SYSTEMS ENGINEERING RESEARCH CENTER

STEVENS INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY®

Transforming Systems Engineering through Model-Centric Engineering / MBSE

Sponsors: NAVAR, CCDC-AC

Dr. Mark Blackburn, Stevens Institute of Technology

WASHINGTON DC | VIRTUAL

NOV. 2-4 2021

ANNUAL SPONSOR RESEARCH REVIEW

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- Rob Cloutier (Co-PI) - Stevens
- Eirik Hole - Stevens
- Gary Witus – Wayne State

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RT-141 (2015)
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RT-157 (2016)
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- Steven Hoffenson - Stevens
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- Leonard Petnga – Univ. of Maryland
- Maria Coelho (Grad) – Univ. of Maryland
- Russell Peak – Georgia Tech.
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- Marlin Ballard (Grad) – Georgia Tech.

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- Rob Cloutier – Visiting Professor
- Robin Dillon-Merrill – Georgetown Univ.
- Ian Grosse – Univ. of Massachucetts
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- Todd Richmond – Univ. of Southern California (Phase I)
- Edgar Evangelista – Univ. of Southern California (Phase I)

RT-195 (2018)
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WRT-1008 (2019)
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- William Stock (Grad) – Georgia Tech.
- Michael Szostak (Grad) – Georgia Tech.
- Donna Rhodes - MIT
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- Maria Coelho (Grad) – Univ. Maryland

WRT-1025 (2020)
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- Maria Coelho (Grad) – Univ. Maryland

ART-002 (2018) – ART-022 (2021)
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- Sahil Panchal – Georgia Tech
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- Gabriel Rizzo – Georgia Tech

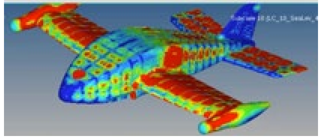
Organization

- **INTRO:** Context and Scope of NAVAIR SE Transformation
- **WHAT:** Digital Engineering Measures Correlated to Skyzer Digital Engineering Lessons Learned
- **HOW:** Evolving Surrogate Pilot & Experiments to Demonstrate Art-of-the-Possible
  - —Authoritative Source of Truth
  - —"Full Stack" Graphical CONOPS, Mission, System, Multi-physics, Ontologies, Ref. Architectures
  - —Stakeholder Analysis Models (e.g., Cost, Airworthiness)
  - —Modeling Methods
  - —Digital Signoffs – Transformation From CDRLs
  - —Cyber Ontology Pilot (being used for DEVCOM Training Course – unclassified/Distro A)
- **HOW WELL:** Contributing Modeling Examples transitioning to Support Workforce Development demonstrating Art-of-the-Possible

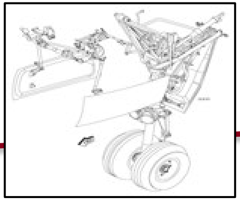
Surrogate Pilot Scenario: Skyzer UAS Search and Rescue Mission

Deep Dives by Phases

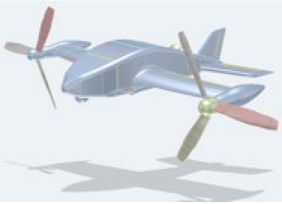
Graphical CONOPS Scenario: Search & Rescue



P1: Multi-physics



P2: Airworthiness



P3: Cost Modeling

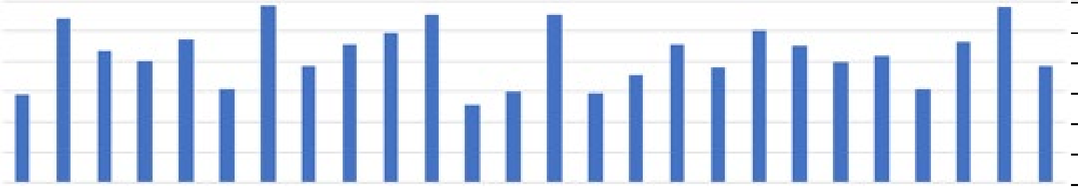
Performance constraints force Multi-physics Design considerations – similar to Bell Eagle Eye

Doing Everything in Models to Demonstrate Art-of-the-Possible

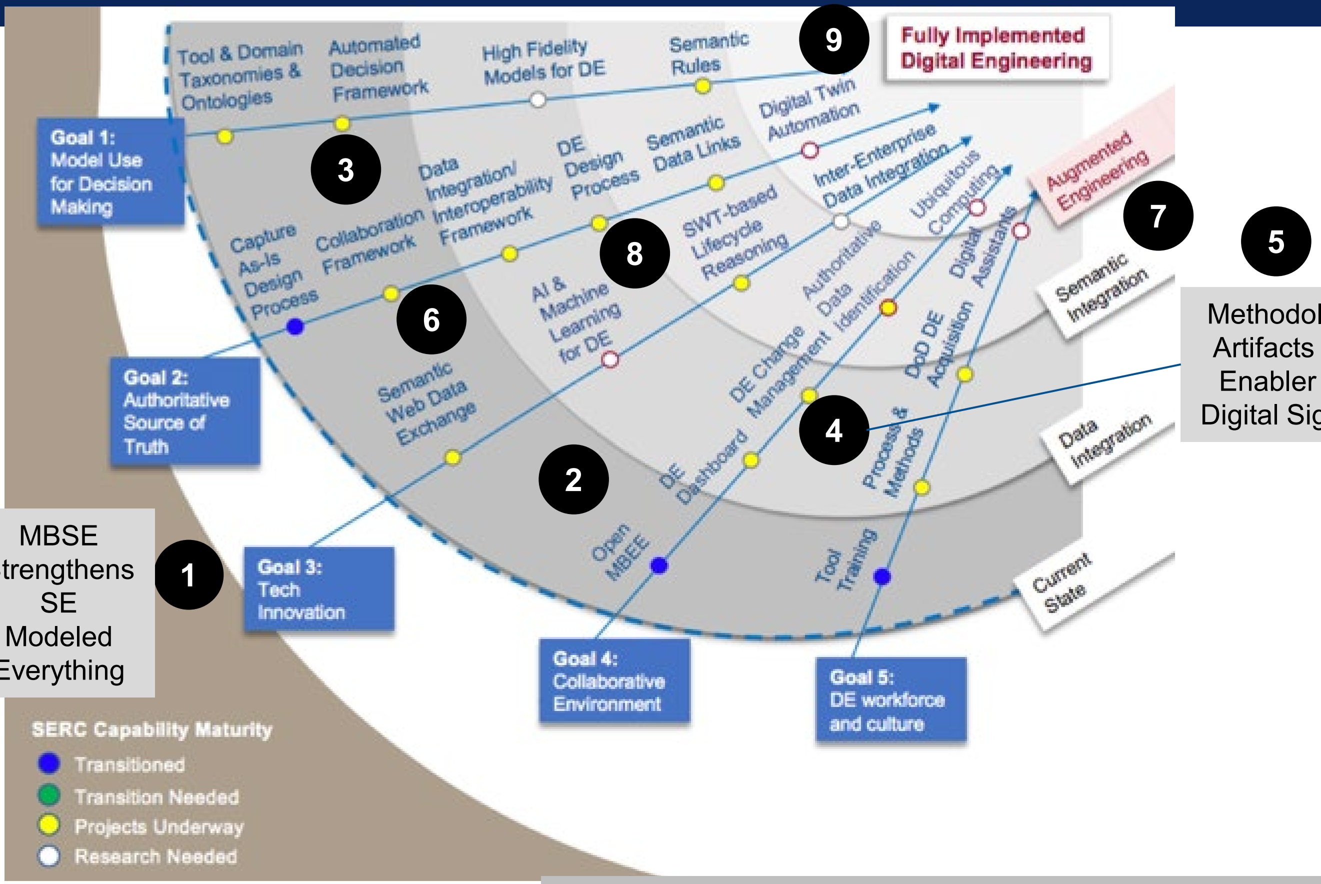
Digital Engineering Measures Correlated to DE Lessons Learned from NAVAIR Systems Engineering Transformation Pilot

- Correlated analysis of 22 DE Success Measure Categories with 17 lessons learned benefits observed during NAVAIR Surrogate Pilot that applied DE methods and tools using an Authoritative Source of Truth that modeled everything to demonstrate the art-of-the-possible

	Quality						Velocity/ Agility							User Experience					Knowledge			Other						Total
Only Top 6 of 17 Shown This analysis is attempting to relate the lessons learned from the Surrogate Pilot to the DE Metrics Categories	Reduce Errors/Defects (16)	Improve Traceability (61)	Improve System Quality (21)	Reduce Risk (22)	Increased Rigor (0)	Reduce Cost (33)	Consistency (44)	Reuse (37)	Efficiency (13)	Improve Standardization	Collaboration/Info Sharing (68)	Integration/V&V (11)	Reduce Time (24)	Automation (0)	Reduce SE Task Burden (0)	Manage Complexity (48)	Productivity (14)	System Understanding (24)	Information Access (27)	Knowledge Capture/Sharing (13)	Architecture/Sys Understanding (23)	Planning	Priorities	Methods	Collaboration Env and AST	Workforce Development		
Total	58	108	87	80	95	62	117	77	91	99	111	51	60	111	59	71	91	76	101	90	79	84	62	93	116	77		
Establish infrastructures for IME tools and AST as early as possible																												153
Technically feasible to develop everything as a model																												160
Use Digital Signoffs as a means for evolving from CDRLs																												146
Establish and align modeling with methods & guidelines																												154
Surrogate Pilot demonstrated a new operational paradigm for collaboration in AST																												149
Technology enables collaborative capabilities in MCE																												150



Digital Engineering for Systems Engineering Roadmap: Goals are Mutually Supportive not Orthogonal



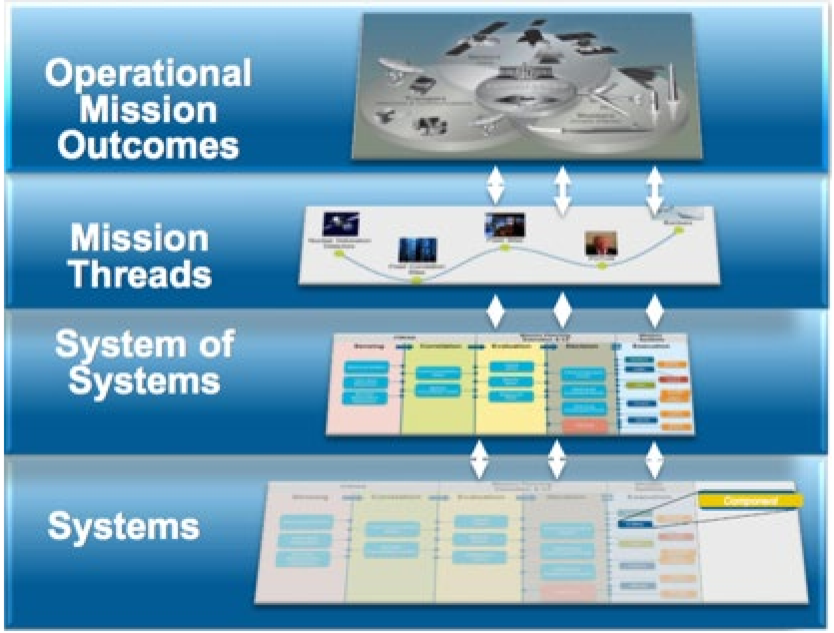
MBSE Strengthens SE Modeled Everything

Methodology Artifacts are Enabler for Digital Signoff

* https://sercuarc.org/wp-content/uploads/2020/01/ROADMAPS_2.3.pdf

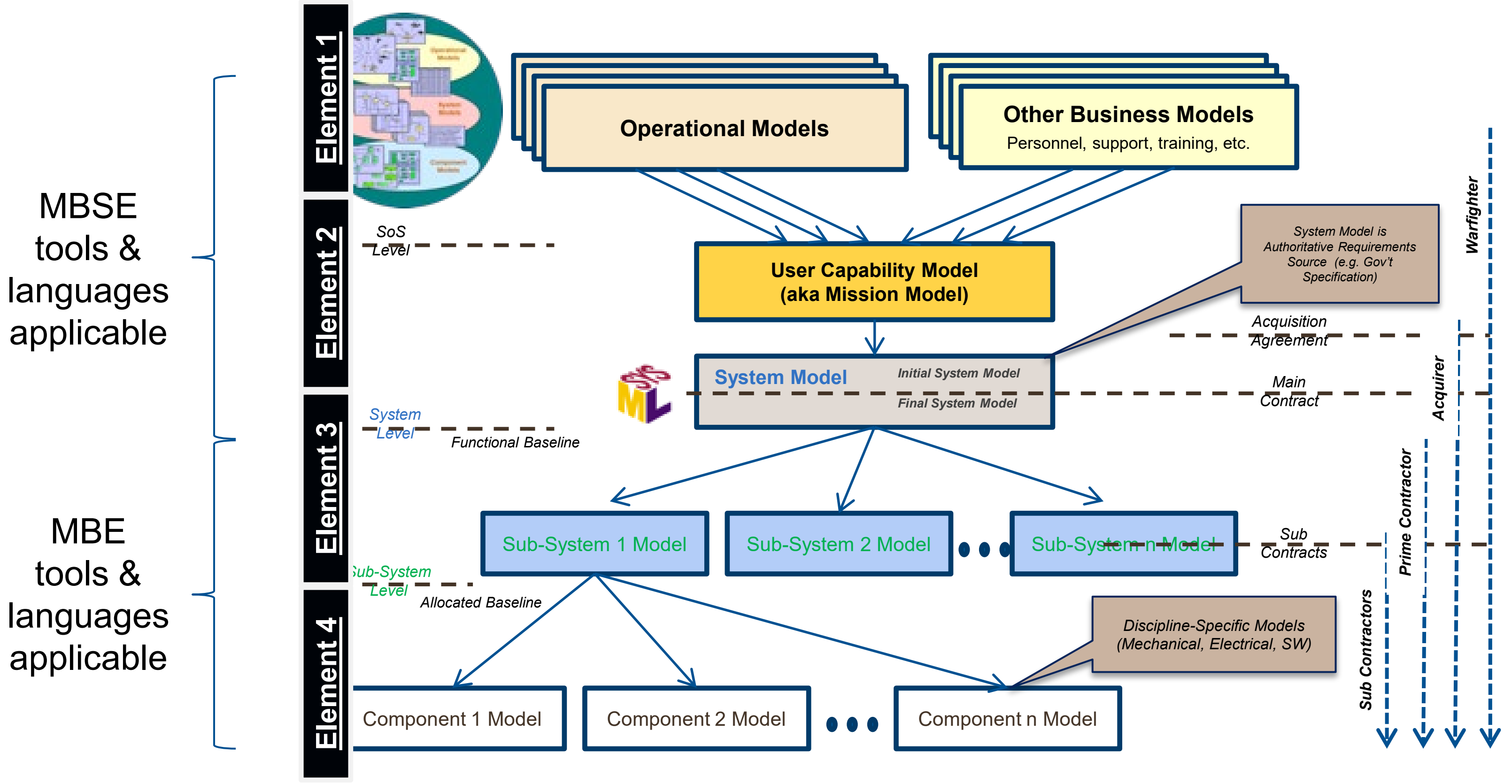
Context Related to DoD Digital Engineering Strategy Goals

- MBSE Strengthens Systems Engineering (Goal 3)
  - Represent Structure, Behavior, Interfaces, Requirements and related interactions
  - Can characterize different levels of abstraction – Mission, System, Subsystem where different types of **methods** are needed
  - Can generate “documents/specifications” based on stakeholder-relevant views
- Need to formalize representation that links information in an Authoritative Source of Truth (Goal 2 – distributed like Internet)
- Need computing infrastructure to access and visualize on need-to-know basis (Goal 4)
- Need to semantically link information from different modeling levels and types to enable tradespace analyses and **decision making** (Goal 1)
- Skyzer models are unclassified examples and are being transformed to support workforce development (Goal 5)



Extending the DoD Digital Engineering Strategy to Missions, Systems of Systems, and Portfolios
P. Zimmerman, T. Gilbert, J. Dahmann
22nd Annual NDIA Systems and Mission Engineering Conference Tampa, FL| 23 October 2019

Skyzer Demonstrates Modeling Methods for SET Framework Elements at Different Abstraction Levels



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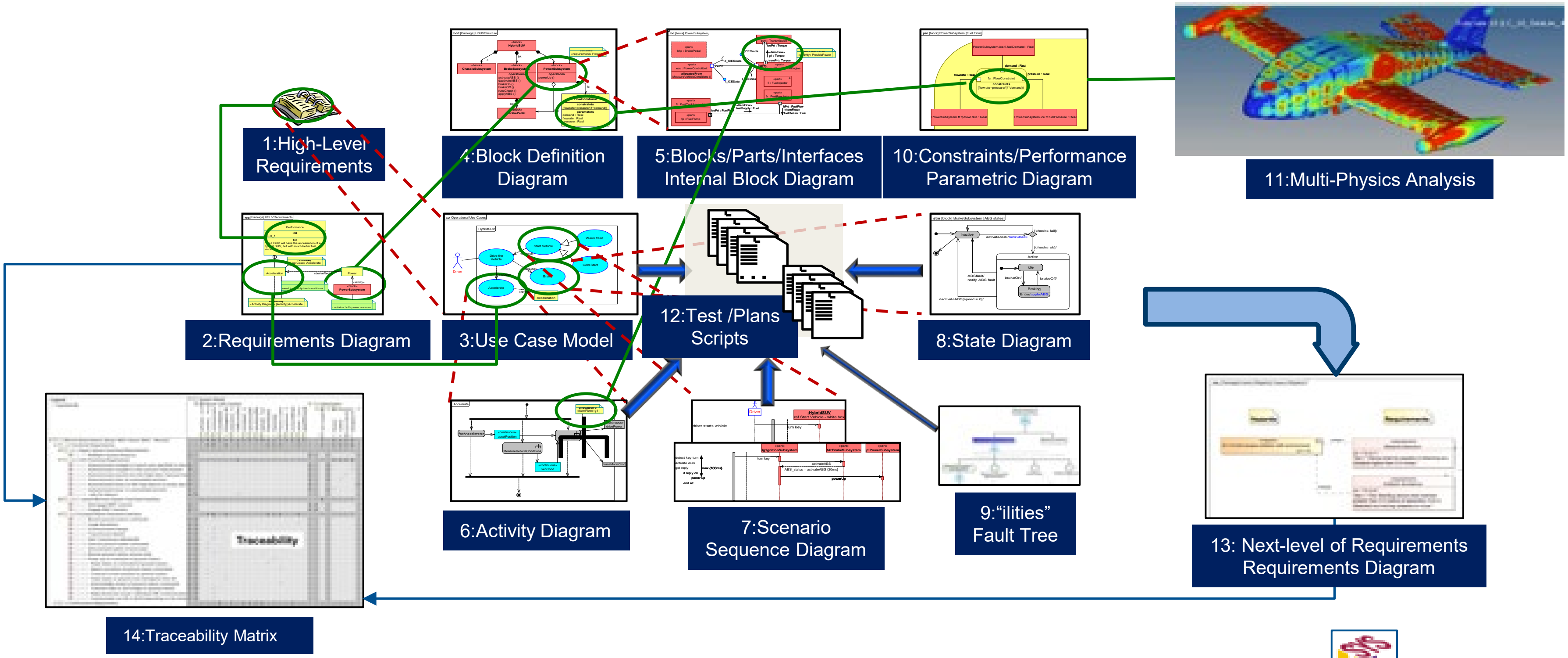
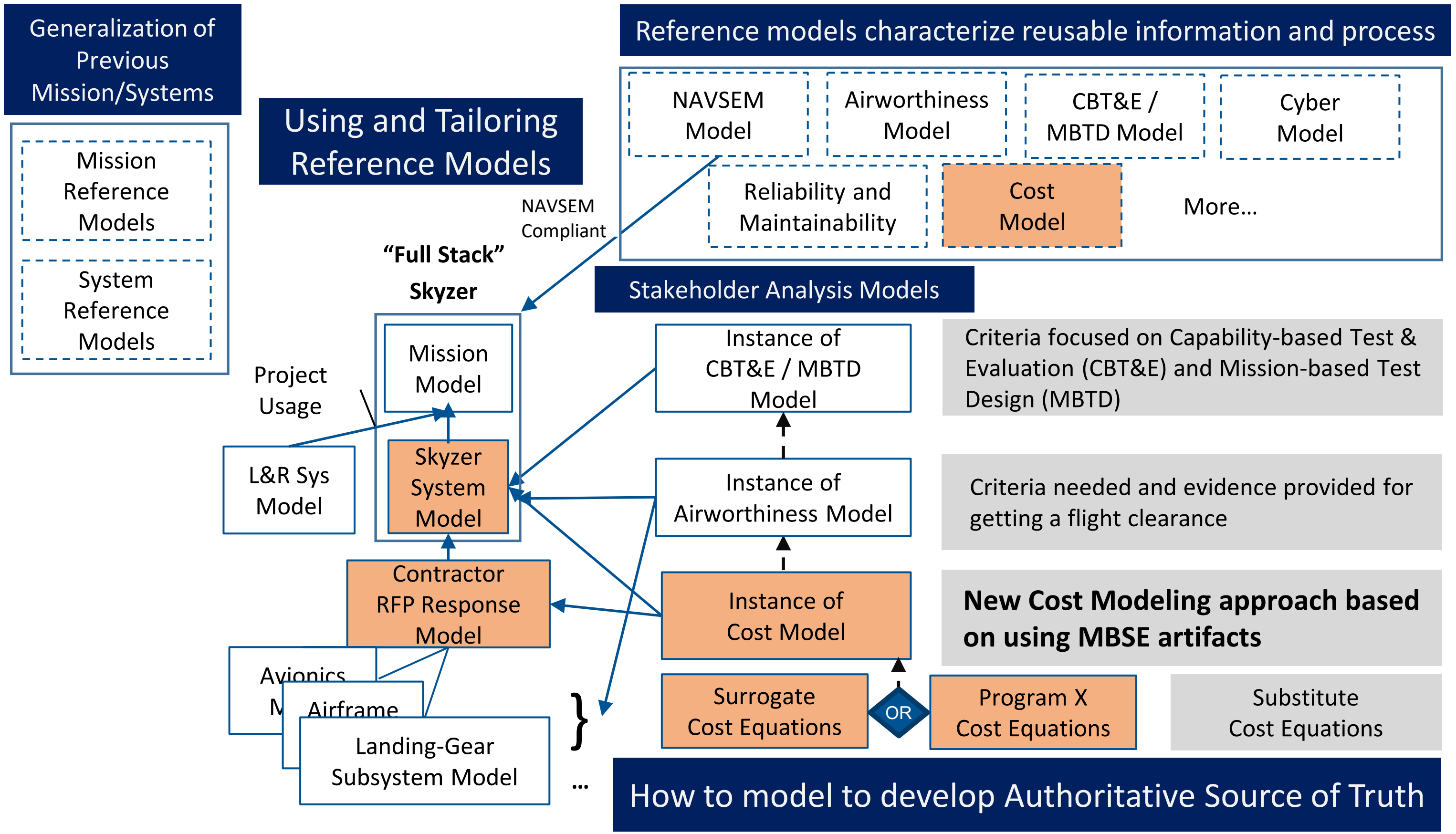
How MBSE Strengthens SE by Characterizing the Analysis of Structure, Behavior and Interfaces

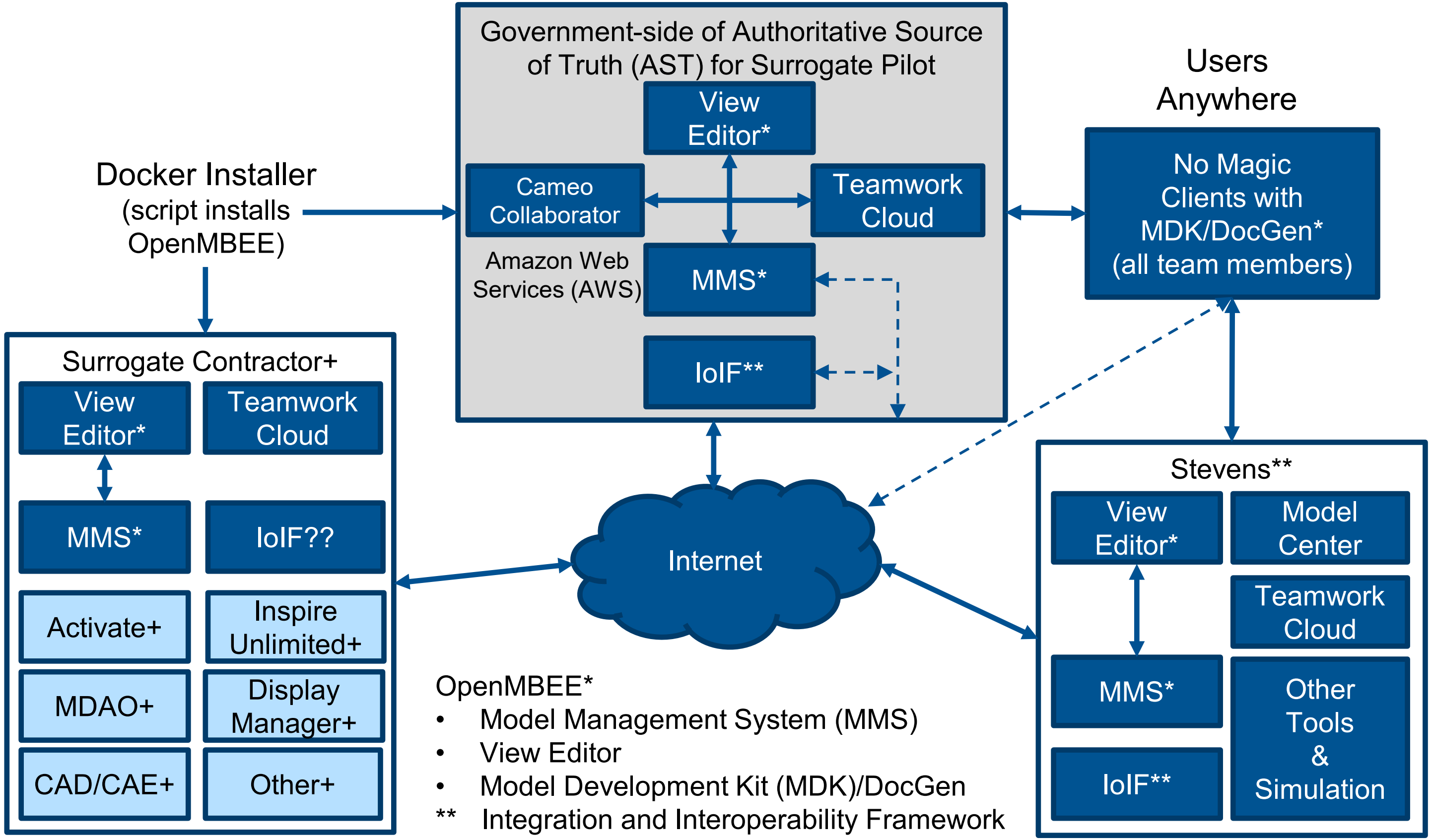


MBSE Artifacts – More than just Requirements

“Full Stack” of Skyzer Models Enables Acquisition Analysis



Elements of Authoritative Source of Truth



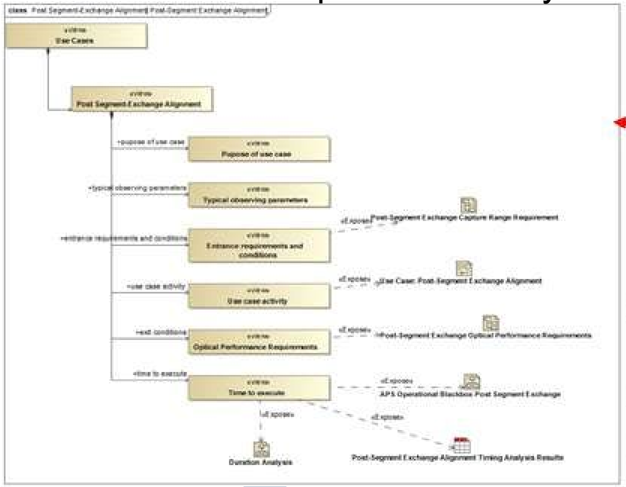
OpenMBEE*

- Model Management System (MMS)
- View Editor
- Model Development Kit (MDK)/DocGen

** Integration and Interoperability Framework

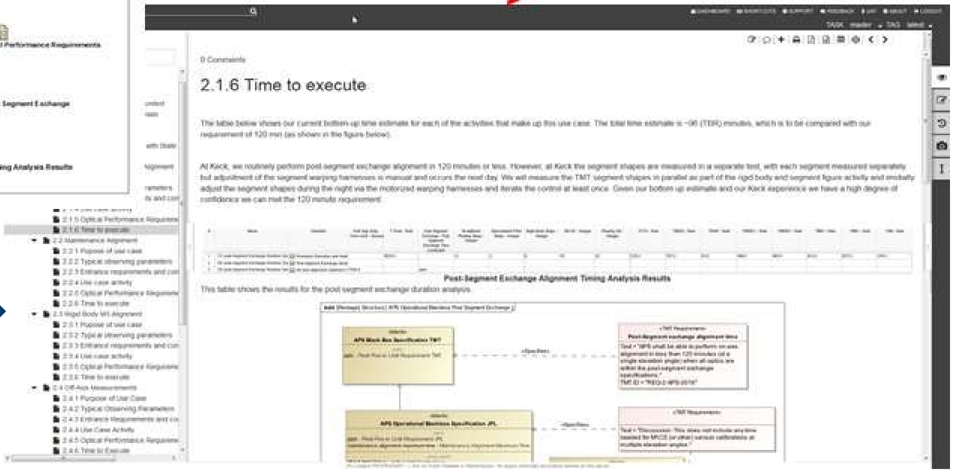
Leverage Capabilities of OpenMBEE as Part of Integrated Modeling Environment

Model Development Kit/DocGen
View and Viewpoint Hierarchy



Model Management System

View Editor



Visualization in View Editor

(allows edits to be pushed back into model)

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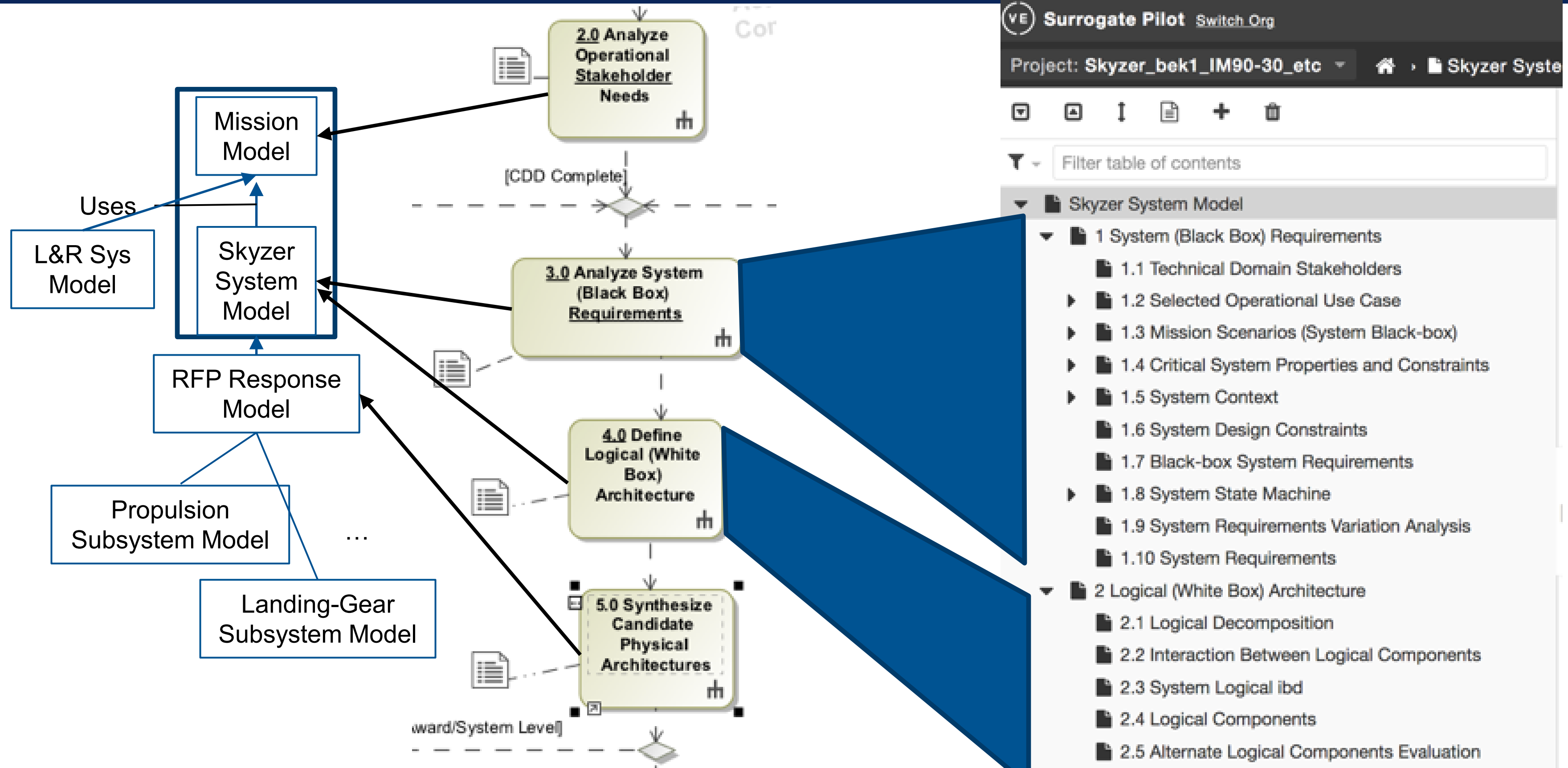
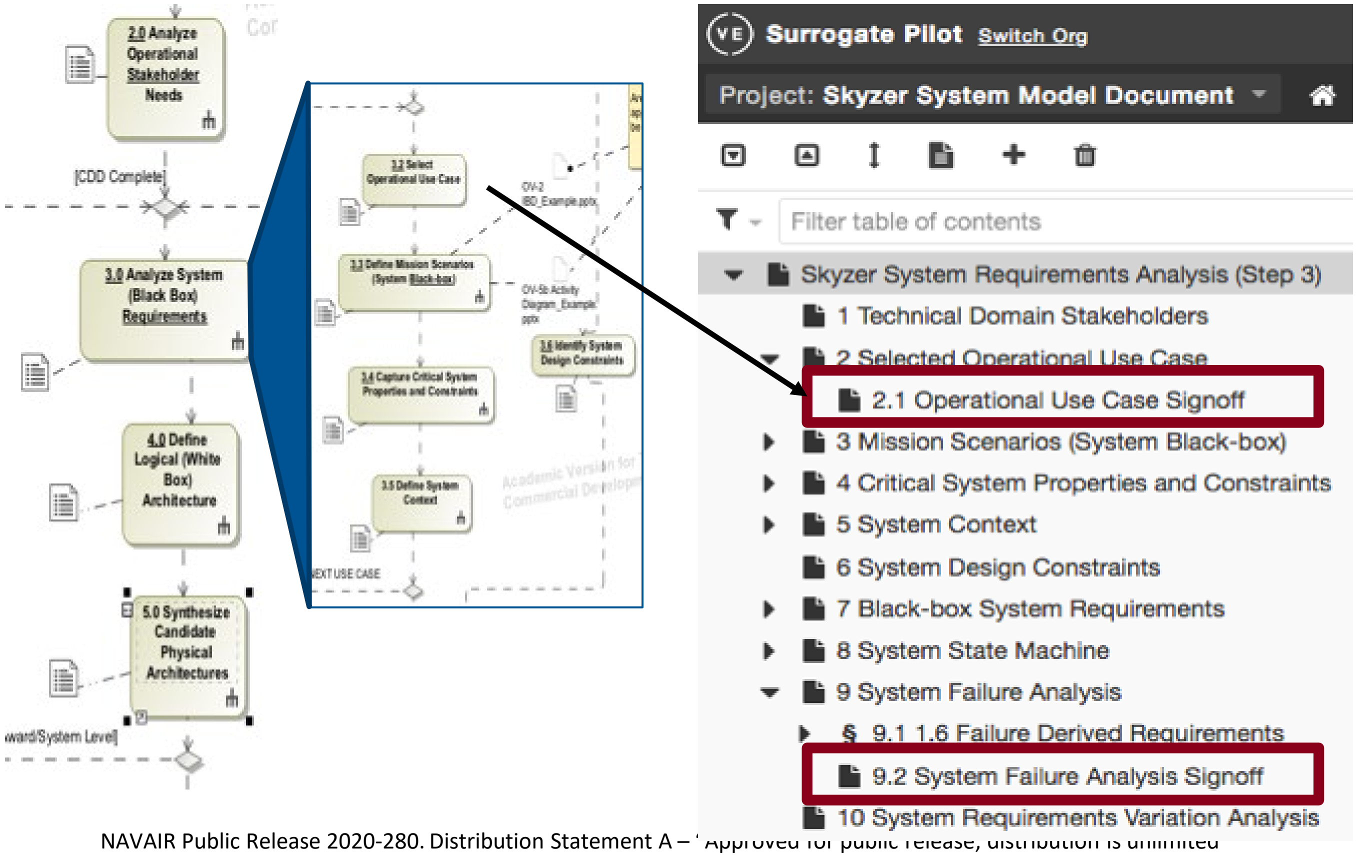
Update View and Viewpoint for Skyzer System Model to Comply with NAVSEM Step 3.0 and 4.0



DocGen Generated View for Skyzer System Model with Digital Signoffs



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Digital Signoff Are Placed in View Hierarchy With Model Artifacts that Should be Exposed

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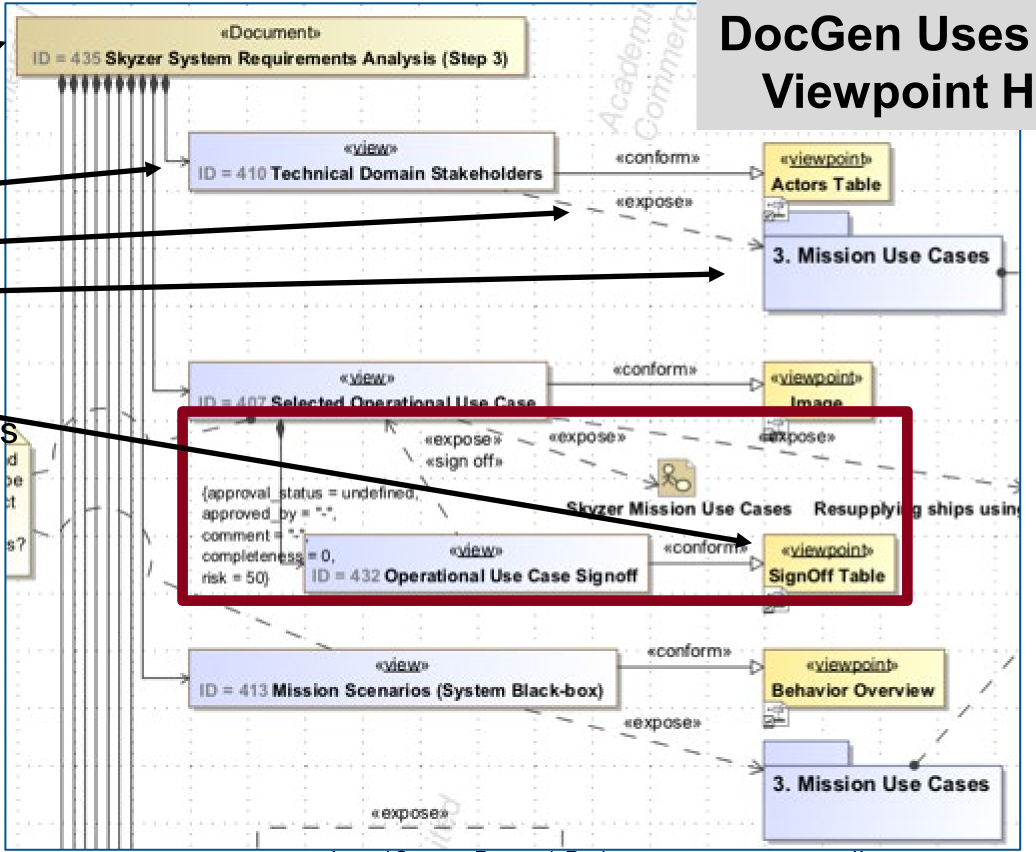
DocGen Uses View and Viewpoint Hierarchy

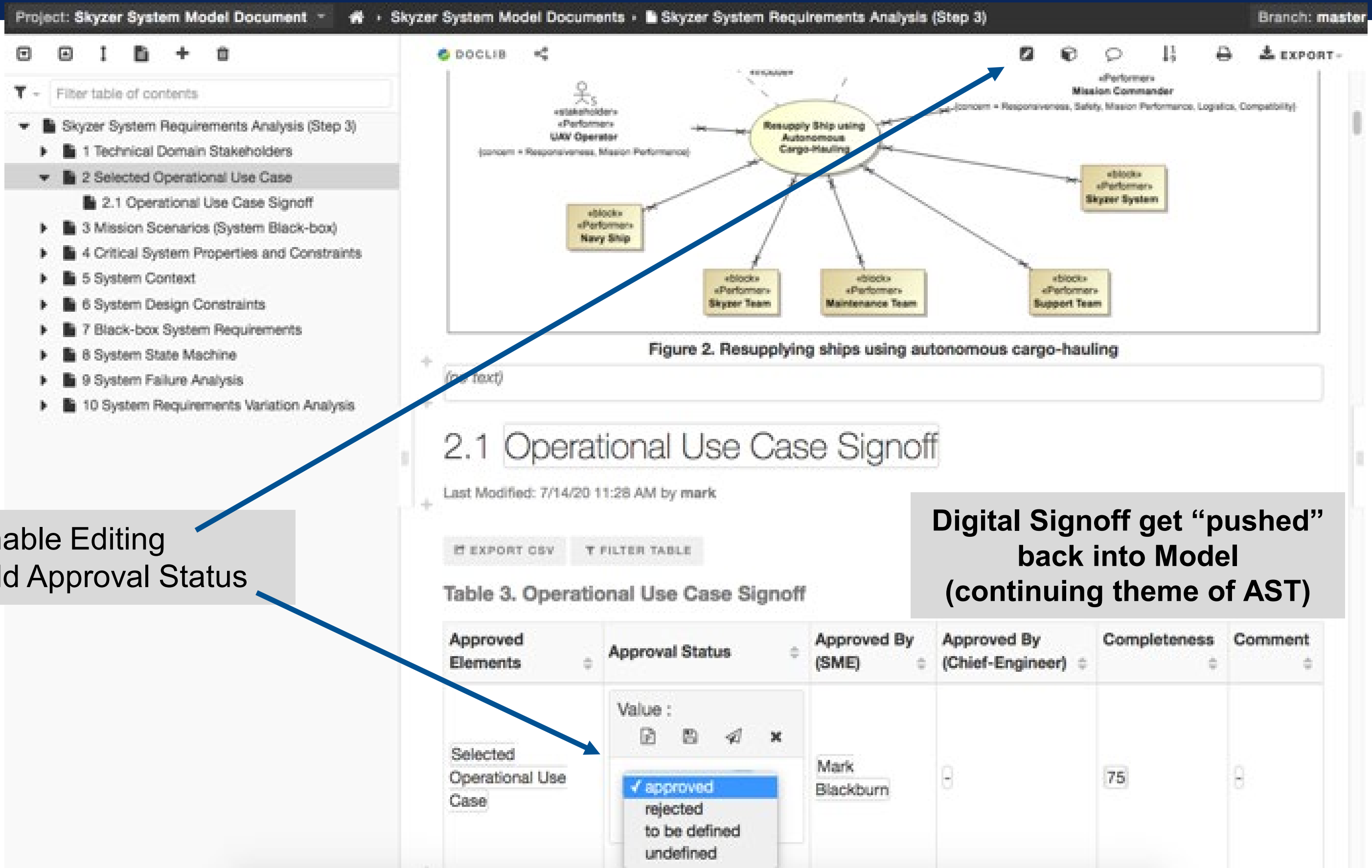
Views define "Document" Structure

View exposes Model Elements

Viewpoints is "program" to extracts specific information from exposed model element to generate View



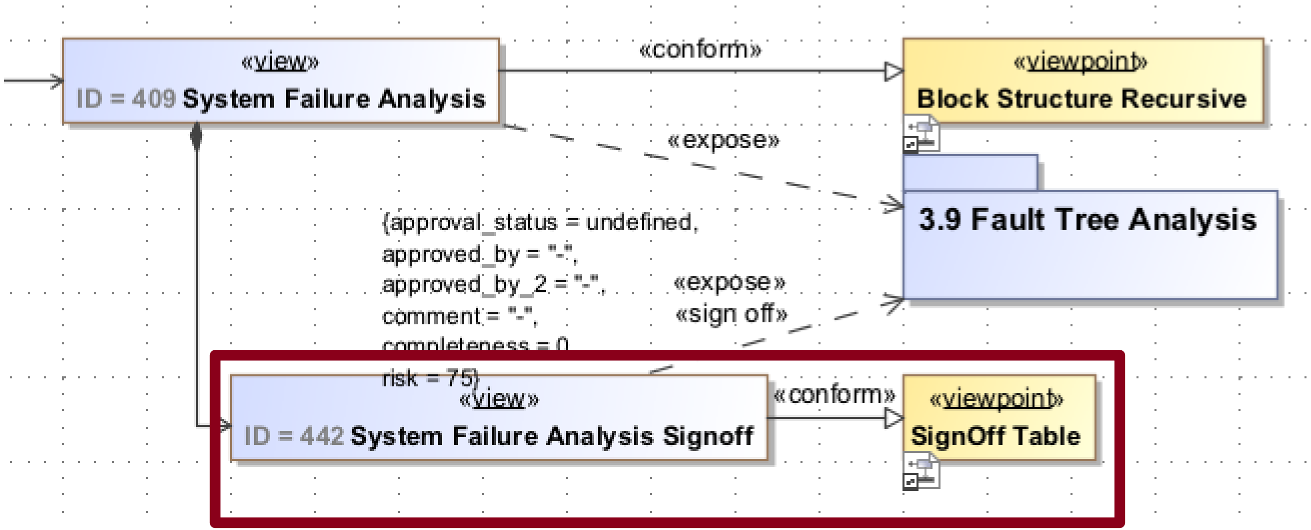
Digital Signoff for Operational Scenario Applicable to System



1) Enable Editing
2) Add Approval Status

Digital Signoff get "pushed" back into Model (continuing theme of AST)

Digital Signoff for Subject Matter Experts



Digital Signoff In View Editor for Subject Matter Experts

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TABLE III. Risk assessment matrix

RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

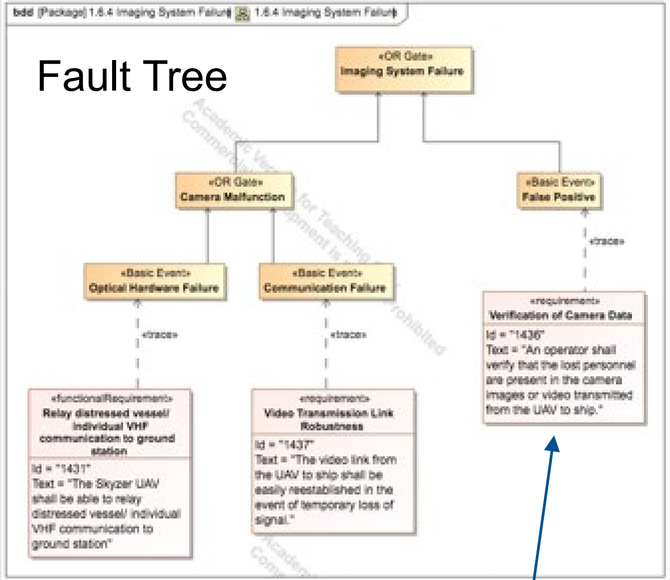


Figure 43. 1.6.4 Imaging System Failure

9.2 System Failure Analysis Signoff

Last Modified: 5/13/20 9:36 AM by ben

EXPORT CSV | FILTER TABLE

Table 176. System Failure Analysis Signoff

Approved Elements	Approval Status	Approved By	Completeness	Probability	Impact	Comment
3.9 Fault Tree Analysis	Value : rejected ADD	Adam Baker	Value : 75 ADD	Value : 25 ADD	Value : 75 ADD	may need an extra basic event added

Mitigation Requirement to address Basic Events that could lead to Mishap

Digital Signoff of Source Selection Technical Evaluation Done In Model as Part of Authoritative Source of Truth

VE Surrogate Pilot Switch Org | Search selected project | UAT | Help

Project: Skyzer_RFP_Altair_v2 › Skyzer_RFP_Response | Branch: mast

Filter items in the tree

- Skyzer_RFP_Response
  - 1 Volume I Executive Summary
  - 2 Volume II Technical Descriptic
  - 3 Appendix

DOCLIB | EXPORT

2.1.1 Technical Cross Reference Sign Off

EXPORT CSV | FILTER TABLE

Technical Cross Reference Sign Off

Approved Elements	Risk	Approval Status	Approved By	Comment
Air Vehicle Performance; Operational Radius	medium	approved	Donald Polakovics	Evaluation Worksheet: Overall the aircraft far exceeds the operational radius KPP. Potential Strengths: Very significant margin for additional mission capability and versatility. Weaknesses: Aircraft may be larger and more expensive than necessary to do the mission. Deficiencies: None Uncertainty: Performance analysis could not be reviewed in its entirety due to some inconsistent data. Margins seems large enough to cover this however.
UAS Capability	very small	undefined	N/A	N/A
Air Vehicle Performance; Endurance	medium	approved	Donald Polakovics	Evaluation Worksheet: Overall the design appears to have sufficient endurance, with adequate development margin.

Need for Further Maturity/Assessment

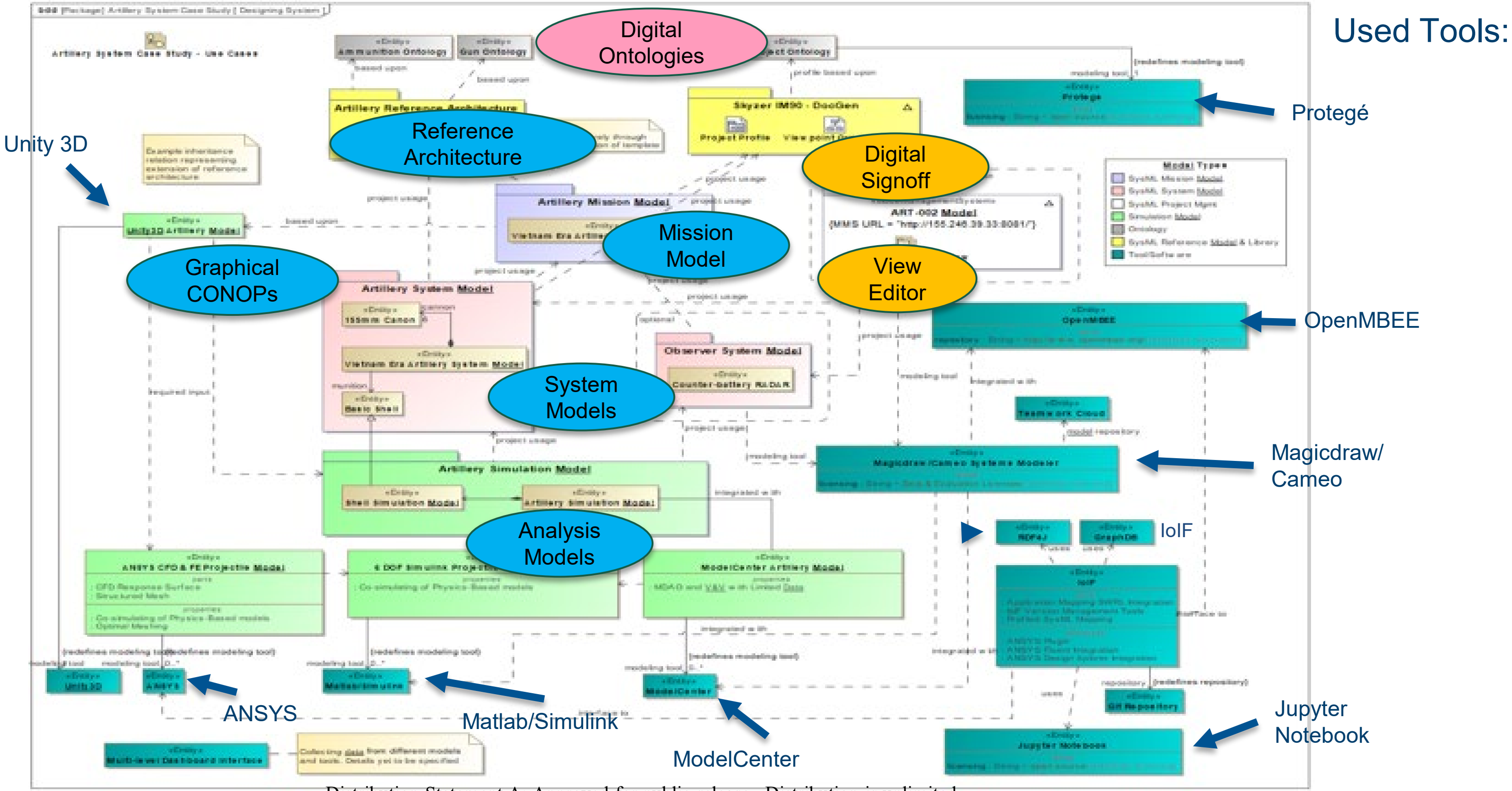
- Formulating various categories of Digital Signoffs – and associated templates to support them
- Investigating how Digital Signoffs represent maturing design to evolve from classical baselines (e.g., PDR, CDR, TRR); considering scheme for Baseline Progress Measures
- Investigating measures used to create Digital Signoff Metrics
- Video: http://www.markblackburn.com/MBSE/WRT_1006_Digital_Signoff_Video_4_29_2020.mp4

2 Signoff Metrics

#	Date	Number Of Sign Offs	Number Of High Risk Sign Offs	Ratio Of Approved Sign Offs	Ratio Of Rejected Sign Offs	Average Risk
1	2020.04.17 13.44	5	1	0	0	55
2	2020.04.29 16.54	5	1	0.6	0.2	40

Figure 6. Signoff Metrics

DEVCOM Example Reference Architecture for "Full Stack" with Tools



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Thank you!

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- Principal Investigator
- Member of SERC Research Council
- Member of OpenMBEE Leadership Team
- School of Systems & Enterprises
- Systems Engineering Research Center
- Stevens Institute of Technology