Enabling Multi-Domain Operations through Simulation Services

Alpesh Patel, Jose Orozco & Bruce Robbins
U.S. Army Program Executive Office for Simulation, Training, and Training & Instrumentation (PEO STRI)
Orlando, FL
alpesh.i.patel.civ@army.mil
jose.l.orozco8.civ@army.mil
bruce.e.robbins.civ@army.mil

Susan Harkrider
U.S. Army Combat Capabilities Development Command (DEVCOM) Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) Center
Ft. Belvoir, VA
susan.m.harkrider.civ@army.mil

Chris McGroarty & Christopher J. Metevier
U.S. Army Combat Capabilities Development Command - Soldier Center (DEVCOM SC)
SFC Paul Ray Smith Simulation and Training Technology Center (STTC)
Orlando, FL
christopher.j.mcgroarty.civ@army.mil
christopher.j.metevier.civ@army.mil

Chuck Sanders
Army Modeling and Simulation Office (AMSO)
Ft. Belvoir, VA
charles.g.sanders.ctr@army.mil

Rob Kewley
simlytics.cloud
Morristown, NJ
rob@symlytics.cloud

Kevin Steffenson
Air Force Research Lab – Aerospace Systems
Dayton, OH
kevin.steffenson.2@us.af.mil

Scott Gallant
Effective Applications Corporation
Oviedo, FL
Scott@EffectiveApplications.com

ABSTRACT

As the United States (US) Department of Defense (DoD) continues to implement the concept of Multi-Domain Operations (MDO), our simulation tools must focus on solutions that enable rapid and continuous integration of all domains of warfare in a multi-national context. The focus of national strategies is turning to Large-Scale Combat Operations (LSCO) and our technical requirements must evolve towards the need for scalable tools that are accessible by a multitude of users in a distributed environment. To that end, the US Army is exploring how the concept of Modeling and Simulation (M&S) as a Service (MSaaS) can meet this need through the ability to enable more flexible simulation environments that can be deployed and executed via an on-demand methodology. This paper discusses insights gained through collaborations within the US Army, US Air Force (USAF), and with the North Atlantic Treaty Organization (NATO) M&S Group (NMSG) – 195 "MSaaS Phase 3". It details how: 1) the concept of Sensor as a Service provides broad applicability and availability across numerous Army M&S Communities, including Acquisition, Experimentation and Test and Evaluation; 2) the One Semi-Automated Forces (OneSAF) program office's implementation of Perception Service that allows simulations to share high fidelity modeled components as a registered provider and consumer of those models within the Bifrost server; and, 3) the US Air Force Advanced Framework for Simulation, Integration, and Modeling (AFSIM) can operate in an MSaaS environment through a demonstration that includes Electronic Warfare sensors, attached to an Unmanned Aircraft System (UAS) platform, interoperating with OneSAF ground forces, in an MDO environment. Finally, we discuss how these excursions are both benefiting from, and informing, NMSG-195 to mature MSaaS to meet the technical requirements being driven by the need to simulate LSCO.

ABOUT THE AUTHORS

Alpesh Patel is the Chief Engineer for the Joint Land Component Constructive Training Capability (JLCCTC) and has 17 years of experience supporting in various capacities from research to acquisition within the science and technology, acquisition, and currently within live and constructive training community. Throughout his career his primary focus has been to deliver cost effective joint capabilities and system of systems. MEng Stevens/BSCEN NJIT.

Dr. Charles Sanders is a Simulation Systems Architect for the Army M&S Office (AMSO) with more than 30 years of experience in M&S, organizational development, strategic policy and planning, and training and learning concepts. With a plethora of expertise in this domain, Dr. Sanders primary focus is the leading change and transformation in how organizations leverage emerging simulation technologies for cloud-based simulation, persistent simulation test bed for coalition experimentation, and migration to simulation as a service. He has and continues to provide innovation advice to executive level government and industry leaders.

Susan Harkrider is the Deputy Assistant Director of the M&S and Power Division within the Army Futures Command (AFC) and has 34 years of experience in M&S. As a leader her primary focus has been in the engineering, development, and experimentation to close simulation capability gaps through collaboration with Army and NATO M&S communities to support collective training. She holds a BSE and MSE from the University of Central Florida.

Dr. Robert Kewley is the founder and Director of simlytics.cloud and has over 20 years of experience in leading cyber analytics, simulation, and soldier, radar, and sensors systems development efforts within the military domain and consulting as an industry partner. The primary focus of his research efforts has been in the development of simulation methodologies and engineering processes to support the application and implementation of simulation as a service of complex system of systems. As an accomplished lead systems engineer, he's served the ASA(ALT), West Point, and NATO in various capacities.

Chris McGroarty is the Chief Engineer for Advanced Simulation within the Army Futures Command (AFC) and has nearly 20 years of experience leading the research, maturation, and insertion of innovate simulation capabilities. The primary focus of his research efforts has been to make complex simulation capabilities more accessible to a multitude of novice users through novel architectures, leveraging gaming technologies, and utilization of artificial intelligence. He has received his Masters and Bachelor of Science in Electrical Engineering from Drexel University.

Christopher J. Metevier is a Branch Chief for Advanced M&S within the Army Futures Command (AFC) and has over 33 years of experience that extends across the acquisition lifecycle supporting the Army and Navy from concept to creation to fielding of simulation capabilities. He received his MBA from Wester University and his Bachelor of Science in Electrical Engineering from University of Central Florida.

Scott Gallant is the CEO and Systems Architect of Effective Applications Corporation and has over 25 years of experience in M&S and distributed computing. As an industry leader and technical expert, he has driven teams for the advancement of distributed software and system of system design in support data analysis, technical assessments, and experimentation. His primary focus been partnerships with the Army and NATO M&S communities in utilizing these advancements for implementation as a service of large-scaled simulation systems.

Kevin Steffenson is the Chief Product Owner and Senior Product Engineer for the Advanced Framework for Simulation, Integration, and Modeling (AFSIM) with over 30 years of combined active duty and civil service experience in Joint and NATO operations, flight test, acquisition, advanced research and development, and M&S. He is charged with prioritization and derivation of the simulation capability gaps of the vast government and industry AFSIM user community through collaboration to guide framework, modeling, and development for virtual and constructive simulation and experimentation.

Bruce Robbins is a lead systems engineer on the Joint Land Component Constructive Training Capability (JLCCTC) and Next Generation Constructive with 20 years of experience supporting in various lead capacities within the M&S community. He was instrumental in the development, integration with the Closed Combat Tactical Simulation (CCTT) and Aviation Combined Arms Tactical Trainer (AVCATT), and fielding of One Semi-Automated Forces (OneSAF) to displace legacy constructive simulation capabilities.

Jose Orozco is the Acting Chief Engineer for One Semi-Automated Forces (OneSAF) with 30 years of experience supporting in various lead engineering and acquisition capacities within the M&S community. He was instrumental in development and integration of constructive capability to live, virtual, and mission command assets for OneSAF enabling platform to simulation training. He has received his BS/MS in Systems Engineering from Mercer University and has MBA/BBA from Wright State University and Polytechnic University of Puerto Rico.

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charles.g.sanders.ctr@army.mil

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rob@symlytics.cloud

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Dayton, OH
kevin.steffenson.2@us.af.mil

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INTRODUCTION

Current battlespace simulations are expensive to operate and slow to modify to accommodate the modeling of new systems performance and behaviors. Simulations across the United States Army are decentralized; they are developed for and managed by six separate Modeling and Simulation (M&S) Communities (Analysis, Acquisition, Experimentation, Intelligence, Test & Evaluation, and Training). Most of the existing simulations were developed in those stovepipes as standalone capabilities tailored to each community's requirements. The distinct requirements of each community and diverse legacy technologies embedded in most of the existing simulations, present technical and fiscal barriers to integration. This means that each community separately creates or collects the same models and data to support their simulation, with very limited ability to share or leverage the investments of others.

The North Atlantic Treaty Organization (NATO) M&S as a Service (MSaaS) concept illuminates changes necessary to modernize the Army's M&S enterprise (Siegfried, 2019). Future constructive simulation components that provide capabilities required for the Warfighter can be delivered as a service; however, a modern simulation interface is required to enable MSaaS. In this paper, we describe the relevant MSaaS background, provide an example Multi-Domain Sensing M&S Architecture, highlight Future Constructive Simulation Services, and describe an exemplar of generating MSaaS services from conceptual models.

THE NEED FOR CHANGE

The current long length of development time and high cost to modify a simulation to support Army modernization efforts is particularly significant, given the complex, unpredictable, and dynamic nature of the forecasted operational environment. The requirement for simulation development to keep up with the pace of change in the Operating Environment is a significant challenge. Modifying or updating legacy M&S tools is not sufficient for meeting emerging requirements, as they are inherently man-power intensive, require specialized coding skills, and are costly to upgrade and sustain. Therefore, a new approach is necessary to develop and modify simulation capabilities more rapidly and with much less post-development integration and re-engineering.

How Simulation Technology Has Changed

Recent developments in cloud computing technology and service-oriented architectures offer opportunities to more rapidly and flexibly utilize M&S capabilities to satisfy critical needs. M&S as a Service (MSaaS) is an emerging concept that includes service orientation and provisioning of M&S applications through the *as-a-service* model of cloud computing and containerization to enable more composable and agile simulation environments that can be deployed and executed on-demand. Service-oriented simulation is designed to be modular, where, as seen in Figure 1, individual functions or domains that are modeled in the simulation are built as individual parts that can be modified or fused to support a particular use case. The MSaaS paradigm supports agile, rapid, and tailor-made simulation solutions from a collection of pre-built and validated models and tools into a unified deployable simulation environment whenever the need arises. The MSaaS paradigm supports stand-alone use as well as integration of multiple simulated and real systems into a unified cloud-based simulation environment whenever the need arises.

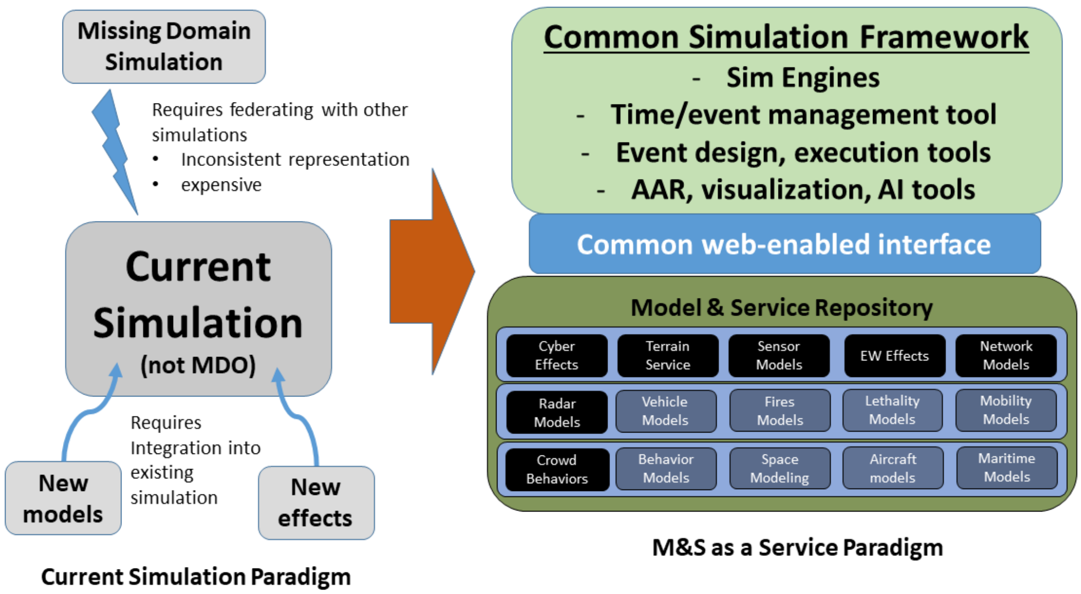

Figure 1. Current Simulation Paradigm versus M&S as a Service

NATO Modeling and Simulation as a Service

NATO defines MSaaS as "an enterprise-level approach for discovery, composition, execution and management of M&S services" (Siegfried, 2015). A series of NATO M&S Groups (NMSGs) have been studying MSaaS and proposing policy to support a NATO transition to its MSaaS vision where "M&S products, data and processes are conveniently accessible and available on-demand to all users to enhance operational effectiveness." After the initial concept development, NMSG-164 "MSaaS Phase 2" validated the concept through experimentation and released the Allied Framework for MSaaS Concept of Employment (NSO, 2022) as a top-level set of definitions, policies, and standards to guide future development of M&S capabilities as services. Figure 2 shows a group of NATO organizations and nations acting together as MSaaS providers through an MSaaS implementation to make M&S products and services available to the users in accordance with service level agreements. The implementation is a specific solution architecture that is derived from the MSaaS Operational Concept Document (STO, 2019) and Technical Reference Architecture. Users interact with one or more MSaaS portals to gain access to M&S services that are either already owned by defense organizations or available from suppliers through a license agreement, purchase order, legal contract, or agreement. A key element of the MSaaS business model is the formation of an ecosystem where the provider offers a value proposition to meet the customer's M&S needs affordably and efficiently by orchestrating the interactions between users and suppliers via a common architecture governed by common standards. The current effort under NMSG-195 "MSaaS Phase 3" continues to mature MSaaS by developing standards, investigating technologies to enhance MSaaS benefits, and starting to build the MSaaS ecosystem.

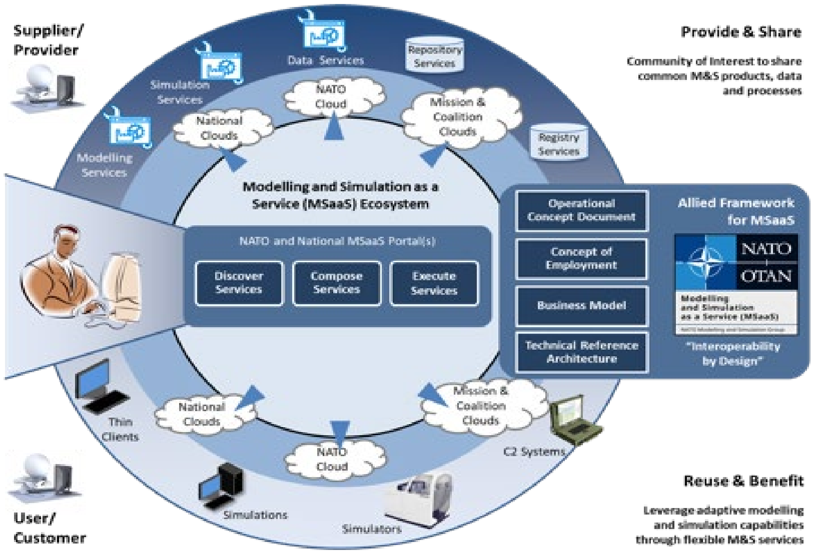

Figure 2. Allied Framework for M&S as a Service

MSaaS offers an opportunity to cost efficiently leverage new technologies and tools as well as create inherently interoperable capabilities faster through cooperative and coordinated research and development efforts. Open-source software development, which avoids the limitations of proprietary solutions, promises to enable crowd sourcing, proven to be much more effective for innovations. This also lowers the barrier of entry to participation by smaller companies with new ideas and technologies. Open-source software development involves many more experts and more cooperation for more frequent innovations. A good example is the development of Linux Operating System (Wikimedia, 2023). Lastly, the use of cloud computing and an MSaaS architecture promises to better enable cooperative and distributed development efforts.

MSaaS is intended to promote discovery, reusability, and composability of M&S services. One key aspect of MSaaS is the use of modularized simulations and tools that can be easily tailored and composed for each use case, rather than rely on a few monolithic simulations that provide all the required simulation functionality and are more expensive and slower to modify. This approach enables executing each distributed simulation use case with less required resources and data streams (Tolk & Mittal, 2014).

Modern Simulation Interface

In order to achieve the goals of MSaaS, a modern simulation interface is required. In recognition of this need, the One Semi-Automated Forces (OneSAF) Program has developed a next generation, Service-Oriented Architecture called Bifrost (Helmy, 2021). Bifrost allows simulations to share simulation state using modern commercial approaches and technology. It optimizes network usage to work efficiently on Army networks, cloud deployments, and long-haul exercises. By not relying on multicast, Bifrost simplifies deployment in commercial or private cloud environments. It has been demonstrated across numerous use cases of differing network quality and information assurance restrictions to scale to over 1M simulation entities. Bifrost's web user interface can control multiple sources of simulated entities through a single user interface across multiple simulations.

As an example of Bifrost enabling an MSaaS approach, OneSAF has interfaced with the US Air Force Advanced Framework for Simulation, Integration, and Modeling (AFSIM) (Clive, *et al.*, 2015) using Bifrost in order to access AFSIM's sensor models, which are higher fidelity. In this demonstration, OneSAF modeled the friendly and hostile vehicles as well as the command and control of the platforms, movement, and state; AFSIM modeled Electronic Warfare (EW) sensors that were attached to an aerial platform. This successful demonstration helped highlight how Bifrost can support bringing together models across disparate simulation environments.

Migration To Modeling and Simulation as a Service

Migration from the current monolithic simulation paradigm to one of agile modeling and simulation services that affords agility and supports rapid simulation development, continuous integration, and deployment is critical for modernization of Army training enterprise. This cannot be achieved through traditional development and acquisition of MSaaS ecosystem.

AMSO intends to establish a simulation integration environment designed to enable exploration and gradual migration to an MSaaS architecture as individual models and tools are created, while still being able to use the existing simulation capabilities. The environment will include a web-enabled interface to provide the required new modeling capabilities faster and gradually. Additionally, it will facilitate migration to a Service-Oriented Architecture (SOA) that provides data sharing between the simulation and each service to provide the desired additional modeling or effect. This approach will also introduce new modeling across the Army M&S Enterprise expeditiously rather than integrating them into each separate simulation.

AMSO, partnering with Army Geospatial Center (AGC) and Engineer Research and Development Center (ERDC), is cooperating to establish a rapid integration environment for simulation, called the M&S Enterprise Innovation Environment, to support integration of M&S services already developed into a simulation framework to enable continuous integration of new or updated services as they emerge from both government and industry partners with existing simulations.

Adopting definitions from the NATO concept, AMSO is the MSaaS provider supporting the Army Futures Command (AFC) customer in its migration to MSaaS to enable multi-domain operations. The M&S Enterprise Innovation Environment will host an MSaaS implementation that offers an MSaaS portal, where Army Futures Command M&S users, such as the concept developers, research and development centers, or analysis centers, can conveniently and affordably access M&S data, products, and services to support their M&S need. NATO's MSaaS Operational Concept Document and Technical Reference Architecture provide guiding concepts for the AMSO solution architecture.

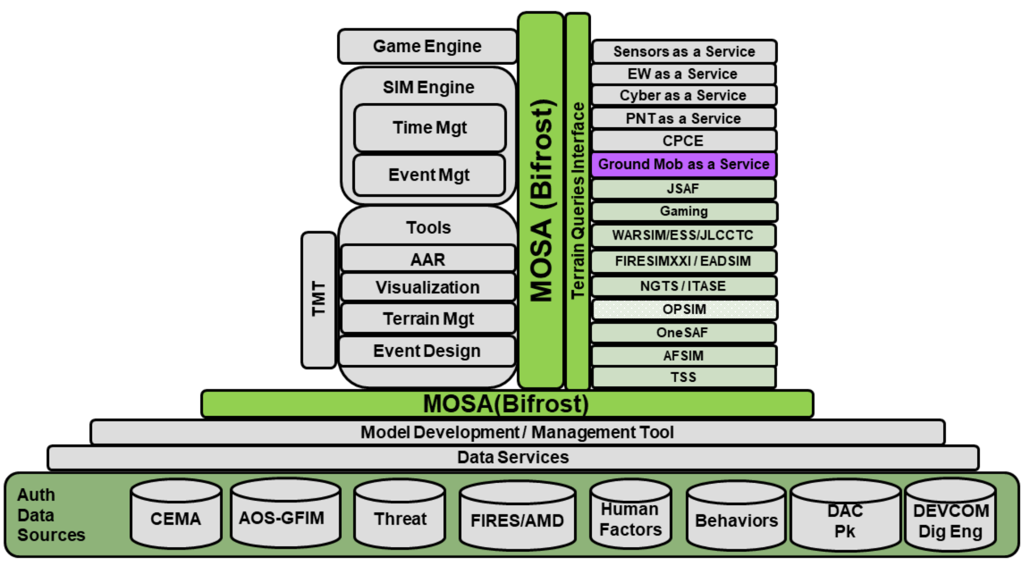

Figure 3. Army M&S as a Service Model Migration

The integration environment shown in Figure 3 uses Bifrost to share simulation state and facilitate integrating M&S services as they are developed into an ecosystem of current simulations, with access to cloud services for testing before employment in a live Cloud Service Provider (CSP). Bifrost's web user interface can be used to control multiple sources of simulated entities (simulation agnostic), providing a common single user interface across multiple simulations.

MULTI-DOMAIN SENSING M&S ARCHITECTURE

The Multi-Domain Sensing M&S Architecture is a multi-year project jointly sponsored by the Army Modeling and Simulation Office (AMSO) and the US Army Combat Capabilities Development Command (DEVCOM) Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) Center, Research and Technology Integration, M&S Division. Its purpose is to develop an MSaaS architecture to allow sensor models, communications models, electronic warfare models, and command and control models to cooperatively develop a Common Operational Picture (COP) adjudicated by sensor and network effects, to present to shooter Command & Control (C2) nodes. This architecture gives users of multi-domain simulations the ability to provide a simulated intelligence data feed to various consumers in a simulation event. The data is also provided to the Army's Integrated Sensor Architecture (ISA), a standard for sharing sensor data (Moulton, *et al.*, 2014) that supports an MSaaS-like implementation. C2 systems already compliant with ISA will be able to consume the data feed to support training or to support validation of intelligence and fusion capabilities embedded in those systems. The data can also support development, test, and validation artificial intelligence algorithms that transform sensor data streams into actionable intelligence feeds. Finally, the data streams support intelligent behaviors in other simulated entities, such as route planning, sensor re-tasking, and sensor to shooter pairings.

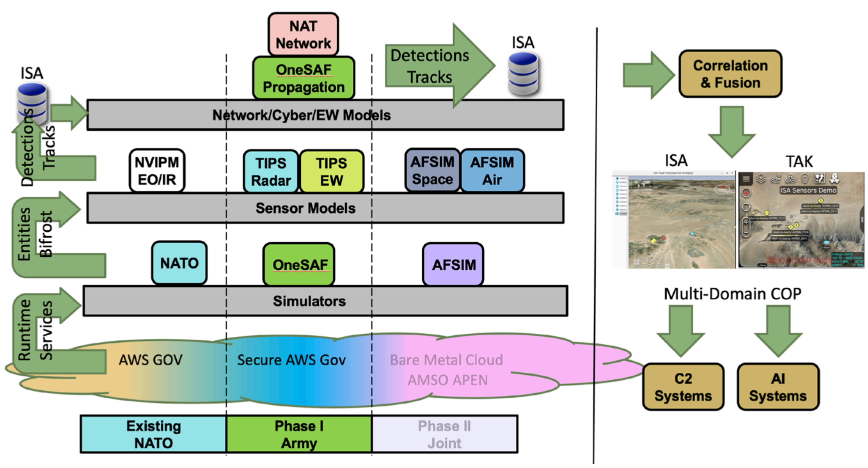

Figure 4. Multi-Domain Sensing M&S Architecture

The development team built the architecture in coordination with AMSO, the OneSAF program, US Army Combat Capabilities Development Command, Soldier Center, Simulation and Training Technology Center (DEVCOM SC STTC), and other Army organizations so that it can be integrated with the shared MSaaS vision discussed in this paper. The technical approach has four architectural layers that evolved with each phase of the project, as shown in Figure 4. During the preliminary research (Kewley, 2020), the development team participated with the NATO Modeling and Simulation Group prototyping MSaaS capabilities for NATO. The capstone demonstration for this group took place at the 2020 NATO Computer Aided Analysis, Exercise, and Experimentation (CA^2X^2) Forum. This was a federated cloud environment with services provided by several different nations. The US provided a sensor service, and radio network service, and a network effects service, which used notational sensor representations. Figure 5 shows the cumulative effect of these services. The sensor service for Electro-Optical and Infra-Red (EOIR) sensors uses the Army's validated target acquisition methodology to assess that a friendly Unmanned Aerial Vehicle (UAV) has identified the entire enemy force. The network effects service published a simple enemy jamming attack, not based on any real-world system, against the company command network, and the radio network service adjudicates that this effect has sufficient power to prevent the company commander from getting situation awareness updates. This is reflected in the partial COP presented to his C2 system. The company was able to overcome this effect by positioning a notional relay station that had sufficient power to overcome the jamming attack.

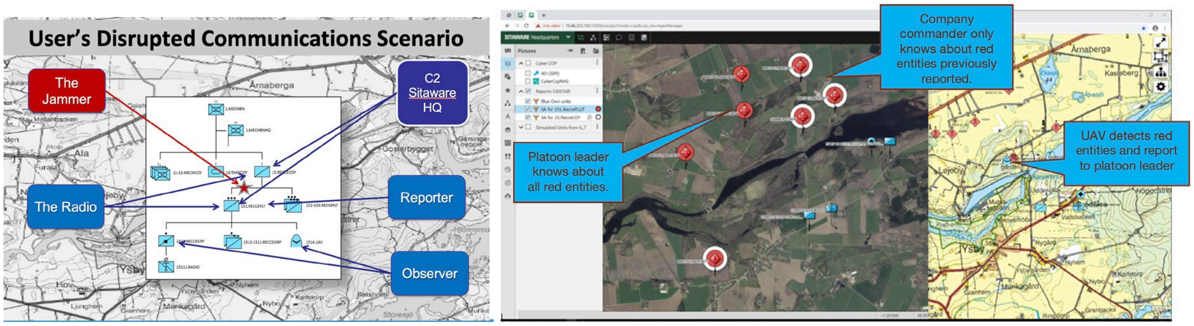

Figure 5. Federated Service Implementing a Jamming Attack

During the first phase of the project, the development team integrated the sensor service in a US Army simulation environment using the unclassified simulation services from the DEVCOM C5ISR Center, DEVCOM Analysis Center (DAC), Program Executive Office for Intelligence, Electronic Warfare, and Sensors, the OneSAF Program, and DEVCOM Soldier Center STTC. The centerpiece of this capability is the Night Vision Integrated Performance Model (Teaney & Haefner, 2016), which gives simulation user's the ability to generate sensor performance data tables for use in the Army's accredited target acquisition methodology. The Tactical ISR Performance suite offered EW and radar sensors as a service. Supporting services provided terrain data and integration with the OneSAF/Bifrost environment. These services combined to feed sensor data to ISA.

During Phase 2 of the project, the team integrated with the DAC Network Analysis Tool (NAT) to provide a connectivity matrix that adjudicates which network nodes can communicate with each other. The Situation Awareness Service uses this matrix to pass situation awareness data from the sensors throughout the network and to provide an adjudicated COP to any node. In addition, the team enhanced the AFSIM integration with Bifrost to support passing sensor status and track information. Figure 6 shows a representation of a joint COP as provided, via ISA, to the Virtual Tactical Assault Kit (VTAK) C2 system (Virtual Heroes, 2023).

Figure 6. Multi-domain COP provided via ISA (left) to VTAK (right)

FUTURE CONSTRUCTIVE SIMULATION SERVICES

Simulation services available through a Modular Open Systems Approach (MOSA) (Zimmerman, *et al.*, 2019), which can be facilitated by Bifrost, can provide an MSaaS-like solution for future constructive simulations. Below are descriptions of the services shown in Figure 7 that are available or are being planned for the near future.

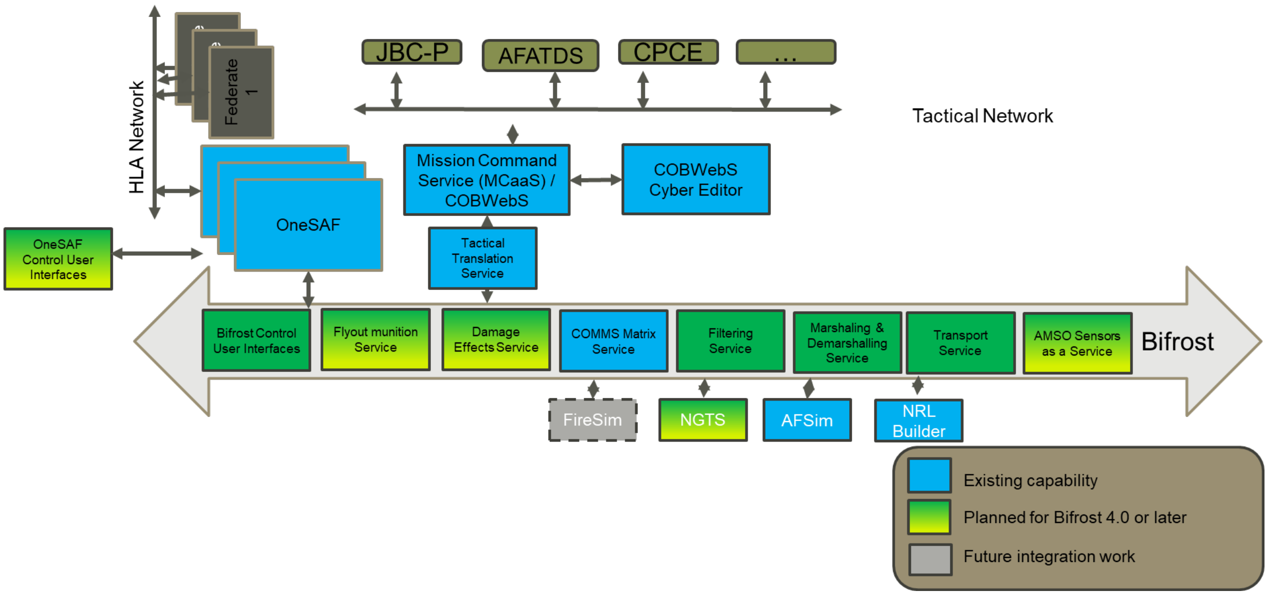

Figure 7. Future Constructive Simulation Services Architecture

Perception Services (PS): As part of the AMSO initiative to provide MSaaS, the OneSAF program has recently created a Perception Service in its Bifrost server. This service allows simulations to register as a provider and consumer of the service to share high fidelity modeling of components. The PS provider serves the entity information and the PS consumer displays the entity. The OneSAF Program demonstrated this PS concept by being the consumer and having AFSIM be the provider of EW sensor data attached to an Unmanned Aerial System (UAS) and perceived targets. OneSAF models friendly and hostile groups vehicles, provides command and control of platforms, represents movement and state (on/off/jammed/etc.), and takes this information to task the appropriate entity to engage hostile threats.

Flyout Munition Service (FMS): The FMS Bifrost service shares high fidelity munition model and trajectory and allows simulations to register as an FMS provider. It leverages the DEVCOM Armaments Center Performance Related Integrated Suite of Models (PRISM) to generate statistics related to weapon success and performance. The OneSAF program has demonstrated this service with OneSAF or PRISM providing this service.

Damage Effects Service (DES): The DES Bifrost shares high fidelity munition damage effects and allows simulations to register as a DES provider.

Communications Matrix Service (CMS): The CMS utilizes a matrix showing the communications status between all combinations of potential sending and receiving platforms. It provides several configurable options for communications based on the needs of the scenario: (1) all platforms can always communicate, (2) have line of sight (LOS) communications, and (3) radio jamming effects on communications. If the scenario calls for the optimal position of platforms, CMS provides options for leveraging higher fidelity models that are capable of computing network communications paths and options to use an algorithm such as Terrain Integrated Rough Earth Model (Eppink, 1994).

Data as a Service (DaaS): DaaS will utilize comprehensive models representing the operational environment, establish standards and formats of databases, and make existing modeling data and metadata accessible across the M&S Enterprise.

Other services planned to be available in the future are the: Filtering Service (FS), Marshaling and Demarshaling Service (MaDS), Transport Service (TS), Electronic Warfare as a Service (EWaaS), and Precision, Navigation, and Timing as a Service (PNTaaS).

MSaaS Service Generation from Conceptual Models

The model services within an MSaaS environment consist of two primary components: the underlying mathematical model(s) and the simulation services which orchestrate these model(s) and connect them within the simulation environment, (Mannaert, 2023). Each of these needs to be represented using conceptual models that enable the full business logic of that layer to be captured. As a result, organizations with expertise in the processes being modeled directly create and maintain the mathematical representations while organizations with expertise in the overarching simulation environment create and maintain the orchestration, translation, and protocol connection layer. This approach improves the accuracy of the models and the resultant orchestrated services. Coupled with a code generation capability, it also allows them to evolve in a more agile and maintainable manner and be kept current with the simulation environment as state-of-the-art technologies change over time.

This breakout of the MSaaS services matches well with the capabilities of the tool chains described above. Each tool captures the system at the conceptual level allowing for a model-driven approach to developing software. DEVCOM SC STTC has created a research project for code generation simulation models called Generative Programming (GenProg). The resultant toolset (McGroarty, 2021) is specifically geared towards the development of physical / mathematical models and their associated logic. Numerous US Army models have already been developed and used in various simulation systems. DEVCOM SC STTC worked with a Belgium-based company, NSX who has developed a system that allows for the conceptual modeling of complex software systems, along with meta-programming, to generate and evolve the system over time. The approach is particularly well suited for the orchestration and integration of physical / mathematical models into simulation environments. To investigate the use of these technologies to generate working simulation models within an MSaaS environment, DEVCOM SC and NSX Normalized Systems partnered up to embark on a research experiment, which is described in the subsequent section.

Demonstration of Conceptual Modeling Approach

To investigate the use of GenProg and the NSX toolset for creating an MSaaS service, we decided to use physical / mathematical models that work together and deploy them as a single service that can be utilized by an entity simulation communicating over a standard simulation protocol (Mannaert, 2023). This service allows us to explore how well the conceptual modeling supports various aspects of an MSaaS service, including:

- Specifying model data structures, inputs, and outputs
- Implementing model business logic
- Orchestrating multiple models and maintaining associated state
- Translating simulation object model data to and from mathematical model data types
- Connecting to the simulation protocol services

The first two aspects were handled by the GenProg research tool while the last three were handled by the NSX tool. For the models, we chose a combination of a Human Exhaustion model based on Pandolf's equations (Drain, 2017) and augmented that with a newly created Entity Load model. The NSX tool represented and implemented the orchestration of the two models working together. For the entity simulation, we chose the Rapid Integration and Development Environment (RIDE) (Hartholt, 2021), which provides an extensible three-dimensional (3D) simulation environment leveraging game-based technologies and contains several scenarios that could leverage the exhaustion service data. For the communications component, we used the WebLVC (Granowetter, 2013) standard along with a simple custom object model.

Each model was implemented using a similar Application Programming Interface (API) with an initialization and update routine. Figure 8 shows the update routine for the exhaustion model in PyFlow (the authoring tool for GenProg). In the case of the exhaustion model, a lower-level model contains the model logic and is imported into this model supporting the desired API. This allows for experimentation with the model interface without needing to duplicate the underlying logic. This design pattern helped simplify the integration of the model into the Human Exhaustion Service.

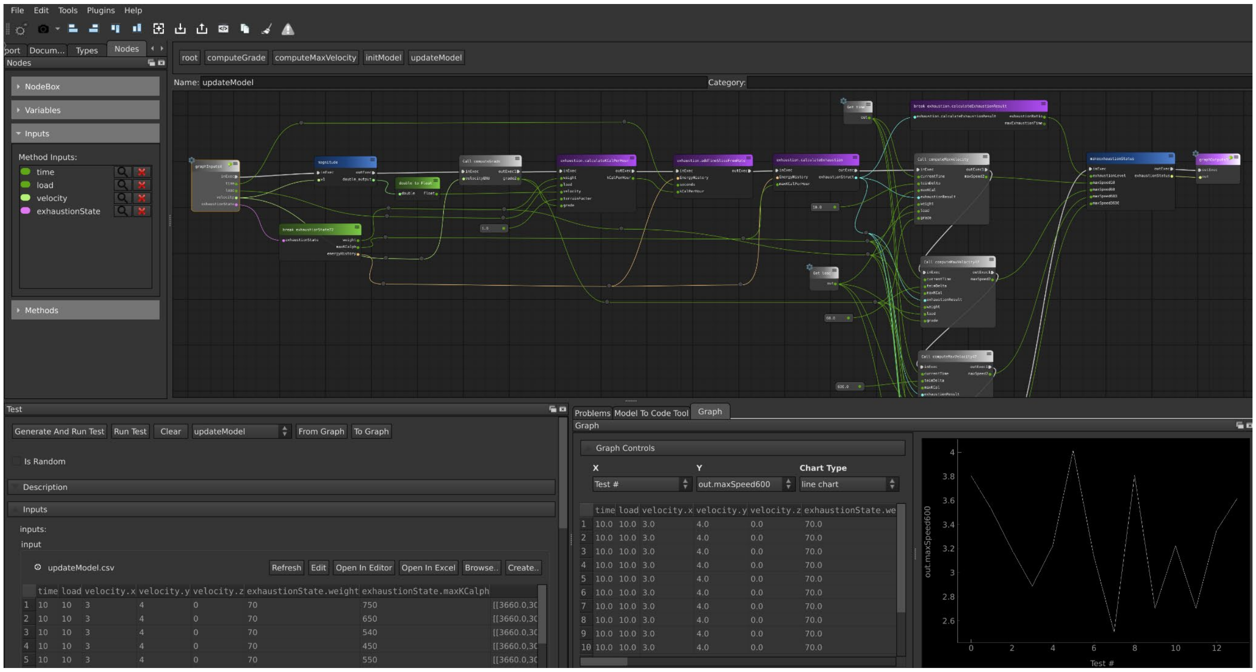

Figure 8. Human Exhaustion Model Update Routine

To provide abstract and reusable messages, an interoperation library was used in both the NSX service and RIDE. The interoperability library provides interfaces to connect and interact with the messaging layer. It also provides an adapter for the WebLVC connection.

Generation of MSaaS services

To orchestrate the simulations, translation, and protocol connection layer, a new Java Enterprise Edition (JEE) application was generated. This application runs in a stateful way so that the simulations are run in the correct order and the data is kept up to date over the WebLVC communication protocol. The GenProg tool code generated working physical / mathematical models to compiled, working software. The NSX toolset code generated a working service that connects to the middleware protocol and orchestrates the workflow to execute the GenProg generated models based on a conceptual model of both the service framework as well as the underlying physics model.

The ability to code generate M&S services based on conceptual models into any programming language and interoperable with any middleware protocol is a massive and practical step towards M&S as a Service. If we can move towards the authoring and management of conceptual models and then code generate software, we can move away from large monolithic simulation applications that are difficult to manage towards a more agile, model-driven service-oriented simulation environment. We introduced this paper by stating that the six separate M&S communities all have their own models and simulation applications. We believe that by moving towards a conceptual model and generative programming paradigm, the M&S communities can share and reuse their models across simulation environments and quickly evolve as the industry's simulation middleware technologies evolve.

SUMMARY

The US Army and its partners have made significant strides in the research, development, test, and demonstration of simulation capabilities as part of a MSaaS architecture concept. Traditional methods for acquisition, implementation, and deployment of simulation capabilities do not meet emerging requirements for a more integrated joint, multi-domain, and multinational training needs. Legacy M&S capabilities are laboriously designed with complexity, carry a large hardware footprint, are man-power intensive, and are costly to upgrade and sustain. The collaborative nature within the M&S community is a testament to embracing modern technologies that deliver capability rapidly and with less complexity in post-development integration or re-engineering. The future state of modeling and simulation will require this continued collaboration to achieve agility, scalability, and a more distributed environment through an *as-*

a-service framework to deliver an MSaaS environment, future constructive simulation services, and service code generation from conceptual models, which will provide consistent model implementation across simulation environments that are easier to manage, quicker to deploy, and customizable for any scenario.

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