1. Overview
This project overview describes ongoing research and development using a transformational analytical modeling framework. Web services are used in an innovative way to connect multiple model components in a flexible, scalable, extensible architecture. Following the strategic trajectory of the XMSF effort, this work starts first with functioning exemplars, then progresses to supporting tools, and then steps up to world-class modeling challenges, analysis and results.

Key sources of functionality for these efforts include:
- SimKit discrete event simulation application program interface (API) developed by the Naval Postgraduate School (NPS),
- Combat XXI under development by the Army and Marine Corps at the Army TRADOC Analysis Center (TRAC), White Sands, which already incorporates SimKit,
- Naval Simulation System (NSS) developed by SPAWAR Systems Center, San Diego.

The following projects are being performed in 2004 for U.S. Navy CNO staff, specifically OPNAV N81, as portions of the World-Class Modeling (WCM) family of projects. The first three projects are establishing web-services interoperability and logical connectivity between existing systems: SimKit/CombatXXI, Naval Simulation System (NSS) and the X3D-based Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) model archive. The final two projects will conduct advanced analysis using this set of hybrid discrete-event simulation (DES) tools.
- WCM-14: Special Operations Forces (SOF) Modeling (Detailed) for PR-07
- WCM-16: SAVAGE to Model Force Protection/Anti-Terrorism Modeling for PR07
- WCM-28: Analytical Workbench for Simkit Modeling
- WCM-19: Improve Strike Module (Detailed) in Combat XXI for PR07
- WCM-15: Joint Forcible Entry Options (JFEO) Modeling in Combat XXI for PR07

Effective hybrid analysis taking advantage of the integration of components from these sources will provide demonstration of a broad, joint set of warfare capabilities. All work will reflect precepts of the XMSF program, utilizing Internet technologies and Web services for common data representations, semantics, protocols, and interchange. This work is expected to lead to application of the new analytical modeling capabilities to operational problems of interest that demonstrate the repeatable, scalable benefits of this technical approach.

Technology overviews and project summaries follow. Questions and comments are welcome.
2. **Background**

The Office of the Secretary of Defense (OSD) has identified a new Analytical Agenda seeking to transform the way the Department of Defense applies Modeling and Simulation (M&S) to challenges of today’s warfighters. Primary focus areas of the analytical Agenda are:

- Service/Agency POM Development
- Studies: Program Budget Review, Defense Planning Guidance (DPG), Analyses of Alternatives (AOA)
- Capabilities-Based Future Force Planning and Future Requirements

The 2001 Quadrennial Defense Review (QDR) defined Capabilities-Based Planning, stating it “shifts the focus of U.S. Force planning from optimizing for conflicts in two particular regions -- Northeast and Southwest Asia – to building a portfolio of capabilities that is robust across the spectrum of possible force requirements, both functional and geographical.” To support this concept, tools are needed that enable analysts to examine a wide range of variability in priority Red, Blue, and Green factors, in order to achieve a broad portfolio of military capabilities that will perform robustly in an uncertain future environment and that are linked to Joint Concepts of Operations. This requires a new class of M&S capabilities, moving away from monolithic, closed system designs to open, M&S frameworks that permit modular, loosely coupled components to be rapidly integrated to create agile analytical capabilities to address the variety of missions conducted by today’s warfighters. These tools must be flexible, extensible, scalable to a variety of scales of combat, re-usable, executable in a desktop/laptop environment, convenient to use, able to exploit the best methods (functionality) available in various domains, and not bound to traditional approaches to combat modeling but able to model future concepts and to provide a framework for introducing wholly new concepts of warfare.

The pattern for success in this transformational endeavor is the Internet and World Wide Web. This computational environment has shown the capability to scale to global dimensions by providing a low cost-of-entry through establishment of standards for exchange of information across any platform and operating system. Recent emergence of the Extensible Modeling and Simulation Framework (XMSF) program from the Defense Modeling and Simulation Office (DMSO) reflects the desire to exploit the great success of Internet technologies, and the massive commercial investment in the advance of those technologies, to meet DoD M&S requirements across analysis, training, acquisition, and experimentation. XMSF is defined as a composable set of standards, profiles, and recommended practices for web-based M&S. The foundational precept is that Internet technologies, including Extensible Markup Language (XML) based languages and service-oriented architectures (e.g., Web services), will enable a new generation of distributed M&S applications to emerge, develop, and interoperate.

3. **Scope**

Paramount project objectives are to produce a new dynamic for analytic capabilities by connecting diverse analytic tools using Web services. This effort involves software analysis, design, and development to review and upgrade existing code bases (SimKit and NSS) leading to integration of functional capabilities with the SimKit-based Combat XXI simulation. The effort also requires design and conduct of analyses addressing specific operational problems. Tasking requires expertise in Operations Research, SimKit Discrete Event Simulation software package, the NSS code base, along with the establishment and management of Open Source software archives for long-term viability.
Simkit Discrete Event Simulation (DES) Overview

WHAT IS SIMKIT?

- A package (API) for easily creating Discrete Event Simulation (DES) models
- Written in Java, runs on any Java 2 platform and modern web browsers
- Open Source
- Installable from the web
- Small execution footprint
- Simkit is the simulation engine for Combat XXI, the Army’s next-generation premier ground combat simulation (replacing CASTFOREM)

WHAT ARE THE ADVANTAGES OF SIMKIT?

- Based on Event Graph Methodology, the simplest and most flexible formalism for DES modeling
- Supports component-based simulation modeling (LEGO Framework)
- Extremely flexible and extensible
- Allows separation of model constructs from data gathering without compromising ability to estimate Measures of Effectiveness (MOEs)
- Formalism ensures that any possible MOE can be estimated from properly constructed model
- Use of listener patterns supports very loose coupling of components
- Wide range of situations capable of being modeled in Simkit
EXAMPLE SIMKIT MODELS

Several example excerpts are presented that are representative of the diversity of Simkit capabilities.

The following is an Event Graph representation of a “Mover Manager” component that controls the behavior of a patrol boat that is protecting a high-value unit against a terrorist attack on a waterfront (Childs, 2002).

PBMM(TypedBasicMover m, Vector v)

-Conditions:
  A: if “m” patrolling and has another way point in “v,” its waypoints vector
  B: if m patrolling but has no more waypoints in its patrol pattern or m has finished an intercept and there are no other immediate threats
  C: if m patrolling but needs to intercept—this cancellation is executed automatically through a “stop” command given by the PBController
  D: if not patrolling (i.e. completing an intercept)
  E: if not patrolling (i.e. completing an intercept) and ordered to intercept another target immediately

The formal descriptions represented in the above simulation graph diagram also map directly to software model instantiations using the Simkit library. Looking ahead, we expect to produce an integrated development environment which provides a visual simulation graph editor. This tool will also load/save/edit such models via an XML file format, run simulations, allow distributed operation, provide statistics and plotting support, and enable debug/diagnosis operations.
The following image is a screenshot from an animation of the scenario. The various entities are each controlled by a distinct set of behaviors specified by their own “Mover Manager.” Since the animation is very loosely coupled with the simulation model, the same model is used both for display of individual runs as well as for batch runs in non-graphical mode for analysis.

Yet another example of Simkit’s use in unconventional settings is a model of peacekeeping operations in an urban environment. What makes such situations challenging for traditional DoD wargaming models is that the measures of performance are often inverted. For example, instead of attempting to maximize enemy casualties, peacekeeping operations seek to minimize casualties of the antagonists. The following is a screenshot from an agent-based model of peacekeeping operations written in Simkit (Erlenbruch, 2002):
Agent-Based Model of Urban Peacekeeping (Erlenbruch, 2002)

SOME RECENT NPS THESES USING SIMKIT

MARGOLIS, MICHAEL, Captain, U.S. Marine Corps, “Operational Availability and Cost
Trade-Off Analysis for the Multi-Mission Maritime Aircraft,” MS in Operations Research,
September 2003.

NAWARA, TERRENCE, LT U.S. Navy, “Tactical Route Planning for Submarine Mine
Detection and Avoidance,” MS in Operations Research, September 2003, Advisor: Steven E.
Pilnick.

FUTCHER, FRANK W., Lieutenant Commander, USN, “Selective Offload Capability
Simulation (SOCS): An Analysis Of High Density Storage Configurations,” MS in


CHILDS, MATTHEW D., Lieutenant Commander, USN, “An Exploratory Analysis of Water
Front Force Protection Measures Using Simulation,” MS in Operations Research, March
2002.

ERLENBRUCH, THOMAS, Captain, German Army, “Agent-based Simulation of German
Peacekeeping Operations for Units up to Platoon Level,” MS in Operations Research, March
2002.
Naval Simulation System (NSS) Overview

WHAT IS THE NAVAL SIMULATION SYSTEM (NSS)?

- Computer-based framework for C4ISR-centric multiwarfare simulation
- Constructive, analytical simulation model of naval theatre operations supporting:
  - Naval and Joint operations planning and decision support
  - C4ISR analyses/assessments
  - Fleet exercises and experiments
  - Fleet training
- Representation of surface, subsurface, air, ground, and space assets
- Intended to provide valid warfare models, certified data to populate the models, simulation capability to execute the models over time, and support tools to assist user in scenario setup and analysis of results
- Program Management: NAVAIR under sponsorship of CNO (N6M) and COMPACFLT (N64).
- Prime Development Contractor: Metron, Inc., Solana Beach CA
- Support and V&V Contractor: Rolands & Associates Corporation, Monterey CA
- Under development since 1994 and used for numerous analysis support efforts for the Fleet and DoD acquisition communities
- Written in C++, runs on any PC under Windows
- Allows configuration of multiple “study nodes” on a network for distributing replications to multiple machines

PRIMARY SOFTWARE COMPONENTS

- NSS Client Applications. Permit user visualization and control of system processes, including simulation instance development, scenario plan development, interactive execution, batch run management, and post-processing. Includes:
  - COA Analysis Tool (CAT). Facilitates detailed, comprehensive NSS scenario file generation. Provides maximum user flexibility in accessing simulation capabilities.
  - Warfare-Specific Support Tools. A set of focused tools for Fleet warfare plan evaluation: Strike Warfare Decision Aid to develop candidate Master Air Attack Plan; Targeting Management System to generate the strike target list; Theater Missile Defense COA Support Tool to evaluate TBMD RECCE plans.
  - CAT Demo Tool. For playback presentation of completed simulation event streams to analysis decision makers.
  - Network Monitor. To facilitate user monitoring and override control of NSS network activities.
  - Database Modernizer. Converts older versions of the NSS database to the most current format, thus making them compatible with the current software version.
  - Configuration Editor. Used to determine the current NSS installation configuration.
  - NSS Server. Manages NSS simulation execution resources on the local area network (LAN). Coordinates network access to the NSS Database by NSS Clients and Model Engine Nodes.
• NSS Model Engine Node. Parses and executes user defined simulation scenarios as directed by the Server. Generates scenario event stream, MOE output data, and execution status. Installed as a module on one or more network machines.

• NSS Database. Contains persistent and volatile data constructs that are processed by the NSS Server, Clients, and Model Engine Nodes. The NSS Database resides within the OODBMS Server (see Required COTS Software below).

![NSS map view and status screen during model execution of a user-defined scenario](image)

• Commercial Off-the-Shelf (COTS) Software
  o Database Management System Server. Contains the NSS Database. Interfaces exclusively with DBMS Clients. Note: NSS development to date has been tightly coupled with ObjectStore OODBMS.
  o Database Management System Client. Facilitates NSS component access to the NSS Database via the DBMS Server. Note: NSS development to date has been tightly coupled with ObjectStore OODBMS.
  o Spreadsheet Application. Facilitates automated manipulation and presentation of NSS interaction table input data and MOE output data. Note: NSS development to date has been moderately coupled with Microsoft Excel.
  o Word Processor. Used to generate preformatted Software Change Requests (SCRs). Note: NSS development to date has been loosely coupled with Microsoft Word.
  o Mathematical Optimization Application. Used in conjunction with NSS optimization code to provide plan recommendation services. Used by the warfare-specific support tools. Note: Currently, NSS optimization services are provided using the COTS GAMS linear and integer programming (LP/IP) solver package.
SOME RECENT NPS THESES USING NSS

Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) Overview

WHAT IS SAVAGE?

- A library of military 3D models, authoring tools, physics-based models and scenarios

Hundreds of scenarios and projects can be rapidly modeled using the SAVAGE 3D library.

The SAVAGE library has been used for reconstruction of real-world events such as the terrorist bombing of the USS Cole in Aden Harbor (top row), the USS Greeneville/Ehime Maru collision (far right, second row above), as well as for Autonomous Underwater Vehicle (AUV) mission planning and visualization (left and middle pictures, second row) and for visualization of Joint Experimentation Limited Objective Experiment scenarios (bottom row).
The SAVAGE library of models: http://web.nps.navy.mil/~brutzman/Savage/contents.html

WHAT ARE THE BENEFITS OF SAVAGE?

- Over eight hundred open source 3D models, physics-based models, model components, authoring tools, and scenarios to facilitate rapid development of immersive, interactive, and dynamic Web-based scenes
- Models are readily incorporated into applications built using the Xj3D open source implementation of the X3D standard, freely available for use in building Web-based 3D applications
- Extensive and consistent documentation in all model files
- Continuing expansion of the library through model submissions from beginning and advanced X3D courses (MV3204 and MV4205)
- Models and tools have been used for detailed reconstruction of real-world events such as the USS Greeneville and Ehime Maru collision and the terrorist bombing of the USS Cole in Aden Harbor

SOME RECENT NPS THESES USING SAVAGE


NEUSHUL, JAMES, CAPT USMC, “Interoperability, Data Control and Battlespace Visualization using XML, XSLT and X3D,” MS in Computer Science, September 2003.


Extensible Modeling & Simulation Framework (XMSF) Overview
http://www.movesinstitute.org/xmsf/xmsf.html

WHAT IS XMSF?

- The Extensible Modeling and Simulation Framework (XMSF) provides the technical basis for transformational interoperability via XML interchange, profiles, and recommended practices for web-based modeling & simulation.

- Broad technical interoperability is provided by open standards, XML-based markup languages, Internet technologies, and cross-platform Web services.

- Supports diverse distributed modeling and simulation applications. Also enables simulations to interact directly and scale appropriately over a distributed network through composable and reusable model components.

- Employs mainstream practices of enterprise-wide software development.

- Provides support for all types and domains of modeling and simulation (constructive, live, virtual, and analytical).

- Excellent support for ISO Extensible 3D (X3D) Graphics Specification with industry-academic-government activity in multiple standards consortia

WHAT ARE THE ADVANTAGES OF XMSF?

- Supports Open Standards in Web, Internet, and XML technologies. Web services allow self-validating syntax and semantics to achieve cross-cutting interoperability in modeling and simulation.

- Development and acceptance of common data and metadata standards provides semantic consistency among systems and services.

- Profiles are specification suites based on international standards, which define common capabilities for content production user/application support.

- Data-driven conversion capabilities and application ubiquity provides both best business case and best technical case on a DoD-wide scale.
WCM-14 Special Operations Forces (SOF) Modeling Project

Intended Outcomes

- **Framework Definition:** Assess existing programs and capabilities. Identify capabilities of SimKit, NSS, and Combat XXI.

- **Standards Identification:** Identify specific standards to be applied to the program, focusing on research directions of the XMSF project and warfare information modeling efforts such as the Battlespace Management Language (BML) and Battlespace Generic Hub. Define the basis for information interchange.

- **Design and Develop Baseline Model Framework:** Create the initial architectural framework for the analytical model, designing functions for input display, scenario construction, data extraction, and display of results. Integrate selected NSS C4ISR and Naval warfare functional capabilities with Combat XXI ground engagement functionality.

- **Demonstration Scenario:** A FORCEnet scenario will be designed and implemented using functional components within the new framework. The demonstration will be a notional SOF scenario that measures the contribution of C3 links to the mission and a Fires network to support Joint ops ashore.
WCM-16 SAVAGE for Force Protection/Anti-Terrorism (AT/FP) Modeling

Intended Outcomes

- **Requirements Analysis and Software Design:** Working with N81 analysts, determine functional capabilities needed to explore FP/AT problems of interest to N81. Perform software design to modify and expand capabilities of the NPS planning tool to meet required capabilities for the studies.

- **Software Implementation and Test:** Implement and test software modifications to the NPS FP/AT planning tool. Demonstrate new and enhanced capabilities of the model to perform desired studies. Work will include upgrading the implementation to use the SimKit discrete event simulation library.

**Problem Definition, Scenario Development, Model Execution and Analysis:** Perform systems analysis to specify the analysis question, identifying the setting, threat and force protection characteristics to be studied. Identify various options to be investigated and design experiments to be run. Determine an appropriate operational setting for the study. Input necessary force structures, weapons characteristics, initial conditions, and other database and scenario initialization data needed to represent the scenario in the model. Conduct necessary model replication runs to obtain statistical data supporting analysis of results. Prepare a document describing the analysis problem, experimental design, scenario and model outcomes, with lessons learned and recommendations for further study.
WCM-28 Analytical Workbench for Simkit Modeling Project

Intended Outcomes

- **Model Capture and Upgrade:** Gather previously developed models from student theses and faculty research that used the SimKit software. Update those implementations for the current version of SimKit. Create a unified repository of the source code and model components with annotations facilitating access and use by an automated simulation development tool. Prepare a summary document describing the model capabilities collected into the repository. For example, simulations developed in the following student theses are candidates for the repository of models:
  
  - ERLENBRUCH, THOMAS, Captain, German Army, “Agent-based Simulation of German Peacekeeping Operations for Units up to Platoon Level,” MS in Operations Research, March 2002.


**Analytical Simulation Workbench:** Design and develop a prototype Analytical Simulation Workbench to access the repository of model components and to assist the user in composing a simulation model from the existing components. Prepare a guidebook describing use of the Workbench to develop a simulation. Provide demonstration of the prototype workbench.

**Final Report:** Prepare a final report describing the design and development of the Analytical Simulation Workbench and providing a guidebook for use of the Workbench.
WCM-15 Joint Forcible Entry Options (JFEO) Modeling In Combat^{XXI}

Intended Outcomes

- **Problem Definition and Experimental Design:** Perform systems analysis to specify the analysis question, identifying the system and force characteristics to be studied. Identify various options to be investigated and design experiments to be run. Prepare a document defining the analysis to be performed.

- **Scenario Development:** Determine an appropriate operational setting for the study. Input necessary force structures, initial conditions, command relationships, communications characteristics and other database and scenario initialization data needed to represent the scenario in the integrated NSS/Combat^{XXI} model. Coordinate with NSS-specific scenario developers to ensure consistency in representations of the battlespace for the study. Prepare a scenario description document.

- **Model Execution and Analysis:** The ability to conduct a full study with the integrated NSS/Combat^{XXI} model is dependent on successful completion of the WCM-14 tasking (SOF Modeling for PR-07). Preparations for conducting the study can proceed as described above in Tasks 1 and 2 in parallel to software development efforts. A key checkpoint in the progress of the development effort and readiness of the software to support this study will occur in June 2004 during the Military Operations Research Society (MORS) Symposium to be held at NPS, Monterey CA. Based on the progress of the development effort, N81 will decide on the direction for continuation of this task (WCM-15); either:
  
  - Demonstration of the designed scenario with identification of shortcomings in the integrated framework that need to be addressed before it can be employed for the full study, or
  - Execution of the study by conducting necessary model replication runs to obtain statistical data supporting analysis of results. Prepare a document describing model outcomes, with lessons learned and recommendations for further study.
WCM 19: Improve Strike Module in Combat^{XXI} for PR07

Intended Outcomes

- **Problem Definition and Experimental Design**: Perform systems analysis to specify the analysis question, identifying the system and force characteristics to be studied. Identify various options to be investigated and design experiments to be run. Prepare a document defining the analysis to be performed.

- **Scenario Development**: Determine an appropriate operational setting for the study. Input necessary force structures, initial conditions, command relationships, communications characteristics and other database and scenario initialization data needed to represent the scenario in the integrated NSS/Combat^{XXI} model. Coordinate with NSS-specific scenario developers to ensure consistency in representations of the battlespace for the study. Prepare a scenario description document.

- **Model Execution and Analysis**: The ability to conduct a full study with the integrated NSS/Combat^{XXI} model is dependent on successful completion of the WCM-14 tasking (SOF Modeling for PR-07). Preparations for conducting the study can proceed as described above in Tasks 1 and 2 in parallel to software development efforts. A key checkpoint in the progress of the development effort and readiness of the software to support this study will occur in June 2004 during the Military Operations Research Society (MORS) Symposium to be held at NPS, Monterey CA. Based on the progress of the development effort, N81 will decide on the direction for continuation of this task (WCM-15); either:
  - Demonstration of the designed scenario with identification of shortcomings in the integrated framework that need to be addressed before it can be employed for the full study, or
  - Execution of the study by conducting necessary model replication runs to obtain statistical data supporting analysis of results. Prepare a document describing model outcomes, with lessons learned and recommendations for further study.
A Transformational Framework for Design, Development, and Integration of Simulation Models

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A new class of Modeling and Simulation (M&S) capabilities is needed to support transformational studies and analyses. Software architectures for analytical M&S tools need to move away from monolithic, closed system designs to open, M&S frameworks. New frameworks are needed to permit modular, loosely coupled components to be rapidly integrated to create agile analytical capabilities that can address the variety of missions conducted by today’s warfighters. Tools built on these frameworks must be flexible, extensible, scalable to a variety of levels of combat, re-usable, executable in a desktop/laptop environment, convenient to use, able to exploit the best methods (functionality) available in various domains, and not bound to traditional approaches to combat modeling but able to model future concepts and to provide a framework for introducing wholly new concepts of warfare.

The Extensible Modeling and Simulation Framework (XMSF) is a composable set of standards, profiles, and recommended practices for web-based M&S that has been emerging as a framework capable of supporting these capabilities. This paper presents an architectural framework for design, development, and integration of simulation models built on XMSF using two existing simulations: Naval System Simulation (NSS) and Simkit. The capabilities will be demonstrated by a web-based simulation model composed using C4ISR elements from NSS together with land-based units from Simkit. The framework provides the needed flexibility with its use of standards suggested by XMSF, especially the exclusive use of Extensible Markup Language (XML) for data transfer. This ensures that additional components can be easily added to the framework without requiring substantial internal modification. This framework therefore illustrates the ability to achieve the requirements for M&S listed above.

Submitted to 72nd MORS Symposium, WG 31 Computing Advances in Military Operations Research
NSS, Simkit, and Combat\textsuperscript{XXI} using XMSF Web Services for Joint Modeling and Analysis

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The elements of SEAPOWER 21...Sea Strike, Sea Shield and Sea Basing...commit the Navy to building, training and operating a force that maximizes the contribution of war winning capabilities in the joint battlespace anytime, anywhere. Tying the three pillars of SEAPOWER 21 together is FORCEnet. FORCEnet is the operational construct and architectural framework for naval warfare in the information age, integrating warriors, sensors, command and control, platforms, and weapons into a networked, distributed and joint combat force. SEAPOWER 21 will be implemented by a Global Concept of Operations (GLOBAL CONOPS) that will provide our nation with widely dispersed combat power from platforms possessing unprecedented joint warfighting capabilities.

The study measures the impact of FORCEnet, improved C4ISR, Seabased forces, SeaStrike and the other pillars of SEAPOWER 21 on the joint ground warfight. It utilizes the improved joint modeling capability based on a composite model using Naval Simulation System (NSS) for sea strike and the Combat\textsuperscript{XXI} to model the ground combat. The models are linked using the Extensible Modeling and Simulation Framework (XMSF), which utilizes web services. This implementation is an examplar for a transformational framework for design, development, and integration of simulation models, a larger effort to provide modeling and simulation interoperability using principles of XMSF.

Submitted to 72\textsuperscript{nd} MORS Symposium, WG 29 Modeling Simulation and Wargaming
Simkit Analysis Workbench for Rapid Construction of Modeling and Simulation Components

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A recurring dilemma in the use of simulation models for analytic support of decision-making has been the length of time required to build the simulation model. Although emerging simulations have improved over legacy models, the problem persists. It is particularly difficult to create a simulation model using existing tools that captures only the desired elements affecting the performance measures to be studied. Additionally, there is often a lack of rigorous methodology underlying the model’s design.

Simkit is an Object-Oriented API for creating discrete Event simulation (DES) models in Java. Based on a solid Event Graph methodology, Simkit has been used to quickly create models in a wide range of areas, including logistics and operational support, undersea models, and models that evaluate algorithms for allocation of weapons and sensors to targets in ground combat. Simkit’s component-oriented approach facilitates the composition of models using some pre-built and some custom simulation components.

This work demonstrates a Graphical User Interface (GUI) for the creation and analysis of Simkit models. It utilizes XML to represent the components, so there is built-in interoperability with many other tools. Specifically, simulation components and models designed in this manner will be capable of interacting with models with Extensible Modeling and Simulation Framework (XMSF) capabilities. In component design mode, a new component is created by drawing the Event Graph and filling in parameters, so that the simulation modeler need not be a sophisticated programmer. In component construction mode, components are hooked together to create a model. In analysis mode, the models are exercised and run according to the desired experimental design. The workbench also has a number of examplar models that have been extracted from recent NPS Master’s Theses.

Submitted to 72nd MORS Symposium, WG 26 Analysis of Alternatives