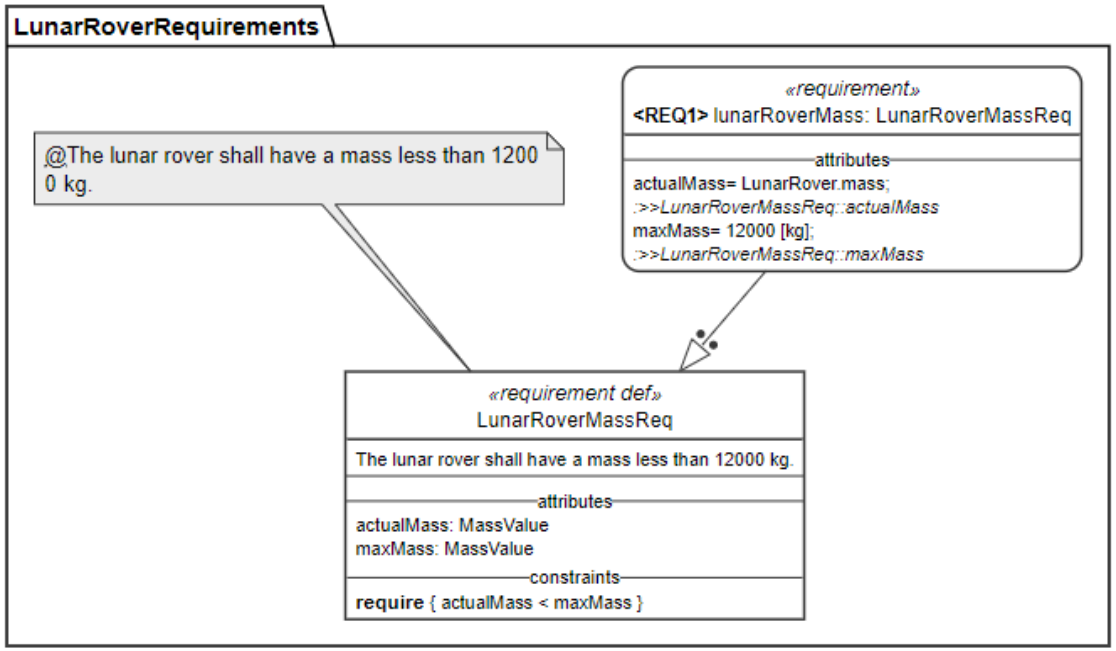
```
        interface : PowerInterface connect
            PowerOut :> battery.powerOut to
            PowerIn :> communicator.powerIn;

        connect body to battery;
        connect body to mobilitySubsystem;
        connect body to communicator;
        connect body to camera;
        connect body to sensorSubsystem.proximitySensor;
        connect body to sensorSubsystem.temperatureSensor;
        connect body to sensorSubsystem.pressureSensor;
        connect battery.powerOut to mobilitySubsystem.motor;
        connect battery.powerOut to camera.powerIn;
        connect battery.powerOut to sensorSubsystem.proximitySensor.powerIn;
        connect battery.powerOut to sensorSubsystem.temperatureSensor.powerIn;
        connect battery.powerOut to sensorSubsystem.pressureSensor.powerIn;
        connect mobilitySubsystem.motor to mobilitySubsystem.wheel;
        connect mobilitySubsystem.brake to mobilitySubsystem.wheel;

    }
}
```



- Items
  - Class of things that exist in space and time
  - May be stored in and/or flow between parts of a system
- Ports
  - Connection point for interactions
  - Contained by part elements
- Interface
  - Connection whose ends are ports
- Connection
  - Relationship and kind of part that classifies connections between related things

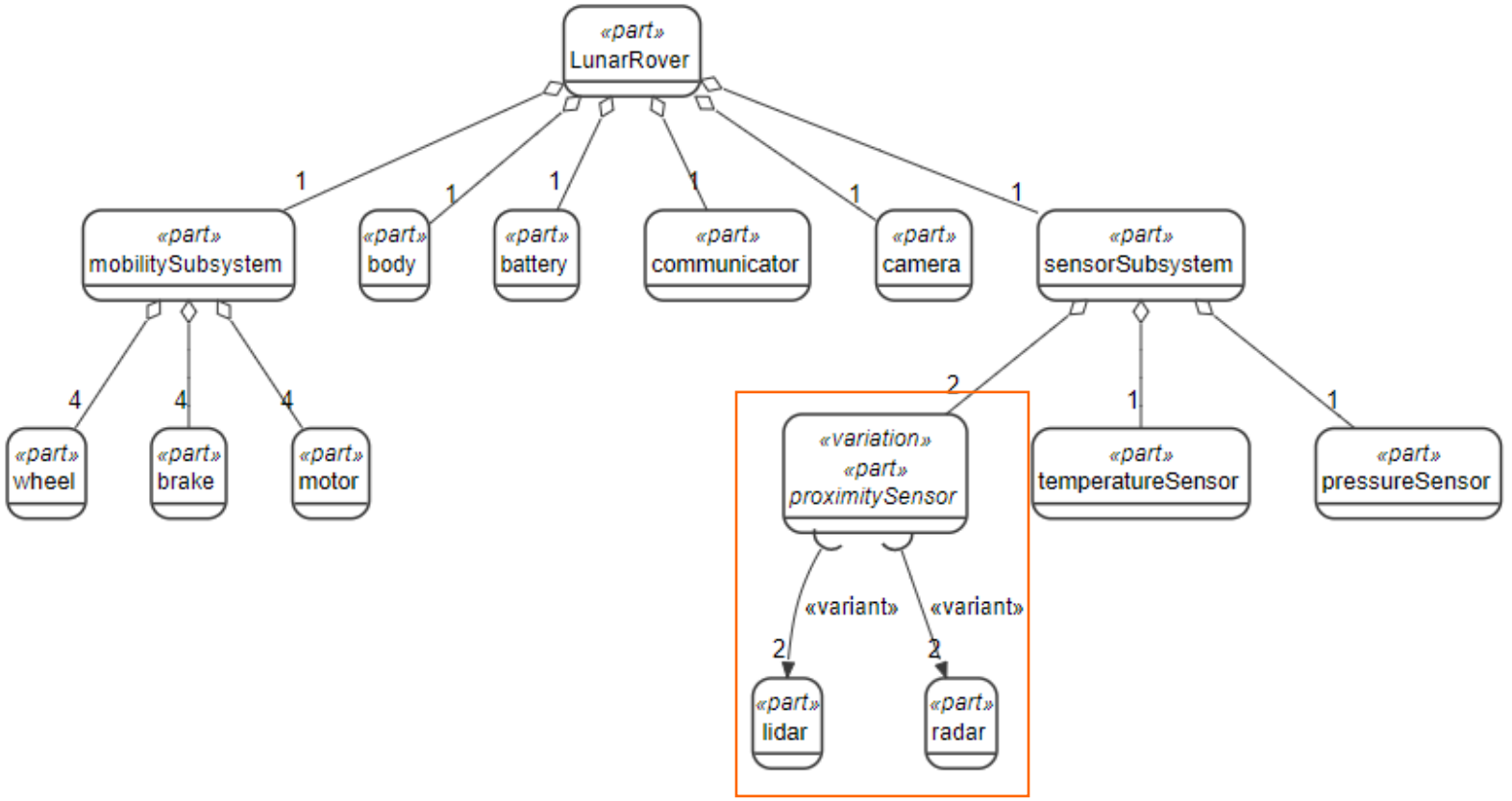
```
import SI::*;
part LunarRover{
    attribute mass = 987 [kg];
}
package LunarRoverRequirements{
    requirement def LunarRoverMassReq{
        doc /* The lunar rover shall have a mass less than 12000 kg. */

        attribute actualMass : MassValue;
        attribute maxMass : MassValue;

        require constraint{ actualMass < maxMass }
    }

    requirement <REQ1> lunarRoverMass : LunarRoverMassReq{
        attribute :>> actualMass = LunarRover.mass;
        attribute :>> maxMass = 12000 [kg];
    }
}
```

- Constraint
  - Reusable, parameterized Boolean expression
- Requirement
  - Specifies stakeholder-imposed constraints that must be satisfied for a design to be a valid solution
  - Has a textual statement, can require constraints, may include assumed constraints, can be parameterized, can specify the subject
  - Requirement usage will often bind the requirement definition parameters to specific values



```
package LunarRover_variant{

    part lidar;
    part radar;

    part LunarRover{
        part mobilitySubsystem{
            part wheel [4] ;
            part brake [4] ;
            part motor [4] ;
            }
        part body;
        part battery;
        part communicator;
        part camera;
        part sensorSubsystem{
            variation part proximitySensor [2]{
                variant part lidar;
                variant part radar;
                }
            part temperatureSensor;
            part pressureSensor;
        }
    }
    part LunarRover11 :> LunarRover {
        part redefines lidar :> sensorSubsystem.proximitySensor;
    }
}
```

- Variation
  - Identifies a variation point
  - Can apply to any kind of definition or usage
  - Can be nested
- Variant
  - Usage elements



Overview of Other Elements

- Action - Occurrence over time that can coordinate with other actions and generate effects on items and parts involved
- Control Nodes - Merge, Decision, Fork, and Join
- Structured Control Actions - If Action, For Loop Action, While Loop Action
- Dependency - Kind of relationship between any number of source and target elements
- Occurrence - Class of elements that have an extent in time and may have spatial extent
- Time Slice - Represents a periods or phases of the lifetime of an occurrence over some period of time
- Snapshot - Represents an occurrence at a specific point in time
- Individual - An occurrence of any kind can be restricted to model a single individual and how it changes over its lifetime
- Viewpoint - Frames the concerns of one or more stakeholders regarding info about a modeled system or domain of interest
- State - Types of states and transitions are types of action; Can be exhibited by a part
- Calculation - Reusable, parameterized expression that returns a result
- Analysis Case - Defines the computation of an analysis of some subject in order to meet an objective and output a result
- Verification Case - Defines a process for verifying whether a subject satisfies one or more requirements
- Use Case - Specifies a sequence of interactions between the subject and various actors, modeled as part usages; Interactions are modeled as messages
- Specialization – Subclassification – Definition; Defines a subset of the classification of its generalization; Inherits features of general definitions; Can have multiple generalizations
- Specialization – Subsetting – Usage; Kind of generalization between features
- Redefines - Kind of subsetting; Replaces the redefined usage in the context of the redefining usage

Research in Understanding and Applying SysML 2.0

GMU SYST 699 Research

- Graduate-level capstone project
- Professor: Dr. Karla Hoffman
- Sponsor: INCOSE Automotive Working Group (represented by David Hetherington and Steve Dam)
- Students: Liza Kossobokova and Tim Lockhart
- Title: Initial Capability and Exploration and MBSE Model Translation
- Key Tasks:
  - Manually replicated LML model to SysML v2 textual notation
  - Developed LML to SysML v2 conversion guide and entity/relationship mapping
  - Developed LML to SysML conversion process

LML to SysML v2 Conversion Guide

Item	LML	SysML v2	Notes
1	Project named "Autonomous Vehicle Sample"	package AutonomousVehicleSample { }	All contents of project/package need to be in between { and }
1a		import ISQ::*; import SI::*; import USCustomaryUnits::*;	Rule of thumb to import packages necessary for units. Insert directly after defining a new package
2	Asset "ABC"	part def ABC { }	All Assets need to first be defined as parts before they can be used. "part def ABC { }" defines ABC, which can later be used. For example: "part abc : ABC; or "part Innoslate : ABC;" are usages of ABC.

3	Asset "ABC" has Asset "XYZ"	part def XYZ{ }
		part def ABC {
		part xyz : XYZ;
		}
			Alternate: part def XYZ { }
			part def ABC { }
			part abc : ABC;
			part xyz : XYZ;

4	Asset "ABC" has Asset "XYZ", which has Asset "EFG"	part def XYZ{ }
		part def ABC {
		part xyz : XYZ;
		part efg : EFG;
		}
			Can nest as much as necessary

5	Connection "CON" is used to connect Asset types "ABC" and "EFG"	connection def CON {
		end : ABC;
		end: EFG;
		}	

6	Assets abc and efg are connected, but the connection is not defined	connect abc to efg;	

7	Asset "abc" has Assets "xyz" and "efg". Assets xyz and efg are connected via connection "CON"	part abc : ABC {
		part xyz : XYZ;
		part efg : EFG;
		connection : CON connect xyz to efg;
		}
			Must first define parts ABC, XYZ, and EFG (i.e. - "part def ABC { }), as well as the connection (i.e. - "connection def CON { }).
			Parts xyz and efg must be of type XYZ and EFG, which are defined as ends in connection def CON.

8	Asset "ABC" has attributes "range" and weight", measured in meters and kilograms, respectively	part def ABC {
		attribute range :> SI::m;
		attribute weight :> SI::kg;
		}
			Must first import the SI package

- Prioritized key modeling entities that could produce the best results
- Focused on closest “1-to-1” matches between the two languages

Item	LML	SysML v2	Notes

9	Model has Resource "Power". Power is stored in Asset "Battery".	item def Power;
		part def Battery {
		item power : Power;
		}
			A SysML v2 "item" is a class of things that exist in space and time but are not necessarily considered parts of a system. Items may also model continuous materials that are stored in and/or flow between Assets. Just like parts, items must be defined, and then can be used.

10	Requirement number "1.1" named "REQ" with text "ABC XYZ"
	The subject of this requirement is "abc" of type "ABC"
		requirement def <'1.1'> REQ {
		doc /* ABC XYZ. */
		subject abc : ABC;
		}
			A requirement definition is always about some subject, which may be implicit or specified explicitly

11	Model has Action "HIJ" with input "KLM" and output "NOP". KLM is a type of "stuff" and NOP is a type of "things"	action def HIJ (in KLM : stuff, out NOP : things);	"stuff" and "things" most both be items defined elsehwere in the model
12	Model has Action "HIJ", which does not have any inputs or outputs	action def HIJ;	
13	Asset "abc" performs Action "hij".	part abc : ABC { perform action hij;	abc is a usage of part definition ABC hij must be a defined action

LML to SysML v2 Entity/Relationship Mapping

- Entities of LML are more easily mapped to the entities of SysML v2
- LML relationship and entities can map to multiple SysML v2 entities depending on context

LML Entity Name	Parent Entity	Description	SysML v2 Entity Name
Action		An Action entity specifies the mechanism by which inputs are transformed into outputs.	Action
			Transition
			Case
			Trade-Off Case
			Use Case
			Analysis Case
			Verification Case
			Accept Action
			Send Action
Artifact		An Artifact entity specifies a document or other source of information that is referenced by or generated in the knowledgebase.	Textual Representation
Asset		An Asset entity specifies an object, person, or organization that performs Actions, such as a system, subsystem, component, or element.	Part
			Actor
			Stakeholder
Characteristic		A Characteristic entity specifies properties of an entity.	State
			Attribute
Conduit	Connection	A Conduit entity specifies the means for physically transporting Input/Output entities between Asset entities. It has limitations (attributes) of capability and latency.	Interface
Connection		A Connection entity specifies the means for relating Asset instances to each other.	Connection
			Binding Connection
			Flow Connection

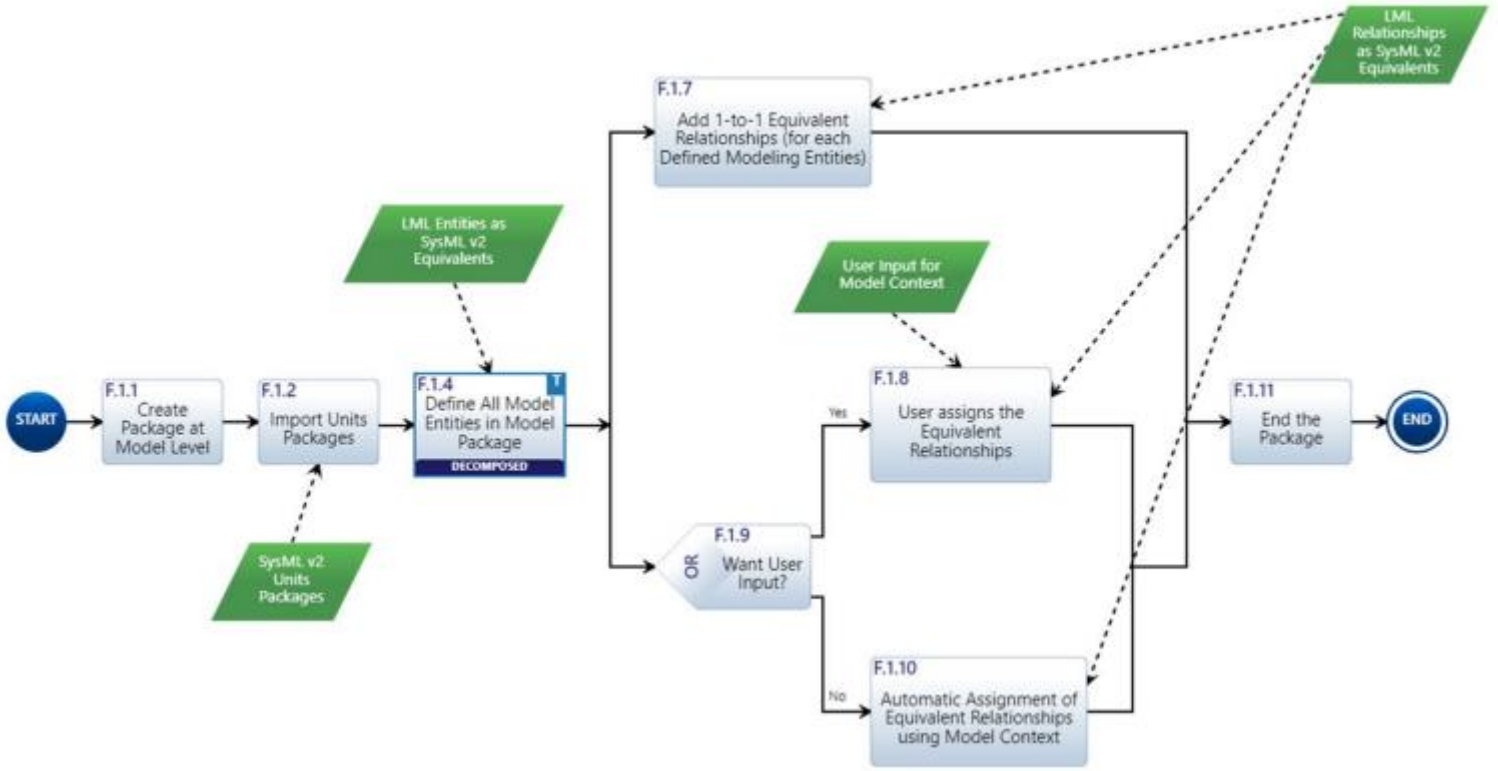
Entity Mapping

LML Relationship	LML Elements Related	SysML relationships
decomposes/decomposed by	All Elements to themselves	Definition, Element Group Membership, subsets, subclassifies, redefines
decomposes/decomposed by	Statement to Statement	Definition, Requirement Group Membership, derives/derived by
related to/relates	All Elements to themselves	Dependency, Association, references/is referenced by, refines/refined by, Element Group Membership, subsets, subclassifies, redefines
related to/relates	Statement to Statement	Relationship between the verification cases and their verification objectives, derives/derived by
references/referenced by	Artifact to All Elements	Dependency, is documented by, explains/explained by, about
specifies/specified by	Characteristic to All Elements	Defined as an attribute (property) of a part, conforms/constrained by
performs	Asset to Action	Allocation, Performs
consumes/consumed by	Asset as Resource to Action	receives/generates, references/is referenced by, flow (A kind of connection that transfers items from a source output to a target input)
produces/produced by	Asset as Resource to Action	causes/is caused by, connector, association, references/is referenced by, flow

Relationship Mapping

LML to SysML v2 Conversion Process

- How to do an LML to SysML v2 conversion
- Complements the conversion guide and entity/relationship mapping



Plans for Implementing SysML v2 in Innoslate®

Plan for Implementing SysML v2 in Innoslate

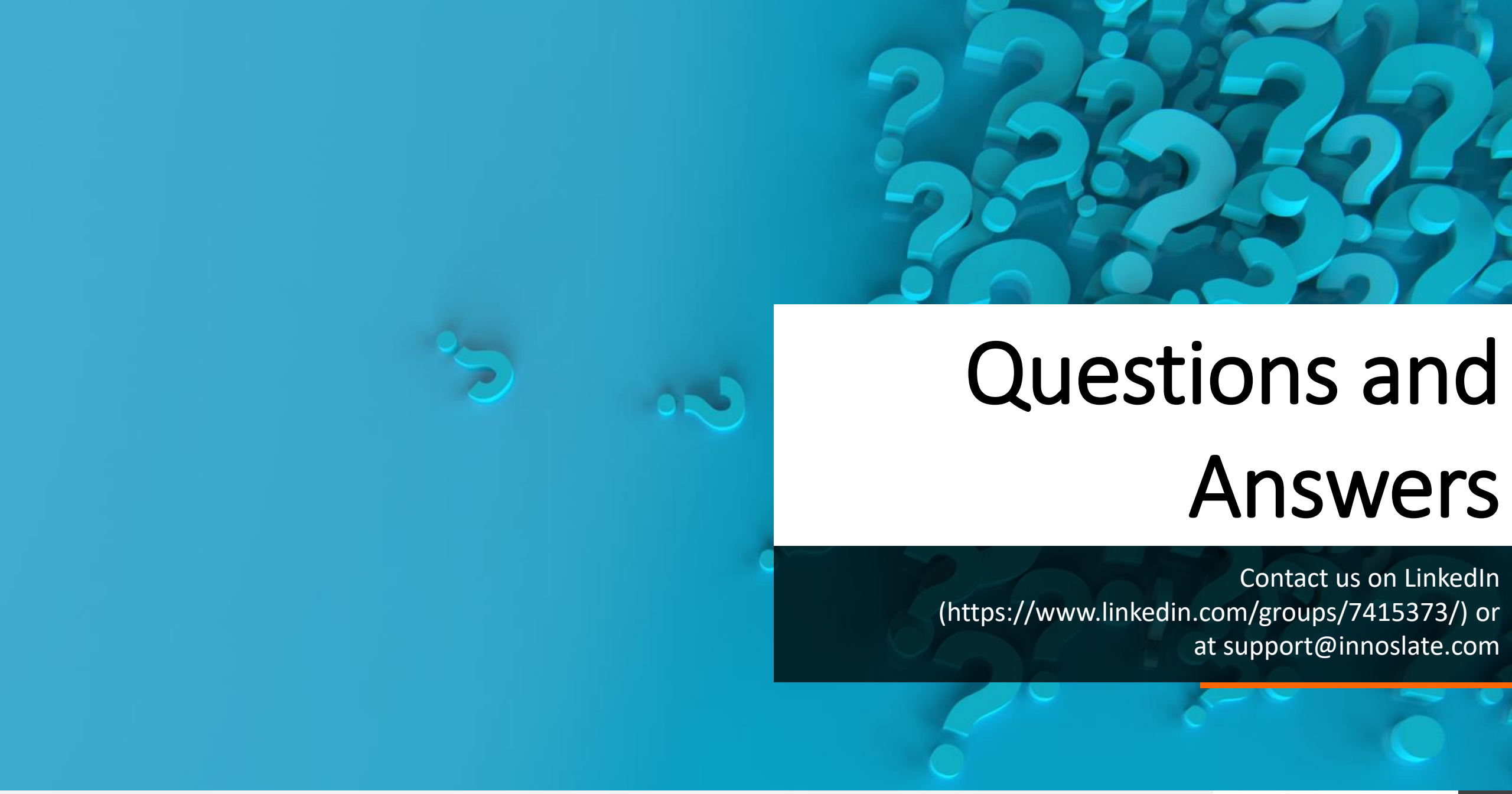
- With the finalization of SysML v2 specification, continue and improve the mapping between LML and SysML v2 in order to be as accurate as possible with translating between them
- Add/update diagrams for modeling SysML v2 in Innoslate
- Explore options for interoperability between tools with the SysML v2 API and/or JSON and/or XMI

Shortfalls

- Difficult to visualize models with only the textual notation
- Learning curve
  - Have to learn the textual notation for the modeling entities
  - Have to learn new concepts introduced with SysML v2
- Long time to implement in tools

References

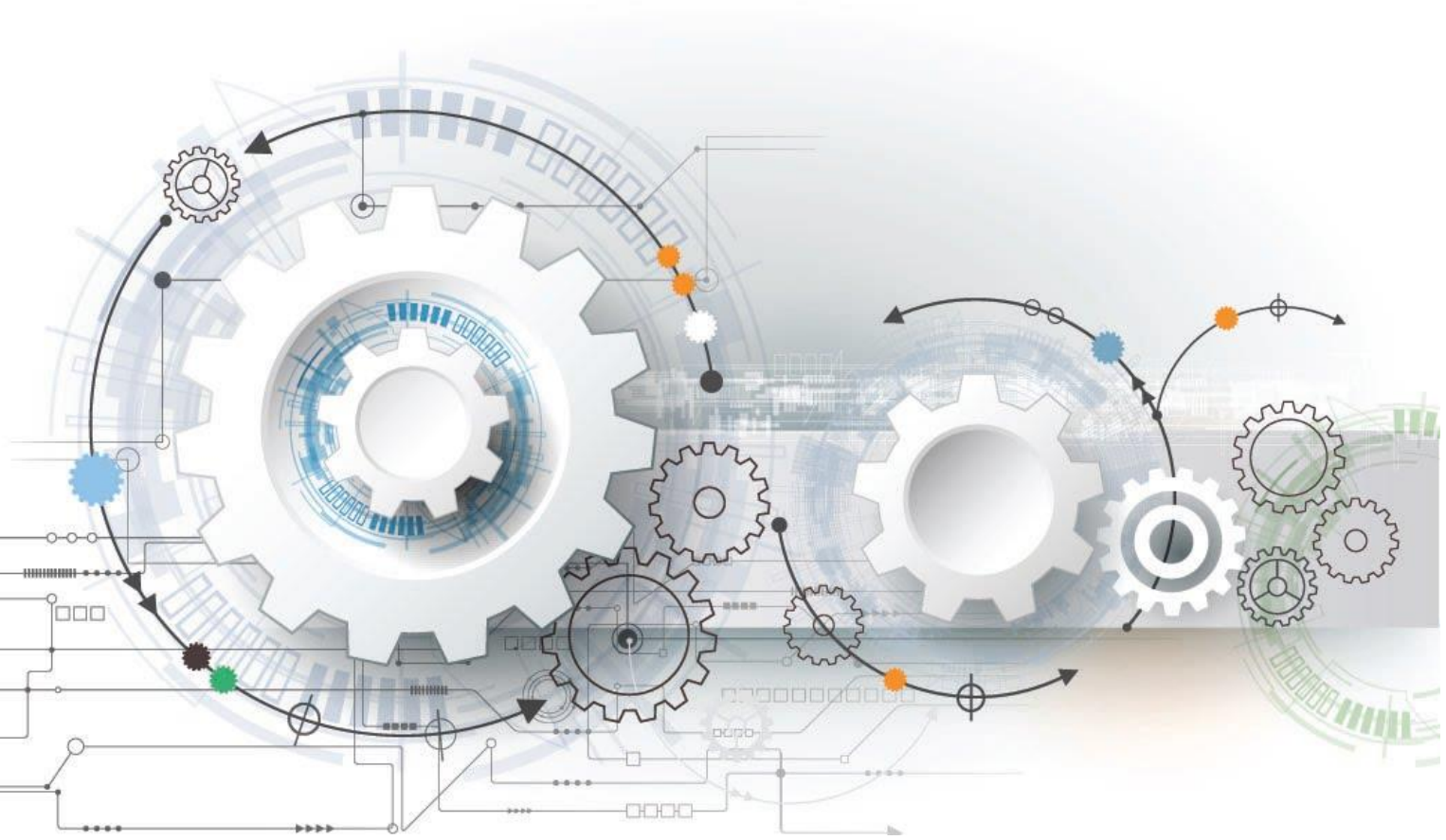
- A Preview of the Next Generation System Modeling Language (SysML v2), Sanford Friedenthal and Ed Seidewitz, pg. 6-22. https://www.ppi-int.com/wp-content/uploads/2020/11/PPI-SyEN-95.pdf
- Systems Modeling Language (SysML v2) Support for Digital Engineering, Manas Bajaj, Sanford Friedenthal, and Ed Seidewitz, pg. 19-24. https://connect.incose.org/Library/InsightMagazine/Practitioners%20Magazine/INSIGHT_v25-1_0331.pdf
- The MBSE Horizon: Advances and Challenges over the next few years, James Towers. https://www.linkedin.com/pulse/mbse-horizon-advances-challenges-over-next-few-years-james-towers/
- The MBSE Podcast: Episode 25 – SysML v2: A look behind the scenes with Ed Seidewitz. https://mbse-podcast.rocks/episode-25-sysml-v2-a-look-behind-the-scenes-with-ed-seidewitz/
- INCOSE Sweden Webinar 20220209 SysML v2 with Tim Weilkiens. https://www.youtube.com/watch?v=ggXknlHSU7Q
- MBSE4U SysML v2 JupyterBook. https://www.sysmlv2lab.com/lab/workspaces/auto-X
- SysML v2 Release GitHub. https://github.com/Systems-Modeling/SysML-v2-Release
- Kossobokova, L., Lockhart, T. (2022). SysML v2: Initial capability exploration and MBSE model translation.



Questions and Answers

Contact us on LinkedIn (https://www.linkedin.com/groups/7415373/) or at support@innoslate.com

Thank you!
Visit **cloud.innoslate.com** for a trial.



SPEC Innovations

@SPECInnovations

Innoslate User Group

Innoslate.com/blog

571.485.7800

specinnovations.com

USD(R&E)

Cross Domain Solutions Tutorial

Mr. Burhan Adam
Director, Systems Security Policy, Standards, and Guidance
Office of the Under Secretary of Defense for Research and Engineering
National Defense Industrial Association Systems and Mission Engineering Conference
November 1-3, 2022

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Agenda

- Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E))
- Department of Defense Instruction (DoDI) 5000.83
- Cross Domain Solutions (CDS) Problem Statement
- CDS Governing Policies
- Definition, Types, and Applications of CDS
- CDS Training Objectives and Plans
- Summary
- Points of Contact

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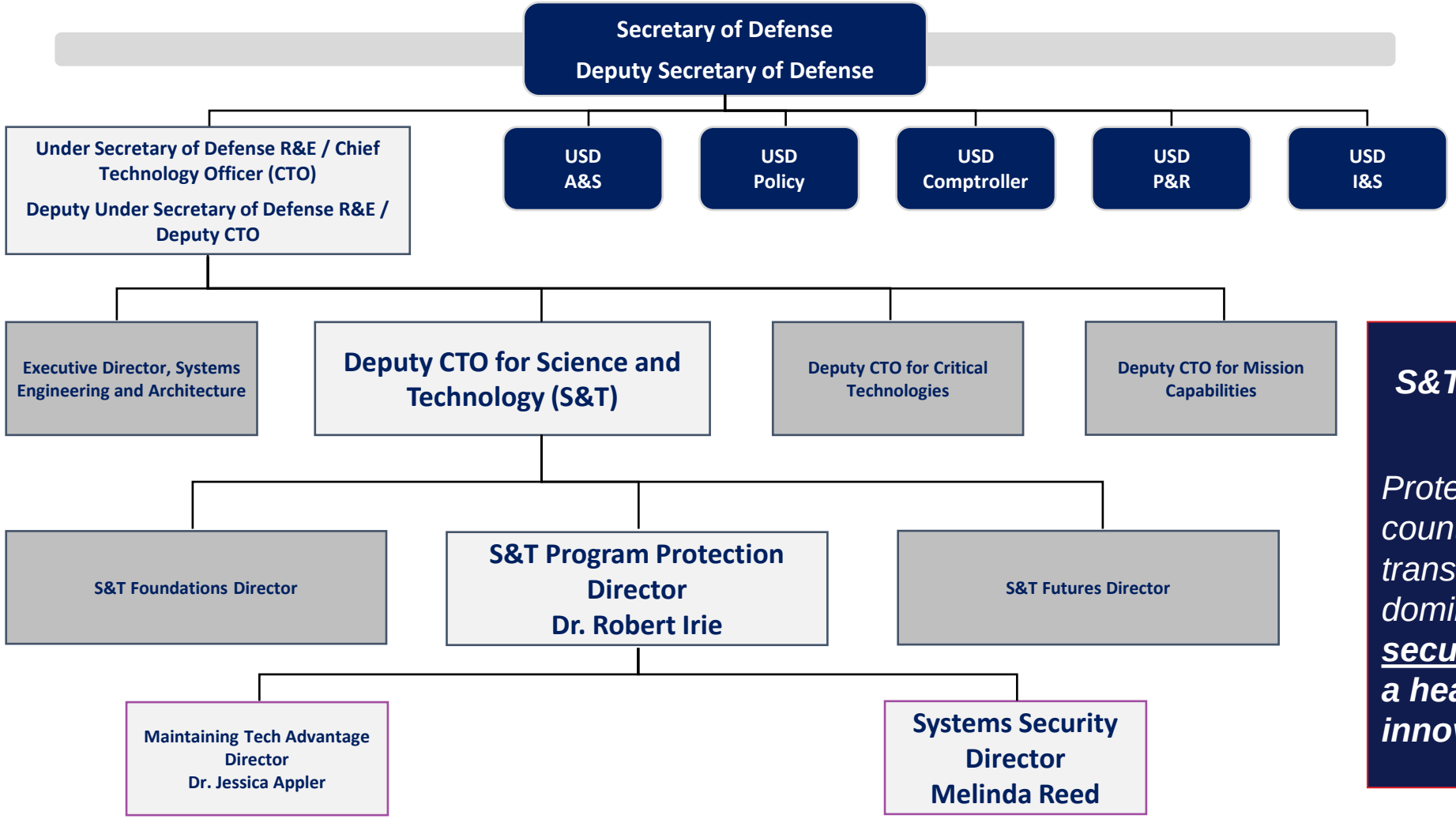
OUSD(R&E) Organization



S&T Program Protection (STPP) MISSION:

Protect technology advantage and counter unwanted technology transfer to ensure warfighter dominance through ***assured, secure and resilient systems*** *and a healthy, viable national security innovation base.*

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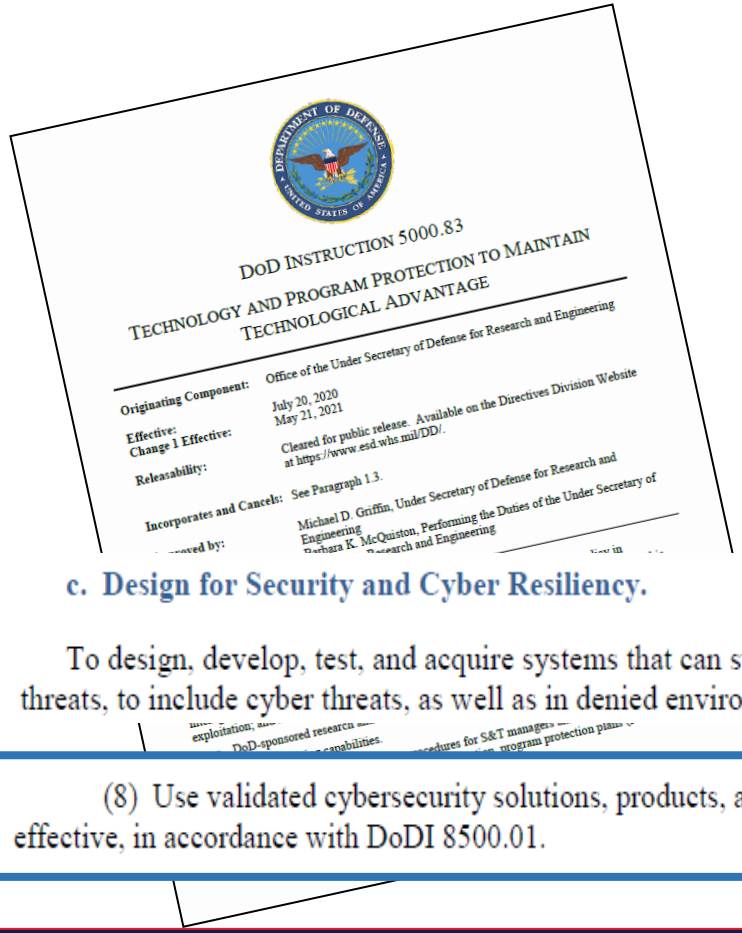
DoDI 5000.83



DoD INSTRUCTION 5000.83

TECHNOLOGY AND PROGRAM PROTECTION TO MAINTAIN TECHNOLOGICAL ADVANTAGE

Originating Component: Office of the Under Secretary of Defense for Research and Engineering

Effective: July 20, 2020
Change 1 Effective: May 21, 2021

Releasability: Cleared for public release. Available on the Directives Division Website at https://www.esd.whs.mil/DD/.

Incorporates and Cancels: See Paragraph 1.3.

Michael D. Griffin, Under Secretary of Defense for Research and Engineering
Barbara K. McQuiston, Performing the Duties of the Under Secretary of Research and Engineering

c. Design for Security and Cyber Resiliency.

To design, develop, test, and acquire systems that can successfully operate in the face of threats, to include cyber threats, as well as in denied environments, lead systems engineers will:

(8) Use validated cybersecurity solutions, products, and services when available and cost effective, in accordance with DoDI 8500.01.

DoDI 5000.83, *Technology and Program Protection to Maintain Technological Advantage*, May 2021

- **Establishes responsibilities and procedures for *S&T managers and engineers* to manage system security and cybersecurity technical risks to:**
  - DoD-sponsored research and technology
  - DoD warfighting capabilities
- **System security and cybersecurity technical risks include:**
  - Hardware, software, supply chain exploitation
  - Cyber, and cyberspace vulnerabilities
  - Reverse engineering, anti-tamper
  - Controlled technical information / data exfiltration

Establishes responsibilities for technology and program protection, includes pre- and post- acquisition protection activities

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Problem Statement

- **Future and contemporary warfighting requires secure information sharing and collaboration across all types of boundaries including international, governmental, federal, agency, state, local, and security.**
  - Warfighters increasingly need to expand information sharing capabilities without introducing security vulnerabilities to their most sensitive systems and data/information.

- **CDS technologies address this requirement by enabling warfighting communities and coalition partners to share information across physically, logically, and administratively separated networks (known as security domains) in a reliable, secure and interoperable manner.**

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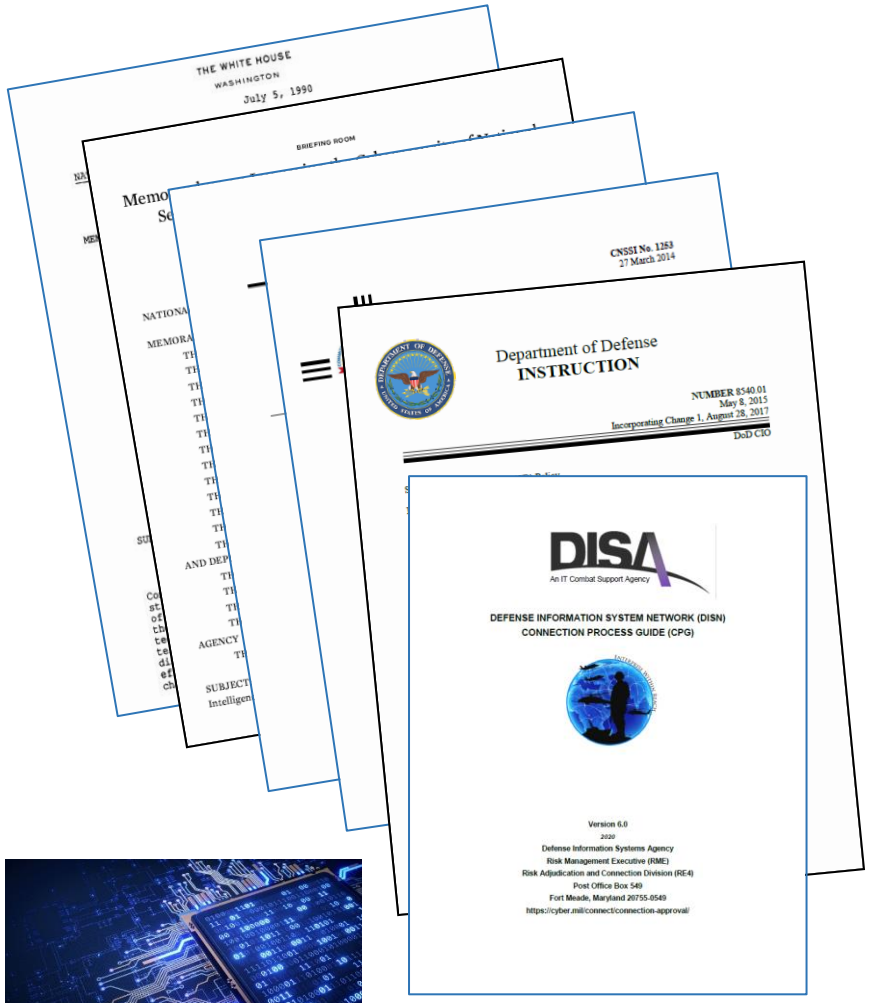
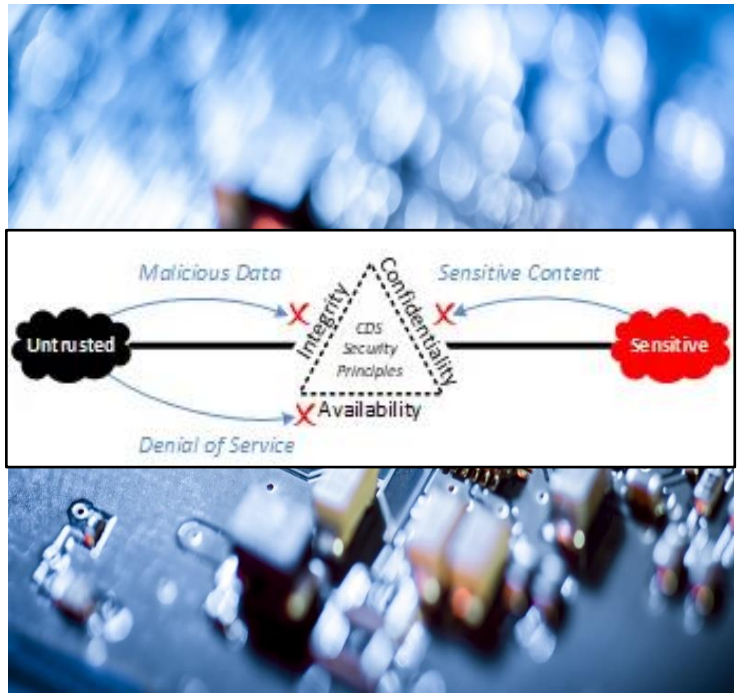
Cross Domain Solutions Policy



- **White House:**
  - *Memorandum on Improving the Cybersecurity of National Security, Department of Defense, and Intelligence Community Systems*, National Security Memorandum 8 (NSM-8), White House, 19 January 2022
    - Assigns National Cross Domain Strategy and Management Office (NCDSMO) its CDS authorities at a national level
  - National Security Directive 42 (NSD 42)
    - Assigns the National Security Agency (NSA) its information assurance authorities and designates NSA as the National Manager for National Security Systems (NSS). Document is confidential
- **DoD:**
  - DoDI 8540.01, Cross Domain Policy, Change 1, dated August 28, 2017
    - The DoD policy governing how to authorize and deploy CDS
  - Defense Information System Network (DISN) Connection Process Guide (CPG), Version 6.0, dated 2020, Defense Information Systems Agency (DISA)
    - Defines the process for connecting a CDS to DoD networks
- **National Institute of Standards and Technology (NIST):**
  - NIST SP 800-53 Revision Rev. 5, *Security and Privacy Controls for Federal Information Systems and Organizations*, dated September, 2022
    - Defines the security controls used by the U.S. Government (USG) to assess IT systems.
- **Committee on National Security Systems (CNSS):**
  - CNSS Instruction (CNSSI) No. 1253, *Security Categorization and Control Selection for National Security Systems*, dated March 27, 2014
    - Applies the NIST-800 53 Security controls to NSS
  - CNSSI No. 1253, Appendix F, Attachment 3, *Cross Domain Solution Overlay*, dated September 12, 2017 or later
    - Applies the CNSSI No. 1253 controls to CDS

Cross Domain Solutions



- **What is a CDS?**
  - "A form of controlled interface (a boundary with a set of mechanisms that enforces the security policies and controls the flow of information between interconnected information systems) that provides the ability to manually and/or automatically access and/or transfer information between different security domains." - NIST
  - A Controlled Interface is "A boundary with a set of mechanisms that enforces the security policies and controls the flow of information between interconnected information systems." - NIST SP 800-37 Rev. 1
- **Why are CDS needed?**
  - CDS are needed to enable secure information sharing
  - Must be implemented securely in order to maintain the necessary data characteristics of confidentiality, integrity and availability
  - Large enterprise data centers with many different networks and security enclaves with a different classification and or releasability requirements often need a CDS

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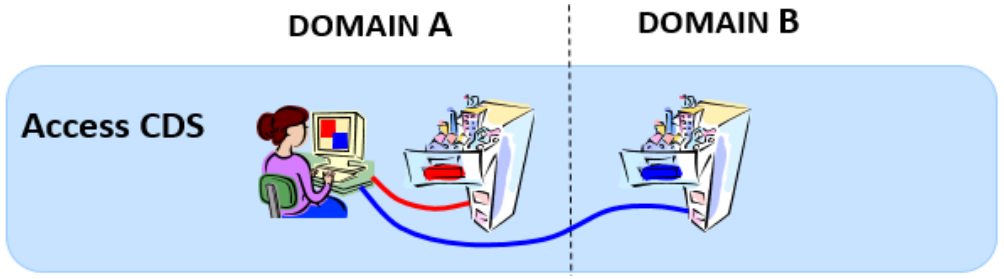
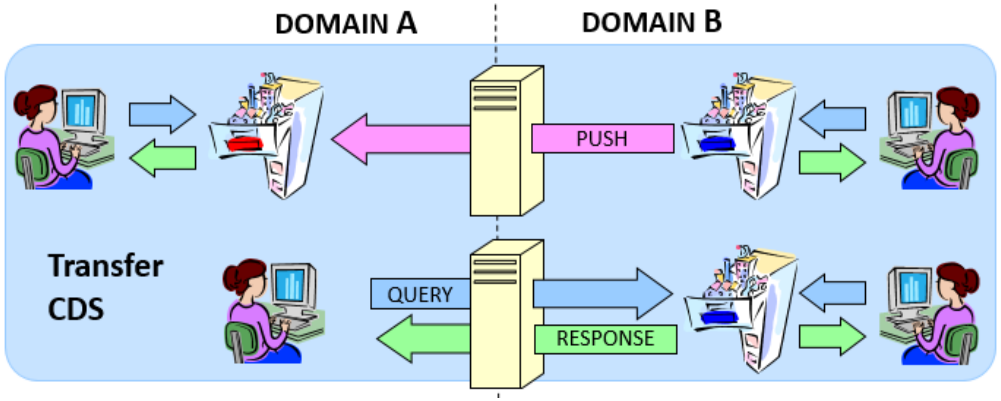
Cross Domain Solutions Types

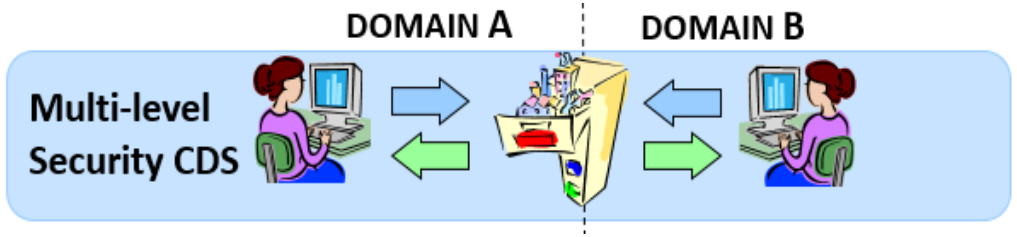
- **Access CDS**
  - Provides access to a computing platforms residing in lower security domains without transfer of user data between the domains. The access function is implemented by transferring keyboard and mouse data down to the lower security domain and sending video/image data up to the higher security domain
  - Largest number of units deployed
  - Two sub-types:
    - Virtual machine-based
    - Remote Virtual Desktop Infrastructure (VDI)-based



- **Transfer CDS**
  - One-way or bidirectional data transfers
  - Transfers data between systems operating in different security domains Filters the data being transferred to remove malicious content and reduce data spills
  - Used in Human2Human, Human2Machine, and Machine2Machine data transfers



- **Multi-Level Security (MLS) CDS**
  - Stores and provides access to labeled data
  - Primarily used for multi-level database or file storage
  - Usually integrated with a transfer CDS to change the label on the data (e.g., a regrade operation)



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Cross Domain Solutions – Applicable Environments

- **Enterprise**
  - CDS operated by specially designated General Purpose Enterprise Cross Domain Service Providers (GP-ECDSP) or Mission Specific Cross Domain Service Providers (MS-ECDSP)
  - List of ECDSPs are on the NCDSMO Portal
    - USG-contracted Cloud Service Providers are operating ECDSP capabilities
    - DISA
- **Point 2 Point (P2P)**
  - Local installation of a CDS in a non-tactical environment
  - Strong push by USG authorizing officials to transition P2P CDS deployments to ECDSPs to reduce long-term security and sustainment costs
- **Tactical**
  - CDS operating in communications and Size, Weight, Power, and Cooling (SWaP-C) constrained environment
  - Typical deployments include satellites, human-wearable, aircraft, ground vehicles, and naval vessels
  - Requires active anti-tamper and TEMPEST
  - Can be integrated with NSA-approved encryption devices

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Cross Domain Solutions Training

- **Provide training material to better support and educate the engineering workforce and their supporting technical staff on introductory, basic CDS concepts and key topics to help establish a foundation for understanding CDS technology and the associated policies, processes, challenges and risks**
- **Collaborative effort between NSA's National Cross Domain Strategy and Management Office (NCDSMO) and OUSD(R&E)**
- **Deliver two products in collaboration with Defense Acquisition University (DAU), National Defense University (NDU), and NCDSMO**
  - CDS Fundamentals Webinar (CDS 101)
    - Virtual webinar
  - CDS Practitioner Tutorial
    - Use-case and scenario building-based
    - In-person training course designed in-depth for the engineering community
- **Long-term: provide formal education and training**
  - Formal training courses
  - Standardizing CDS as a secure cyber resilient engineering (SCRE) design pattern for the community

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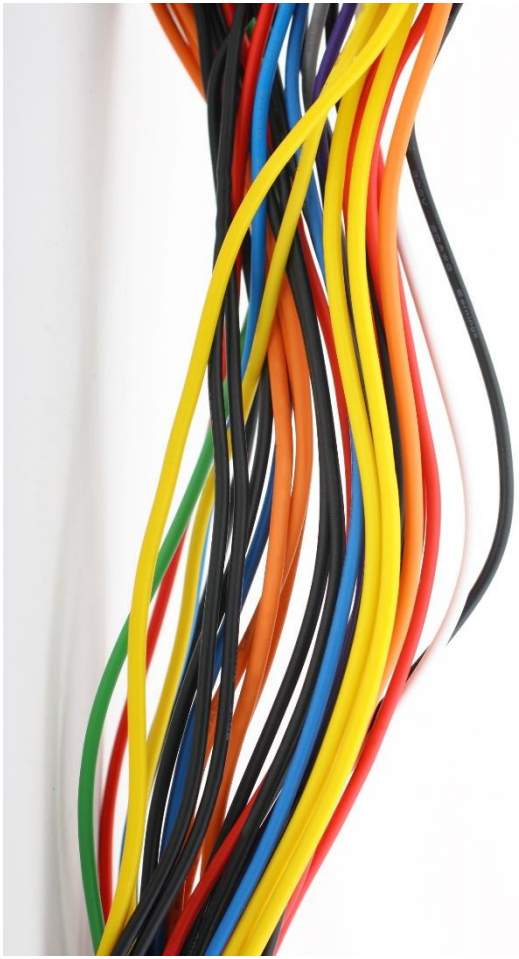
Cross Domain Solutions Fundamentals Webinar (CDS 101) Objectives

- Understand CDS terminology and the CDS types
- What is the NCDSMO and its role?
- Understand USG and DoD CDS policies
- Understand the functions of CDS
- Understand how to identify a cross domain problem in system architecture
- Understand how to determine if you need a CDS
- Making a “buy, modify, or build” decision
- Overview of the CDS testing process
- Overview of the CDS accreditation and authorization process
- CDS lifecycle issues



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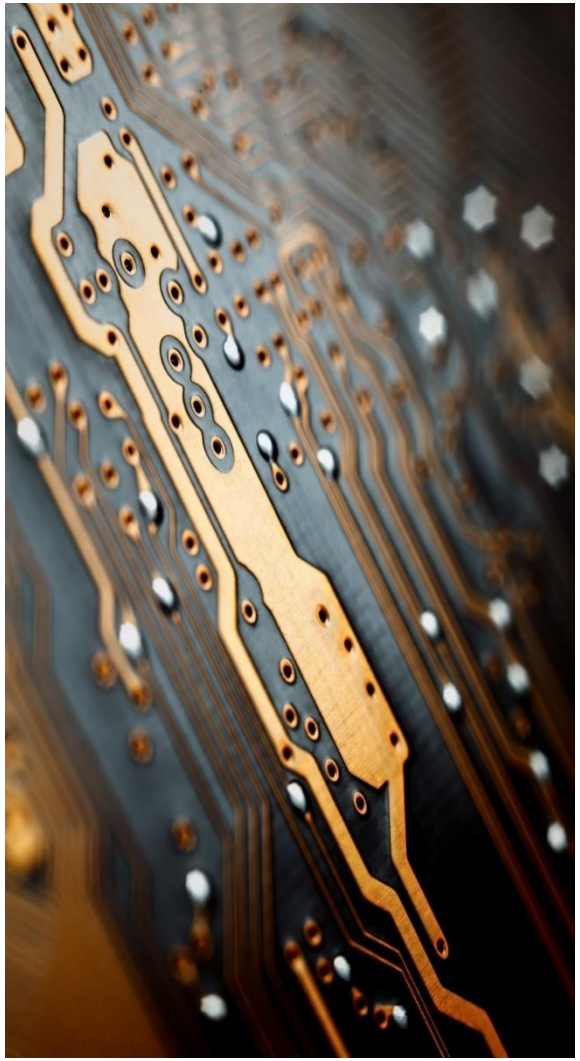
Cross Domain Solutions Practitioner Training Objectives



- How to define/capture, analyze, and decompose cross domain security requirements
- Cross domain security principles
- Security domains and their connectivity considerations and requirements
- Understand how to develop, assess, and balance between information security requirements, operational objectives, threats, and business objectives
- Key considerations for secure CDS architecture and design development
- Integration and deployment considerations
- CDS testing requirements and process
- CDS accreditation and authorization process, requirements, and considerations
- CDS lifecycle/sustainment Issues and how to develop a strategy for them
- Management of technical risks
- CDS governing policies and guides

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Summary

- **The need to interconnect complex and critical weapons systems/systems of systems (SOS) and their security domains often necessitates the deployment of CDS**
  - CDS are required to support connections between different security domains
  - A CDS will enforce a security policy, developed to meet an organization's information sharing requirements, whilst upholding the security and risk acceptance assumptions of the security domains involved
  - Secure Cyber Resilient Engineering (SCRE) solution
- **The DoD acquisition engineering and technical community need to master how to define requirements for CDS; develop CDS architecture and design; and integrate, test, and deploy CDS**
  - Understand governing policies and processes

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Points of Contact

- **Cross Domain Support Element or the NCDSMO**
  - NCDSMO can be reached at:
    - Email: ncdsmo@nsa.gov
    - NIPRnet: https://intelshare.intelink.gov/sites/ncdsmo (CAC/PIV required)

- **Further questions about the training courses:**
  - Mr. Burhan Adam
    - burhan.y.adam.civ@mail.mil
  - Ms. Singi De Silva
    - singithi.n.desilva.ctr@mail.mil

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