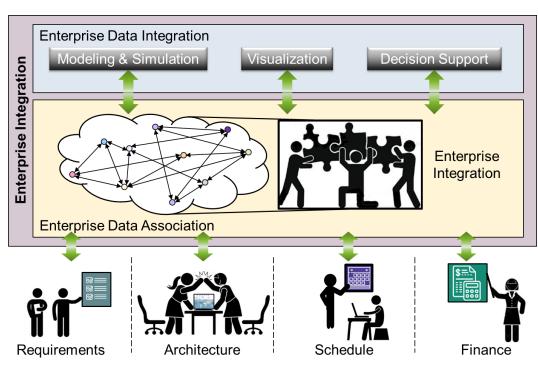


InDEPTH Team: (SED) Rachel Pope, Fredda Lerner, Jeff Banks, Trent Severson, Monty Greer, Lauren Hale, Greg Furumoto, Aaren Rice, Alex Chang, Karel Marshall, Mihir Patel, (VSD) Jaron Chen, (ISCD) Karina Martinez, Manny Sanchez, Jennie Fujisaki, Joan Gauna, Derek Lo, Austin Baird, (PWW) Bob Nelson, Bryce Christopherson, (DTIO) Megan Wolf, (SSG/ZA) Danny Fain

InDEPTH Objectives

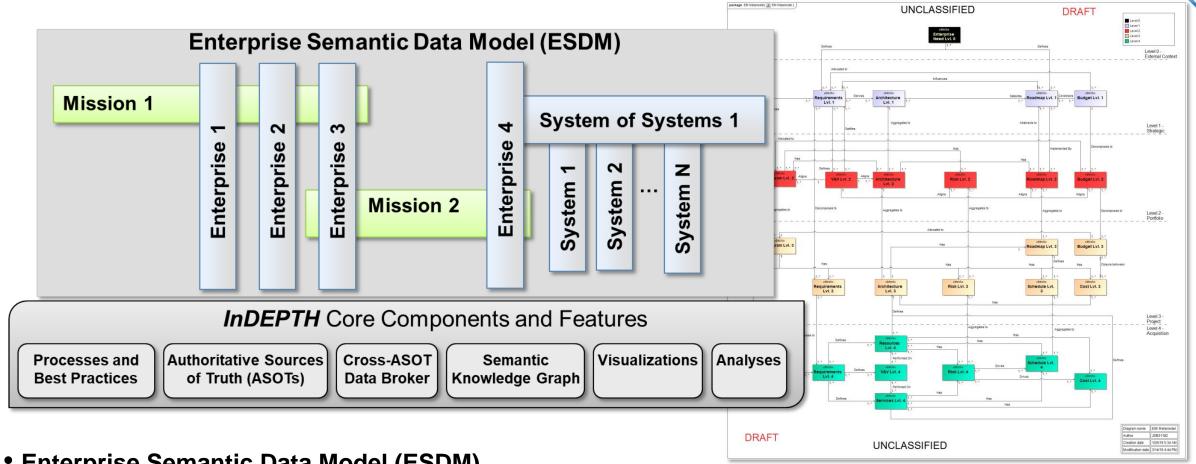
Integrated Digital Engineering Prototyping Testbed Hub (InDEPTH)

- Primary Objective for InDEPTH is to <u>demonstrate the value of an integrated DE environment</u> throughout the full enterprise/system lifecycle
 - Demonstrate the value of data-centricity where data are standards-based, non-proprietary and re-usable and disparate applications can use data without the need for customized point-to-point APIs
 - Demonstrate the complexity, analysis, and value of a standards-based integrated enterprise
 - Demonstrate the value of modeling an enterprise specifically showing change propagation and interconnected data sets
 - Collaborate, learn from, refine, and document DE best practices and lessons learned
 - Collaborate, learn from, and refine engineering models, methods, best practices, and standards at the Enterprise, System-of-Systems, and System levels
- Secondary Objective of InDEPTH is to better understand and exploit the appropriate application of methods and tools for digital integration through "plug 'n play" experimentation
 - Demonstrate the value of purpose-driven, standards-based extensible models and change propagation – benefits of building modularity for "plug 'n play"
 - Utilize modular data sets for experimentation with varying data types and tools
 - Develop a modular integration engine to facilitate experimentation with different methods (data ontologies, APIs, etc.) and tools for integration (Syndeia, Huddle, etc.)



InDEPTH Platform At-a-Glance (with Lexicon)

Integrated Digital Engineering Prototyping Testbed Hub (InDEPTH)



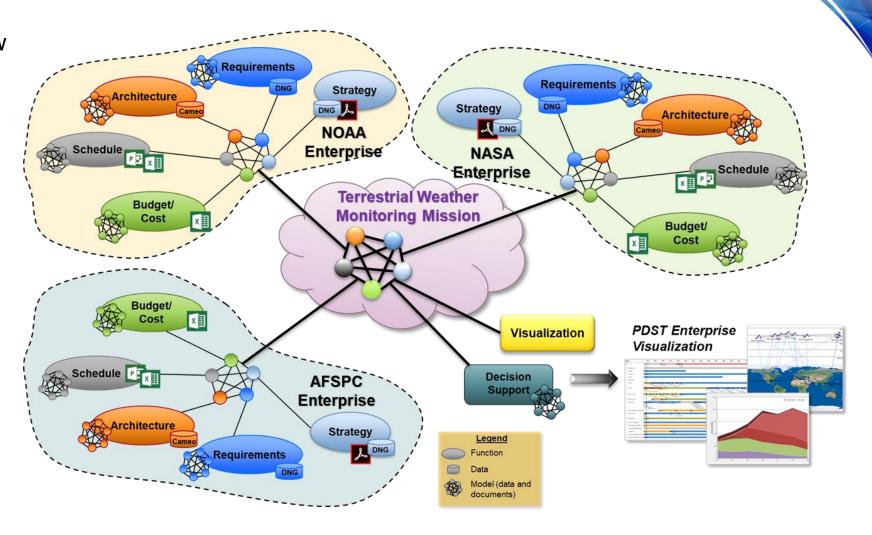
Enterprise Semantic Data Model (ESDM)

- Describes the relationships between various types of enterprise concerns, e.g., strategy, architecture, requirements, projects, programs, budget, etc.
- Contains the rules of engagement, guidelines, and standards applicable to all enterprise mission models

Space-Based Environmental Monitoring (SBEM) Exemplar

Integrated Digital Engineering Prototyping Testbed Hub (InDEPTH)

- Capability Area Strategy Review (CASR) for SBEM
 - Periodic assessment of a capability area
 - Ensures that the capability area is threat-informed, consistent with enterprise space strategy, and on-track to satisfy capability-level and derivative requirements
- Notional "Digital CASR"
 - Mission Baseline Review
 - Resource Reallocation (GOES-13/EWS-G)
 - Program Cancellation (ORS-8)
 - "New" Requirement Trace



InDEPTH focuses on federating disparate, stovepiped data sources, defining a DE data management approach for multiple instantiations of the enterprise, and implementing interfaces with M&S and visualization applications

InDEPTH Demonstration Video

Integrated Digital Engineering Prototyping Testbed Hub (InDEPTH)

- 13-min technical video showcasing InDEPTH's capabilities was produced in 2020 (UNCLASSIFIED//FOUO)
 - Available upon request to U.S government personnel (Distribution Statement B)



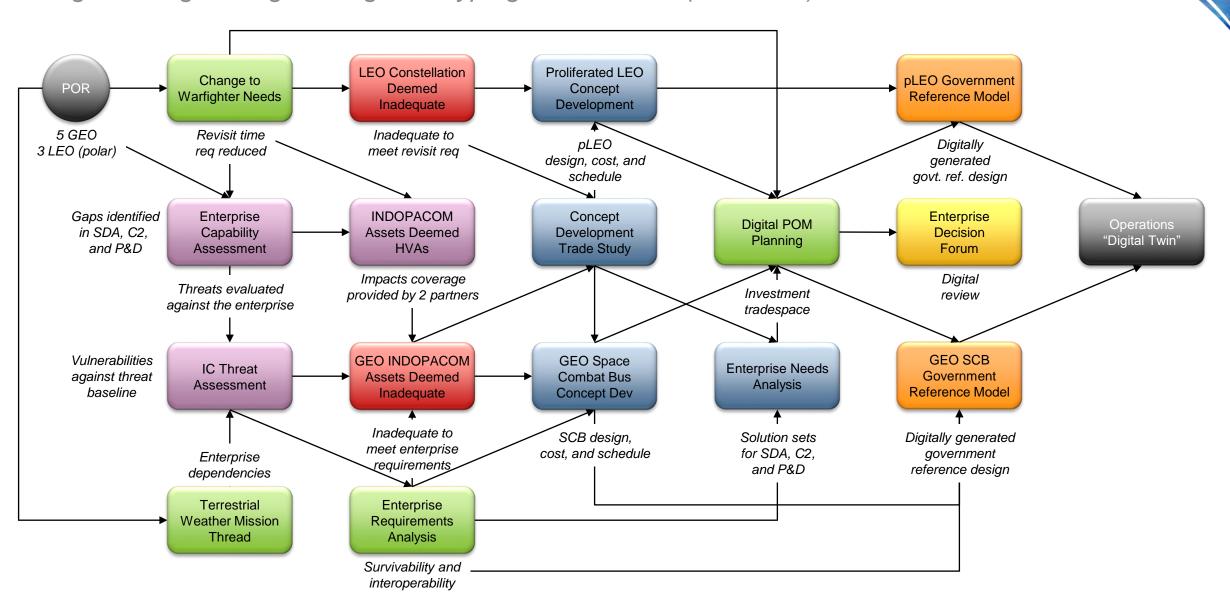
Requests for this demo video may be made through your Aerospace POC or via email (dean.a.bucher@aero.org)



Digital USSF Pathfinder

Digital USSF Pathfinder Notional Vignette (Terrestrial Weather)

Integrated Digital Engineering Prototyping Testbed Hub (InDEPTH)



Digital USSF Pathfinder Data/Software Architecture (InDEPTH) Visualization/ **MS&A Layer** \bigr neo4j **Confluence** MySQL. **DigiEngine Technical Attributes** Markov Analysis SEC Web-Based Portfolio Decision Engagement/Wargame Enterprise **Database Decision Forum** M&S and Visualization **Huddle-Interfaced M&S** Review and Query Support Tool ©AMEO SYSTEMS MODELER Integration Layer Engagement/ meo4j MySQL Wargame Models Enterprise **©**AMEO Integrated InDEPTH SYSTEMS MODELER Database oncepts Layer **Enterprise Integration Model Huddle Service Concept Design** Center Database Х Descriptive Data Jama **Jama** software SYSTEMS MODELER meo4j MySQL. SOEA **ASOT Layer** MySQL. Mission Threads **Enterprise Red Threat** Capability/ Enterprise **ABIDES** Schedule Model (DTM) Mission Strategy and Wx Mission **SMC Common** Policy Architecture Requirements .json Reference Model DIVIO COMMINION meo4j **PDST** X PPJ Reference Model jama ©AMEO SYSTEMS MODELER SIVIO COMMINON software[®] Enterprise Red/Blue (3) Reference Model Project Cost and Arch DB Combined Arch DB Survivability Survivability Budget Schedules Architecture Requirements

InDEPTH Digital USSF Pathfinder Demo Video

Integrated Digital Engineering Prototyping Testbed Hub

• Executive level illustration of the art-of-the-possible for

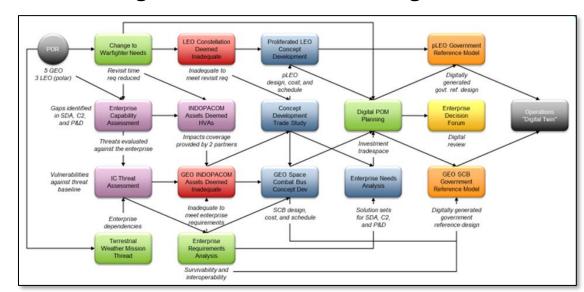


Digital USSF Pathfinder Demonstrations

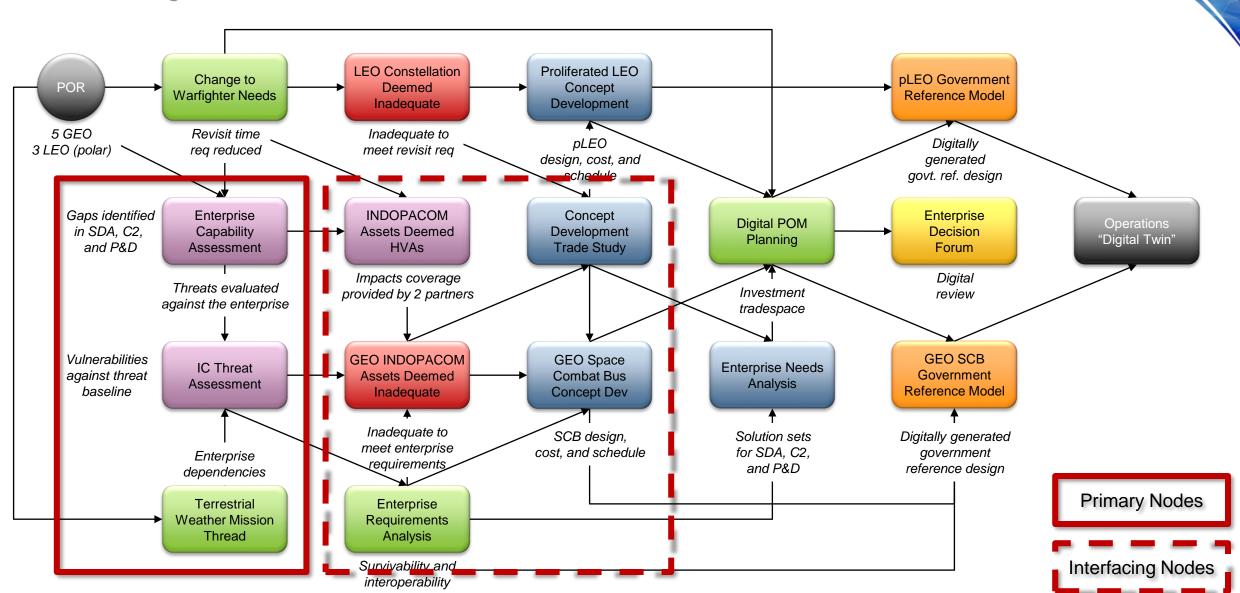
Integrated Digital Engineering Prototyping Testbed Hub (InDEPTH)

- Digital Enterprise Capability and Threat Assessment (GRACE, DTM, Wx Mission Thread)
- Digital Enterprise/Cross-Mission Requirements Analysis (SCB Enterprise/Survivability Requirements)
- Digital POM Planning Proof-of-Concept (PDST)
- Digital Enterprise Decision Forum (Confluence)
- Concept Design Center (CDC)-Generated Government Reference MBSE Model (Huddle, PDST-CDC Interface, Common Ref. Model)
- DigiEngine/SimEngine "Digital Twin" Platform (MX Transition, BRPO, DTM Interface, PySOAP)

Digital USSF Pathfinder Vignette

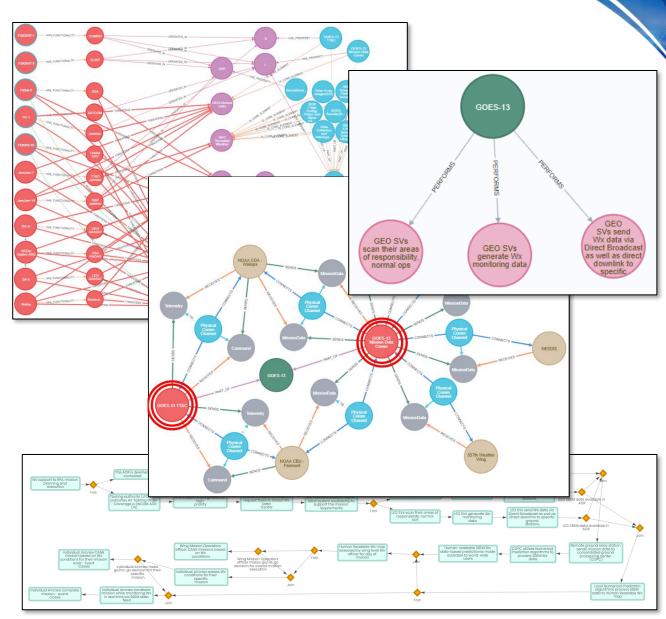


Digital Enterprise Capability and Threat Assessment



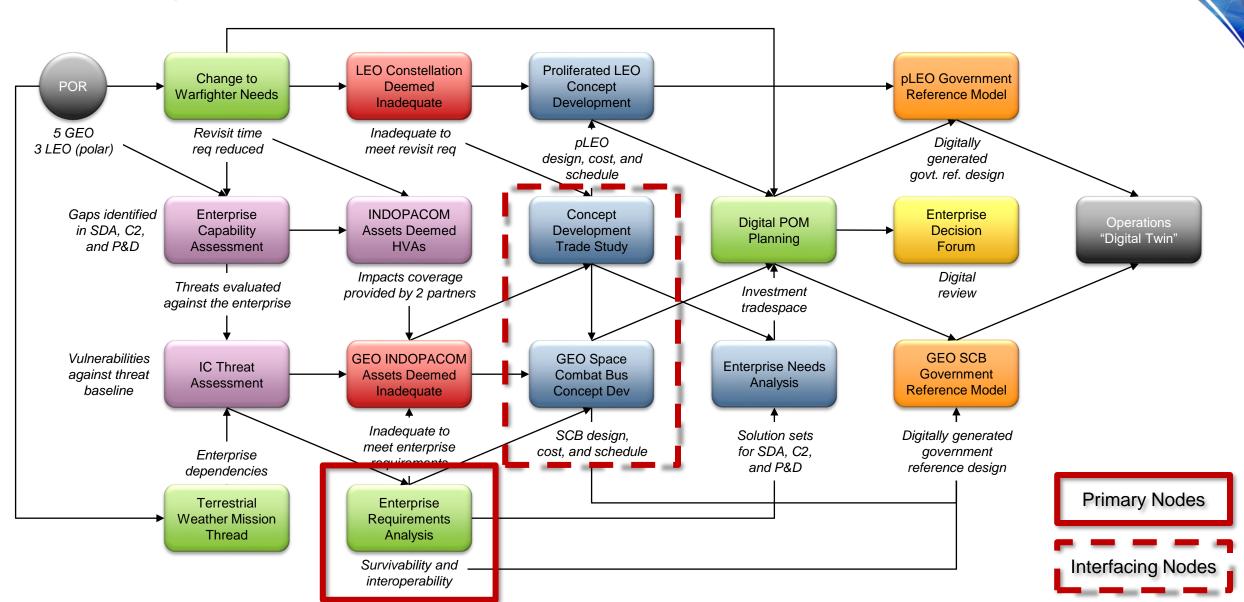
Digital Enterprise Capability and Threat Assessment

- Digital threat assessment conducted using an integrated Red/Blue graph database
 - Leverages the Blue GRACE Database and the PWW Digital Threat Model (DTM)
 - Demonstrates an approach for defining "interface nodes" between Red and Blue assets to support vulnerability/resiliency analyses
- UAS Joint Mission Thread developed that utilizes the Cloud Characterization capability provided by LEO and GEO assets
 - Demonstrates how graph data can be used to dynamically bring Red and Blue architectures into contact with one another through the context of a Mission Thread
 - Applies a Markov Chain Analysis (1) to compare the probability of mission failure for multiple Markovian models of mission threads and (2) to determine the relative impact of different threats resulting in mission failure



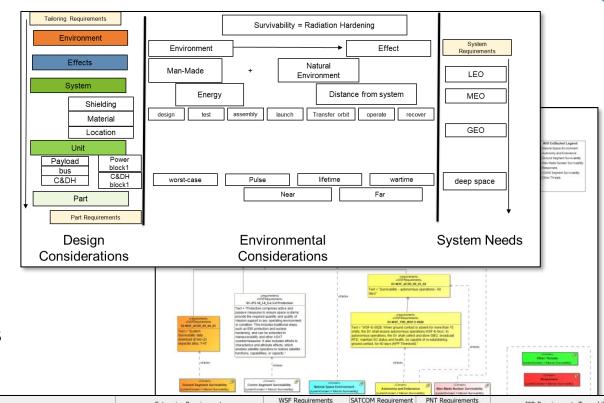
Digital Enterprise/Cross-Mission Requirements Analysis





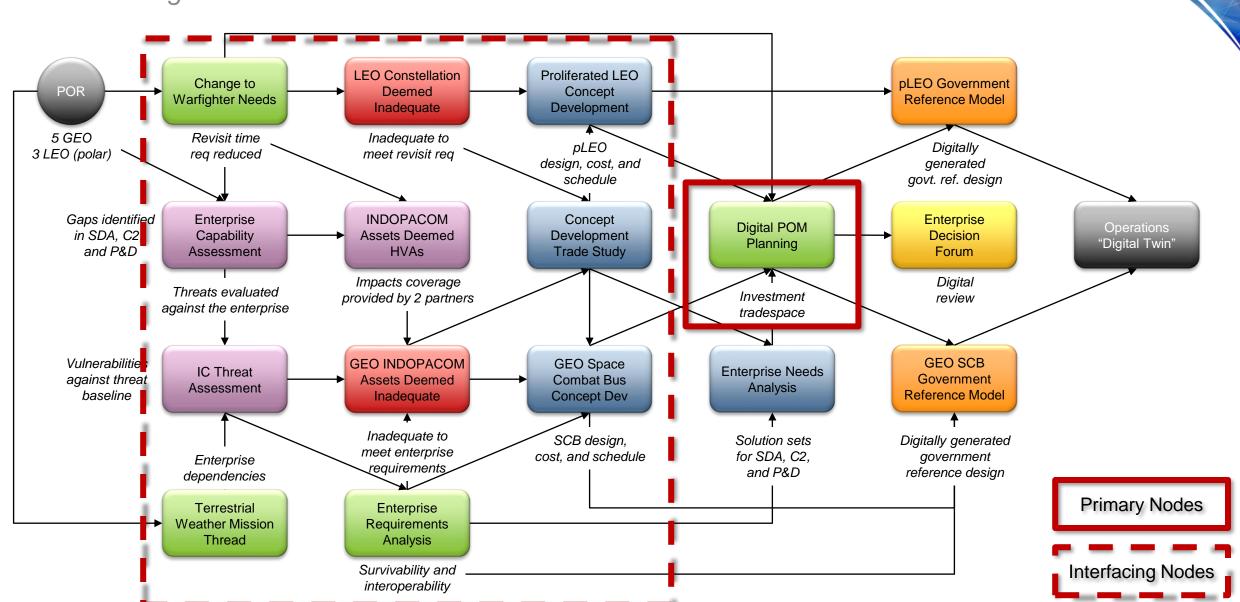
Digital Enterprise/Cross-Mission Requirements Analysis

- Based on a digital threat assessment and MIL-STD-3053 for Survivability, a model-based crossmission requirements analysis was conducted
 - Leverages the cross-mission survivability requirements analysis capability being developed for Space Combat Bus (SCB)
 - Utilizes InDEPTH connectivity between Cameo Systems Modeler and the Jama requirements management toolsets
- Model-based cross-mission requirements analysis used to identify USSF enterprise solutions
 - Establishes a requirements tradespace for supporting trade studies to define cross-mission minimum capability needs (e.g. SCB)
 - Enables enterprise requirements to be derived based on mission/ capability-specific requirements



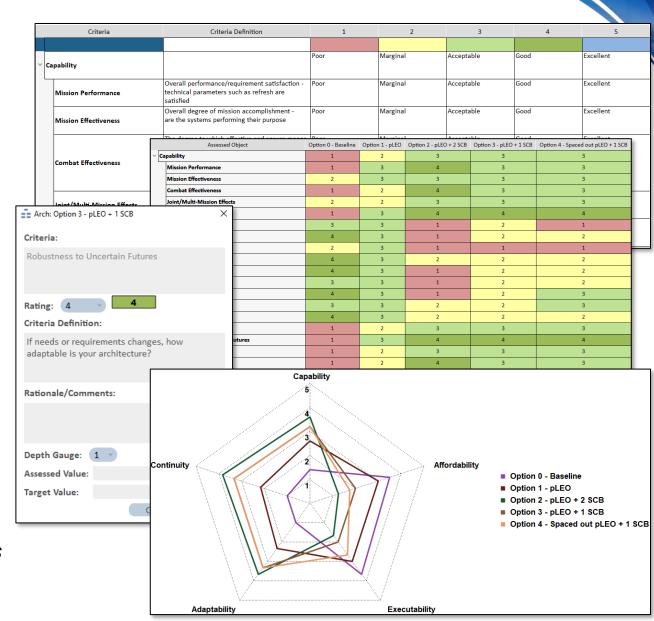
	△ Name	Enterprise Requirements	Traceability	Traceability	Traceability	ISR Requirements Traceability
E	Man-Made Nuclear Survivability			7		
2	9.11 Micrometeoroids and orbital debris (highly orbit dependent)	Enterprise Requirement 03			Orbital Debris	ISR-193 Orbital Debris
3	№ 9.12 Atomic Oxygen (LEO only)	Enterprise Requirement 03			Atomic Oxygen	Atomic Oxygen
1 [9.13 Several Prompt Nuclear Effects (threat dependent)	Enterprise Requirement 05	R SRRSyndeia-REQ-49 01-JP			ISR-355 Nuclear Effects
5	№ 9.13.1 Fission Debris	Enterprise Requirement 05		Fission Debris	Fission Debris	Fission Debris
5	⊕ 9.13.2 Nuclear detonation X-rays	Enterprise Requirement 05		GPS-283 Nuclear de	PNT-484 Nuclear detor	ISR-356 Nuclear detonation X-rays
7	№ 9.13.3 Nuclear detonation gamma rays	Enterprise Requirement 05		Nuclear detonation	Nuclear detonation gar	Nuclear detonation gamma rays
3	29.13.4 Nuclear detonation neutrons	Enterprise Requirement 05		Nuclear detonation	Nuclear detonation net	Nuclear detonation neutrons
9	№ 9.14 Various EMP effects	Enterprise Requirement 07		EMP Effects	EMP Effects	EMP Effects
0 ⊟	Natural Space Environment					
1	№ 9.1 Whole-Mission Proton Fluence	Enterprise Requirement 01		Proton Fluence	Proton Fluence	Proton Fluence
2	⊕ 9.2 Whole-Mission Worst Case Proton Flux	Enterprise Requirement 01		Proton Flux		ISR-441 Proton Flux
3		Enterprise Requirement 04		Heavy Ion1	Heavy Ion2	ISR-568 Heavy Ion
4	№ 9.4 Whole-Mission Electron Fluence	Enterprise Requirement 04		Electron Fluence	Electron Fluence	Electron Fluence
5	9.5 Whole-Mission Worst Case Energetic Electron Transients	Enterprise Requirement 04		Electron Transients	Electron Transients	Electron Transients
6	⊕ 9.6 Total Ionizing Dose (TID)	Enterprise Requirement 08		SATCOM-306 Total	Total Ionizing Dose	
7	№ 9.7 Displacement Damage (DD)	Enterprise Requirement 08		Displacement Dama	Displacement Damage	Displacement Damage
8	№ 9.8 Low Energy Plasma Fluence	Enterprise Requirement 06		Plasma Fluence	Plasma Fluence	Plasma Fluence
9	№ 9.9 Low Energy Plasma Worst Case Transient	Enterprise Requirement 06			Plasma Worst Case Tra	
0	9.10 Ultraviolet Radiation Environment	Enterprise Requirement 02	R SRRSyndeia-REQ-49 01-JP	SATCOM-833 Ultrav	PNT-532 Ultraviolet Ra	

Digital POM Planning Proof-of-Concept

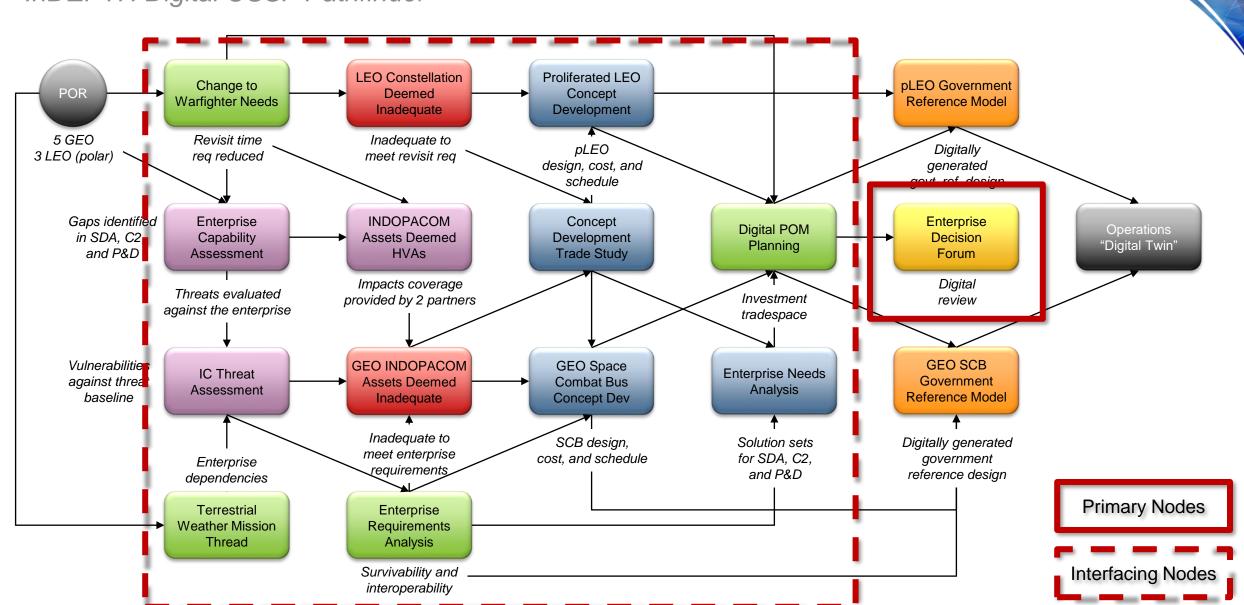


Digital POM Planning Proof-of-Concept

- Digital POM Planning Proof-of-Concept conducted to demonstrate a data and analysis-driven approach to the budget formulation process
 - Leverages the Aerospace Portfolio Decision Support Tool (PDST) to define assessment criteria, enable configuration comparison, and directly link data and analytical products as a basis for assessment
 - Applies structured POM criteria to support the evaluation of the investment portfolio tradespace and to drive the data and analyses needed to support investment decisions
- For the Digital USSF Pathfinder, proof-of-concept scoped to options that might be considered for the next generation of SBEM architectures
 - Five configurations, including the baseline, generated by a Concept Development Trade Study
 - Assessment ratings scored based available analyses performed in the InDEPTH DE testbed and SME evaluation of ASOT datasets and models

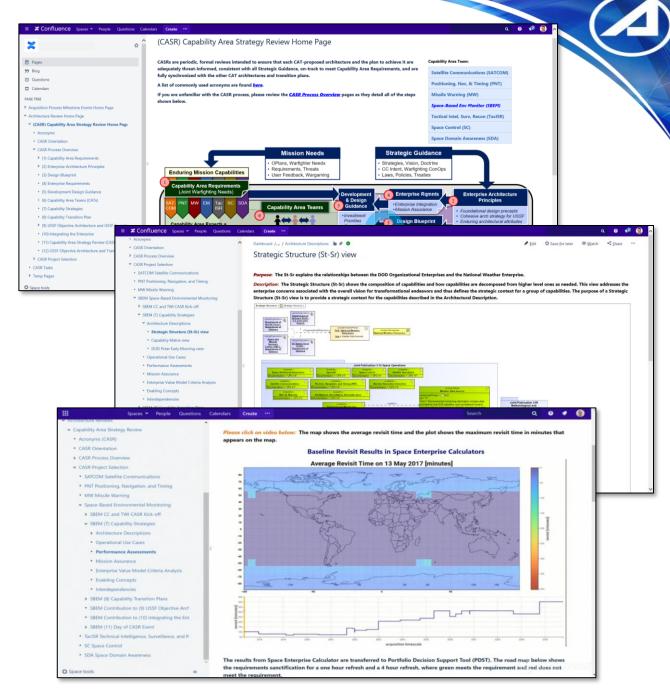


Digital Enterprise Decision Forum

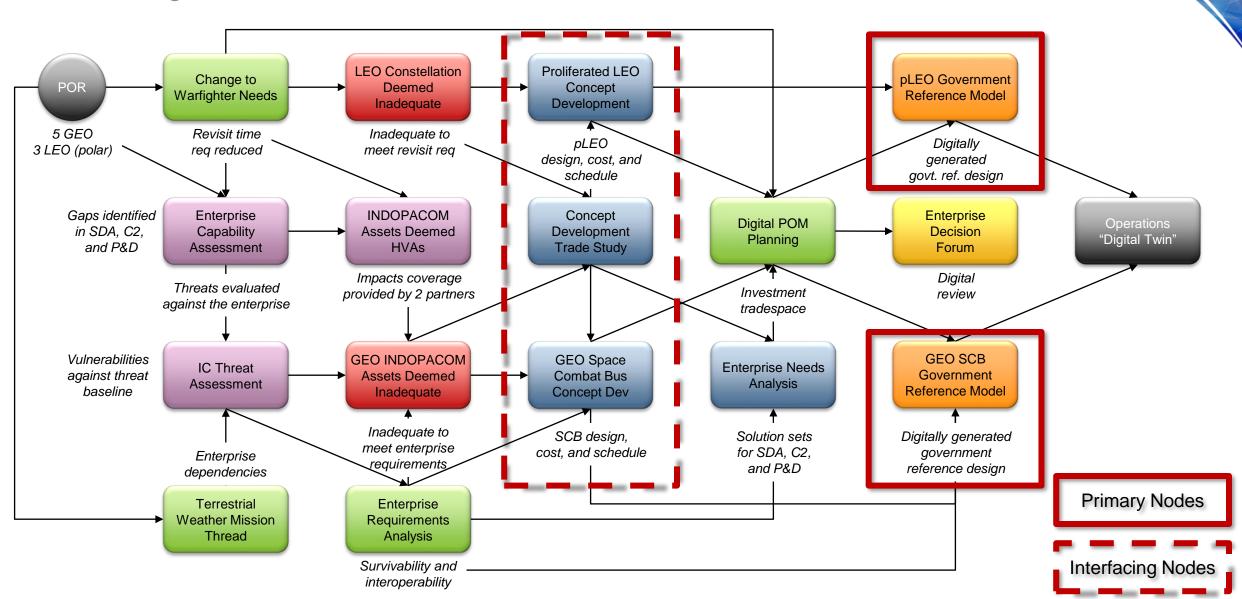


Digital Enterprise Decision Forum

- EDF is an interactive website that extends upon the InDEPTH testbed to support execution and successful completion of architecture reviews and acquisition milestone events
 - Simulates multi-disciplinary user teams and stakeholders participation in collaborative processes in model-based, ESE/DE ecosystems
 - EDF includes real-time process information, model views, requirements, etc. from which participants can drill down and extract information necessary to make better, faster, data-driven decisions
 - Enables access to ASOT data in real-time to facilitate the review process and enable data-driven architecture and acquisition decision-making
- EDF currently contains the following use cases:
 - Architecture Reviews: Capability Area Strategy
 Review (CASR) Go/No-Go decision
 - Acquisition Process Review: Enterprise System Requirements Review (SRR) – Approved requirements baseline

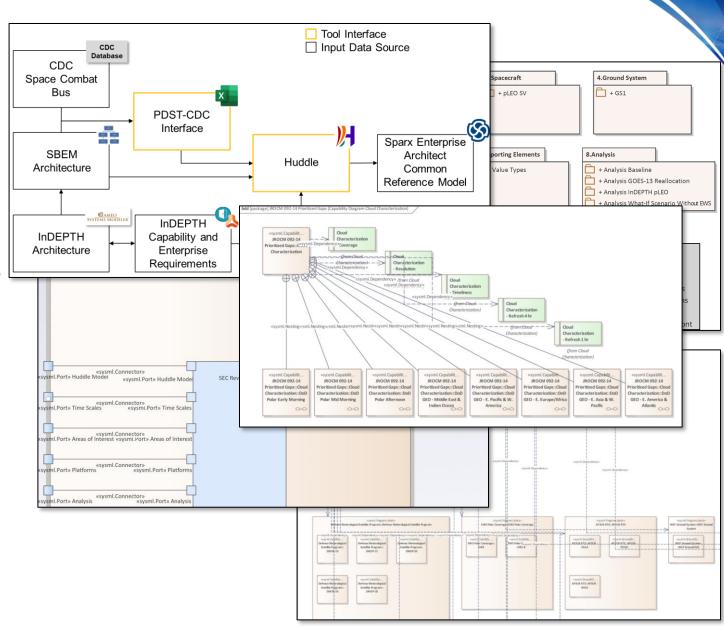


CDC-Generated Government Reference MBSE Model

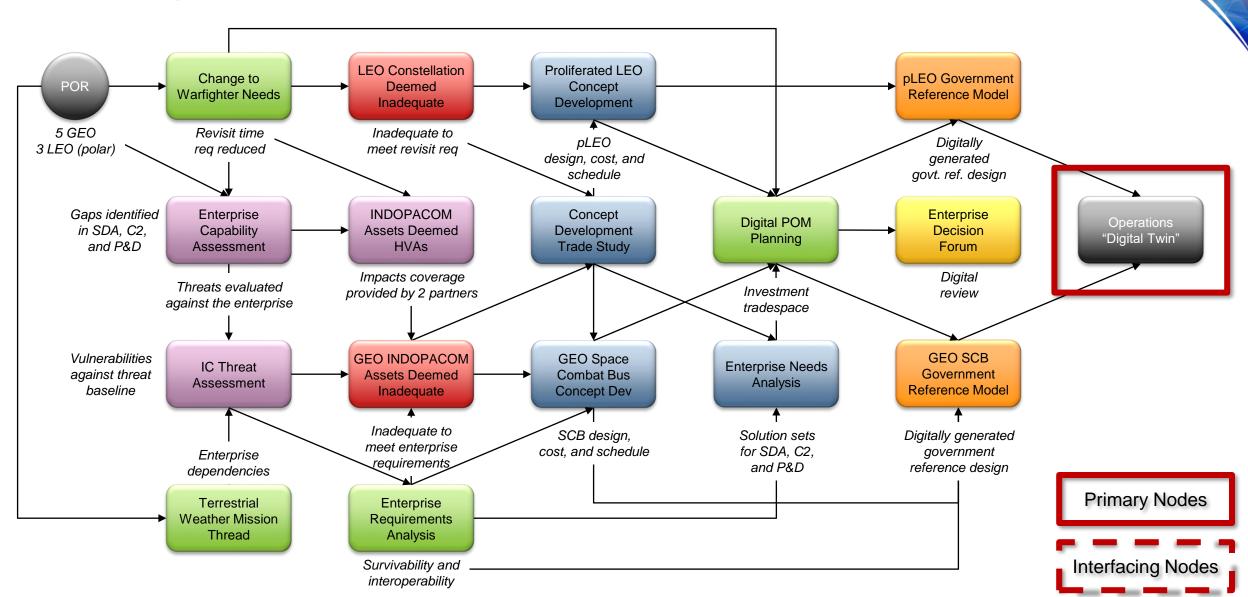


CDC-Generated Government Reference MBSE Model

- Auto-generated MBSE Government Reference Model (Point of Departure)
 - Based on system/architecture concepts from the CDC in combination with the baseline data from the InDEPTH ASOT Database
 - Leverages a Common Reference Model developed in SparxEA by SSG
 - Utilizes the IDEAS CDC interface and Huddle transformation tools to facilitate the translation of data objects
- Multiple artifacts auto-generated within the Government Reference MBSE Model
 - Auto-generated Package Diagrams to highlight model contents
 - Auto-generated BDDs to visualize relationships to all systems, requirements, and sub-capabilities
 - Auto-generated Parametric Diagrams capture Revisit Time analyses conducted using Space Enterprise Calculators (SEC)



DigiEngine/SimEngine "Digital Twin" Platform



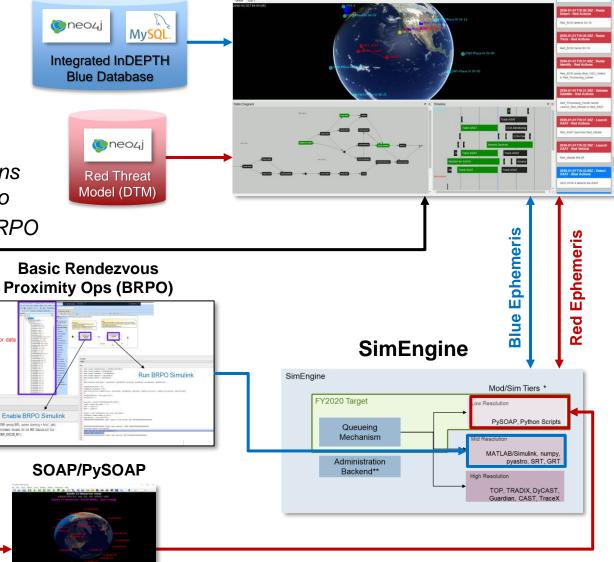
DigiEngine/SimEngine "Digital Twin" Platform

InDEPTH Digital USSF Pathfinder

type maneuvers

- DigiEngine is a DE simulation platform based on the concept of digital twins having defined physical models that take in real or simulated inputs
 - Connects to authoritative sources of truth (ASOTs) for both the Blue architecture and Red threats
 - Utilizes a SysML Activity Model to define the interactions between Red and Blue during an engagement scenario

Connects to physical models for satellites performing RPO



DigiEngine Application

Blue Model

Red vs.



Questions?