Model-Based Validation of U.S. Military Mission Scenarios with Digital Threads

C1C J.R. Cook, C1C Andrew Hancock, C1C Mac Steiner, C1C Wes Park, Lt. Colonel Jeff Newcamp
United States Air Force Academy

Abstract

In order to meet the Space Development Agency's (SDA) vision for a multilayer satellite constellation within its Proliferated Warfighter Space Architecture (PWSA), COSMIC (Concept of Operations Simulation and Model Integration Capability) was developed as a prototyping technique to simulate a systems modeling language (SysML) model of the various satellite vehicles. These satellites are expected to provide real time, 24/7 launch detection, and relay pertinent information to the user. COSMIC utilizes digital threading techniques to meet these requirements and satisfy critical mission threads (CMT). The COSMIC digital testbed is a multi-software approach binding Cameo Systems Modeler and third-party analytical tools, such as Systems Tool Kit (STK) and NS-3 using a Python application program interface (API) to control the third-party analytical software. COSMIC executes SysML behavior diagrams in Cameo to simulate the population of satellites into STK given orbital parameters in Cameo diagrams. COSMIC model execution uses "opaque expressions," or application-layer JavaScript code embedded in the model allowing for in-the-loop data exchanges with STK. The COSMIC digital tool enables the testing of potential operational scenarios, leveraging satellite vehicles to model how this satellite communications network can track threats in real-time and best support the warfighter. This research illustrates the value of scenario development via Cameo, STK, NS-3, JavaScript, and Python and outlines the steps taken to formalize these links using digital threading techniques.

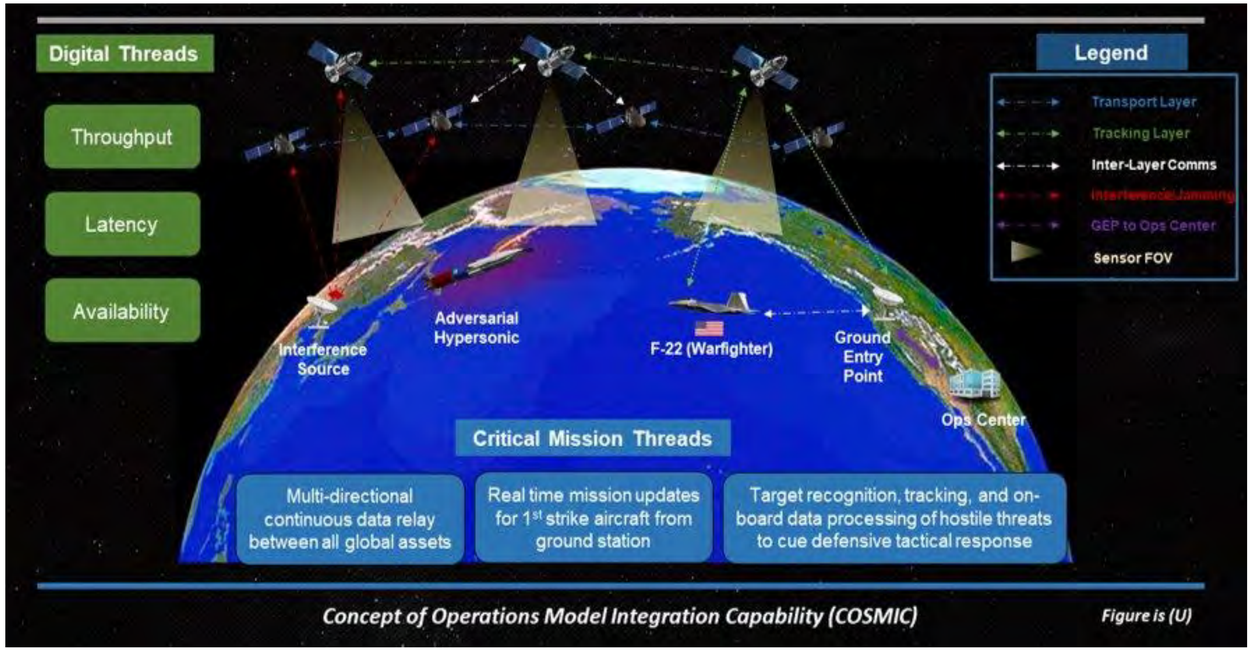

Figure 1: Sensor-to-Shooter Kill Chain Analysis OV-1

SDA Model Development

- Model designed in CAMEO with SysML
- Cameo Single Source of Truth allows immense variability of model to develop multidomain warfighting scenarios enhanced by PWSA
- Opaque Java expressions in Cameo to export system data through xml to execute through software APIs

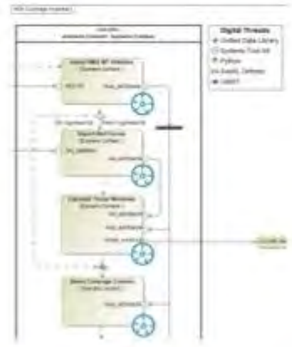

Figure 2. Activity diagram with functions to execute in each software

Digital Thread Creation

- Digital Thread Analysis in STK and NS-3
- Tracking Window Availability windows for a hypersonic launch with and without red team interference
- Packet latency and throughput defined by transport layer satellite node network

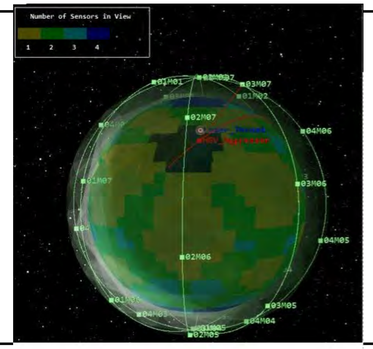

Figure 3. STK visual of Tracking layer tracking a hypersonic with interference outages

Discussion and Future Work

- Increase the fidelity of model with classified technical information
- Enhance current plug-ins and third part tool usage to include software such as SOLIDWORKS, or AFSIM to better define the model

References

Hancock, Andrew, et al. "Model-Based Validation of U.S. Military Mission Scenarios with Digital Threads." *Aerospace Research Center*, American Institute of Aeronautics and Astronautics, 19 Jan. 2023, https://arc.aiaa.org/doi/abs/10.2514/6.2023-0259.

Special Thanks to: Infinity Systems Engineering