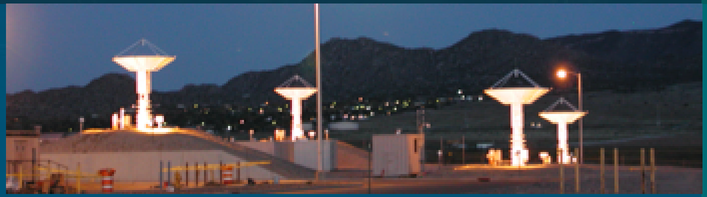
SAND2019-0470C

Sandia National Laboratories

How MBSE is Reducing the Duration of the Nuclear Weapon Development Lifecycle



PRESENTED BY

Anthony Matta – Manager, Model Based Systems Engineering

- Casey Noll
- Erik Olson
- Ryan Coleman

U.S. DEPARTMENT OF ENERGY NNSA

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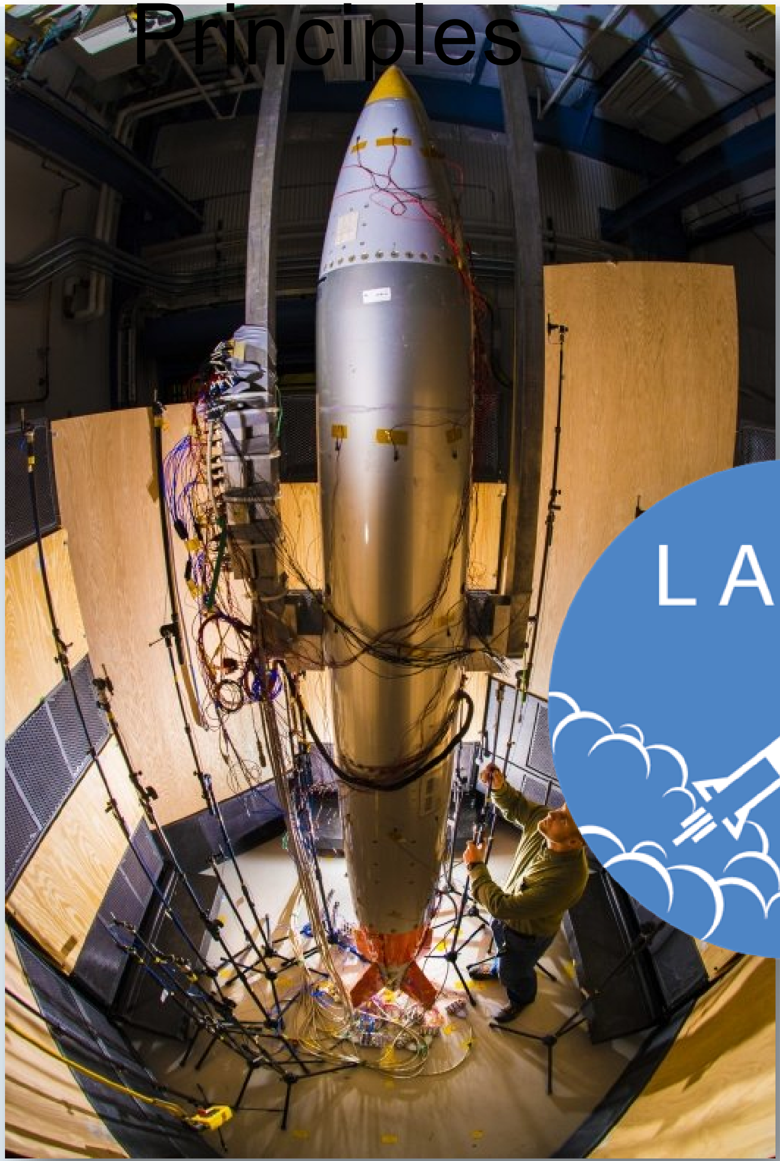
Sandia National Laboratories (SNL) Enterprise Pillars

Current Stockpile, Nuclear Triad, & Design Principles



ALWAYS perform when intended

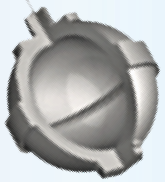
NEVER at any other unapproved time

Unique Nuclear Weapon Activities

Warhead systems engineering & integration

Design agency for Non-nuclear components

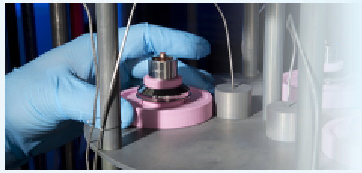
Safety systems



Gas transfer systems

Radar

Arming, fuzing & firing systems



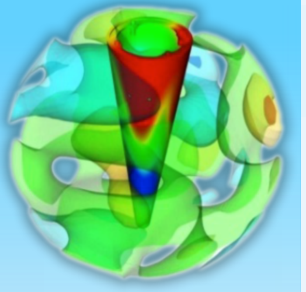
Neutron generators

Multi-disciplinary capabilities required for design, qualification, production, surveillance, experimentation/computation

Major environmental test facilities & diagnostics

Materials Science

Light initiated high explosive

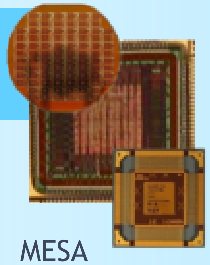


Computational analytics

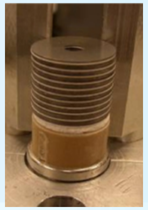
Production agency

Sandia External Production

Neutron generators

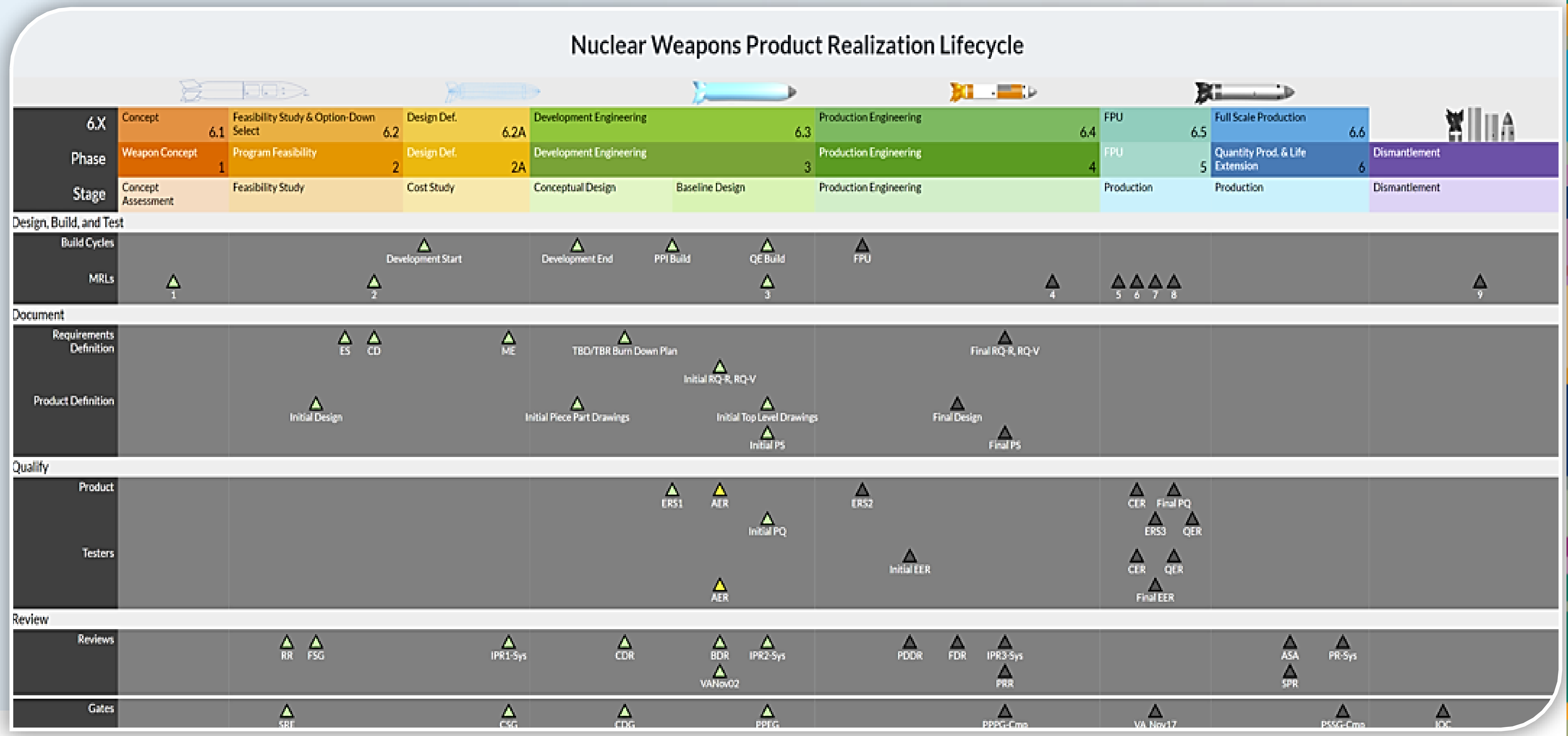


MESA microelectronics



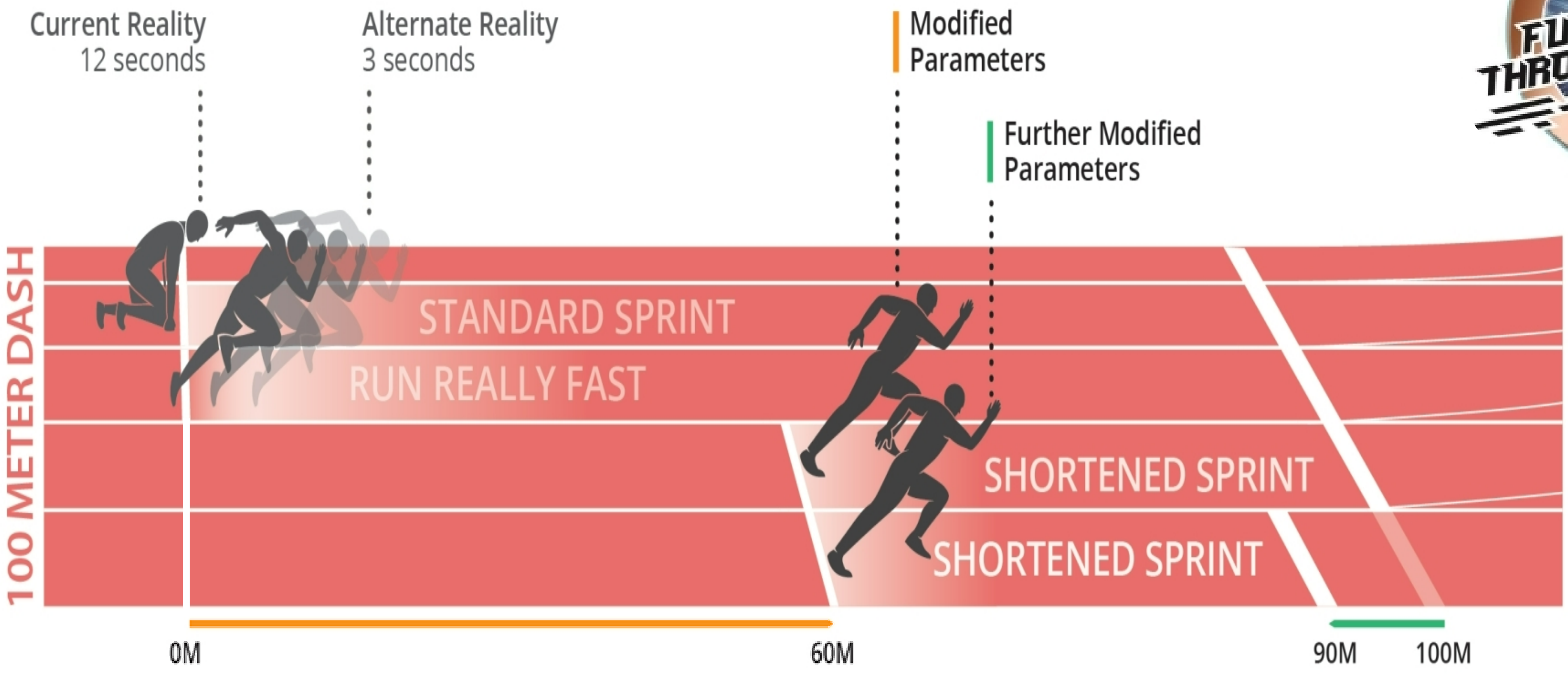
Thermal battery back up

Phase 6. NW Product Realization Lifecycle



Strategy

Two methods toward achieving the dramatic speed up:

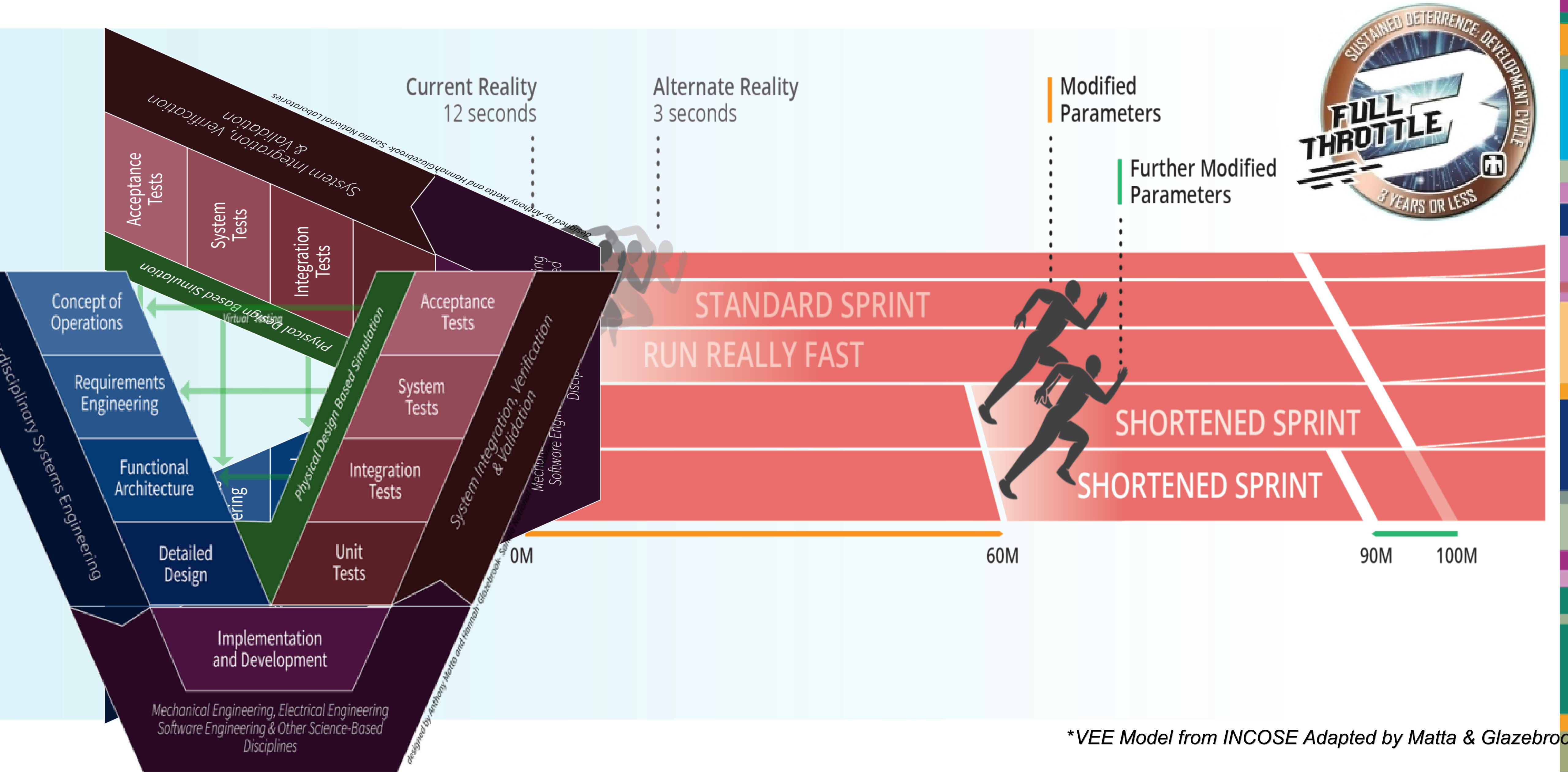


Move the starting line by building infrastructure

- Model-based design
- Common testers
- Design libraries
- Component reuse
- Modular architectures

May shorten the required distance by possibly performing some qualification after FPU

Strategy



*VEE Model from INCOSE Adapted by Matta & Glazebrook

Focus Area Representatives

NW DESIGN LIFECYCLE FOCUS AREAS

Current Cycle Time

~12 Years

AND

Casey Noll

- Verification & Validation activities
- Complex testing and environment reference architectures

Erik Olson

- Reduced order modeling
- Interrelating high fidelity physics codes for early design engineering

Ryan Coleman

- Digital Twin Data Strategy for Integrated Models
- Ontologically based integrated data sets

AND

Objective Cycle Time

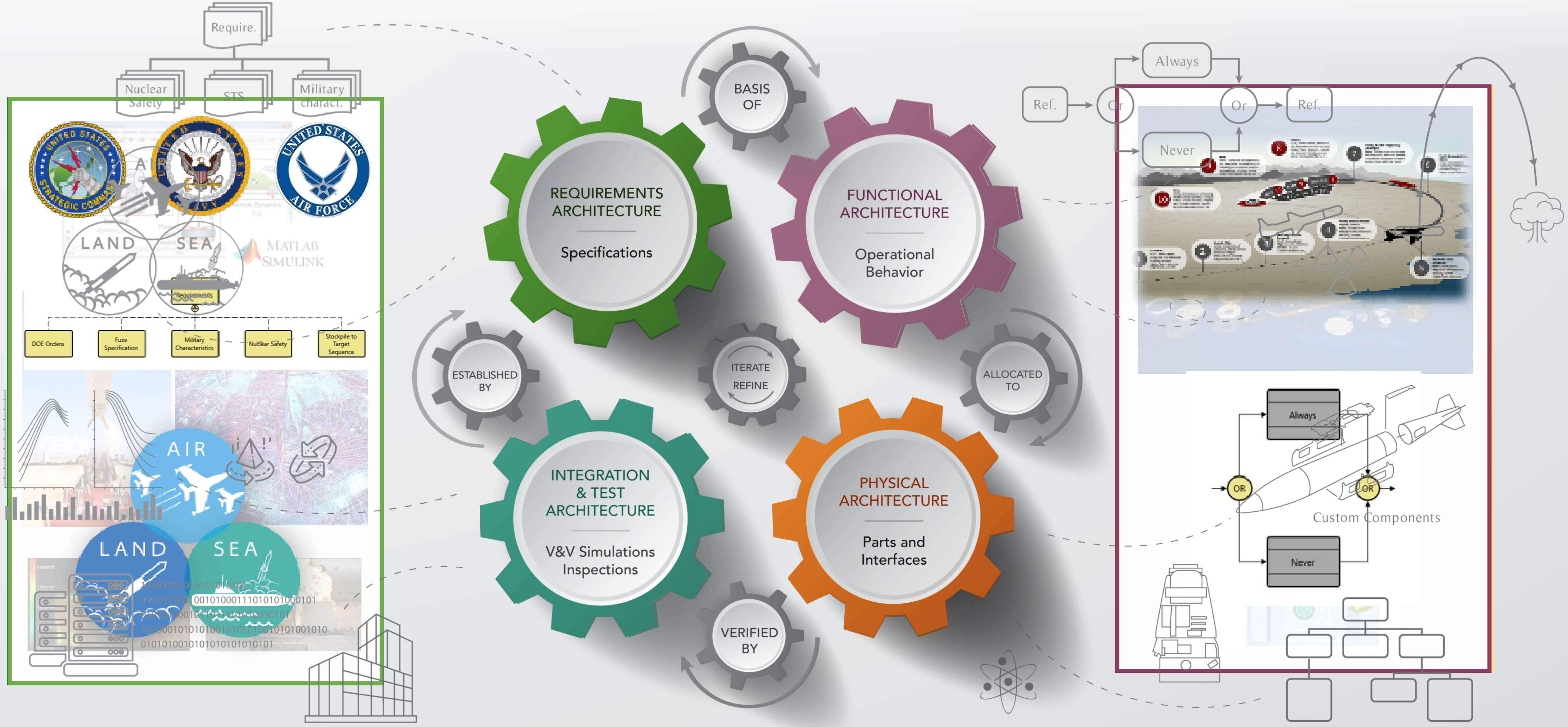
<3 Years

How Modeling Verification and Validation Activities Reduce the NW Development Time

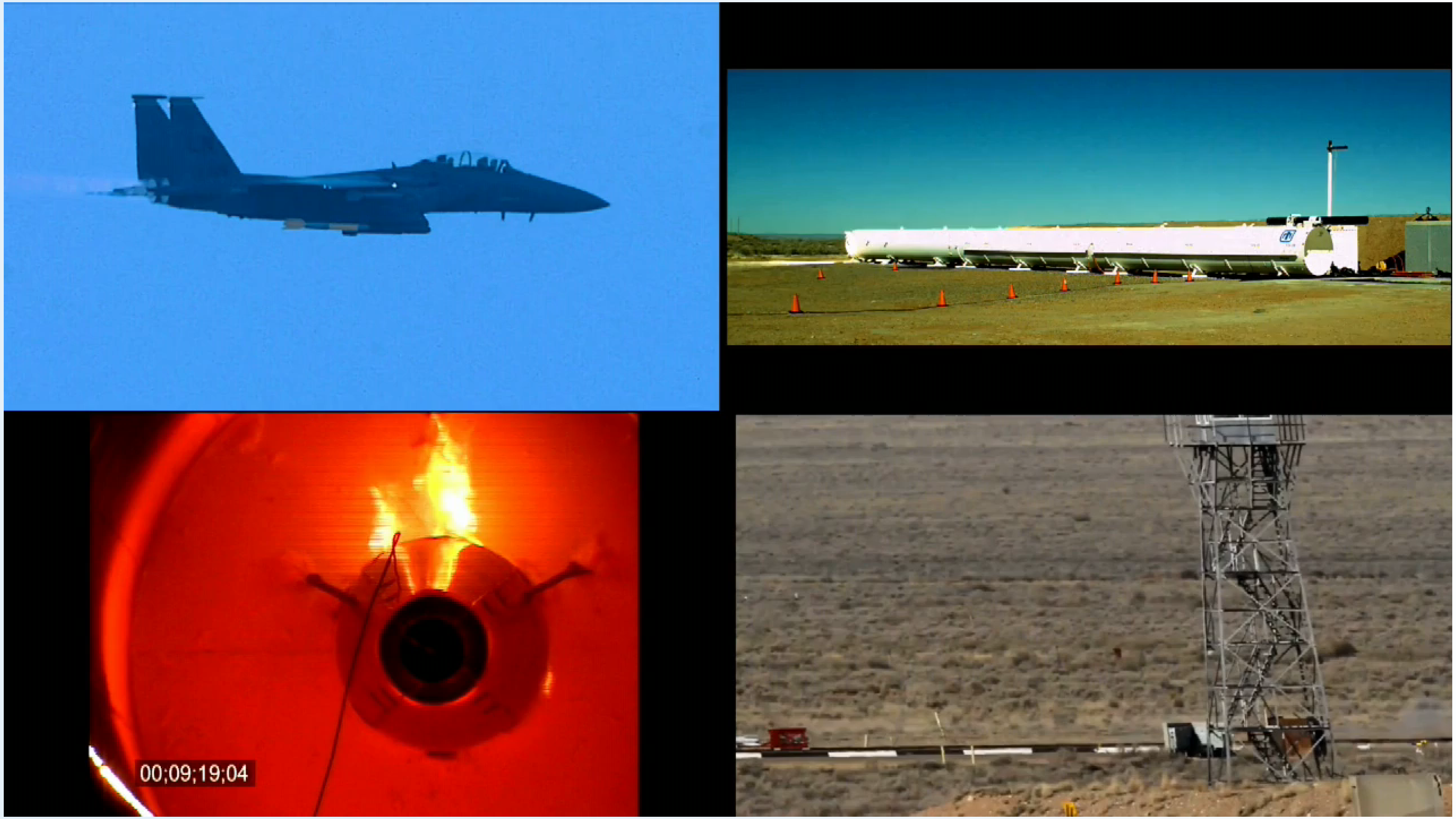
Casey Noll
R&D Systems Engineering

Served as a Nuclear Weapon (NW) component Product Realization Team (PRT) Lead responsible for the development and transition to production of custom high reliability components supporting multiple programs impacting the NW stockpile. Casey has his BS/MS in Engineering Management, from Missouri University of Science and Technology and is currently pursuing his Master in Systems Engineering from Stevens Institute of Technology.

MBSE for Nuclear Deterrence

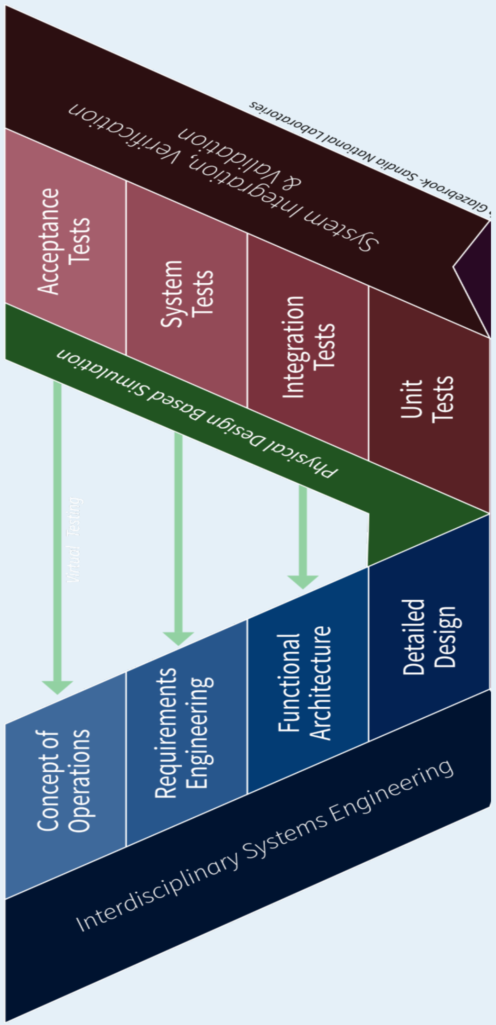


Verification & Validation



How can V&V modeling contribute to reducing the lifecycle for NW?

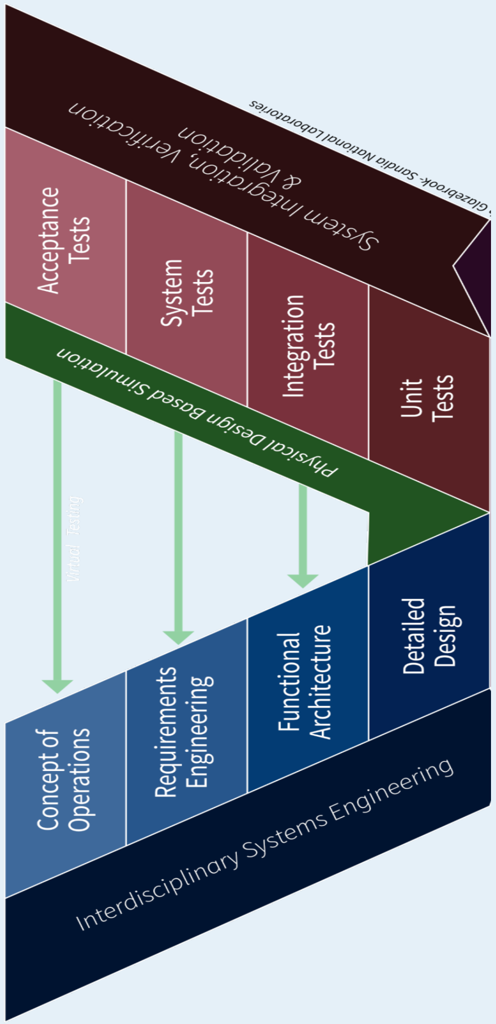
Verification & Validation

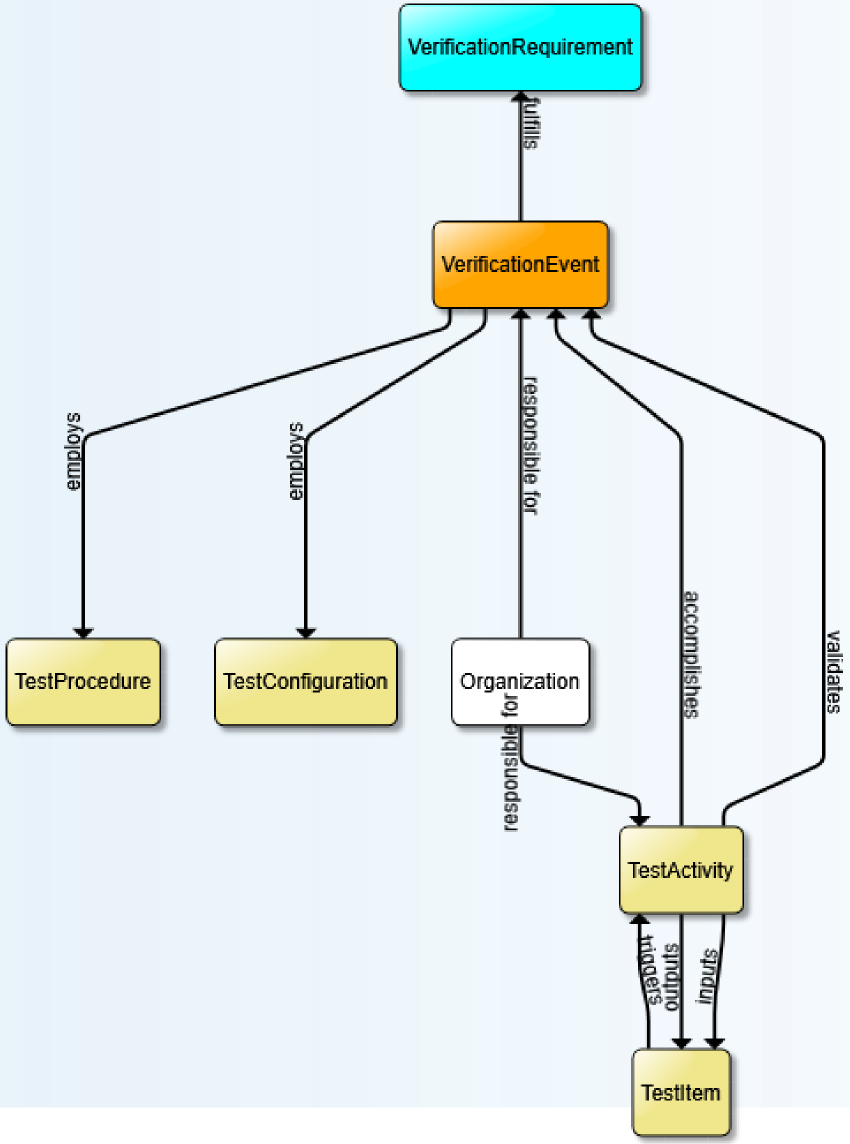


Requirement No.	Document	Paragraph	Shall Statement	Verification Success Criteria	Verification Method	Facility or Lab	Phase[a]	Acceptance Requirement?	Preflight Acceptance?	Performing Organization	Results
Unique identifier or each requirement	*Document number the requirement is contained within*	*Paragraph number of the requirement*	*Text (within reason) of the requirement, i.e., the "shall"*	*Success criteria for the requirement*	*Verification method for the requirement (analysis, inspection, demonstration, test)*	*Facility or laboratory used to perform the verification and validation.*	*Phase in which the verification and validation will be performed.*	*Indicate whether this requirement is also verified during initial acceptance testing of each unit.*	*Indicate whether this requirement is also verified during any pre-flight or recurring acceptance testing of each unit*	*Organization responsible for performing the verification*	*Indicate documents that contain the objective evidence that requirement was satisfied*
P-1	xxx	3.2.1.1 Capability: Support Uplinked Data (LDR)	System X shall provide a max. ground-to-station uplink of…	1. System X locks to forward link at the min and max data rate tolerances 2. System X locks to the forward link at the min and max operating frequency tolerances	Test	xxx	5	Yes	No	xxx	TPS xxxx
P-i	xxx	Other paragraphs	Other "shalls" in PTRS	Other criteria	xxx	xxx	xxx	Yes/No	Yes/No	xxx	Memo xxx
S-i or other unique designator	xxxxx (other specs, ICDs, etc.)	Other paragraphs	Other "shalls" in specs, ICDs, etc.	Other criteria	xxx	xxx	xxx	Yes/No	Yes/No	xxx	Report xxx

Source: NASA Systems Engineering Handbook

Verification & Validation





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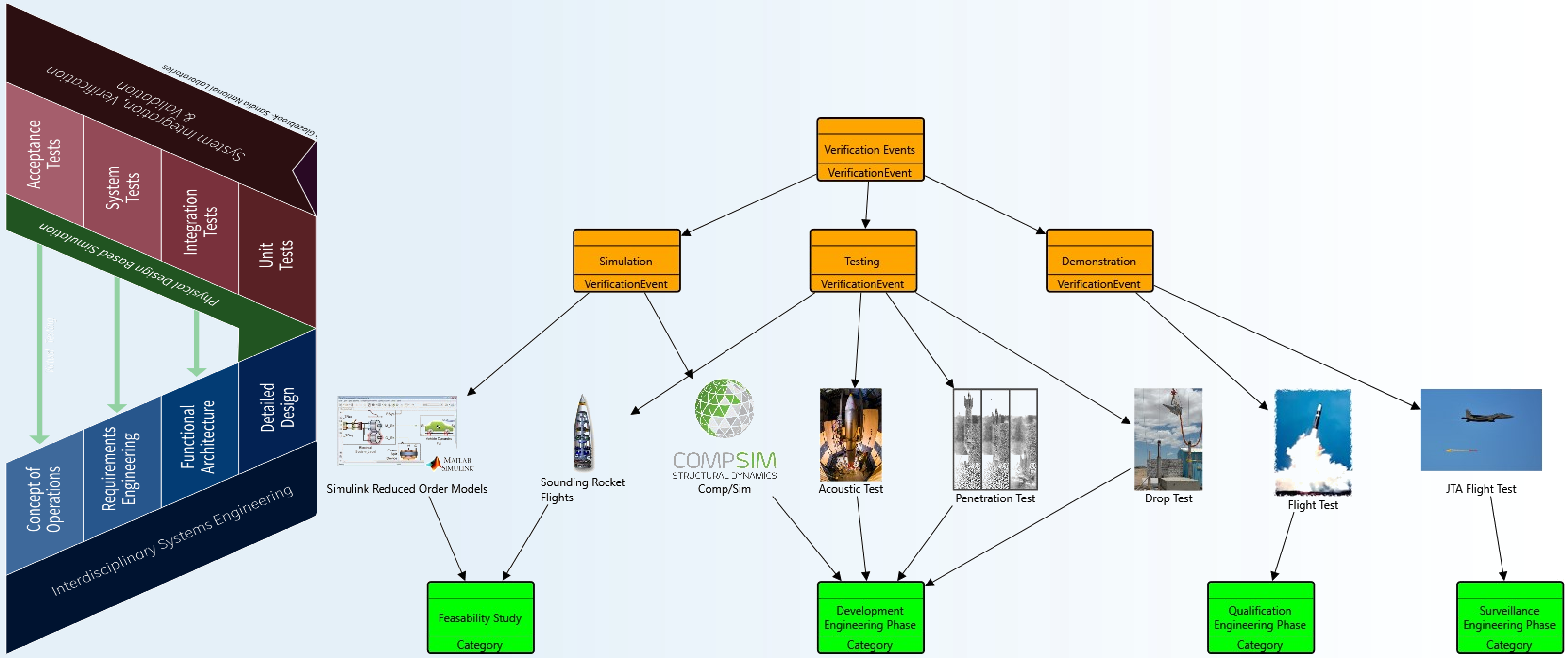

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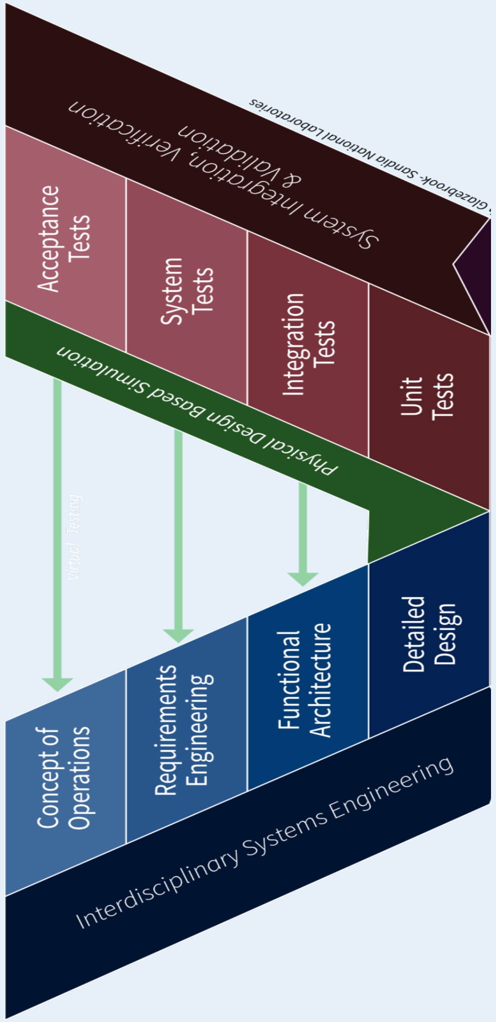
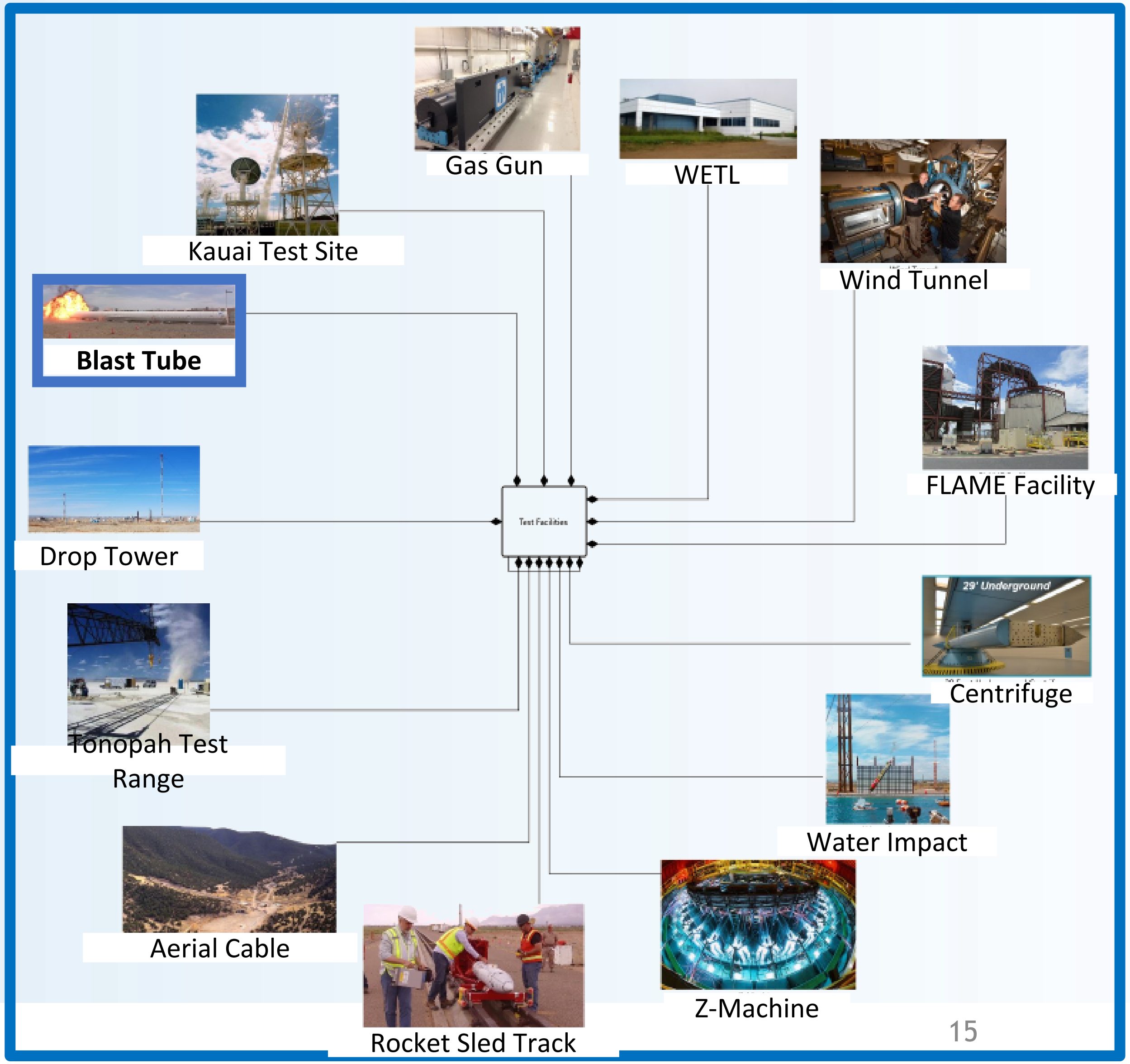
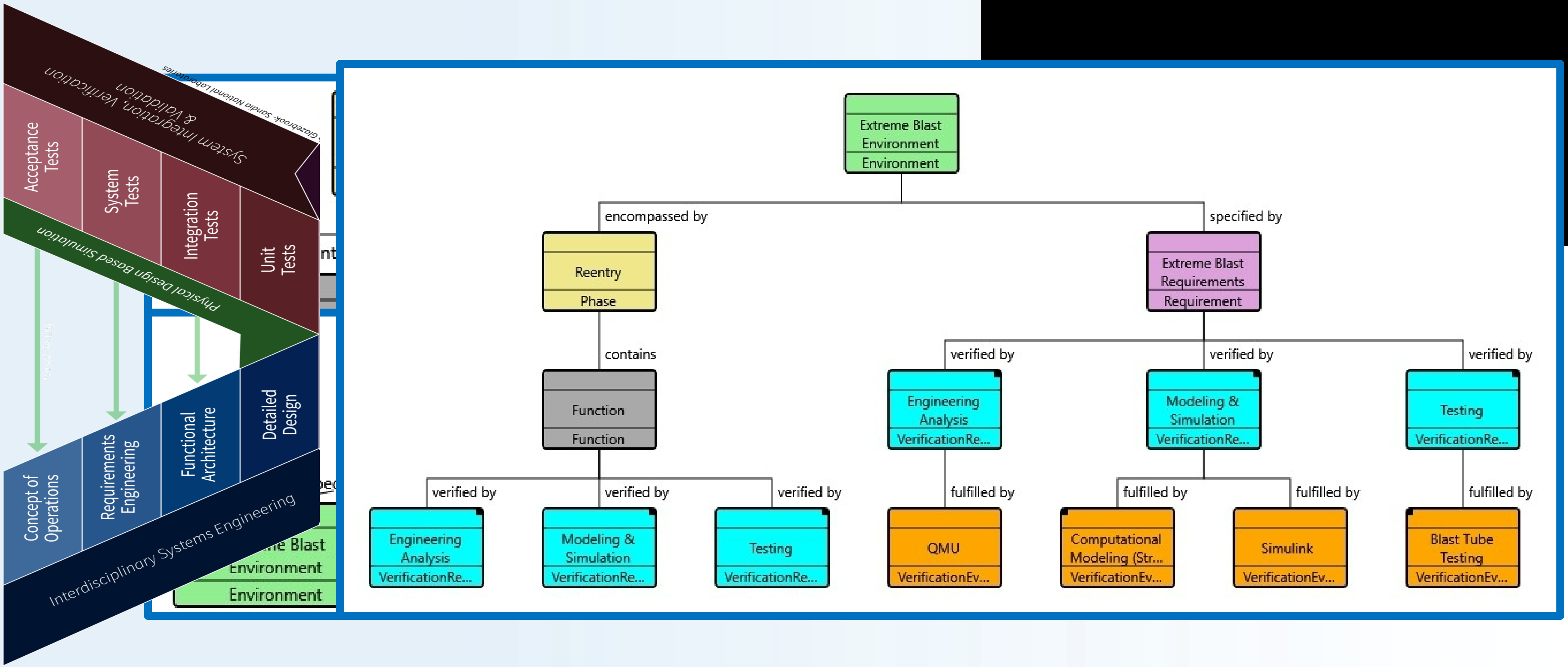




Verification & Validation



V&V modeling moves the “starting line” to shorten the lifecycle of NW

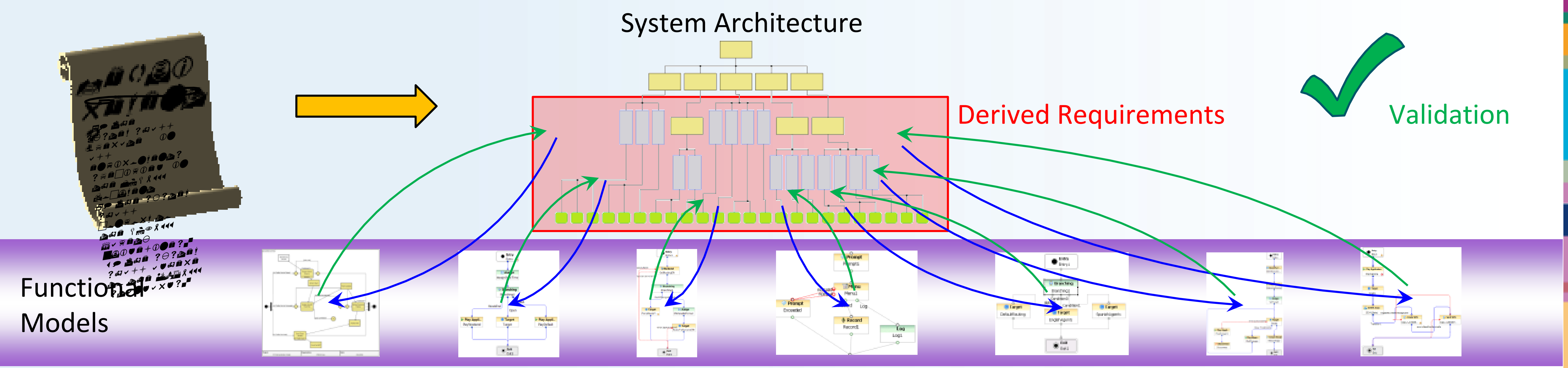
Erik Olson

R&D Electrical Engineering

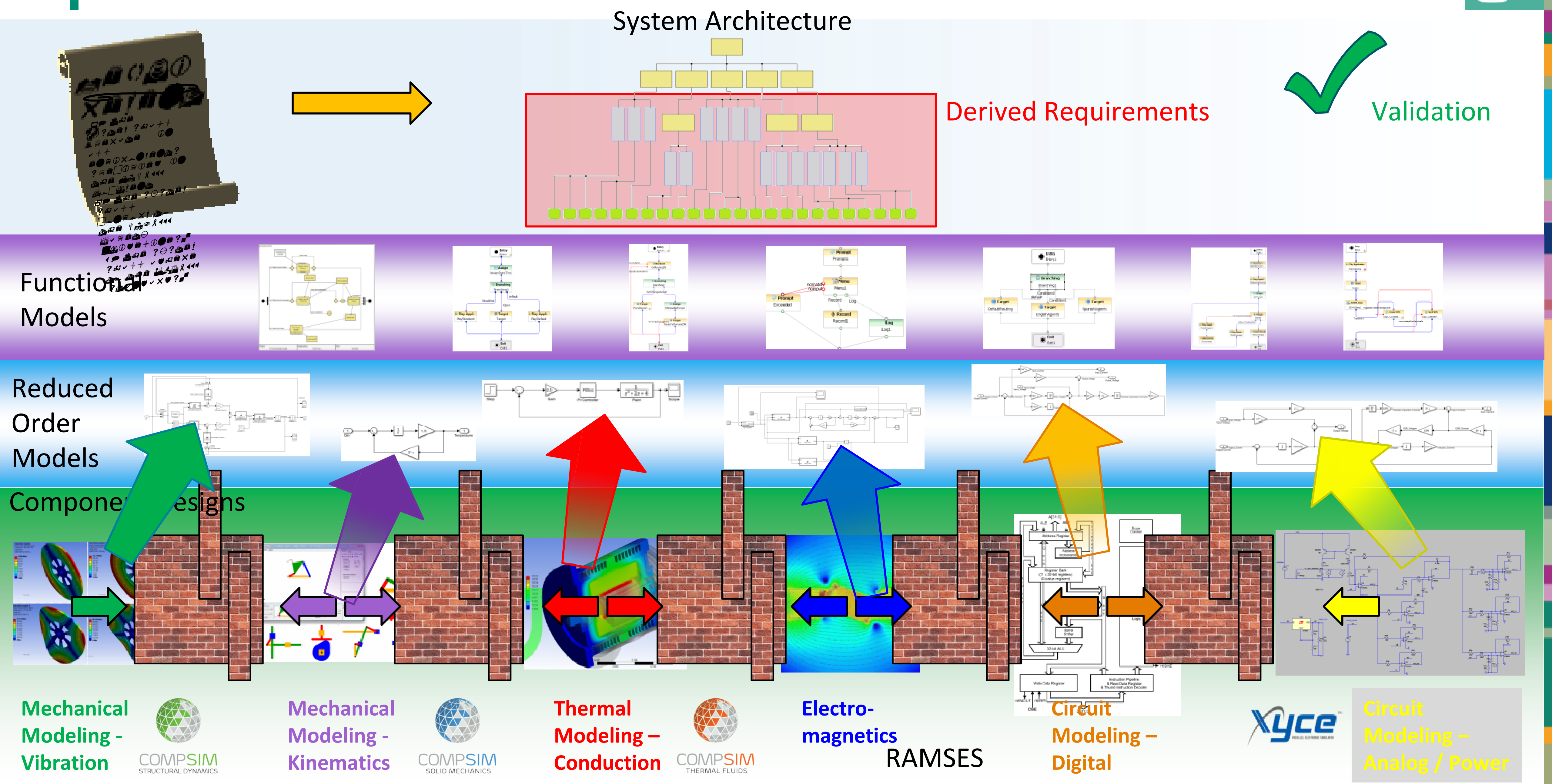
How Bridging MBSE with Reduced Order Modeling Reduces Development Time

Erik Olson has a background in both Electrical and Mechanical Engineering. He has his PhD in Electrical Engineering from University of Wisconsin. He spent the last ten years working in Sandia's satellite programs, and spent two years as an R&D engineer at Tyco thermal Controls in Menlo Park, California.

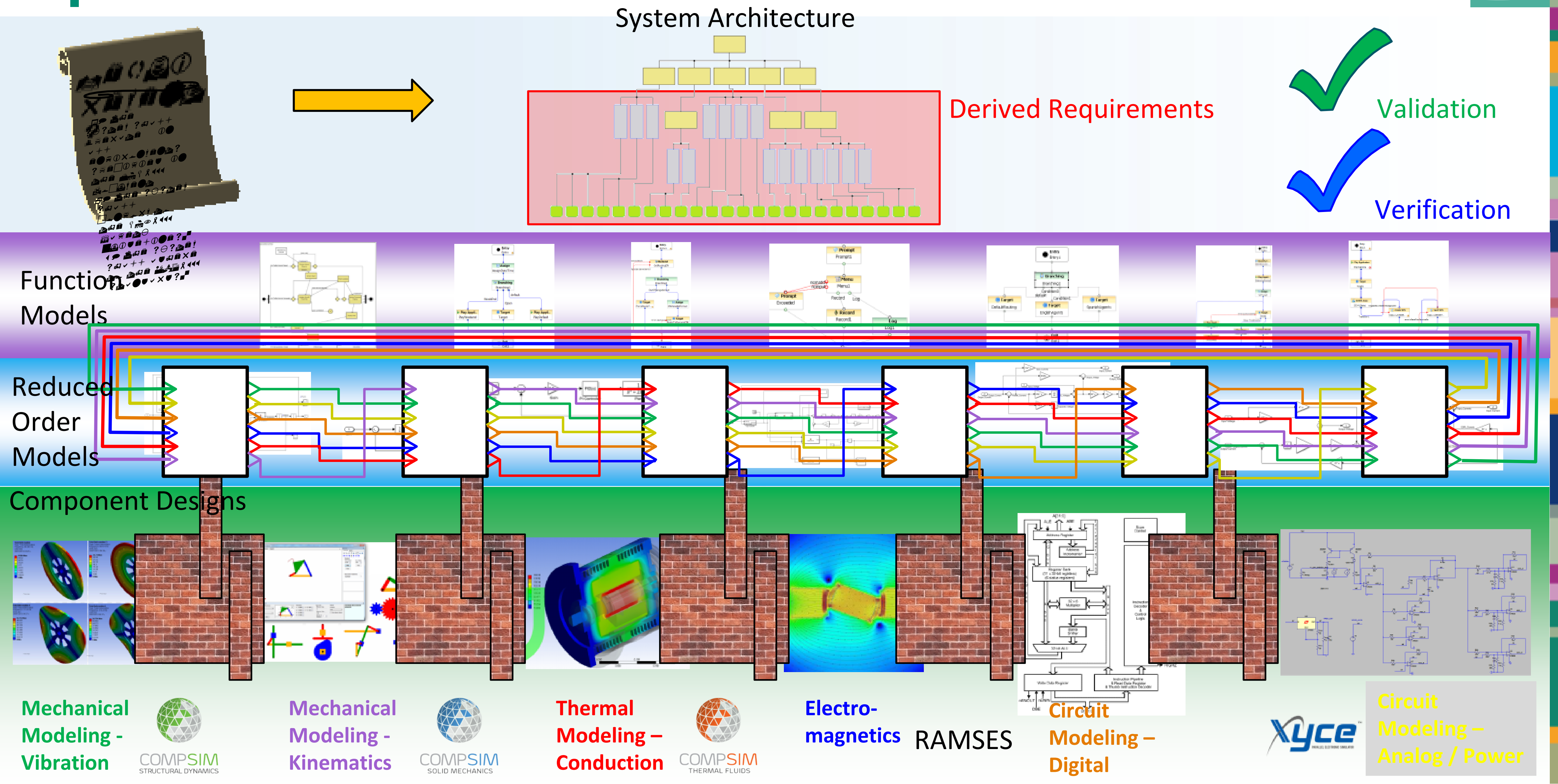
The Role of MBSE and Reduced Order Modeling



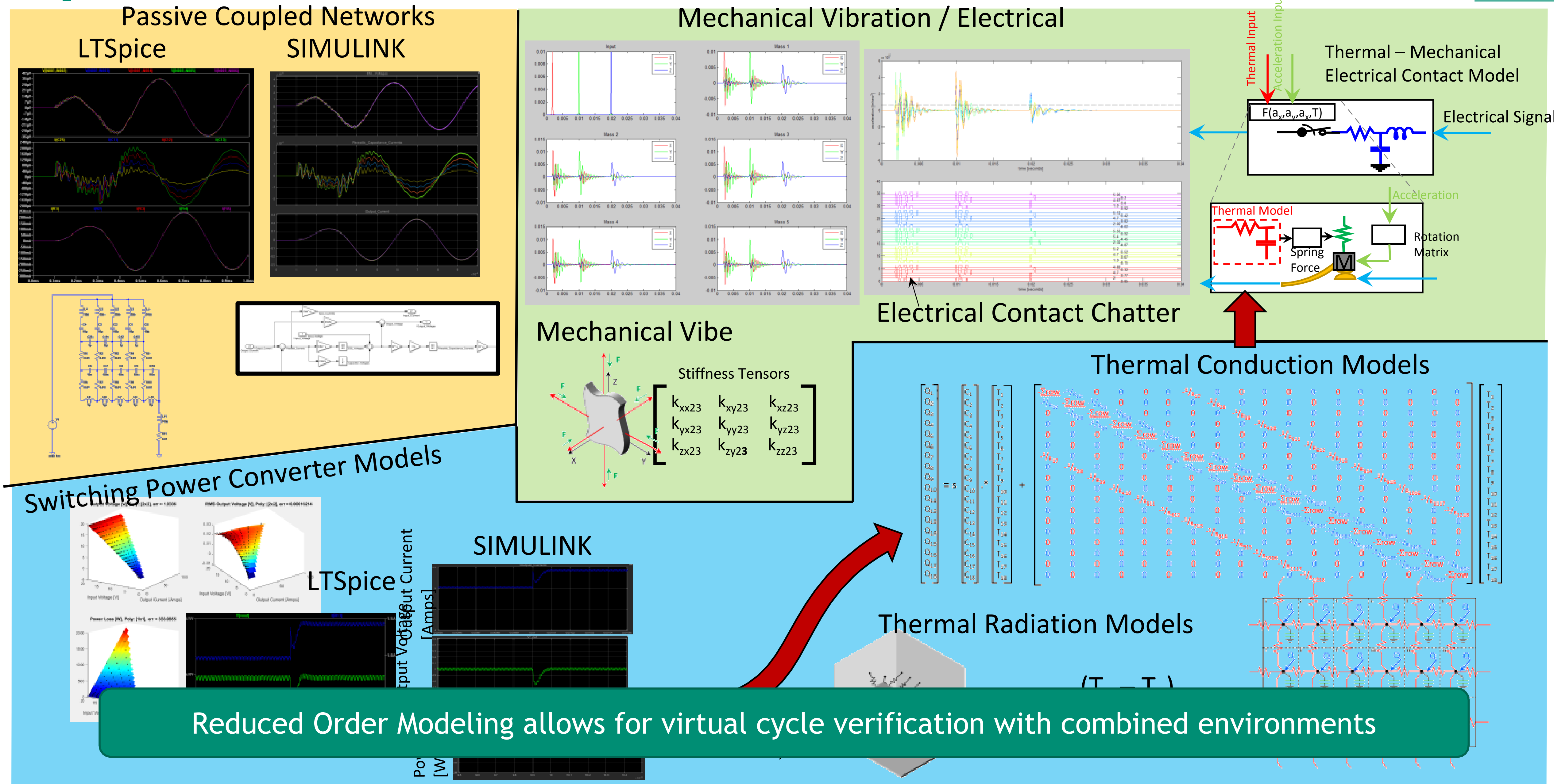
The Role of MBSE and Reduced Order Modeling



The Role of MBSE and Reduced Order Modeling



Equivalent Simulink Models



Reduced Order Modeling allows for virtual cycle verification with combined environments

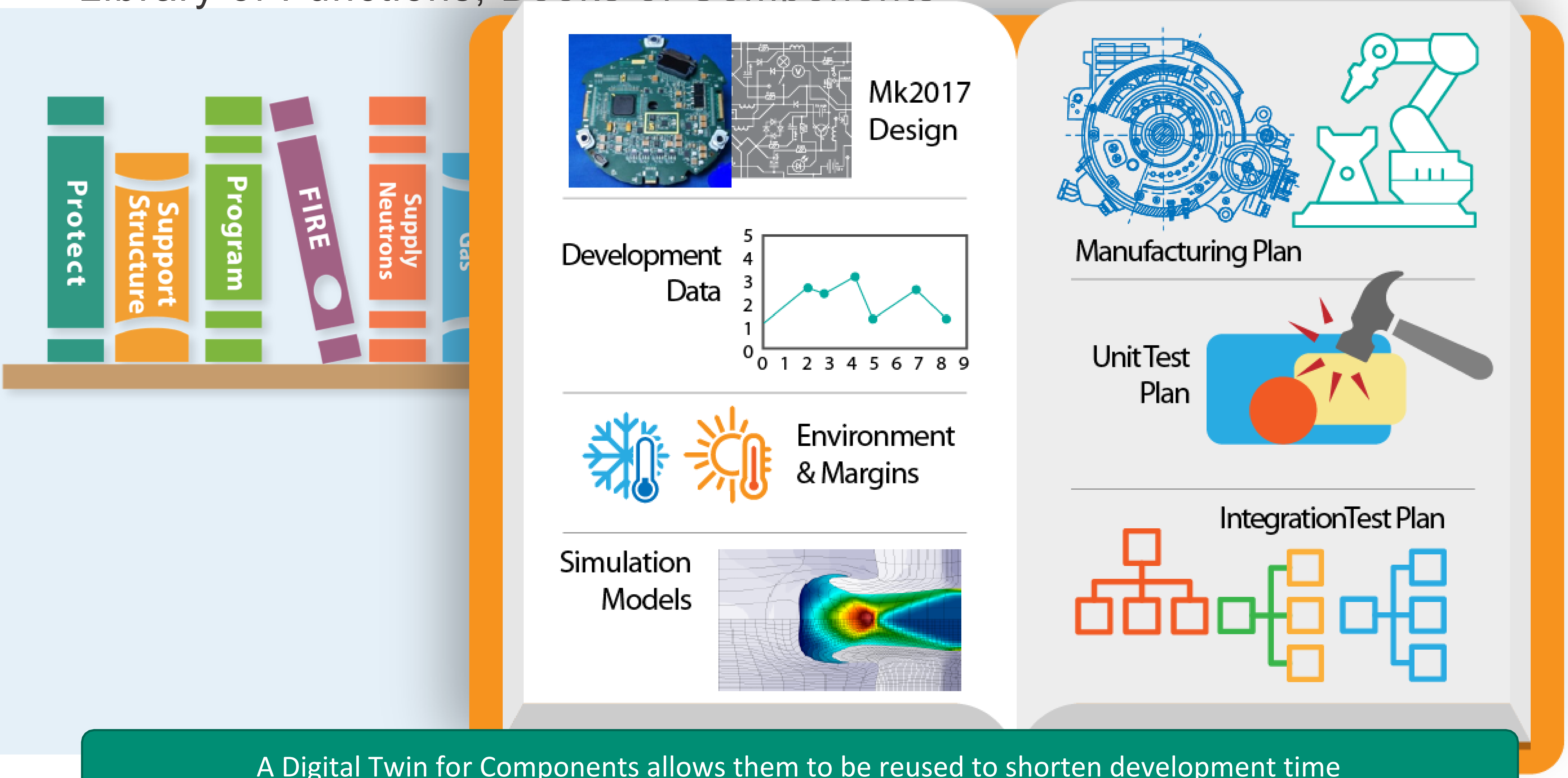
How Data Strategy For The Digital Twin Reduces NW Development Time

Ryan Coleman
R&D Computer Scientist

Ryan has experience in abnormal environments and detonator modeling, and many of the advanced simulation and computing analyses for nuclear weapons qualification. Immediately prior to joining Sandia, Ryan was an academic postdoc in Pharmaceutical Chemistry at University of California San Francisco, where he built and used software systems for drug discovery. Ryan has degrees in Computer Science, Philosophy, and his PhD in Computational Biology.

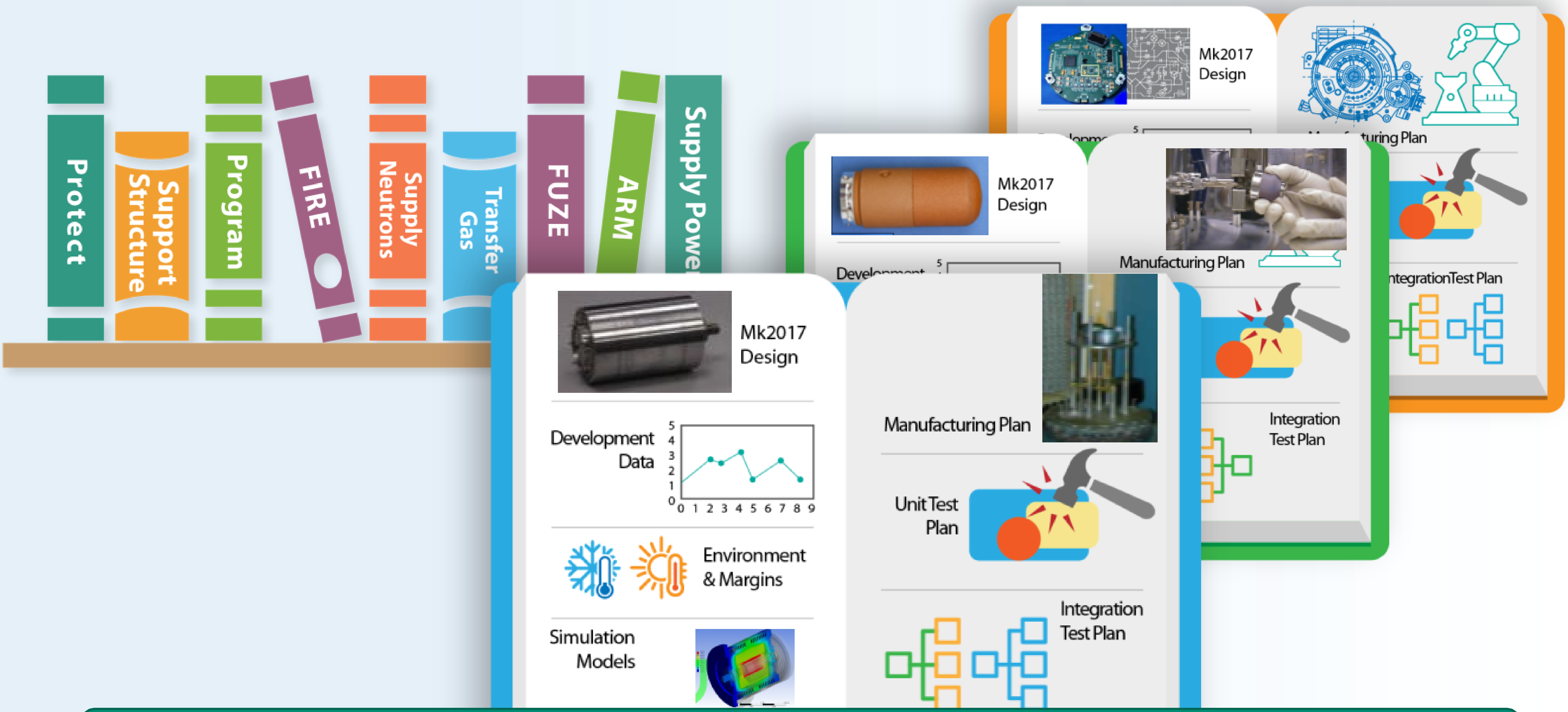
Library of Functions; Books of Components

Library of Functions; Books of Components

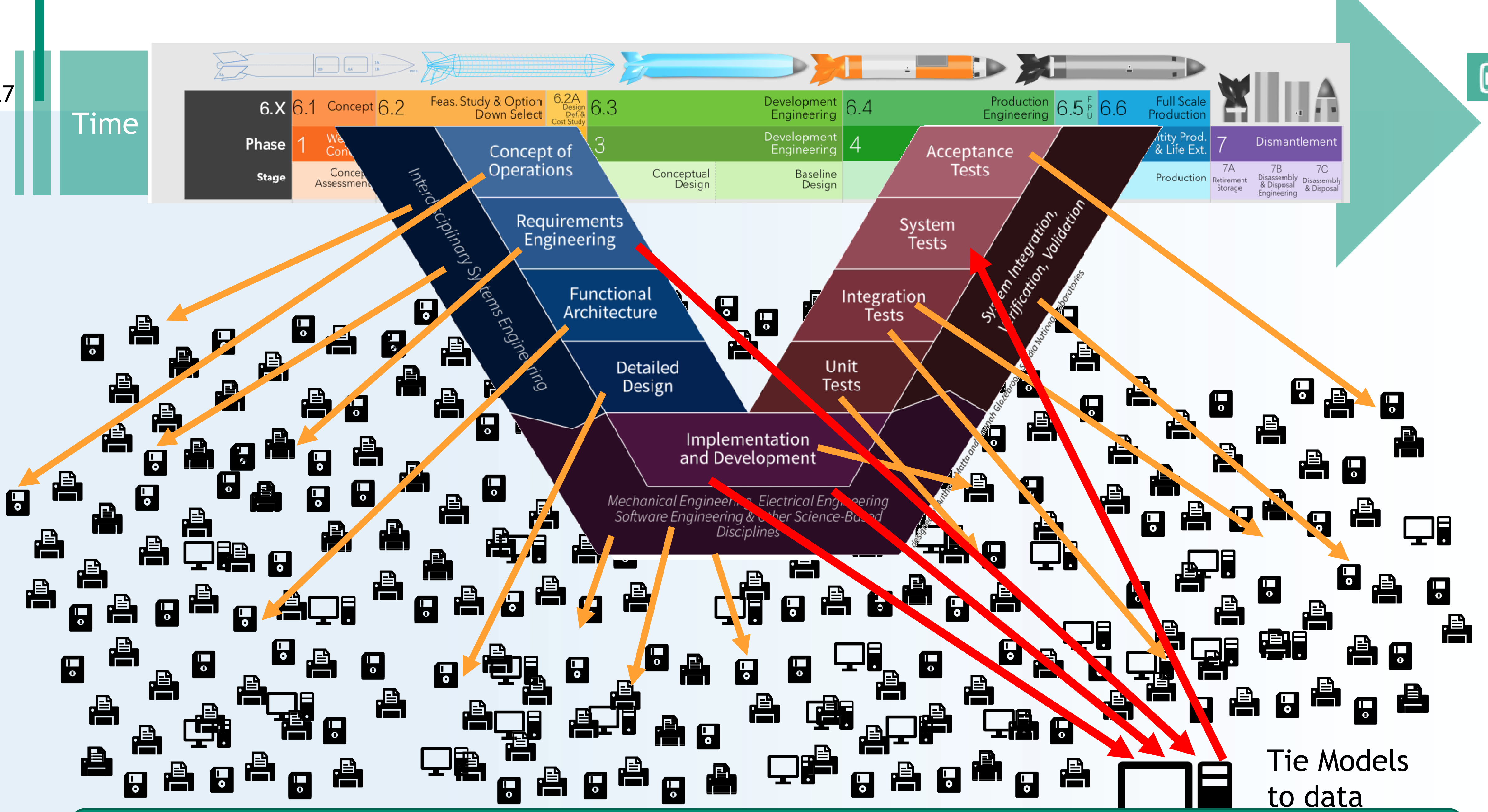


A Digital Twin for Components allows them to be reused to shorten development time

Library of Functions; Books of Components

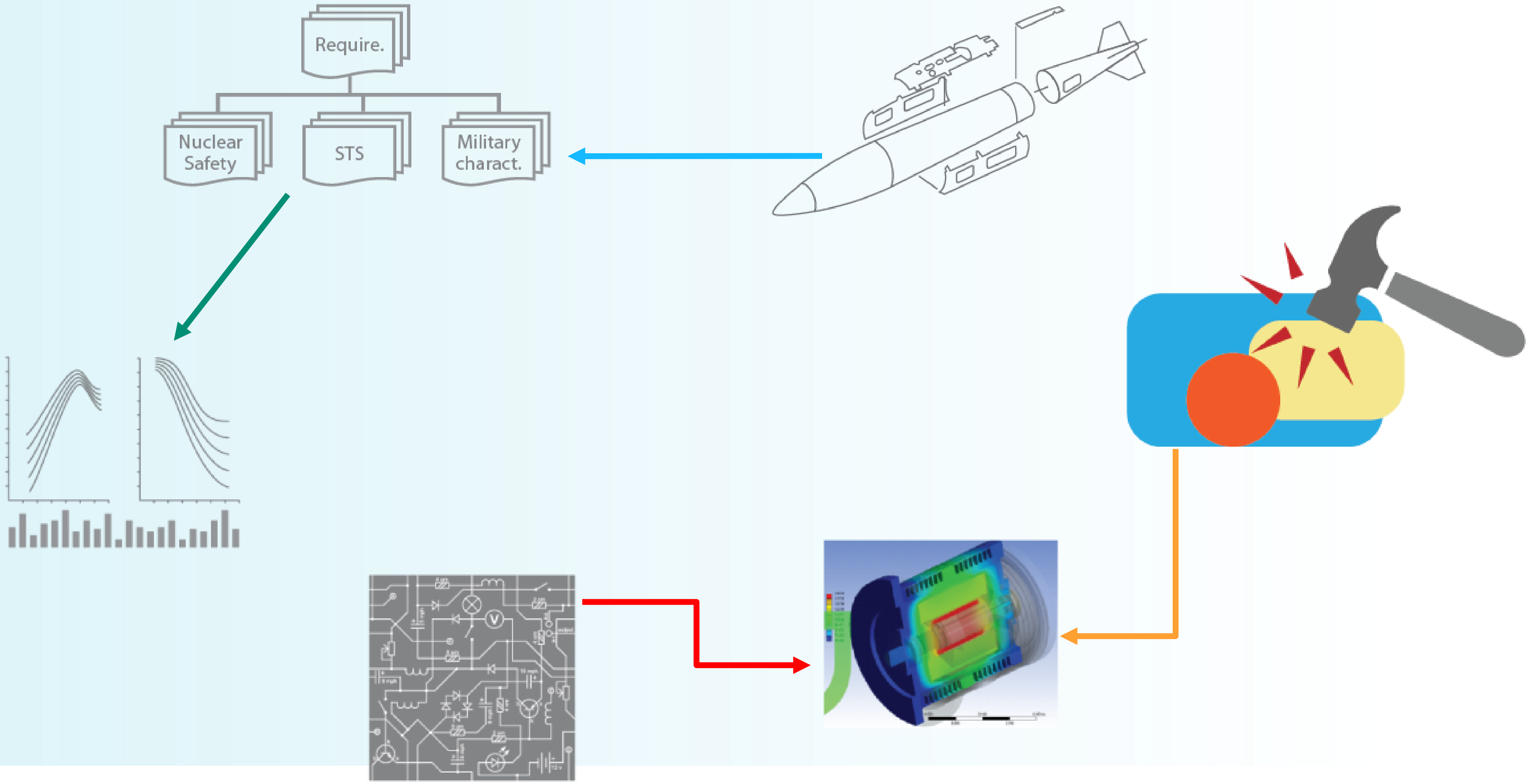


Infrastructure to reuse components will reduce development time

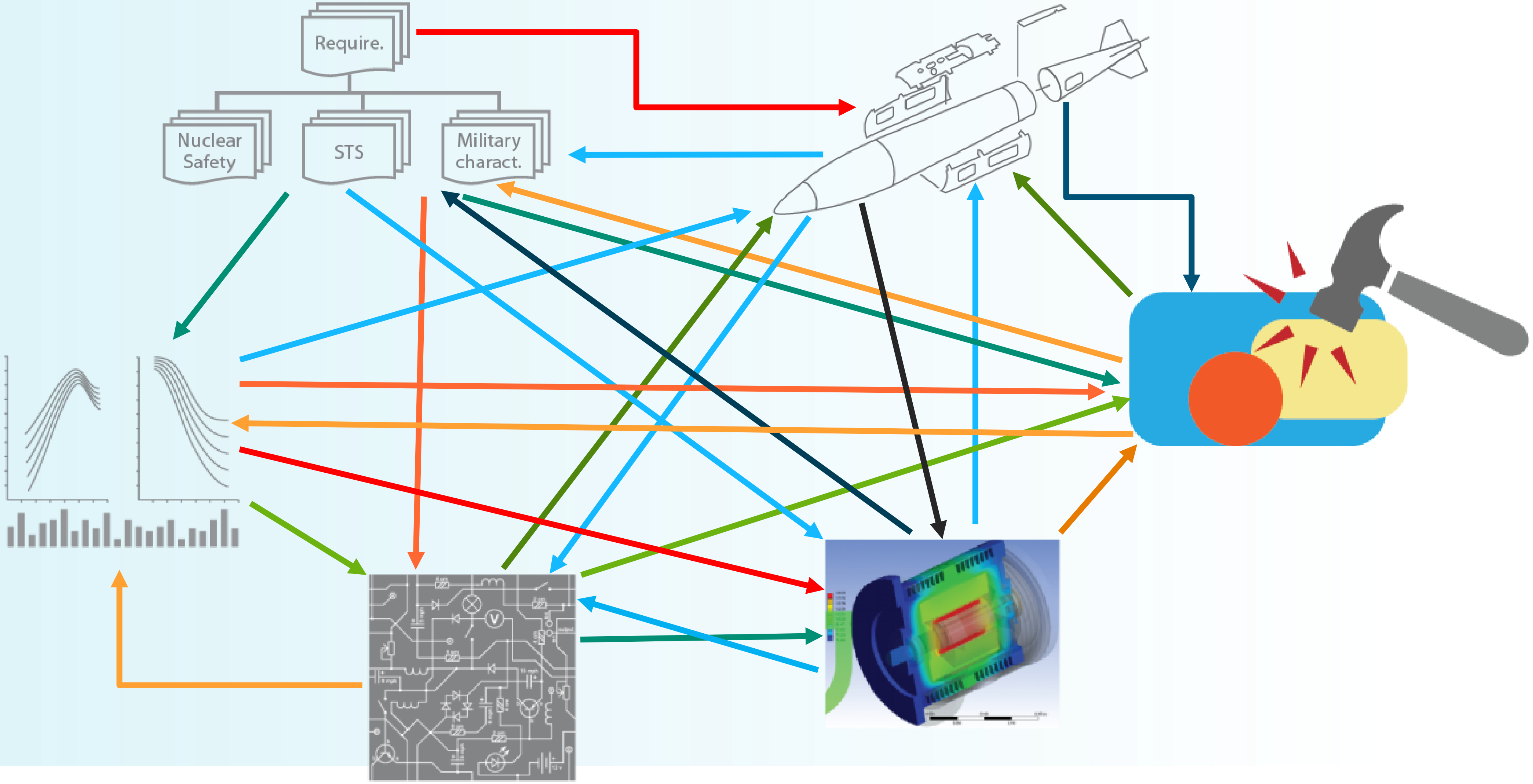


Digital Twin of Each Weapon System will reduce development time

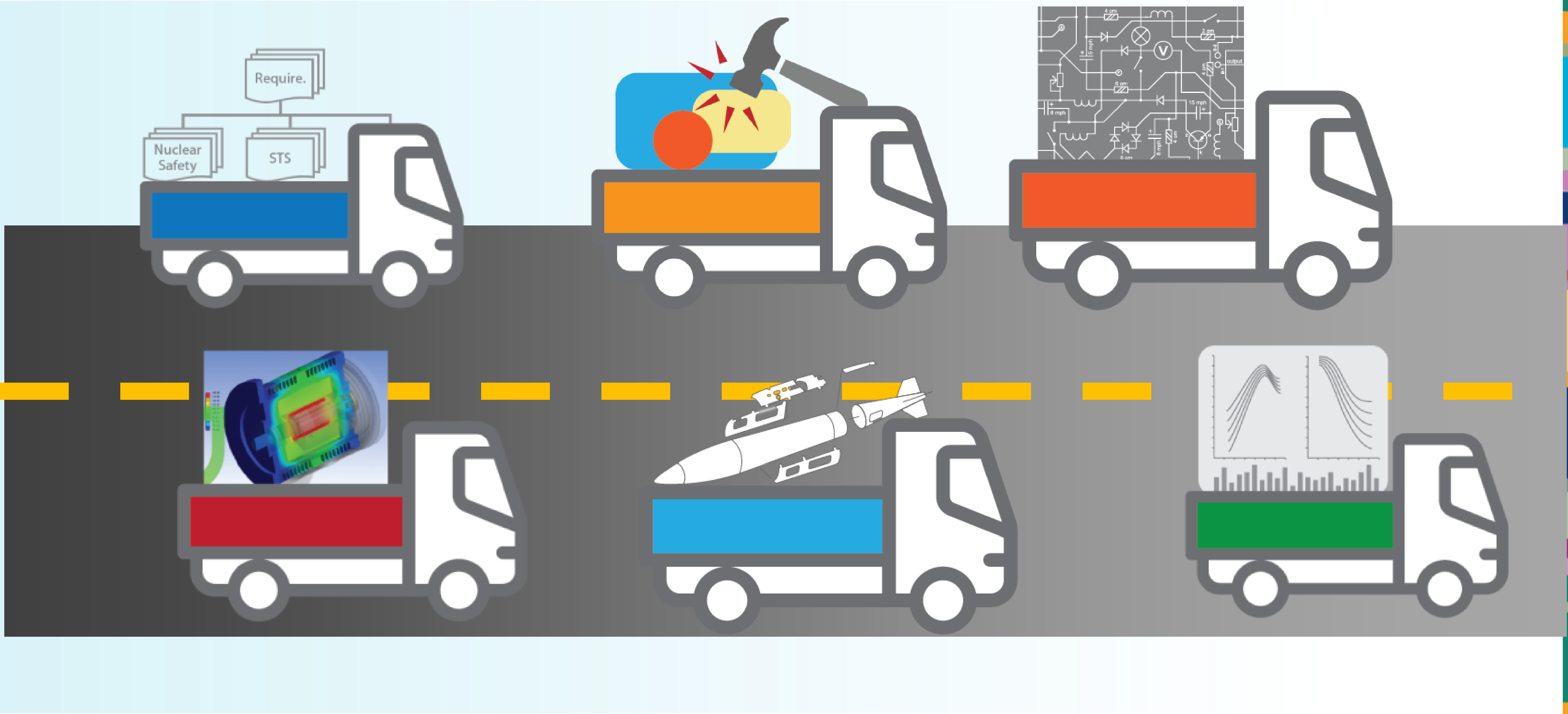
Architecting the Connections Between Diverse and Disparate Sources



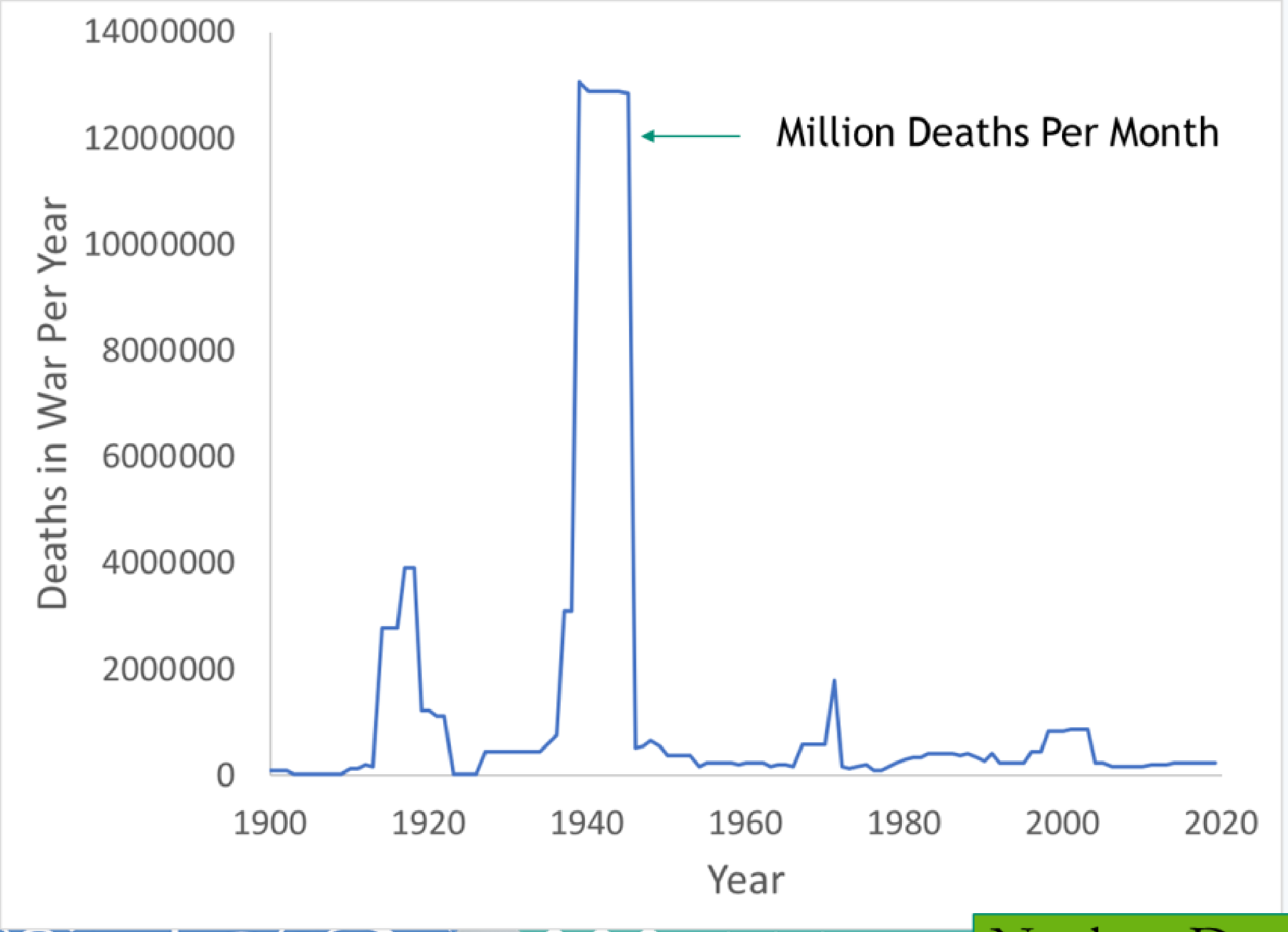
Architecting the Connections Between Diverse and Disparate Sources



Merging Complex Data Sources



Nuclear Deterrence



Nuclear Deterrence Works

Respond to Threats, Sustained Deterrence