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MODELING, SIMULATION, AND VISUALIZATION FOR SUBMARINE TRANSIT SECURITY AND COAST GUARD CONTINGENCY PREPAREDNESS

by

Marlon Heron

June 2015

Thesis Advisor:	Don Brutzman
Second Reader:	Terry Norbraten

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13. ABSTRACT

The U.S. Navy's Strategic Systems Program (SSP) and the U.S. Coast Guard (USCG) Maritime Force Protection Unit (MFPU) have a close working relationship, access to advanced Modeling and Simulation (M&S) tools, and a mutual interest in the safe escort of naval submarines. The USCG Contingency Preparedness and Exercises (CPE) Branch has a strong interest in maritime security, which extends to the safe navigation of vessels in U.S. territorial waters, including naval submarines. CPE rarely interacts with SSP and the MFPU; further, CPE does not have access to modern M&S tools.

The goal of this thesis is to demonstrate that SSP and MFPU can greatly increase maritime security in the littoral waterways used by submarines and other naval vessels by partnering with CPE.

A mixed method approach was used to provide an overview of existing maritime security roles and partnerships, and a 3D-simulation experiment was also developed to demonstrate how CPE can enhance exercises by utilizing robust 3D M&S resources.

This thesis establishes that CPE can drastically improve maritime security and other missions by leveraging M&S and Visualization tools. The thesis also found that by partnering with SSP and the MFPU, CPE can accelerate maritime security improvements.

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MODELING, SIMULATION, AND VISUALIZATION FOR SUBMARINE TRANSIT SECURITY AND COAST GUARD CONTINGENCY PREPAREDNESS

Marlon Heron
Lieutenant, United States Coast Guard
B.S., Roosevelt University, 2004

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Author: Marlon Heron

Approved by: Dr. Don Brutzman
Thesis Advisor

Terry Norbraten
Second Reader

Dr. Dan Boger
Chair, Information Sciences Department

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This thesis establishes that CPE can drastically improve maritime security and other missions by leveraging M&S and Visualization tools. The thesis also found that by partnering with SSP and the MFPU, CPE can accelerate maritime security improvements.

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LIST OF ACRONYMS AND ABBREVIATIONS

2D	Two Dimension(al)
3D	Three Dimension(al)
ADIOS 2	Automated Data Inquiry for Oil Spills, Version 2
AI	Artificial Intelligence
AIS	Automatic Identification System
aka	Also Known As
ALOHA	Areal Locations of Hazardous Atmospheres
AM	Additive Manufacturing
AMIO	Alien Migrant Interdiction Operations
Ammo	Ammunition
AMS	Area Maritime Security
AMSP	Area Maritime Security Plan
AOR	Area of Operation
AT/FP	Anti-Terrorism / Force Protection
AtoN	Aids to Navigation
AUVM	Autonomous Unmanned Vehicle Workbench
C2	Command and Control
CAC	Common Access Card
CAD	Computer Aided Design
CBP	Coastal Patrol Boat
CG-CPE	(U.S.) Coast Guard Contingency Preparedness and Exercise
CI/KR	Critical Infrastructure and Key Resources
CONOPS	Concept of Operations
COOP	Continuity of Operations
COTS	Commercial Off-the Shelf
COVE	Conning Officer Virtual Environment
CPE	Contingency Planning Exercise
CPPM	Contingency Planning and Preparedness Manual
CUI	Controlled Unclassified Information
DDG	Guided Missile Destroyer

DES	Discrete Event Simulation
DHS	Department of Homeland Security
DIS	Distributed Interactive Simulation
DOD	Department of Defense
DOE	Design of Experiment
EST	Exercise Support Team
FAS	Federation of American Scientists
FBM	Fleet Ballistic Missile
FMBT	Full Mission Bridge Trainer
FMSC	Federal Maritime Security Coordinator
FOUO	For Official Use Only
GNOME	General NOAA Operational Modeling Environment
GPS	Global Positioning System
GTS	Generic Training Station
GUI	Graphical User Interface
HAZMAT	Hazardous Material
HLA	High Level Architecture
HTML	Hypertext Markup Language
HTMLS	Hypertext Markup Language Secure
HVU	High Value Unit
HWII	Hello World Indian Island
IAW	In Accordance With
ICS	Incident Command System
IEEE	Institute of Electrical and Electronics Engineers
IJ	Investment Justification
IOS	Instructor Operations Console
IRB	Institutional Review Board
IT	Information Technology
JC3IEDM	Joint Command, Control, and Consultation Information Exchange Data Model
LOE	Limited Objective Experiment
LRF	Laser Range Finder

m	Meter(s)
M&S	Modeling and Simulation
MAR	Mixed Augmented Reality
MARPLOT	Mapping Application for Response, Planning, and Local Operational Tasks
Max	Maximum
MFPU	Maritime Force Protection Unit
MIL-STD	Military Standard
Min	Minimum
MLB	Motor Life Boat
MMOWGLI	Massive Multiplayer Online Wargame Leveraging the Internet
MOE	Measures of Effectiveness
MOP	Measures of Performance
MPH	Miles Per Hour
MSRAM	Maritime Security Risk Analysis Model
MVCS	Multiple Vessel Control Station
N/A	Not Applicable
NAVSEA	Naval Sea Systems
NAWCTSD	Naval Air Warfare Center Training Systems Division
NCP	National Contingency Plan
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NOFORN	No Foreign Nationals
NPS	Naval Postgraduate School
NSC	National Security Cutter
O/S	Operating System
OFAT	One-Factor-at-a-Time
OLED	Organic Light-Emitting Diode
ONR	Office of Naval Research
PATCOM	Patrol Commander
PCL	Property Change Listener
PDF	Portable Document Format

PISCES	Pollution Incident Simulation Control and Evaluation System
R&D	Research and Development
RBS	Response Boat-Small
RDC	Research and Development Center
Ret.	Retired
RHIB	Rigid Hull Inflatable Boat
ROSAM	Remote Operated Small Arms Mount
SAR	Search and Rescue
SAVAGE	Scenario Authoring and Visualization for Advanced Graphical Environments
SEA	Systems Engineering Analysis
SMAL	SAVAGE Modeling and Analysis Language
SME	Subject Matter Expert
SPC-LE	Special Purpose Craft-Law Enforcement
SPC-SV	Special Purpose Craft-Screening Vessel
SSBN	Ballistic Missile Submarine
SSGN	Guided Missile Submarine
StdDev	Standard Deviation
SWOS	Surface Warfare Officers School
SWS	Strategic Weapons Systems
TAML	Tactical Assessment Markup Language
TAO	Tactical Action Officer
TAP	Trajectory Analysis Planner
TCP	Terrorist Cell Planner
TPTS	Transit Protection Training System
TTP	Techniques, Tactics, and Procedures
U.S.	United States
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UNCLAS	Unclassified
USCG	United States Coast Guard
USG	United States Government

USN	United States Navy
USNR	United States Naval Reserve
UUV	Unmanned Underwater Vehicle
VOIP	Voice Over Internet Protocol
VR	Virtual Reality
WBIED	Water-Borne Improvised Explosive Device
WHEC	High Endurance Cutter
WMEC	Medium Endurance Cutter
WPB	Patrol Boat
www	World Wide Web
XML	Extensible Markup Language

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I. INTRODUCTION

A. OVERVIEW

Tracing back to primitive times, man has sought safety in numbers. Cavemen found it easier to gather food, to hunt, and to fend off predatory attacks in groups. Today, the United States Coast Guard (USCG), United States Navy (USN), and many agencies in the United States government (USG) are faced with new challenges—challenges such as, how to manage a growing set of responsibilities on shrinking budgets, and challenges that may reignite primal instincts to form groups, establish bonds, and develop partnerships. As man discovered in days of old, federal agencies today may also find solace and safety in numbers.

As the federal deficit skyrockets to new heights, budgetary spending in the Department of Homeland Security (DHS) and Department of Defense (DOD) have shriveled. Reduced funding does not equate to the diminished importance of ongoing military campaigns, nor is the mission of coping with the continuous challenges of combating crime and terrorism on United States (U.S.) soil minimized. Many agencies are being forced to look at alternative ways of completing their missions, while maintaining strict budgetary diets.

Collaborative ventures between the USCG and USN are important to counter the negative effects of having less to spend. Though the core mission sets of both services are largely different, the USCG and USN share a maritime nexus, have some common mission areas, have similar needs and thus will likely benefit from sharing capabilities and intellectual property. The USCG Maritime Force Protection Unit (MFPU) and the USN Strategic Systems Program (SSP) have forged an enduring partnership to facilitate the safe littoral transit of submarines. Separately, the USCG's Contingency Preparedness and Exercise (CPE) Branch facilitates a complementary layer of maritime security in accordance with the USCG's Area Maritime Security Plans (AMSP), which are regionally coordinated contingency plans. Due in part to the specialized nature of the SSP

and the MFPU mission, they rarely interact with USCG Area Maritime Security (AMS) planners or participate in traditional AMS drills or exercises.

Organizations are increasingly turning to technology for cost-friendly solutions to complex problems. Inter/Intra-agency collaboration is an effective way for the USCG and USN to share technology-based resources to enhance overall maritime security capabilities, while on leaner budgets. Technologies like modeling and simulation (M&S) hold the promise of providing cost-effective tools that can help the military in many functional areas. M&S tools focused on improvements in shared mission areas provide logically sound reasoning for collaboration. Consequently, SSP, the MFPU, and CPE, which oversees contingency preparedness, can logically benefit from M&S tools focused on refining the tactics, techniques, and procedures (TTPs) used in support of maritime security.

This thesis highlights how a strong collaborative partnership between the USCG Marine Force Protection Unit (MFPU) and the USN Strategic Systems Program (SSP), can be bolstered by leveraging CPE's capabilities. Since all three parties share mutual interests in safeguarding common sections of domestic waterways, this thesis also explores ways CPE can use existing USN M&S tools to offset the problem of scarce resources and improve maritime security. Towards these ends, an experiment illustrates how 3D M&S tools can be used to test the effectiveness of maritime security measures.

B. PROBLEM STATEMENT

The USCG MFPU and USN SSP rely on close collaboration to ensure the safe transit of Navy submarines through domestic waterways. Though they do not generally work directly with the MFPU or SSP, the USCG CPE has a stake in ensuring the safe transit of all vessels through navigable waterways. CPE's AMSP provides an additional layer of security for all vessels in U.S. coastal waterways, including submarines. As budgets decline, cuts in the areas of drills and exercises remain a strong possibility and can have an adverse effect on CPE's ability to conduct drills and exercises. Reduced exercise budgets may impact crucial programs like the AMSP and its maritime security focus. M&S tools developed by the USN may offer a solution.

This study examines the extent to which 3D M&S tools can be used to test and improve existing maritime security measures. By utilizing M&S tools, CPE has the potential to increase the variety of tests conducted annually, greatly increase the sheer number of tests, complement or augment future drills and exercises, and provide a more fiscally resilient method of maintaining force readiness.

C. OBJECTIVES

This thesis demonstrates and explores ways the USCG can partner with the USN to strengthen maritime security by establishing a working relationship between SSP, the MFPU, and CPE, in concert with integrating 3D modeling and simulation (M&S) tools into the contingency exercise program. Visualization of scenarios was used to illustrate each scenario alternative.

This thesis leverages M&S tools to explore their benefits in improving maritime security. The objective of this research is to create a low cost method to improve maritime security that is repeatable across a range of shared mission areas, can support long-distance collaboration, and can complement the existing USCG exercise program.

D. THESIS ORGANIZATION

Chapter II contains a high-level synthesis of literature on M&S from eleven resources: three foundational books and eight research documents. Chapter III details USCG interests related to maritime security and M&S. Chapter IV outlines the research methodology used for this research. Chapter V focuses on the results and analysis of the research experiment. Chapter VI, the final chapter, presents conclusions and recommendations based on this research effort. Annexes present additional information on Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) Studio, Operational Symbols of Military Units, and the Massive Multiplayer Online Wargame Leveraging the Internet (MMOWLI).

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II. LITERATURE REVIEW

A. TECHNOLOGICAL FOUNDATION OF MODELING AND SIMULATION (M&S)

1. Introduction

The three books referenced in this Literature Review discuss concepts and techniques that are common in the Modeling and Simulation (M&S) research projects referenced in this thesis, whereas elements of the seven research papers form the basis for this thesis.

2. "Theory of Modeling and Simulation" (Zeigler, 1976)

a. Brief Overview

In 1976 Bernard P. Zeigler (1976) authored the *Theory of Modeling and Simulation* (M&S) because he felt "theory [was] necessary to help bring about coherence and unity to the ubiquitous field of Modeling and Simulation (M&S)." Zeigler was motivated by a notion that the practice of M&S was pervasive; however, the concepts of model description, simplification, validation, simulation and exploration, could be isolated and abstracted.

Zeigler (1976) covered a broad range of topics for a diverse audience: from teaching students fundamental M&S concepts to filling in the gaps of advanced concepts for veteran practitioners. Zeigler sought to provide a perspective on why we model and simulate, in addition to discussing what can and cannot be achieved through M&S. The book provided a universal language for communicating the structure and behavior of models, and a platform for discussing mathematical systems theory as they relate to more specialized sciences, including computer science (Zeigler, 1976).

Concepts Zeigler discusses in 1976 are still relevant today. Zeigler highlights speed of performance as being one major benefit of using models based on Discrete Event Simulation (DES) as opposed to using time-oriented models, since DES models can rapidly advance through a series of events without time constraints. The DES

modeling architectural framework is commonly used in the naval research projects referenced in this Literature Review of this thesis (Zeigler, 1976).

b. Future Objectives

This early textbook stimulated a great many endeavors that continue to evolve today.

3. "Theory of Modeling and Simulation," 2nd Edition (Zeigler et al., 2000)

a. Brief Overview

Zeigler teamed with two other M&S professionals to follow-up on his original publication. This *Second Edition* was inspired by the notion that, "M&S lore is still fragmented across the disciplines making it difficult to share the advances, reuse other disciplines' ideas, and work collaboratively in multi-disciplined teams" (Zeigler, Praehofer, & Kim, 2000).

Following the September 1996 approval of the DOD's milestone High Level Architecture (HLA) standards, which established an interoperable framework for all DOD M&S projects, Zeigler's original book was merged with the contributions of two major M&S professionals into one book (Zeigler et al., 2000). The authors were also motivated by the belief that a widely accepted framework and theoretical foundation was still needed. The *Second Edition* was also written to synthesize various disciplinary fragments into cohesive wholes. The authors introduce the architecture for modeling and simulation in Figure 1 (Zeigler et al., 2000).

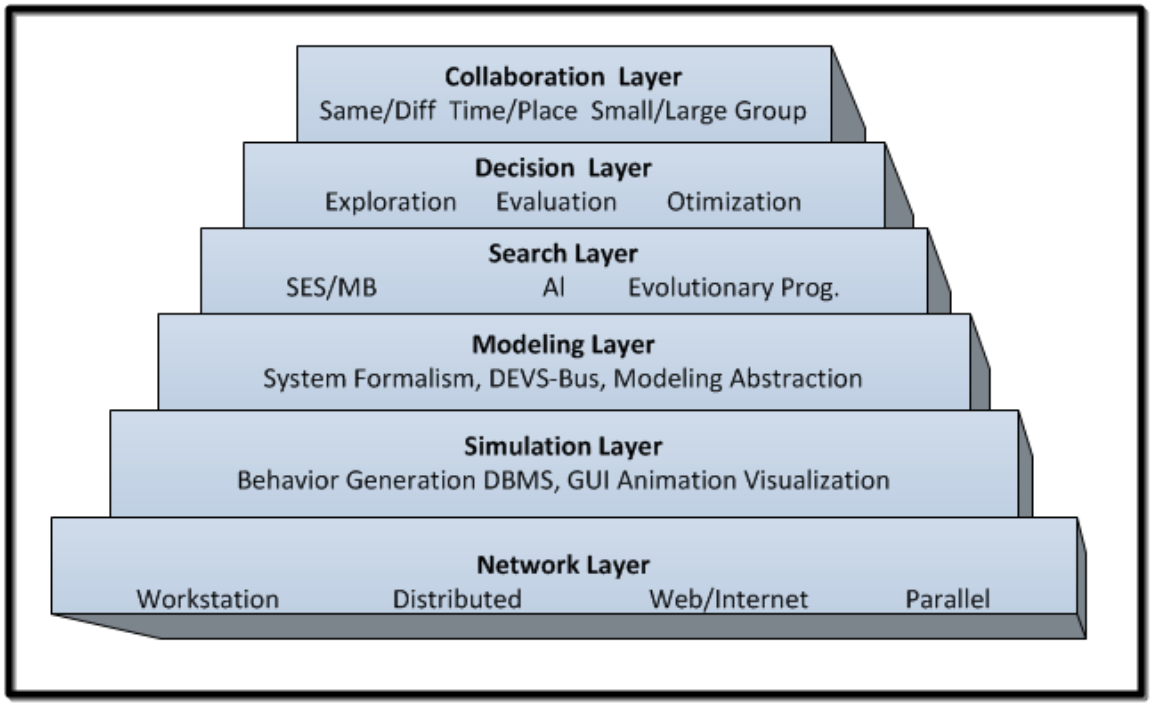

Figure 1. Architecture for modeling and simulation (from Zeigler et al., 2000).

b. Future Objectives

The authors outlined the following areas for future research (Zeigler et al., 2000):

- Fundamental issues such as model credibility (e.g., validation, verification and model family consistency) and interoperability (e.g., repositories, reuse of components, and resolution matching) are in need of attention.
- What are the benefits of collaboration specific to M&S? How can collaborative architecture, expressed at the logical design level, be implemented in current and foreseeable hardware and software platforms?
- How can M&S be used to study alternative implementation designs of the collaboration architecture?
- Can [M&S] environments be "boot strapped" into existence - using a rudimentary implementation to design successively more capable ones?

4. "X3D: Extensible 3D Graphics for Web Authors" (Brutzman & Daly, 2007)

a. Brief Overview

Recognizing that 3D remains a complex niche technology normally mastered by experts who create scenes with costly software and specialized tools, Brutzman and Daly wrote this book to show students and web authors how to build and connect X3D models and explain broad principles and details pertaining to X3D scene construction. *Extensible X3D: 3D Graphics for Web Authors* was also written to enable a larger cross-section of the population to create and compose 3D objects using the royalty-free X3D file format. Through the publication of this book, the authors intended to provide more users with a clear path to learn how to build increasingly sophisticated 3D models and 3D worlds. X3D graphics were used in all of the naval research projects referenced in the Literature Review of this thesis (Brutzman & Daly, 2007).

b. Future Objectives

The graphics standard continues to evolve according to the architectural principles presented in this work. Recent and ongoing efforts that comparably extend X3D include Computer-aided Design (CAD) exports, Distributed Interactive Simulation (DIS), geospatial scenes, Mixed Augmented Reality (MAR), Virtual Reality (VR) interfaces, 3D printing for Additive Manufacturing (AM), and plug-in free integration with Hypertext Markup Language Secure (HTMLS) web browsers using the open-source X3DOM library.

B. NAVAL MODELING AND SIMULATION (M&S) RESEARCH

1. Introduction

The U.S. Navy (USN) has conducted significant research in the area of M&S. The following references cite naval M&S research projects conducted at the Naval Postgraduate School (NPS).

2. Creating Military Limited Objective Experiments (LOE) that Take Advantage of Available 3D Tools and Technology (Blais et al., 2002)

a. Brief Overview

Fueled by the idea that the military's Limited Objective Experiments (LOEs) do not take full advantage of available 3D tools and technology, NPS researchers sought to help analysts more effectively assess tactics, techniques, procedures, weapons, and a host of other systems by providing them with simplistic, rapid, low-cost visualization or integrated 3D tools. Working on the premise that the creation of virtual environments had the potential for forming the base for deeper understanding as this would enable analysts to visualize and evaluate actions or consider alternative events by viewing them as if they had occurred, or should have occurred, the team assembled and integrated compatible software applications to deliver enhanced 3D user experience (Blais, Brutzman, Harney, & Weekley, 2002).

b. Future Objectives

The team identified several future objectives including (Blais et al., 2002):

- Develop near real time reporting for objects, so that they can be represented accurately in a distributed, multi-user 3D world, using the DIS-Java-VRML methodology for networked, interactive 3D simulations.
- Pinpoint source(s) of commercial GPS location errors. Take steps to augment 2D situation displays used by Operations Centers with 3D visualizations in order to enhance the overall user/training experience.
- Exploit ability to dynamically update and route 3D visualizations across a network to present quality Web3D visualizations during future web-based Peer-to-Peer (P2P) LOEs.

3. Develop User-Centric 3D Design (Harney, 2003)

a. Brief Overview

Harney's experience as a naval officer led him to conclude that U.S. naval warfighters lacked user-friendly Information Technology (IT) tools that could be used to run "what-if" scenarios which could then be used to influence the development of tactical plans. Through research, he sought to give end-users with basic computer skills 3D desktop tools that provided the greatest insight to aid tactical planning against surface-borne terrorist threats. More specifically, Harney's research focused on leveraging M & S technologies to assess prototypical planning tools to improve tactical Anti-terrorism and Force Protection (AT/FP) postures of USN ships (Harney, 2003).

b. Future Objectives

Some future research objectives identified through Harney's (2003) research include:

- Coordinate with the USN AT/FP Schoolhouse to develop courses featuring web-base open source tools.
- Explore how 3D tools can be used to uncover the most effective use for unmanned research vehicles like Spartan, one of the Navy's autonomous surface crafts.

4. Use SAVAGE Modeling and Analysis Language (SMAL) to Create Fast and Accurate 3D Processes (Rauch, 2006)

a. Brief Overview

Recognizing that typical watchstanders, with minimal 3D graphics experience, were not equipped to effectively use 3D tools, Rauch believed that 3D tools needed to be simplified enough to enable users with basic computer skills to create virtual environments quickly and accurately by leveraging data-driven customization of content from model archives. Recognizing that many potential benefits of 3D M&S remain out of reach for a large number of military users due to the inherently time consuming nature of existing tasks, Rauch's research focused on creating standardized and automated

procedures for creating 3D scenes. Rauch (2006) used Extensible Markup Language (XML) metadata standards to collect and organize the information necessary to create and populate a tactical 3D virtual environment—the Savage Modeling and Analysis Language (SMAL). For more information on SMAL, "the NPS MOVES [Modeling, Virtual Environments and Simulation] strategy for identifying tactical, physical and simulation-oriented information regarding models for vehicles, terrain and entities in virtual environments," visit https://savage.nps.edu/Savage/Tools/SMAL/SMAL.html (Naval Postgraduate School, 2015).

b. Future Objectives

Rauch's (2006) research identified future research topics, including:

- Use links that point to metadata instead of oversaturating models by embedding them with data.
- Develop stylesheets that directly translate between SMAL and X3D.
- Unlock the full potential of each 3D model in both the SAVAGE and SAVAGE Defense library by enabling SMAL.
- Explore the use of SMAL Snippets Over XML Tactical Chat Channels or as DIS-XML Payloads.
- Create XML-based DIS enumerations for use with SMAL.
- Determine the feasibility/utility of mapping SMAL to other command and control models such as JC3IEDM (Joint Command, Control, and Consultation Information Exchange Data Model) and TAML (Tactical Assessment Markup Language).

5. Repeatable Framework for Scene Generation and Agent-Based Simulation (Sullivan, 2006)

a. Brief Overview

Sullivan (2006) recognized that force protection professionals rely on information from numerous sources to create test scenarios, develop action plans, and to steer AT/FP risk mitigation procurement and that they did so without the ability to conduct robust preliminary testing or detailed analytics. His research targeted producing a scalable and repeatable methodology for generating AT/FP scenarios through the creation of software tools and exemplar models that provided a means to conduct harbor security studies, visualize the scenario outcome, and gain quantitative insight into problems of interest using statistical analysis. Sullivan's research focused on creating ways to arm AT/FP professionals with complimentary analytical capabilities by utilizing M&S tools and emerging technologies to create 3D visualizations of complex scenarios while also providing statistical analysis for a variety of AT/FP scenarios (Sullivan, 2006).

b. Future Objectives

Sullivan's (2006) research flagged several future research topics, including:

- Use the resulting technology to create complex scenes to test AT/FP capabilities.
- Optimize existing sensor arrays to more closely emulate real-world sensor packages.
- In order to decrease the overall time required for setting up the harbor environment, Savage Studio should be optimized to allow complete scene authoring.
- Conduct a real-world study to evaluate the accuracy of M&S products against expected behavior of their real-world counterparts.

6. Joint Venture to Enhance Modeling and Simulation Capabilities (Brutzman et al., 2006)

a. Brief Overview

The research team came to the realization that, "the challenges facing the naval installation security problem are complicated by the widely varying nature of the threats to be addressed, by the diversity of existing systems, equipment and Concept of Operations (CONOPS), and by the fact that there are more than 100 U.S. naval facilities, each of which can be expected to have a different set of Anti- Terrorism/Force Protection (AT/FP) requirements and solutions for harbor defense and installation security" (Brutzman, Blais, & Norbraten, 2007). By limiting their scope, researchers focused on the development of an open-source/ open-standard analysis tool that supported an assessment of the effectiveness of various sensor, barrier, and response systems to enable decision makers to make good judgments on what to purchase and employ. The team employed accepted M&S methodologies to develop tools that allow users to choose from a vast array of sensors, barriers, and response systems, "to assemble simplified representations of actual systems that allow an understanding of underlying relationships among sensors, combatants and their behaviors, all against the backdrop of 3D, immersive displays of actual locations such as a harbor and surrounding areas." By doing so, this gave analysts a way for leveraging M&S to find the most effective solutions for each environment and the most effective solutions (Brutzman et al., 2007).

b. Future Objectives

The research team identified areas for future research, including (Brutzman et al., 2007):

- Introduce an AT/FP website that offer a threaded discussion or email list, and is open to all users.
- For enhanced user experience, provide help to the user that is sensitive to the user's current situation is very useful for improved usability.

- Develop a tool that would allow a sufficiently trained individual to modify features of an existing port (Brutzman et al., 2006)

7. Predict Behavior of Seadiver Unmanned Underwater Vehicle (UUV) by Using Discrete Event Simulation (Seguin, 2007)

a. Brief Overview

After observing that the "capabilities of complex machines such as autonomous vehicles cannot be fully known prior to field tests," Seguin's research sought to reduce uncertainty by using simulations to virtually test Unmanned Underwater Vehicle (UUV) capabilities and configurations against environmental constraints prior to the completion of construction. Seguin created simulations using Discrete Event Simulation (DES) methodology that in turn produced playback missions for the complementary NPS simulation software called the Autonomous Unmanned Vehicle Workbench (AUVW). AUVW was used to determine the probability of Seadiver, a specific type of UUV, conducting successful exemplar missions (Seguin, 2007).

b. Future Objectives

Seguin's (2007) research identified future research possibilities, some of which are listed here :

- Use the research framework to conduct a real-world classified study of Seadiver UUV.
- Create 3D sensor packages that accurately reflect actual capabilities of those used on the Seadiver. Validate research results against actual Seadiver performance metrics.
- Use M&S to test Seadiver performance using different search patterns. To allow for easier implementation of inheritance, there is a need for native Viskit event graphs to extend each other.

8. Identify Gaps in Force Protection against Small-Boat Attack during Swarm Attacks Using Modeling and Simulation (Tiwari, 2008)

a. Brief Overview

After observing that international law and freedom of navigation makes the identification of and defense against hostile small craft extremely difficult, particularly when transiting through straits, Tiwari focused his research on using M&S to evaluate current weapons and tactics by collecting data on saturation of crew-served weapons, engagement timelines, and lines of approach. Further motivated by documented incidents of U.S. warships being harassed in the Straits of Hormuz, and the deadly attack against the USS Cole in Aden Harbor stimulated Tiwari's desire to use 3D M&S to determine if current Rules of Engagement (ROE) adequately protect warships against small boat attack. His research expand on prior AT/FP M&S capabilities, "by adding functionality to simulate small boat and swarm attacks against underway Arleigh Burke Class Guided Missile Destroyers (DDGs) conducting straits transits using variable, realistic Artificial Intelligence (AI)" (Tiwari, 2008).

b. Future Objectives

Tiwari (2008) flagged topics for future research, including the following items:

- Further development of Savage Force Protection tool. Optimize the current model to: allow each watchstander to serve as independent sensors; modify the communications messages so that they align with contact reports; include more traffic in the scene; explore the dynamics of nighttime transits.
- Activate more Listeners (software data collectors) to maximize lessons learned from the scene.
- Consider the use of inexpensive remote controlled boats to simulate small boat swarms during real-world training events involving live fire.

9. Ongoing X3D Tool Development

The creation of 3D models and tactical behaviors requires specialized skillsets. Developers can find themselves losing capabilities or re-doing work because software

systems change rapidly. To reduce the likelihood of this dilemma, the NPS SAVAGE Group have used open-source software modeling tools to build open-standards models, which do not time-out or become inoperable due to independent commercial product changes. Appendix A.B contains a list of on-going modeling tools the SAVAGE Group have developed and refined over time.

10. Literature Review Contributor Timeline

One could draw several conclusions from the timeline in Figure 2. Since the period between 1976 and 2000 is suspiciously inactive, one may conclude that there were few innovations in the M&S field during this timeframe. Based on the flurry of activity which took place following the approval of the Institute of Electrical and Electronics Engineers (IEEE) Distributed Interactive Simulation (DIS) protocol standard, one could also conclude that the DIS was a catalyst in the M&S field. Inactivity between March 1998 and January 2000 could be interpreted as the M&S community required a period of pause to digest, adopt, and implement DIS standards. However, Zeigler and his fellow authors referenced the HLA standard in the Second Edition book. Though individuals may develop biases, both HLA and DIS are the primary M&S interoperability standards that have had an overall positive effect on the greater M&S community. This thesis research project and the naval research projects referenced in this thesis conform to the IEEE DIS standard.

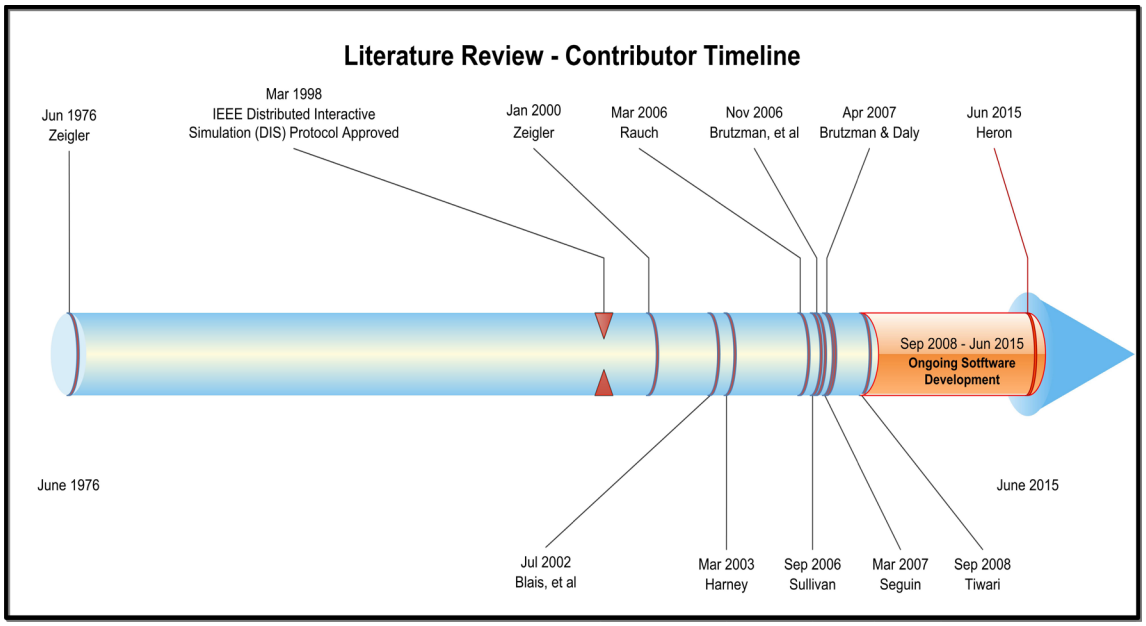

Figure 2. Timeline showing the contributors mentioned in this Literature Review and the approval of IEEE's DIS protocol standard.

C. SUMMARY

The DOD has established a solid foundation by using M&S to solve real world problems. Past naval research findings have concluded that 3D technologies can be used for area familiarization, to help warfighters create LOEs, and as an expanded platform for enhancing many aspects of AT/FP. The USCG and USN share a strong maritime nexus and some common missions. This connection suggests that many existing M&S tools developed for, and being used by, the USN can be repurposed for USCG implementation with little or no modification.

Harney states a need for, "creating a preconstruction of possible scenario events or conducting a static reconstruction following the experiment's conclusion can prove interesting, being able to play 'what-if's' to gain greater insight towards execution of future exercises or real events proves to be one of the true powers of modeling and simulation (M&S) technologies" (Harney, 2003). This research will explore how the USCG Contingency Preparedness and Exercises (CG-CPE) Branch can benefit from M&S by using tools and technology developed by the USN.

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III. U.S. COAST GUARD INTERESTS

A. INTRODUCTION

This chapter outlines existing U.S. Coast Guard (USCG) and U.S. Navy (USN) partnerships including, the Maritime Force Protection Unit (MFPU) and the Strategic Systems Program (SSP), and covers the Transit Protection Training System (TPTS), in use between them. This chapter further discusses the USCG Contingency Preparedness and Exercises (CPE) Branch missions, exercise programs, and the broad spectrum of military and civilian partners they involve. Next, this chapter provides an overview of existing USCG M&S capabilities.

B. OVERVIEW AND MOTIVATION

The USCG and the USN are two of the five primary uniformed services of the United States. The USN is the naval warfare service branch of the DOD: "The mission of the Navy is to maintain, train and equip combat-ready naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas" (U.S. Navy, 2013). The Coast Guard is a maritime, military, multi-mission service unique among the U.S. military branches for having a maritime law enforcement mission (with jurisdiction in both domestic and international waters) and includes a federal regulatory authority as part of its mission set (U.S. Coast Guard, 2013). The USCG operates under the DHS during peacetime, and can be transferred to the USN by the U.S. president at any time or by the U.S. Congress during times of war (U.S. Coast Guard, 2013).

The USCG and USN operate in the maritime domain and share common interests, one of which is the protection of Ballistic Missile Submarines (SSBNs) inside U.S. territorial waters. The partnership between both military branches extends beyond the protection of strategic military assets. The USCG has reused USN modeling and simulation (M&S) technology to support Coast Guard missions with great effect. Though the USCG has a history of using M&S tools to support some missions, other segments of the organization could benefit from using M&S tools. One of those segments is the USCG's Contingency Preparedness and Exercises (CPE) Branch. USCG CPE may

directly benefit from adopting USN M&S tools to conduct exercises, and the USN submarine community may, curiously, become indirect benefactors of this partnership because of shared interests.

C. PARTNERSHIP WITH U.S. NAVY STRATEGIC SYSTEMS PROGRAMS (SSP)

The SSP and MFPU have maintained a close partnership to ensure the protection of SSBNs during littoral transits. This section provides an SSP overview, a brief summary of the MFPU, and discusses how M&S tools are being used to enhance their mission.

1. Strategic Systems Programs (SSP)

Generally speaking, there are two types of mutually overlapping Strategic Systems Program (SSP) missions: pier-side and underway transit. The pier-side mission involves tending to and protection of submarines while they are moored, and also entails product development, administrative functions, and system integration. Though submarines generally operate on the surface during littoral transit, both surface and submerged movements are considered underway transits. The Department of Defense (DOD) provides pier-side security but the USCG is the lead agency ensuring safety of the public and protection for submarines during underway transits.

SSP is responsible for Strategic Weapons Systems (SWS) aboard Fleet Ballistic Missile (FBM) submarines, the nation's only survivable strategic nuclear deterrent. SSP traces its roots to 1955, and has amassed an impressive track record for safety and innovation over the last 55 years. SSP developed the world's first underwater-launched ballistic missile from a submarine, the Polaris missile. To date, SSP "has produced more than 3,600 missiles in six generations, each more capable than its predecessor: Polaris A1, A2, A3; Poseidon C3; TRIDENT I C4; and TRIDENT II D5" (Lewia, 2009).

SSP's mission for providing sea-based deterrence includes broad but related functions that are managed across six internal business lines.

- *Strategic Weapons System (SWS)*, responsible for providing the principal strategic deterrent for the U.S. and United Kingdom (UK), currently the TRIDENT II missile (U.S. Navy, 2014).
- *Nuclear Weapons Security (NWS)*, chiefly responsible for ensuring, "security and safety of nuclear weapons while in U.S. Navy custody (e.g., at Strategic Weapons Facilities (SWFs), weapons storage facilities, and on board submarines)" (U.S. Navy, 2014).
- *Ohio-class Guided Missile Submarine (SSGN) Attack Weapons System (AWS)*, whose responsibility was to develop and integrate Tomahawk missile AWS into SSGNs (U.S. Navy, 2014).
- *Payload Integrator*, charged with developing an open and flexible architecture that retains the fidelity of legacy methodologies, while allowing for rapid integration of payloads (U.S. Navy, 2014).
- *Emerging Missions*, charged with rapid integration of future submarine-borne capabilities to support select warfighter needs (U.S. Navy, 2014).
- Navy Treaty Implementation Program (NTIP), responsible for ensuring SSP is compliant to applicable agreements and treaties (U.S. Navy, 2014).

Collectively, SSP's six business lines allow the USN to provide a credible strategic sea-based deterrence, while working with new, complementary fields to accommodate emerging needs of the warfighter.

2. Maritime Force Protection Unit (MFPU)

The USCG's Maritime Force Protection Units (MFPUs) provide enhanced security for Ballistic Missile Submarines (SSBN) within their homeport transit area. MFPUs' have the authority to exercise "broad law enforcement authority, including the authority to establish, patrol, and enforce exclusionary zones, naval vessel protective zones, restricted navigation areas, and security zones supporting naval operations" (Naval Submarine Base Kings Bay Public Affairs, 2007). MFPUs are the result of a close partnership between the USCG and the USN, in which the Navy plays a pivotal role in

the development of specialized training and techniques, in addition to providing specialized equipment used by the MFPU to safeguard SSBNs during transit (Naval Submarine Base Kings Bay Public Affairs, 2007).

3. Transit Protection Training System (TPTS)

To ensure an optimal level of readiness, Coast Guard MFPU units conduct a wide array of training, including traditional military-grade drills and exercises and interactive, scenario-based training conducted via a high-fidelity locally networked simulator - the Transit Protection Training System (TPTS). TPTS is the result of a close collaboration between the USCG and the USN. TPTS is based on the Conning Officer Virtual Environment (COVE), which is a dynamic ship handing simulator used by the Navy's Surface Warfare Officers School (SWOS) to provide realistic training in vessel operation, management, and shipboard tactics (Lundquist, 2013). By combining the COVE's high-end M&S technology with commercial off the shelf (COTS) hardware, the Navy created a tool scalable enough to permit individual training or support several teams training on multiple afloat platforms simultaneously. With relatively minor modifications to the core software, the Navy "helped adapt the COVE simulation technology to the immersive environment of the Coast Guard units that escort ballistic-missile submarines in and out of port" (Lundquist, 2013).

TPTS uses "a full-scale, real-time simulation of [numerous] MFPU Force Protection scenarios," to "permit multiple units to work together, such as when escorting a high value unit (HVU)" (Lundquist, 2013; Treen, 2014). All MFPU teams are collocated in the same building during simulations. MFPUs use the TPTS to hone several aspects of their mission. The system is robust enough to support the vast number of protocols and tactics employed by the MFPU to establish security perimeters. The types of scenarios that can be produced are almost endless, thanks in part to a massive library containing hundreds of entities, such as: pontoon boats, fishing vessels, commercial vessels, recreational vessels, pleasure crafts, and even aircraft. For example, "multiple boats can interact with the command boat and the HVU for various scenarios, including the introduction of potential threats" (Lundquist, 2013). Patrol Commanders

(PATCOMs), gunners, boat coxswains and crew members operating in various force packages use the 14-station simulator to practice mission essential tasks ranging from normal radio communications to tactical boat handling measures. The stations are flexible enough to be configured to function as any vessel in the MPFU's inventory, other vessels in the TPTS library, or as hostile forces (Lundquist, 2013).

Each simulated training mission contains a unique name for tracking and play-back purposes, clear mission objective, force package configuration, enabling objectives for the team, and a narrative to initiate the scene. The simulation coordinator can stop the scene to highlight or discuss an action or allow the entire simulation to run, then playback specific portions of the simulation to gain greater insight from group discussion. In addition to running the main simulation, the coordinator also has the ability to inject minor tangent activities to observe how the team(s) reacts. The simulation evaluator(s) use a structured format to assess each enabling object. A formal hotwash is conducted at the end of each simulated mission to discuss best practices and lessons learned.

The TPTS is versatile enough to be configured to train practically any federal, state, or local maritime partners, which strengthens their rolls during HVU escorts and has been used to cross-train strategic international partners from United Kingdom Royal Navy, Royal Marines and Ministry of Defense Police Force (Lundquist, 2013; Treen, 2014). The TPTS is so adept at replicating the handling characteristics of vessels, environmental conditions, and functional characteristics of other equipment used by MFPU personnel, that they exploit virtualized scenarios to demonstrate proficiency on select practical factors for qualification; a feat normally reserved for demonstrating in the real-world. TPTS is routinely upgraded to add more features and capabilities. The MFPU maintains a list of desired upgrades for future implementation. Past upgrades have expanded the Navy's ability to train with the MFPU and enabled forces ashore to join the scenario (Lundquist, 2013). A list of desired TPTS enhancements, dated May 2015, is included as a Supplemental Annex to this thesis. Dissemination controls for this list is maintained at the For Official Use Only (FOUO) level.

The TPTS may be considered the modern-day benchmark for how the Coast Guard can adapt existing Navy M&S technology to directly improve unit readiness and

mission execution. TPTS is a, "great utilization of the taxpayers' money," which started as an initial investment by the Navy, has now been adapted to benefit multiple Coast Guard missions (Lundquist, 2013). TPTS is bringing people together – multiple stakeholders, agencies, groups and international partners. TPTS is scalable, is still evolving, and a drastic enabler, allowing the Coast Guard, Navy, and other stakeholders to buy-down risk through modeling and simulation. TPTS has established a blueprint for reusing technology and presents a compelling argument to explore how other M&S tools can be adapted to enhance more Coast Guard missions.

D. CONTINGENCY PREPAREDNESS EXERCISES

The USCG and USN have active roles in preserving homeland security and upholding maritime defense. Though the statutory mission sets of both services are largely different, both military branches share a maritime nexus, have some common mission areas, have a mutual interest in the protection of some of the same assets and thus will likely benefit from further collaboration and the sharing of intellectual property. Both branches routinely use drills and exercises to test force readiness. There are seven types of exercises, each designed to produce a different output. Drills and exercises belong to one of two categories; discussion-based (seminar, workshop, tabletop, and game) or operations-based (drill, functional, and full scale) (U.S. Coast Guard, 2011). Drills and exercises are effective ways to evaluate readiness. However, both methods of evaluation feature inherent limitations, which restrict the frequency in which tests are performed, the variety of tests, and the type of empirical data which is collected during testing.

The USCG Contingency Preparedness and Exercise (CPE) Branch steers all hazard planning for the Coast Guard and for others. CPE's policies and plans are far reaching and extend beyond the Coast Guard, the Department of Homeland Security (DHS), the military, and far beyond the federal government. CPE field units manage a portfolio of plans, some of which are community-based, meaning they extend to and include civilian agencies, their response strategies, resources, and capabilities. Drills and exercises are a core component used to test the plan(s) by identifying strengths and

weaknesses. Communications, more specifically the communications that takes place before, during, and after responses is a major area of focus because so many local, state, and federal agencies are involved, in addition to a number of commercial maritime entities and recreational maritime user groups – the maritime community. Though not perfect, the USCG excels in communicating fluidly across a wide partner spectrum, be it sensitive information or public broadcasts, with law enforcement or law breakers, with civilians or with the armed forces.

CPE's exercise program is designed to improve the ability to conduct effective contingency operations by using drills and a variety of exercises to test the effectiveness of contingency plans. CPE's exercise programs span across multiple mission areas and touch on many areas of focus, including but not limited to: Mass Rescue, Major Marine Disaster, Alien Migrant Interdiction Operations (AMIO), Anti-terrorism, Oil Spills and Hazardous Material Release, Continuity of Operations (COOP), Force Protection, and Natural Disasters. The Area Maritime Security Training and Exercise Program (AMSTEP), which places emphases on anti-terrorism measures are detailed in the Area Maritime Security Plan (AMSP). Though the AMSP has a broad focus, elements of the plan directly align with the MFPU and SSP mission of safeguarding submarines during transit.

CPE exercises are somewhat unique, due in part to the diverse mix of exercise participants. It is quite common for civilian port partners, members from multiple military branches, firefighters, law enforcement, environmental agencies, and other representatives from local, state, and federal government agencies to take part in USCG contingency exercises. Since the USCG coordinates and collaborates with multiple agencies during contingency operations, exercises are a crucially important element in:

- "Validating plans, policies, doctrine, procedures and the ability to conduct contingency operations.
- Building, clarifying, and strengthening relationships with partners and stakeholders prior to an actual threat or response.

- Assessing preparedness [and] readiness with an emphasis on identifying shortfalls and closing gaps.
- Refining plans, identifying available resources and capabilities, conducting training, and evaluating training plans.
- Providing familiarization and on-the-job training for players in their roles and responsibilities for conducting contingency operations.
- Familiarizing players with National Incident Management System/Incident Command System (NIMS/ICS) terminology and processes." (U.S. Coast Guard, 2011)

Unavailability of resources is a common limitation of drills and exercises. Considerable coordination is required to ensure participating personnel, facilities, vessels, venues, and supporting resources are simultaneously available for scheduled training evolutions. Environmental conditions also have an effect on training. Many aspects of drills and exercises are notionalized for various reasons, requiring participants to use their imagination for the notionalized component. Drills and exercises are often conducted under favorable weather conditions, when it is "safe to train," yet the systems and processes that trainees protect can be compromised under any weather condition. Training via adaptive 3D simulation, on the other hand, can continue despite external weather conditions. As an added benefit, inclement weather can be incorporated into the simulated training environment thus providing greater training breadth and depth. Adaptive 3D simulation reduces the need to rely on notional scenarios. Any event that might normally be notionalized during drills and exercises can be included as a part of the simulation thus providing a greater sense of realism. The use of adaptive 3D simulation can also reduce the complexity of synchronizing the availability of numerous resources to be present during a fixed training event. Simulated training can occur at any time of day, on any day, with the entire group or in smaller groups.

E. MODELING AND SIMULATION CAPABILITIES IN THE U.S. COAST GUARD

The USCG has a history with using M&S tools in the CPE environment, during real-world responses, and in the area of Research and Development (R&D). Many examples of the USCG using M&S tools involve discrete units with a targeted focus. This section highlights some of the ways the USCG has embraced M&S solutions.

1. Contingency Preparedness and Exercises (CPE)

USCG CPE teams have experience using M&S tools but only for the purpose of simulating oils spills. The Coast Guard's Exercise Support Team (EST) uses a rudimentary M&S tool called the Pollution Incident Simulation Control and Evaluation System (PISCES) to coordinate large-scale oil spill response exercises. PISCES is used to construct simulated oil spills, drift models, and to simulate the extraction of petroleum products by on-scene spill response equipment. There are isolated accounts of the USCG using other M&S tools to support contingency exercises but no other M&S tools are consistently utilized in the exercise realm.

2. Real-World Responses

The USCG has a statutory responsibility to plan for, and respond to, hazardous material (HAZMAT) releases and oil spills within the coastal zones and inland coastal zone defined in the National Contingency Plan (NCP), as outlined in (40 CFR 300.5). In the event of a HAZMAT release or oil spill, the USCG relies on the modeling services provided by the National Oceanic and Atmospheric Administration (NOAA). NOAA oceanographers use M&S software for trajectory forecasting, real-time tracking of oil and chemical spills, and air plume forecasts (U.S. Department of Commerce, 2010).

NOAA uses several models to determine HAZMAT characteristics. NOAA developed the GNOME (General NOAA Operational Modeling Environment) to simulate the movement of a substance on or in the water. NOAA uses the ADIOS 2 (Automated Data Inquiry for Oil Spills, ver.2) model to estimate, "the evaporation, natural dispersion, and other weathering processes of oil in the ocean for up to the first five days after it is spilled" (U.S. Department of Commerce, 2010). NOAA also uses models designed to

limit the destructive effects of HAZMAT spills, prior to the event. The TAP (Trajectory Analysis Planner) uses statistical analysis to identify areas most likely to be affected by oils spills. TAP consequence analysis data is then used by the USCG and port partners to develop response Area Contingency Plans (U.S. Department of Commerce, 2010). NOAA spill trajectories are also routinely used in USCG spill exercises to ensure participants are familiar with the products and how they should be used in the event of an actual spill.

NOAA partnered with the Environmental Protection Agency (EPA) to develop a suite of chemical incident models, which are critical tools used in response to fast acting and potentially lethal chemicals. The software suite known as CAMEO (Computer-Aided Management of Emergency Operations) contains an extensive database for thousands of chemicals, their properties, and response recommendations. "The CAMEO integrated suite of applications includes:

- CAMEO – Data management modules used to keep track of information (such as chemical inventories and contacts) and an interface for navigating between other programs in the CAMEO suite.
- CAMEO Chemicals – A database of hazardous chemicals—with physical properties, hazards, and response recommendations—and a tool for predicting how chemicals might react if mixed.
- ALOHA (Areal Locations of Hazardous Atmospheres) – An air dispersion model that estimates threat zones for chemical releases.
- MARPLOT (Mapping Application for Response, Planning, and Local Operational Tasks) – A simple mapping program, which can display ALOHA threat zones and CAMEO facilities.
- Chemical Reactivity Worksheet – Similar to CAMEO Chemicals, this program focuses solely on hazards, and allows users to add their own chemicals to the database." (U.S. Department of Commerce, 2010)

3. USCG Modeling and Simulation Center of Expertise

The USCG Research and Development Center (RDC) maintains a portfolio of projects that support the Coast Guard's missions. The Modeling and Simulation Center of Expertise is one of seven main program areas within the RDC. One of M&S Center's charters is to provide program managers and operational commanders access to M&S analysis to meet mission needs (U.S. Coast Guard, 2015a).

On June 3, 2014, the USCG celebrated the creation of a 3,200 square-foot Modeling and Simulation Center with a ribbon cutting ceremony. Instead of using contractors extensively, the center relies more heavily on in-house staff expertise, "to help Coast Guard managers and commanders make better-informed decisions by giving them timely, cost-effective access to powerful modeling and simulation capabilities and analysis" (U.S. Coast Guard, 2015a). The RDC allows the USCG to consolidate previously scattered capabilities in one location, for greater synergy and efficiency. The new center is expected to, "make it easier for Coast Guard leaders to obtain modeling and simulation services" (U.S. Coast Guard, 2015a).

The range of services the RDC provides includes the assessment of emerging commercial technologies to determine their viability and leveraging relationships with other military branches, such as the Office of Naval Research (ONR) and the Naval Sea Systems (NAVSEA) Command Warfare Systems, to evaluate which technologies can be adapted to support USCG missions. The RDC is also working to develop M&S tools that help the USCG to determine which fleet mix is most effective, thereby "support[ing] acquisition decisions by reducing the cost of design, development, testing and evaluation of new aircraft, cutters and mission systems" (Keeter, 2008).

RDC M&S programs impact current operations and are helping to shape the future. Practical applications may include using M&S to determine the type of boats and/or cutters needed to support a specific mission in a designated area of operation (AOR) or "[create a] model that would involve increasing the number of migrants expected to arrive to the U.S. by ship to determine if there are enough Coast Guard vessels to prohibit migrants from entering the U.S." (Somers, 2014). By using M&S data

and analysis, the RDC can evaluate which vessel types, sizes, capabilities, and other factors are best suited to performing Coast Guard missions, thus helping decision makers to determine future acquisitions (Somers, 2014).

4. Full Mission Bridge Training Simulator (FMBT)

The USCG modified existing M&S Navy technology to better prepare for Department of Homeland Security (DHS) maritime missions. Similar to the TPTS, the Full Mission Bridge Training Simulator (FMBT) is direct descendant of the Navy's COVE system but its software is designed to support the Coast Guard Cutters and small boats. FMBT provides a realistic training environment by integrating a suite of monitors, communications systems, and helm mock-up configurations with sophisticated M&S software. FMBT simulations are used to reinforce a number of seamanship skillsets. Some of the core elements include: basic ship piloting and handling; navigation "Rules of the Road"; aids to navigation (AtoN) recognition and utilization; electronic and paper chart plotting, time, speed, distance; plotting visual, radar and Global Positioning System (GPS) fixes to triangulate ship's exact position at all times; radio communications between Sector control and other ship traffic; and leadership and team coordination fundamentals. The simulator can also be used for search and rescue (SAR) operations coordination and to train on anchoring, docking and towing. The FMBT has been so effective that the, "International Maritime Officer Candidate school has also expressed interest in training in the SIM as well" (U.S. Coast Guard, 2015b). Figure 3 shows an image of an FMBTS training station.

Figure 3. Image of Full Mission Bridge Training Simulator (from U.S. Coast Guard, 2015b).

The FMBT is used by boat and ship drivers at three of the USCG's primary schoolhouses; the Coast Guard Academy, the Training Center in Yorktown, VA, and the Training Center in Petaluma, CA (Lundquist, 2013). There are currently a total of six USCG training simulator platforms being used: 410' NSC (National Security Cutter, Bertholf Class); 378' WHEC (High Endurance Cutter, Hamilton Class); 110' WMEC (Medium Endurance Cutter); 87' WPB (Patrol Boat); 47' MLB (Motor Life Boat); and the 25' RBS (Response Boat-Small) (U.S. Coast Guard, 2015a).

F. EVALUATION AND ASSESSMENT

M&S tools can be used to improve operational mission success. It is clear the Coast Guard currently lags behind the USN in leveraging 3D Modeling and Simulation (M&S) tools to solve complex problems, in certain mission areas. The sharing of existing M&S tools has tightened the gap between these military branches. The 2014 opening of the USCG's M&S Center will likely lead to more breakthroughs and a greater adoption of M&S tools throughout the Coast Guard. Through persistent partnership, the USCG and USN have an opportunity to mutually benefit from the growing potential of M&S tools.

The USCG CPE Branch has clearly stated that they value M&S tools. According to the Coast Guard's Contingency Planning and Preparedness Manual (CPPM), Volume III, one of the USCG's guiding principles for exercises,

"Simulation and modeling is used primarily to enhance the realism of operations-based exercises, but can also be incorporated into discussion-based exercises. Use of simulation or modeling software should reduce the number of support personnel needed for simulation activities in an exercise. Software can also be used to simulate scenarios in which personnel must respond and deal with the effects of their decisions and actions" (U.S. Coast Guard, 2011).

Based on a variety of background factors, this may be the best time for CPE to collaborate with the USN and other agencies to identify existing 3D M&S tools to support its missions. The USCG leveraged its close relationship with the USN to identify and repurpose Navy M&S tools to support Coast Guard missions. The foundational examples discussed in this chapter have special significance because modifying existing solutions instead of building them from scratch has result in substantial savings, an area of intense focus in budget constrained climates. The FMBT simulator and TPTS clearly illustrate how one branch of the military can invest in R&D, perfect the technology then share the technology with other government entities to minimize implementation time and maximize return on the original investment. The USCG and USN should jointly explore more ways to reuse existing M&S tools because the precedence of collaborating and sharing has been set, and has already yielded positive results. Furthermore, now that the USCG M&S Center is fully operational, the Coast Guard is poised to more fully embrace the benefits of M&S tools by formalizing a channel for M&S Center collaborative ventures between the Coast Guard and all government agencies.

The USCG's CPE Branch oversees a wide range of contingency focus areas, and thus targeted use of 3D M&S tools has the potential of benefitting many Coast Guard mission areas and a wide range of exercise partners throughout the continental U.S., its territories, and commonwealths. One of USCG CPE's mission areas focuses on maritime security, a shared concern for the USN, especially as it relates to the escort of SSBNs.

SSP, the MFPU, a wide variety of port partners, and members of the general public will benefit from improvements CPE makes in the area of maritime security. By establishing a closer relationship with the CPE Branch, SSP and the MFPU can have an expansive impact on improving overall maritime security in U.S. territorial waters, thus improving the submarine escort mission and facilitating the safe transit of other naval vessels. Furthermore, CPE can leverage years of M&S expertise that SSP and the MFPU have acquired to accelerate the adoption of robust M&S tools. To that end: SSP & CPE must develop a stronger partnership; CPE must adopt M&S tools to accelerate lasting improvements; and CPE should explore the adoption of existing M&S tools before developing tools from the ground-up.

G. SUMMARY

This chapter discussed SSP's, the MFPU's, and CPE's role in maritime security. Since CPE's role in maritime security is so far-reaching and affects so many agencies, this chapter also established that SSP and the MFPU can drastically improve the mission of submarine escorts by more closely collaborating with CPE and by assisting CPE to adopt robust M&S tools.

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IV. RESEARCH METHODOLOGY

A. INTRODUCTION

This chapter uses the functional flow of a modeling and simulation (M&S) demonstration, designed for this thesis, to outline the features and capabilities of SAVAGE (Scenario Authoring and Visualization for Advanced Graphical Environments) Studio. Since the M&S tools used in this thesis are based on open source software platforms, this chapter also provides a balanced summary of some of the advantages and disadvantages of using open source software resources. Next, this chapter provides a brief overview of MMOWGLI, a crowd sourcing tool used to collect anonymous user input.

B. OVERVIEW AND MOTIVATION

The Federal Highway Administration claims there were over 212 million licensed drivers in the U.S. in 2013 (U.S. Department of Transportation, 2013). Though licensed drivers may be proficient at operating virtually any automobile on the market, only a fraction of the population cares to understand the finer points concerning spark plug gap settings, optimal air/fuel mixtures, compression ratios, or many of the other engineering wonders responsible for propelling vehicles safely down the road. Similarly, a fairly large segment of the population has a firm grasp of basic computer skills but is disenchanted by the thought of learning computer coding, expanding their vocabulary to include phrases like "backface culling," and has little to no interest with what goes on "under the hood" of 3D technologies. Yet this audience is interested in leveraging 3D tools and technology to solve real-world problems. The tools used to create the Hello World Indian Island (HWII) scene discussed throughout this chapter were developed with these types of users in mind.

"Hello World" is recognized as one of the simplest programs, a starting point, in the computer programming industry, in which the words "Hello Word" are displayed on a screen or sent to another output to demonstrate basic computer programming concepts. The scene discussed in this chapter is a Scenario Authoring and Visualization for

Advanced Graphical Environments (SAVAGE) Studio demonstration of advance 3D concepts using a basic scenario known as HWII.

C. SIMULATION ANALYSIS CAPABILITIES

In the mid-2000's a team of NPS Researchers partnered with military and private industry professionals to develop a 3D ecosystem primarily using Java programming language-based applications and open source software tools to replicate harbors and the maritime environment U.S. military forces operate in, graphically visualize tactical execution of military force protection plans, and link them with statistical data to support findings (Brutzman et al., 2007). With over a decade of refinements, the tools, technologies, and processes have evolved into the current iteration of the SAVAGE Studio, a 3D modeling and simulation (M&S) authoring tool with drag-and-drop functions allowing for "rapid generation" of scenarios of interest with little or no programming experience required.

The research experiment conducted in this chapter is based on Discrete Event Simulation (DES) principles. SAVAGE Studio provides a Graphical User Interface (GUI) to other software-based M&S tools, thus giving users easy access to the benefits of an entire suite of applications, used to develop DES projects. Core software tools used to conduct this research includes SAVAGE Studio and the following applications:

- Simkit, a Java package for creating Discrete Event Simulation (DES) models (Naval Postgraduate School, 2015).
- Diskit, Java package for adding the Institute of Electrical and Electronics Engineers (IEEE) Distributed Interactive Simulation (DIS) protocol to Simkit models (Naval Postgraduate School, 2015).
- Viskit, a visual programming tool to create, run and analyze Simkit models (Naval Postgraduate School, 2015).

1. Rapid Scenario Generation

SAVAGE Studio makes it possible for non-technical users to quickly create high-quality 3D scenes by using inherent feature-rich tools. SAVAGE Studio encapsulates Viskit, the Discrete Event Engine which drives the scene, and the visual browser. To demonstrate the ease of use, this chapter has been written as a narration which coincides with the HWII scene, but the readers can also logically understand these concepts without

viewing the associated scene. Figures in this chapter are direct snapshots from the HWII demonstration scene. The HWII scene is available at https://savage.nps.edu/norbraten/SavageStudio-Scenario-Demo.2015JAN08.mp4 (accessed April 25, 2015).

Topics discussed in this chapter carefully follow the flow of the HWII demonstration. As such, a few concepts are briefly introduced then expanded upon further in the chapter.

Figure 4. HWII demonstration, demonstration available from SAVAGE Studio https://savage.nps.edu/norbraten/SavageStudio-Scenario-Demo.2015JAN08.mp4 (accessed April 25, 2015).

2. Choose Location

Choosing a location is similar to opening files from popular software applications like Microsoft Word or Adobe Acrobat. Users select "Open" to navigate to the file's location, select the desired file, and then click "Open" to display the desired location (or map) on the SAVAGE Studio palette, as seen in Figure 5. Icons showing maps from the SAVAGE Content Catalog appear in the left pane of the screen, allowing for easy access. SAVAGE Studio displays a 2D *.png* snapshot of the map, which is used to overlay 2D

icons of 3D images, and also works with the following three file extensions: *.xml*, *.x3d*, and *.smal*.

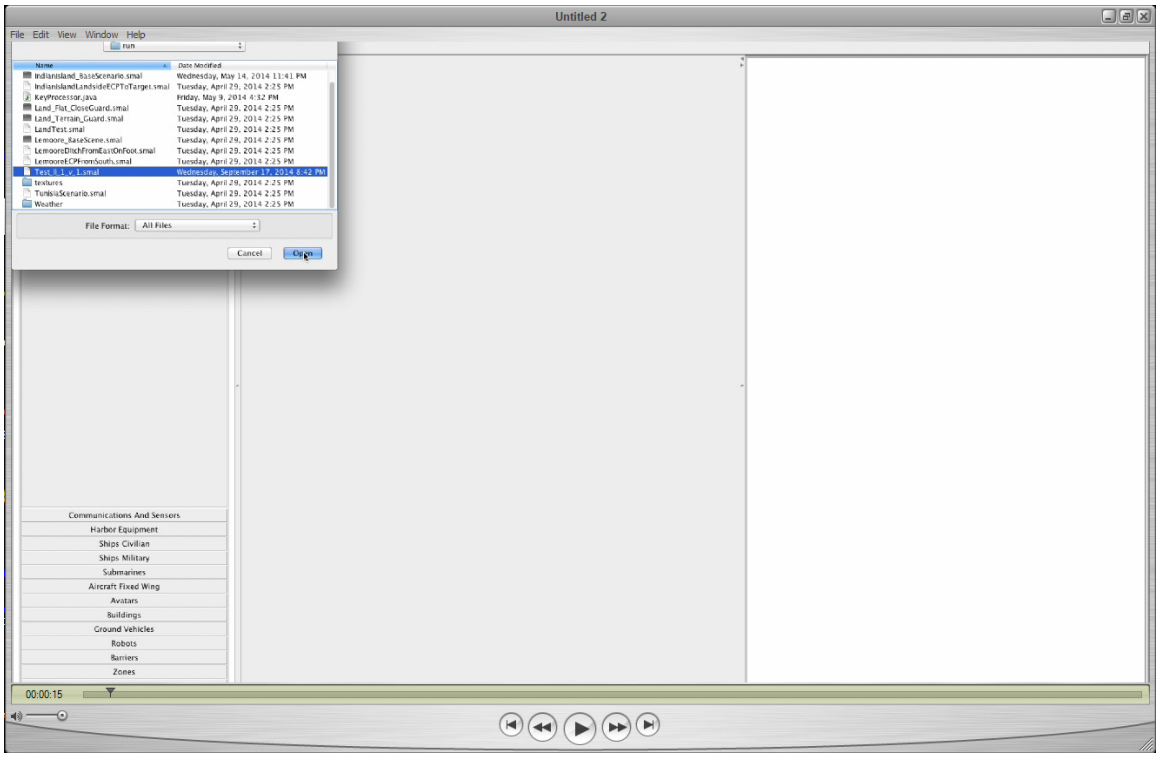

Figure 5. SAVAGE Studio example of user selecting a 3D map for the scene.

3. Pan and Zoom

Many users will find the SAVAGE Studio pan and zoom features easy to use, as its functions work similarly to many online mapping tools. Pan and zoom features give users the ability to focus on specific areas of the map. The arrow cluster in the upper left corner of the map is associated with the pan function, giving users the ability to move the map in the corresponding direction of the pressed arrow. A zoom slider is located just below the pan cluster. Pressing the "+" of the zoom slide magnifies the image, whereas pressing "-" reduces the size of the image. Though the HWII scene only shows pointer mode functionality, it is important to note that the user can also pan and zoom in hand mode. User experience in either pointer mode or hand mode will be similar to that of popular mapping applications such as Google Maps and MapQuest, as seen in Figure 5.

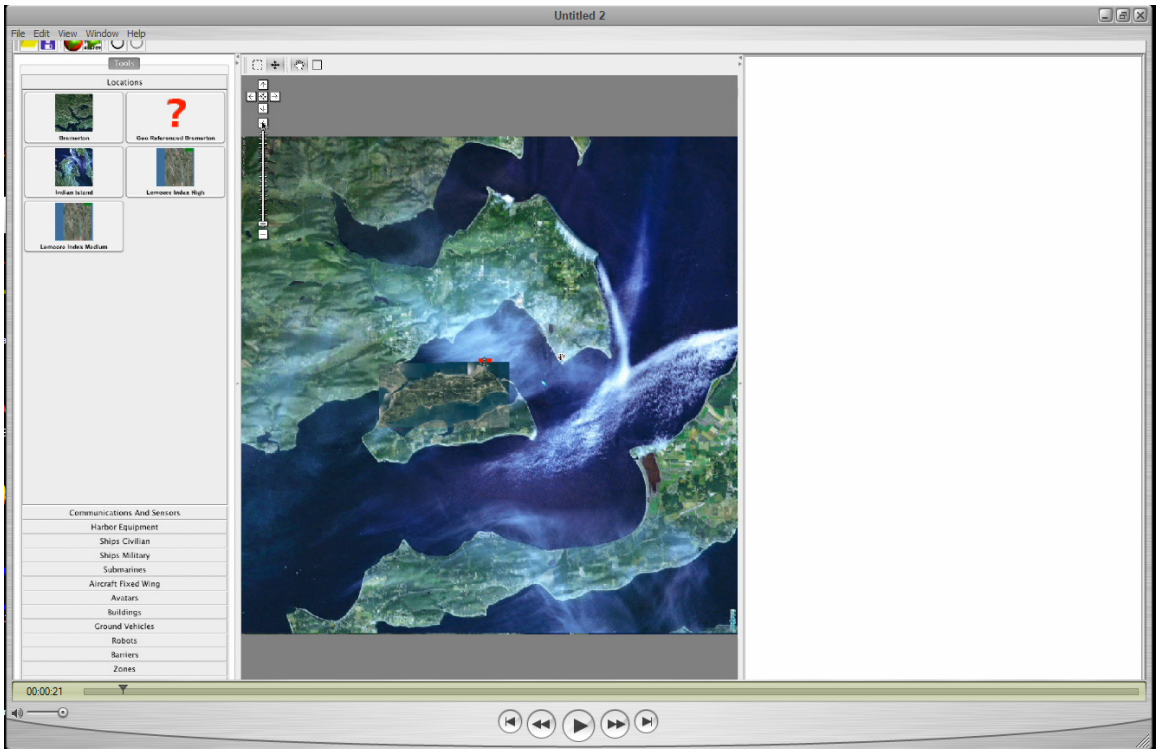

Figure 6. Map of Indian Island, Washington selected within SAVAGE Studio.

4. Entity Library

SAVAGE Studio gives users the ability to choose a vast array of 3D objects from the Entity Library. The Entity Library is composed of two distinct 3D model archives, SAVAGE and SAVAGE Defense. SAVAGE is the *unclassified* (UNCLAS) content catalog and SAVAGE Defense is a content catalog that is designated *For Official Use Only* (FOUO) and has a distribution criteria of *No Foreign Nationals* (NOFORN). In addition to containing military objects, SAVAGE Defense features enhanced tools, scenes, and other objects not found in SAVAGE. Each archive contains an auto-generated catalog, which categorizes a broad range of objects from which users can browse and choose. Locations, Sensors, Ships Civilian, Ships Military, Submarines, Aircraft Fixed Wing, and Ground Vehicles are among some of the available categories depicted in the Entity Library, located on the left pane of the HWII scene and in Figure 6. Each object in the Entity Library can be identified by an icon with an image and text description but a "?" will appear on the icon selector in cases whenever an image has not been assigned.

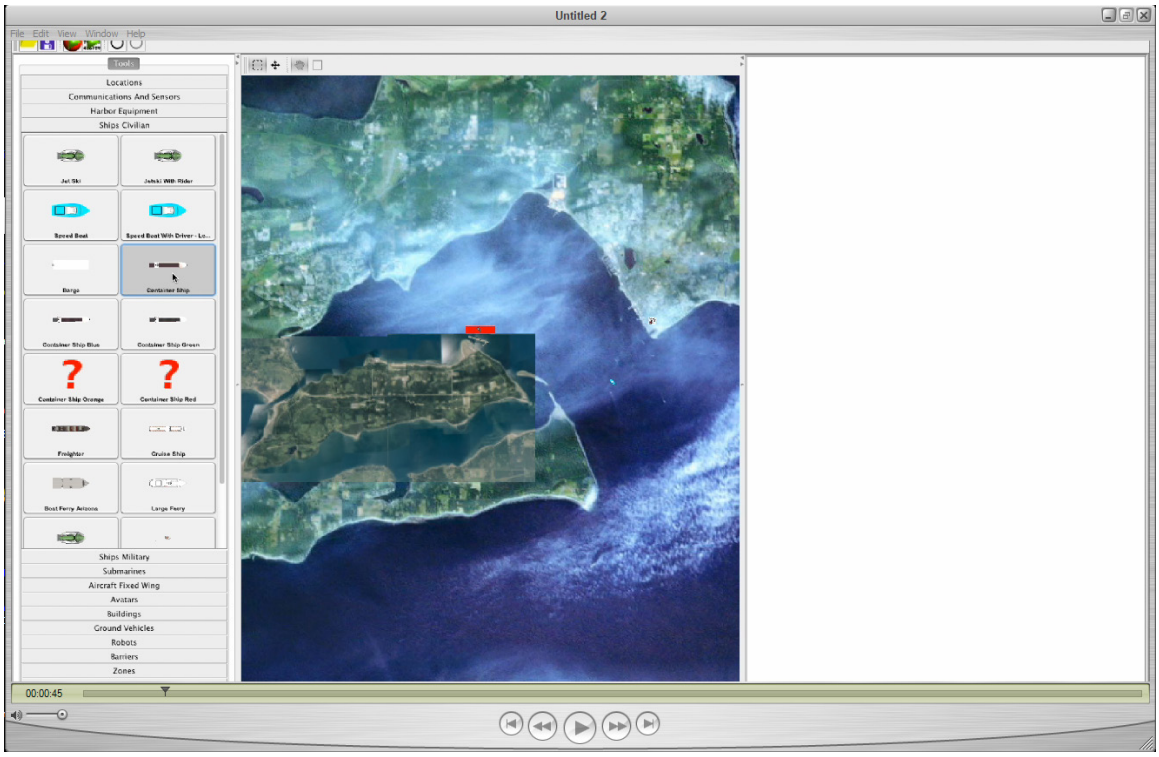

Figure 7. An snapshot of the Entity Library and Indian Island, WA map.

5. Drag and Drop Editing

Users are spared the need to know about the complex relationships, file association, and metadata which powers the Entity Library, but instead can focus on rudimentary hand-eye coordination skills needed to drag and drop items of interest. The user can easily place the desired objects in the scene by selecting them from the Entity Library then dragging to the preferred location on the scene. After selecting a specific object then releasing the mouse, SAVAGE Modeling and Analysis Language (SMAL) Meta-data, a detailed description of the object, will appear in the pane to the right, as seen in Figure 6. Figure 7 illustrates that clicking on the map produces a general, non-descript SMAL output, located on the right side of the image. Multiple copies of the same object can be added to the scene by holding down the "CTRL" key on the keyboard while dropping objects by repeatedly left clicking on the mouse. Objects can be deleted by clicking on "Edit" from the SAVAGE Studio tool bar then selecting "Delete" as shown in Figure 8.

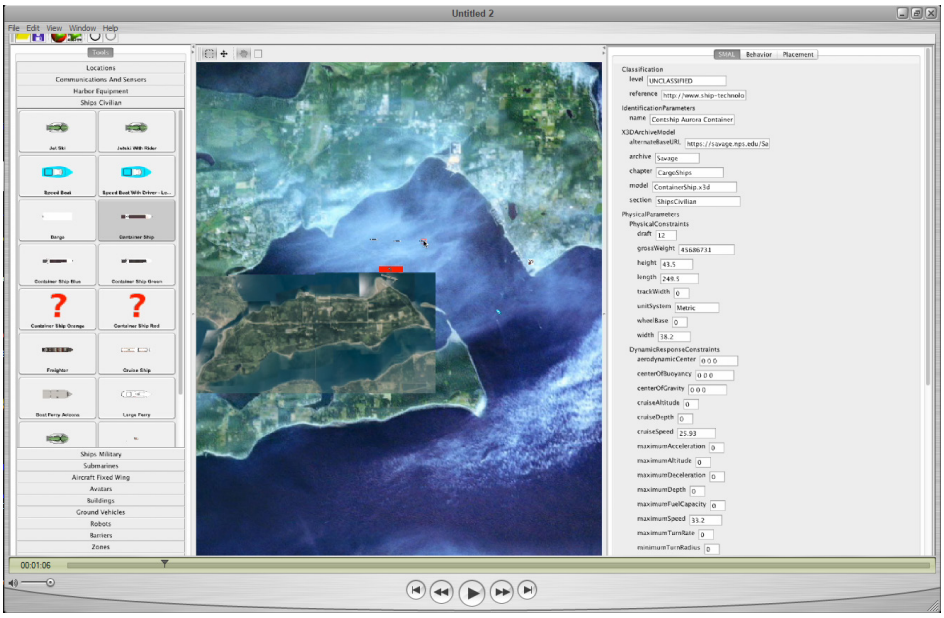

Figure 8. A snapshot showing how to delete objects from the scene: first select, then use edit button to delete.

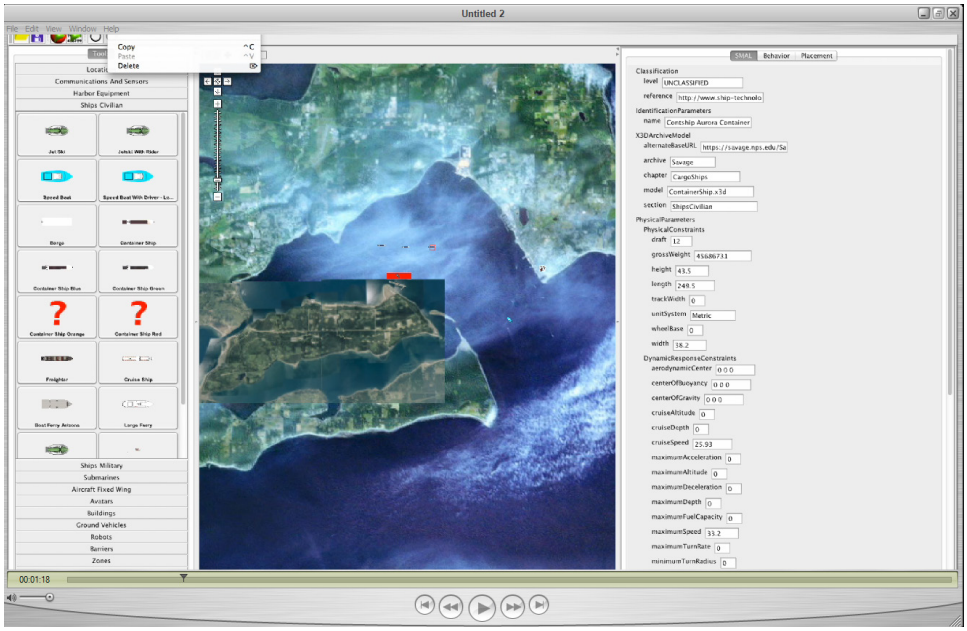

Figure 9. Screen shot of the Entity Library, map, and SMAL metadata of map (From left to right).

Each time the user drags and drops objects onto the 2D (two dimension(al)) map located in the center of screen, SAVAGE Studio assigns those objects unique numeric Entity Identification (ID) numbers. SAVAGE Studio also writes Extensible Markup

Language (XML) code behind the scenes that links Entity IDs with objects and appends related metadata, permitting validatable records of each scenario to be stored, revised and adapted in follow –on work.

6. Observe SAVAGE Modeling and Analysis Language (SMAL) Metadata

Each object in the Entity Library is embedded with a metadata organization standard called SMAL. Rauch describes SMAL as, "the informational 'glue' necessary to perform tactical modeling, simulation, and analysis used by networked, physics-based X3D virtual environments" (Rauch, 2006). SMAL captures useful entity capability information that is significant in rapid scenario generation. Each entity is pre-populated with inherent characteristics so users are not burdened with programming or setting these values each time an object is selected. For instance, SMAL captures important details, such as, tactical constraints, dynamic response constraints, minimum [operational] depth, overall length, top speed, and vessel endurance, which allow simulated objects to mimic their real-world counterparts. Each field displayed in the SMAL pane is an attribute of the object. SMAL data fields are also editable, which opens up an immense range of possibilities through customization. The cursor movement during the HWII scene emphasizes the following SMAL values: URL location, section, model, and chapter. Figure 9 also highlights the "forceID" field and displays the available options for this attribute.

It is important to clarify the difference between SMAL metadata and *.smal* files, as there are distinctly different. The *.smal* files contain information to generate important files for the scene, such as; chosen objects, and the top-level 3D map. In essence, *.smal* files facilitate the generation of Viskit assembly files through *.xml* links, and the placement of the location and objects in the scene. The *.smal* files also synchronize the objects so that when each is activated they perform according to the corresponding behavior.

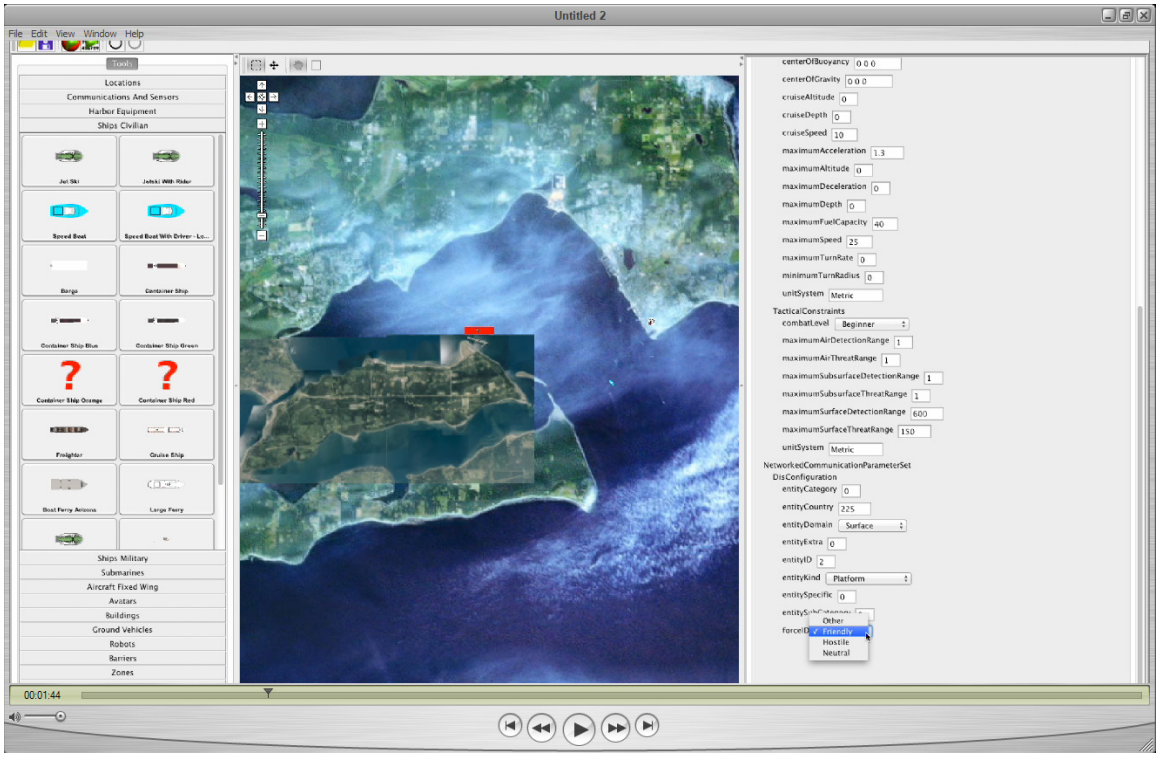

Figure 10. Screenshot of additional SMAL meta-data values, with and expanded view of "forceID."

7. Assign Model Behavior

SAVAGE Studio allows users to assign behaviors to objects they have selected from the Entity Library. General behavior choices include: Friendly, Neutral, Hostile, Obstacles, and Utility. Sullivan outlines the organizational structure of the objects used in the HWII scene, Figure 10 (Sullivan, 2006).

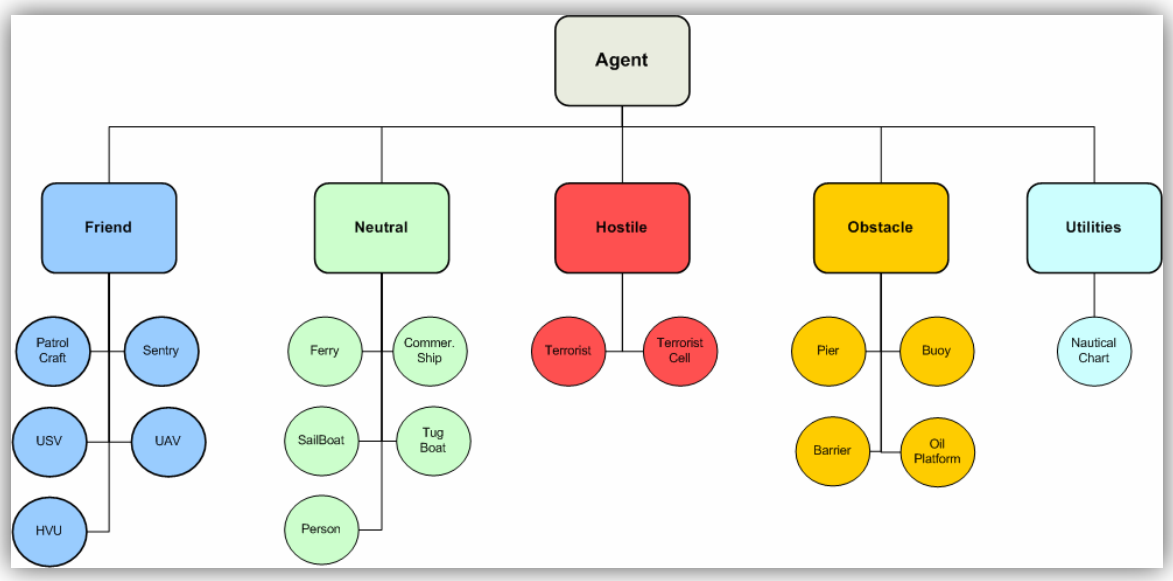

Figure 11. Diagram of the organizational structure of agent relationships and affiliations in the AT/FP project (from Sullivan, 2006).

Painstaking attention to detail was given to modeling the 3D object's behavior to ensure they closely resemble their real world counterparts. A closer examination of *watchstanders* illustrates how this was achieved. Watchstanders are personnel that are on watch, typically on a ship or in a military enviornment. Each behavior has been carefully crafted to match the actions of a normal qualified watchstander performing their job in accordance with applicable plans and instructions, such as the Force Protection Manual. One of the fields located under *TacticalConstrains* is *combatLevel*. The *combatLevel* parameter takes into account natural variations attributed to *watchstander* skill level. SAVAGE Studio gives users the ability to finetune watchstander profficiency by choosing from the following weighted levels: beginner, intermediate, novice, basic, and advanced. Once behaviors are assigned, objects portray the associated charicterists during a sumulation run. A similar level of scrutiny is used to define the capabilities of many objects located in the Entity Library by cross-referencing recognized open sources such as the Federation of American Scientists (FAS) and Jane's Fighting Ships. Analyst have the option to utilyze other informational sources and may assign classification levels as appropriate.

Each object's behavior can be changed by first selecting an object then clicking on the "Behavior" tab from the SMAL pane on the right of the screen. The name of the assigned behavior is located in the "type" field. Users can assign a new behavior to the object by clicking on "Open," selecting the folder labeled "DefaultProject," followed by the folder labeled "EventGraphs," selecting from any of the available folders, and then clicking the "Save" button. For example, an Ohio Class Ballistic Missile Submarine and a Rigid Hull Inflatable Boat (RHIB) are "Friendly" agents in the HWII scene. Opting for the folder labeled "Friendly," as seen in Figure 11, assigns the following characteristics to the object (aka agent) (Sullivan, 2006):

- The ability to define and use a layered defense strategy.
- The ability to define and use patrol areas and areas of responsibility.
- The ability to use a simulated Command and Control (C2) system.
- The ability to coordinate efforts and actions.

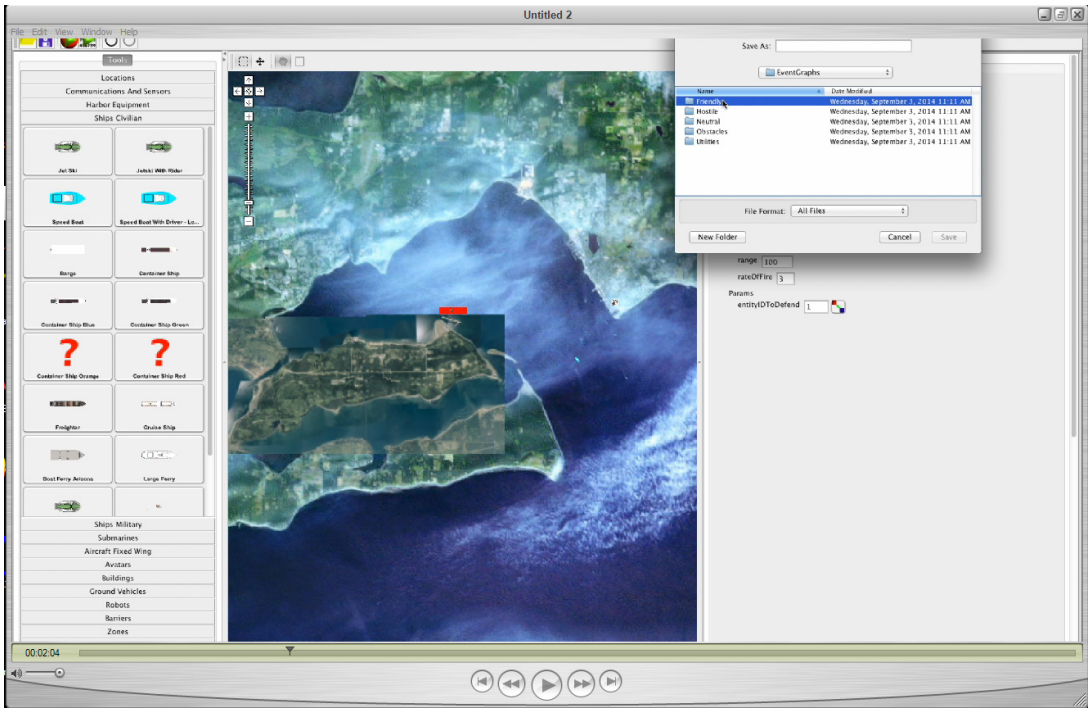

Figure 12. Screenshot showing the assignment of "Friendly" Viskit tactical behavior to virtual vessel in the scenario.

8. Assign Bad Actor

Behaviors can be attributed to many of the objects in the Entity Library. Sullivan defined Hostile agents (aka Bad Actors) as those entities that intend to do harm or damage to Friendly agents (Sullivan, 2006). Users can assign a Bad Actor behavior to an object by starting from the SMAL pane then clicking on "Open," selecting the folder labeled "DefaultProject," followed by the folder labeled "EventGraphs," select "Hostile" (as seen in Figure 12), and then clicking the "Save" button. A speedboat was selected to be the Bad Actor for the HWII scene.

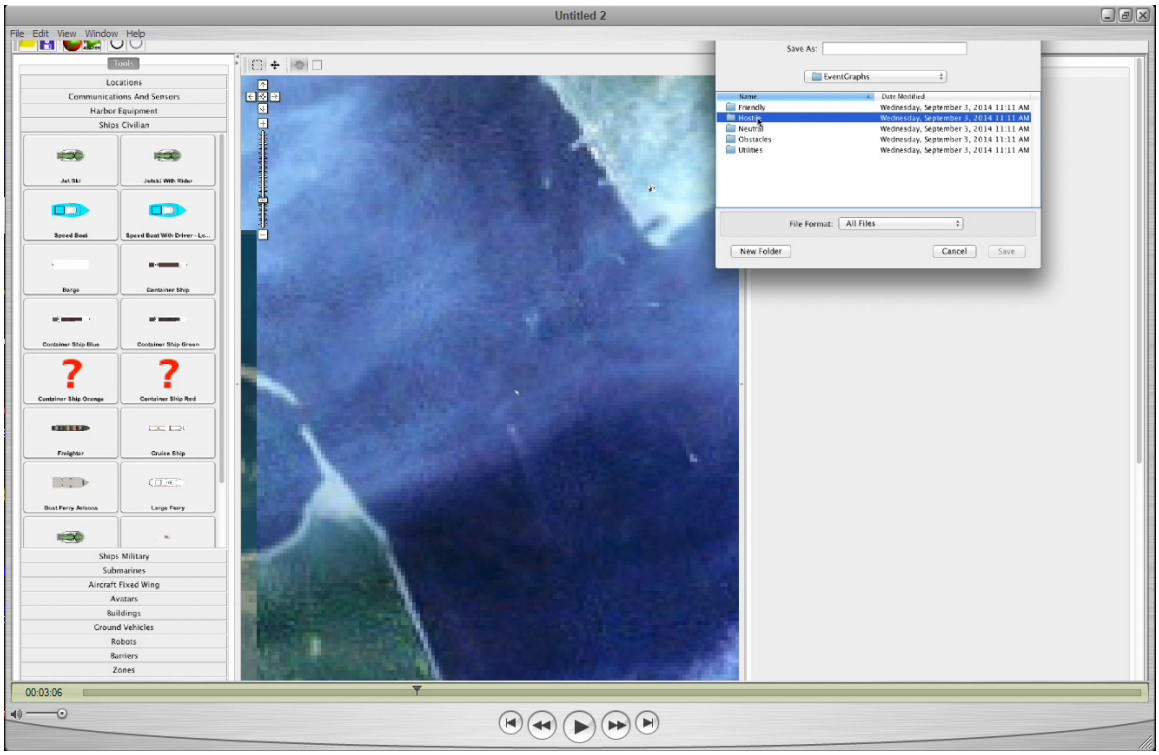

Figure 13. Screenshot showing the assignment of "Hostile" Viskit tactical behavior to a vessel in the simulation.

A comprehensive list of Hostile agent threat modes and the behaviors they are likely to portray are based on intent (Tiwari, 2008). The model shown in Figure 13 has been incorporated into SAVAGE Studio to represent possible real-world scenarios.

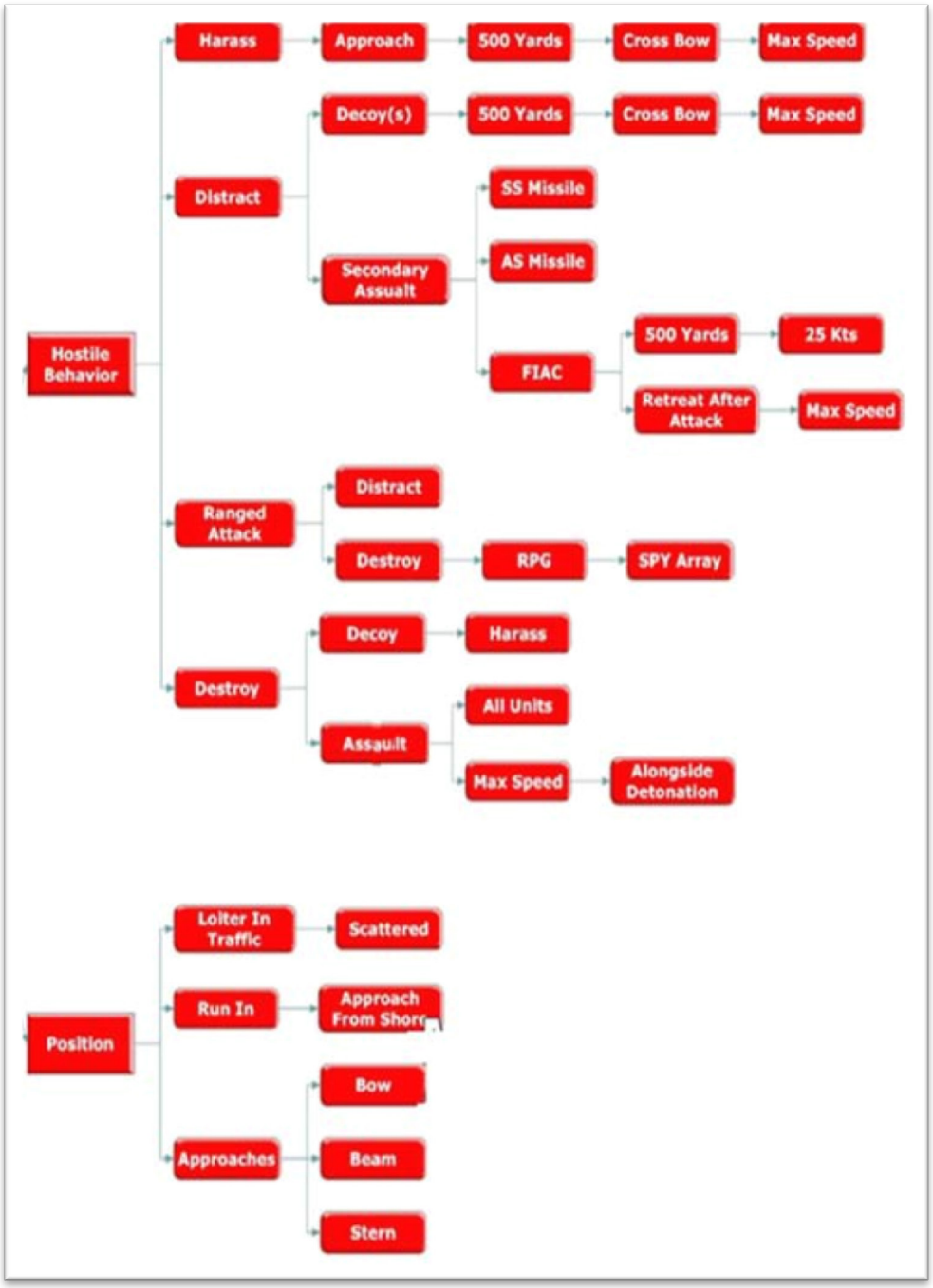

Figure 14. Diagram of conceptual design for threat behavior (Tiwari, 2008).

9. Event Graph Model

Users need not develop a deep mastery 3D programming or technical wizardry to invoke highly technical 3D capabilities. Simple actions on the part of the user from the Graphical User Interface (GUI) such as those previously described in this chapter, trigger numerous behind the scenes processes. The Event Graph pictured in Figure 14 is one of the behind the scenes components. Event graphs allow users to represent all stimulus-response behavioral aspects of a model in one graphical object (Sullivan, 2006). Event graphs have an asynchronous flow format therefore are not written or read from left to right. Bearing some resemblance to a flow chart, Event Graphs are logic-based decision trees used by objects to govern their actions and response to events in the 3D scene. Unlike conventional flow charts which are fairly linear, in that action generally flow from one to the other. Event Graphs can have multiple input-stimulus entry points with corresponding responses that can be triggered independently. Unlike flow charts, processes in the Event Graph are triggered by other process nodes (events) that may not be physically connected by solid or dotted lines.

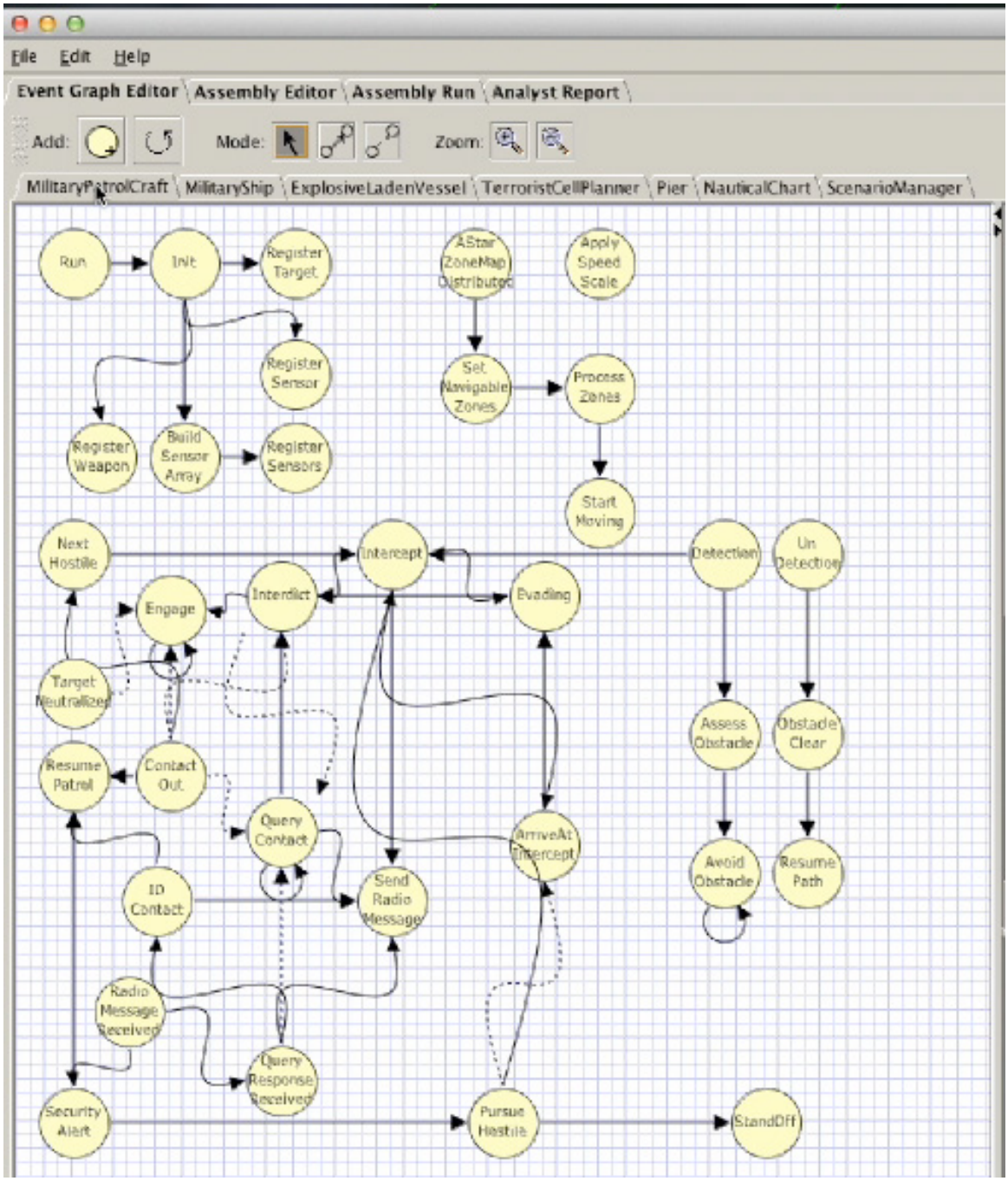

Figure 15. Example of an Event Graph, which contains the expected behavior for a military patrol craft, modeling defined roles and responses defined in typical Tactics, Techniques, and Procedures (TTPs).

Event Graph methodology is based on the premise that activities in the scene are event-driven as opposed to being driven by time. Since discrete events are not bound by time, events in the scene can occur much faster than they do in the real-world. This is an

important concept which allows users to rapidly run multiple simulations in succession or in clusters.

10. Generate Scenario

The HWII scene is comprised of four primary objects that will be apparent to the viewer: the map with a utility behavior, one small boat with a bad actor or Hostile agent behavior, one idle submarine with a Neutral agent behavior, and one small boat with a Friendly agent behavior. A Scenario Manager essentially referees everything that occurs in the scene. A tool called the Terrorist Cell Planner (TCP) serves as a forward deployed scout, reporting the visible actions of Friendly agents to the Hostile agent. This gives the Hostile agent an advantage and simulates how adversarial forces may coordinate attacks in the real world. Though the TCP works with the Hostile agent, it does not control the Hostile agent, giving the attacking force a degree of autonomy, and thus freedom to choose an attack vector. The freedom to choose is moderated by a pseudo-random generated algorithm, which is a product of the component of SAVAGE Studio known as Simkit.

With all of the aforementioned steps in place, the user is poised to generate a scenario for the scene. Users generate scenarios by clicking on the "Run" icon, which resembles the universal play symbol found on many audio and video devices, located just under the "View" option on the menu bar. This action generates a window called the Simulation Window, populated by the map and all of the objects specified by the user during the previous steps. Figures 15–16 displays the initial and final stages of the scenario generation process for the HWII scene, respectively.

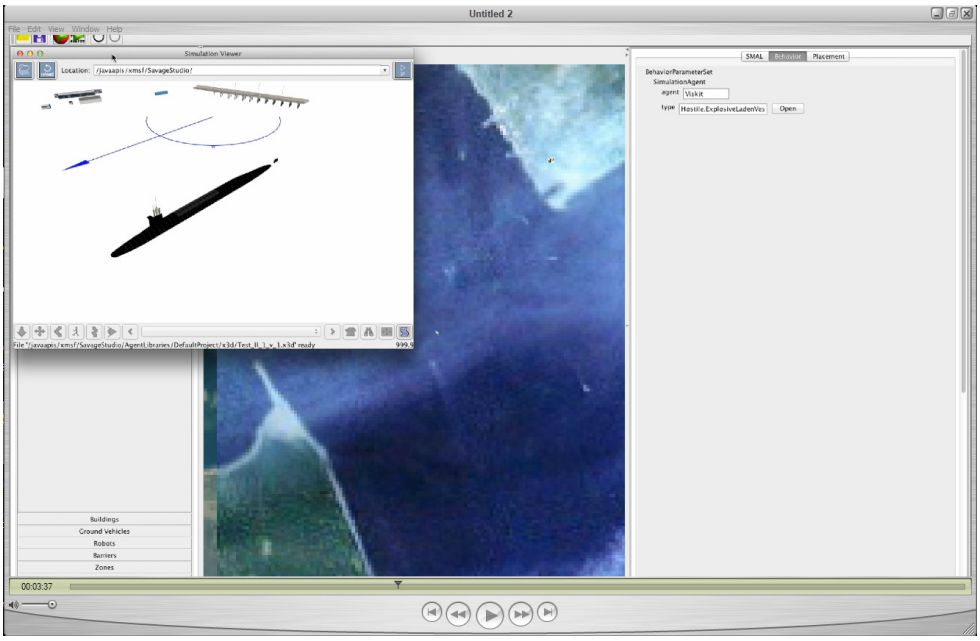

Figure 16. Overhead view of military submarine moored at a pier during the initial stages of Scenario Generation.

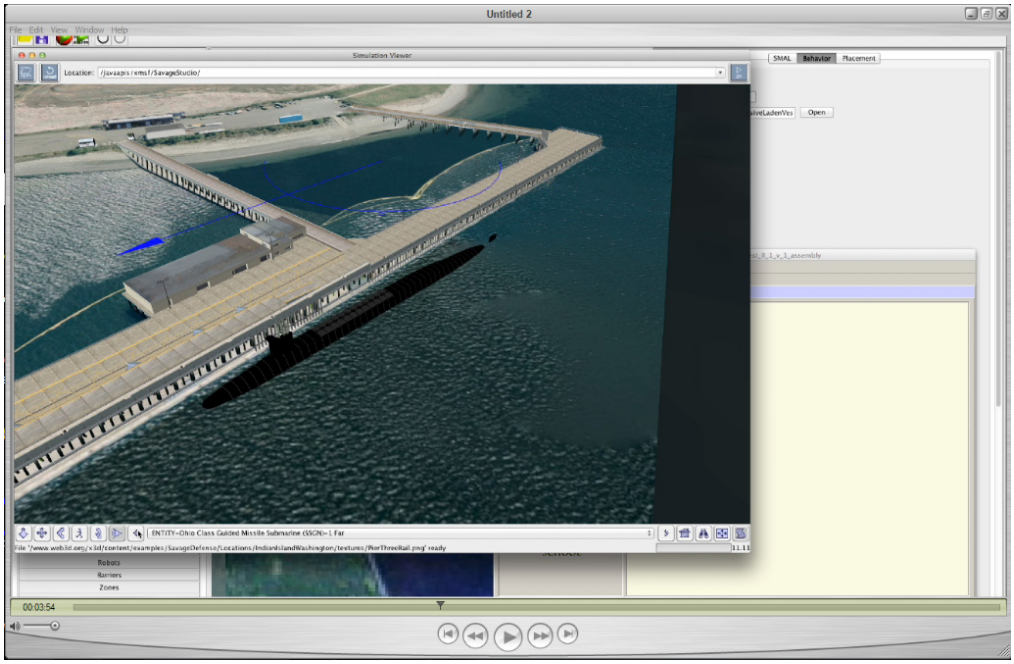

Figure 17. Overhead view of military submarine moored at a pier during the final stages of Scenario Generation.

11. X3D Graphics Visualization

X3D Graphics is the 3D visualization technology used to add greater sense of realism in the HWII scene which allows participants to move through the scene and view objects from many vantage points. These features enhance the 3D experience, which is important when adapting 3D tools for the purpose of training. By giving users many high-quality 3D perspectives within scenes, the experience feels more realistic, thus enriching the overall experience for participants. Figure 17 is a landside view of the loading pier. Figure 18 is a depiction of an Ohio Class Guided Missile Submarine moored at a loading pier at Indian Island, Washington. Figure 19 provides an overhead view of the same objects in the scene. Figure 20 is a high altitude image of the submarine moored at the pier with a RHIB portrayed as stylized blue (aka cyan) circle with arrow. The blue circle and red diamond, which will be introduced later in this chapter, are tactical DOD symbols depicting "Friendly" and "Hostile" forces, respectively (U.S. Department of Defense, 2014). Arrows attached to tactical shapes indicate the direction they are moving. An excerpt from DOD Military Standard (MIL-STD) 2525D containing an expanded view of tactical symbols is located in Appendix B (U.S. Department of Defense, 2014). These symbols are commonly recognized by Tactical Action Officers (TAOs) and tactical watchstanders, and have been incorporated into SAVAGE Studio. SAVAGE Studio automatically assigns the correct MIL-STD 2525 symbol based on the object's correlating behavior.

Figure 18. Landside view of the loading pier show shore-based infrastructure.

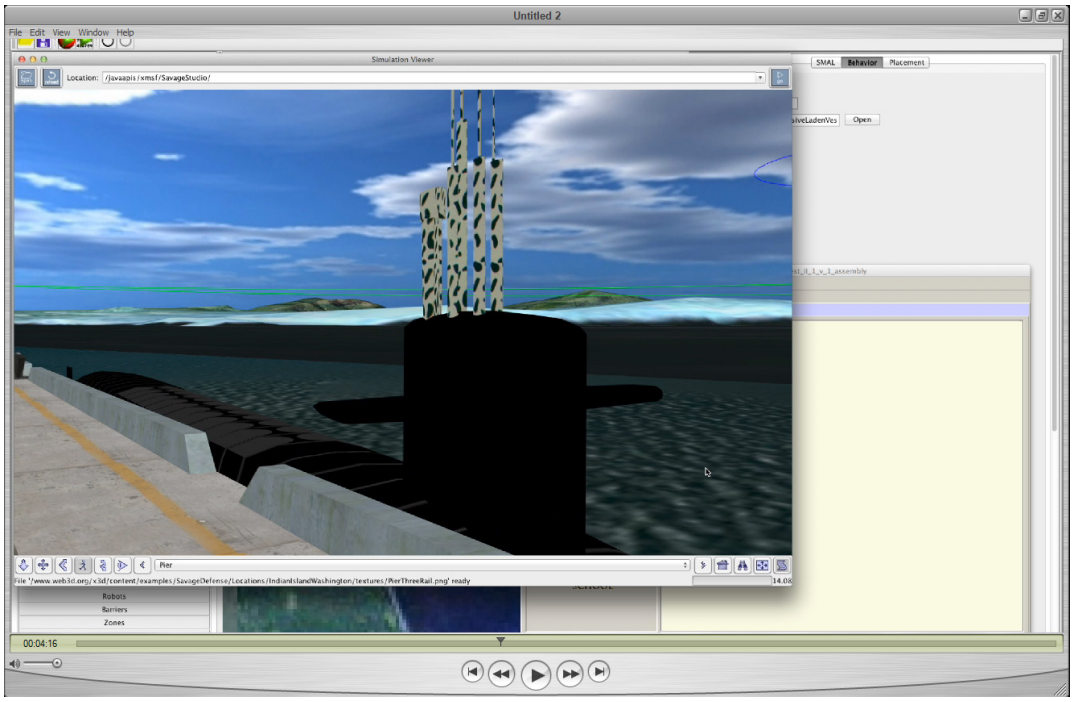

Figure 19. Pier side view of a military submarine and adjacent mooring pier.

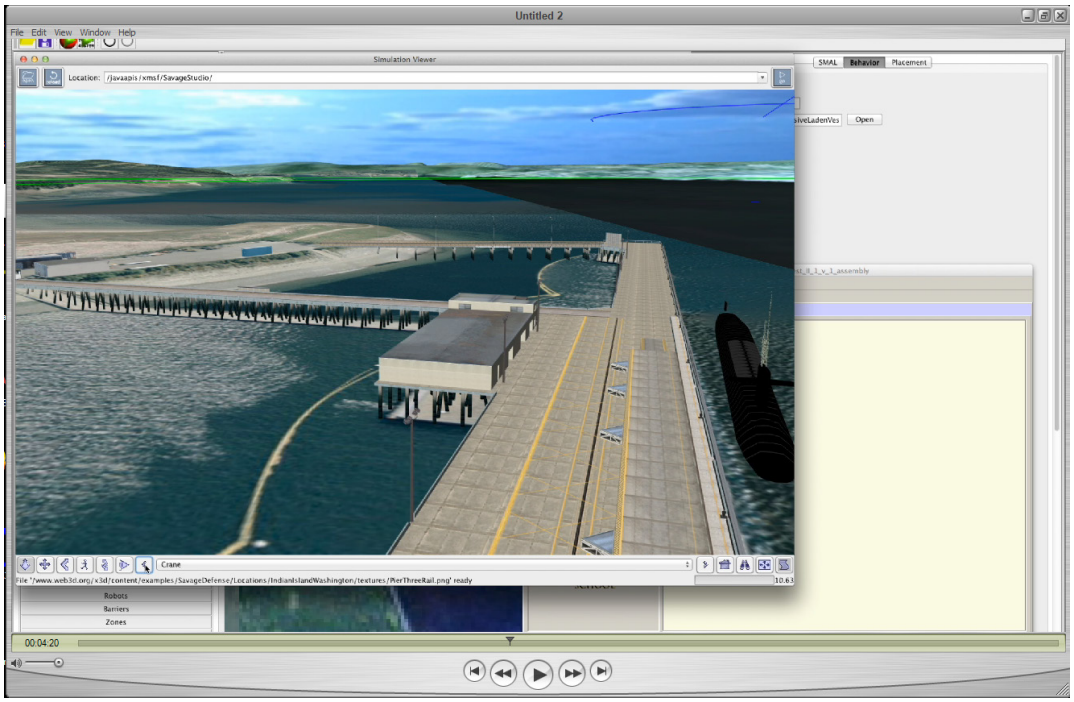

Figure 20. Overhead view of the pier and submarine.

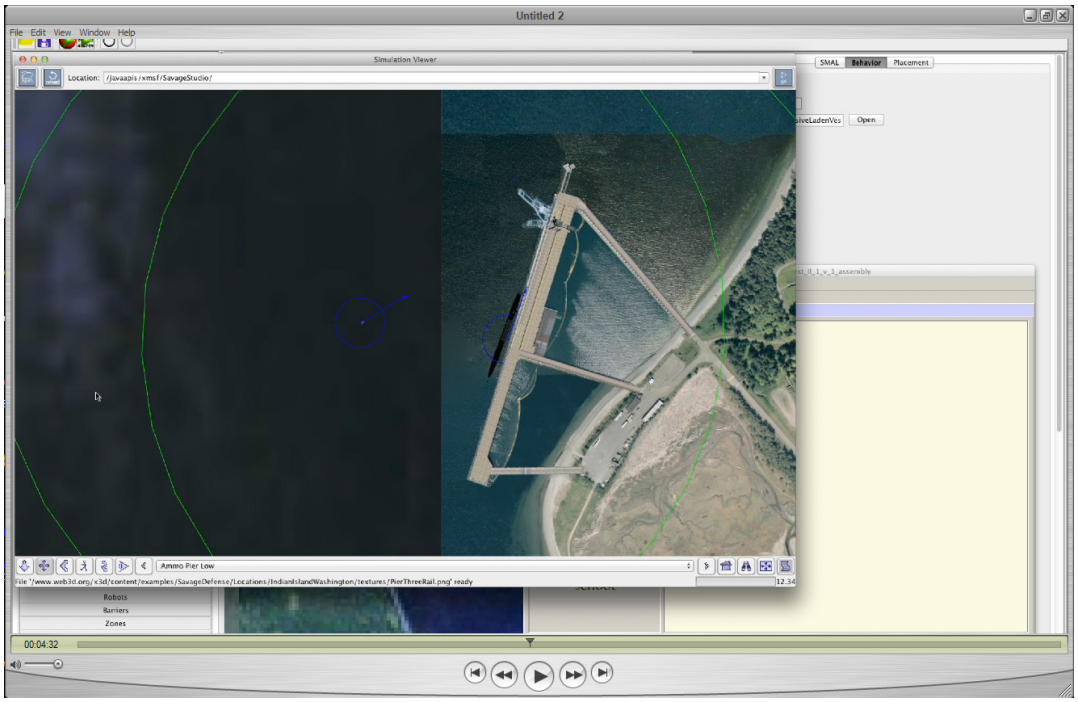

Figure 21. High altitude image of the submarine moored at the pier with a stylized portrayal of the RHIB (blue circle with arrow).

12. Discrete Event Simulation (DES) Assembly

Discrete Event Simulation (DES) assemblies link multiple objects (represented by Event Graphs) into a single scenario, which is one of the processes that Viskit automates when 3D scenes are generated in SAVAGE Studio. DES links the objects in the scene to the Scenario Manager, the TCP to the Bad Actor, pulls in the map, and provides a DES Pinger, or clock, for synchronization. These items clearly labeled and represented by the purple boxes (aka Event Graph nodes) are located on the DES Assembly tab, as seen in Figure 21. Clicking on any of the Event Graph nodes prompts the Event Graph Inspector (editing wizard) to pop up. Figure 22 shows an image of the Event Graph Inspector Window with DES Assembly tab in background.

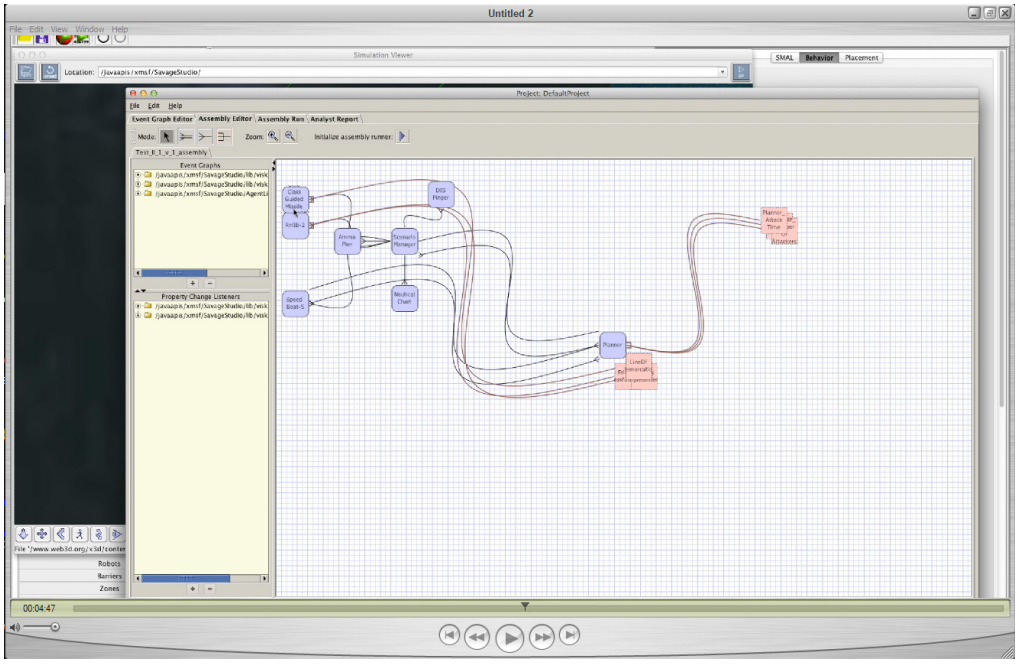

Figure 22. An image of the DES Assembly tab showing Simulation Entities for this Scenario Experiment.

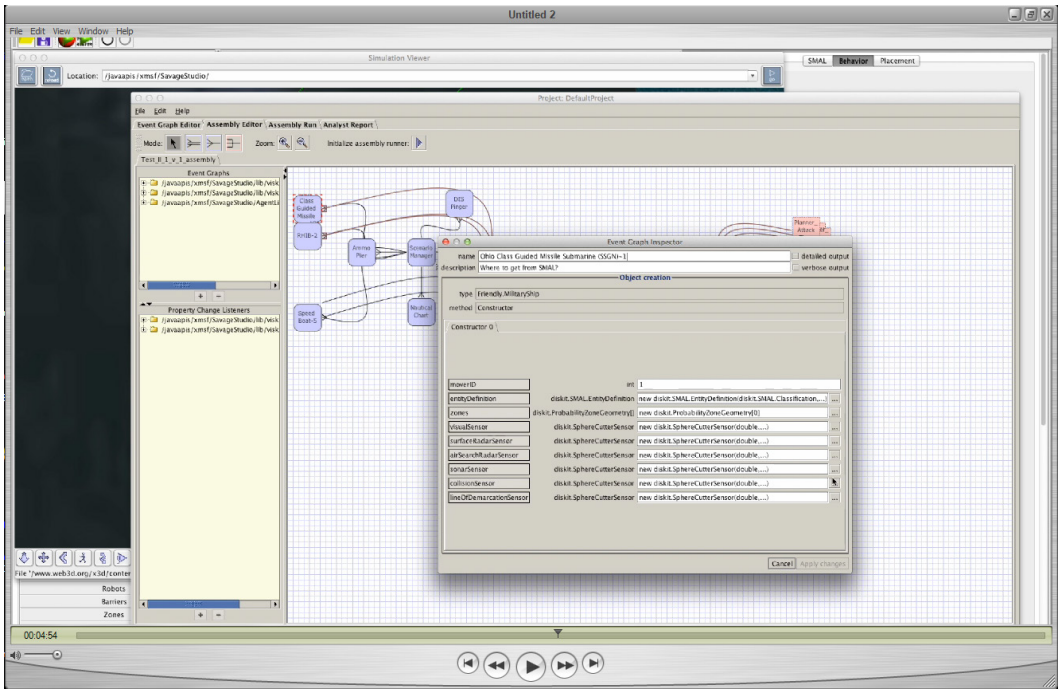

Figure 23. An image of the Event Graph Inspector Window with DES Assembly tab in background.

13. Statistical Listeners

Statistical Listeners are nodes that monitor activities in the scene for specific items of interest, while disregarding other events. Evaluation of any model usually depends on Measures of Effectiveness (MoEs) and Measures of Performance (MoPs). This is a critical task for the analyst. Statistical Listeners allow monitoring and measurement for parameters of interest.

The TCP behaves as a forward observer for the Bad Actor. Bad Actor(s) pay close attention to the TCP by way of simulation event listening connections. During the scene a discrete event paradigm is established where specific actions generated from entities will affect the way the terrorists respond. Viskit establishes listener patterns whereby listener event nodes attentively monitor activities in the event for tripwires. In the HWII scene, tripwires trigger different responses by the TCP and subsequently by the terrorist. Some tripwires cancel or prevent certain actions from occurring while other tripwires will prompt an event to occur.

Each purple node is equipped with a unique set of Statistical Listeners. Users can change Statistical Listener conditions from the Property Change Listener (PCL) Inspector window, which are involked by clicking on each purple node (see Figure 22). Activating Statistical Listeners generates clearly labeled salmon colored (aka Statistical Listener nodes) boxes on the DES Assembly tab, as seen in Figure 23. Inactive Statistical Listeners are never displayed. Statistical Listeners are covered in greater detail in the following section.

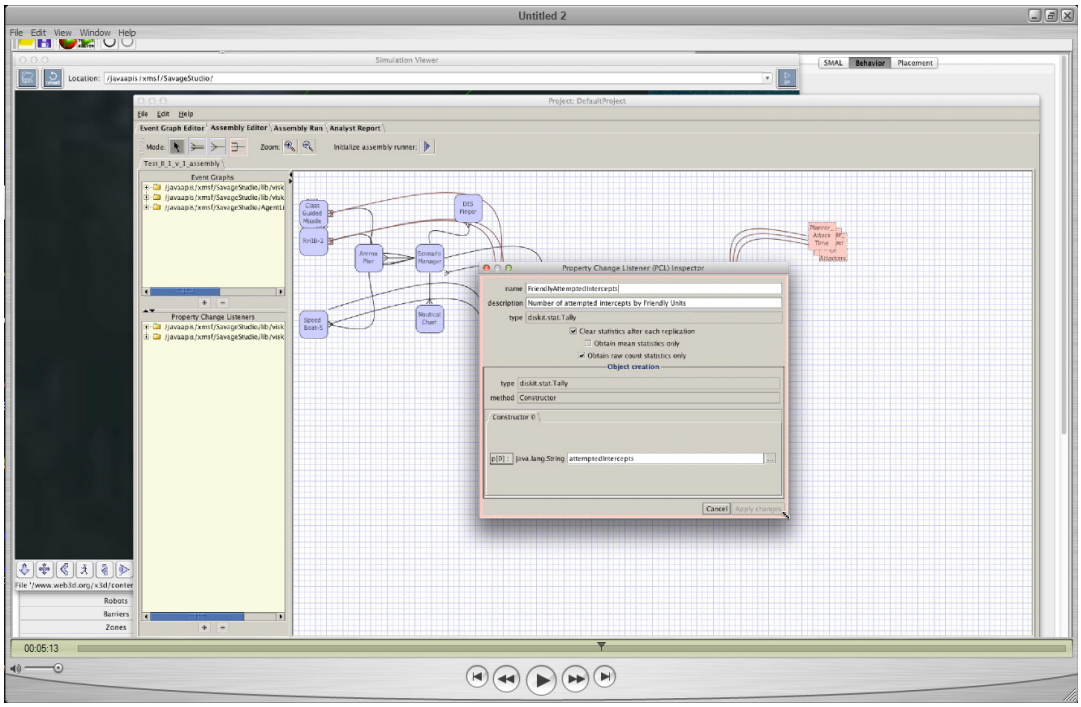

Figure 24. An image of the Property Change Listener (PCL) Inspector window with DES Assembly tab in background.

14. Behavior Models

When a scenario assembly is generated, Viskit automatically pulls in behavior models for each relevant item in the scene. Behavior models for MilitaryPatrolCraft, ExplosiveLaddenVessel, TerroristCellPlanner, Pier, NauticalChart, and ScenarioManager are visible in the lower row of tabs shown in the in Figure 24. Clicking on the behavior models tabs will display its event graph on the left pane, and description, event graph parameters, state variables and other relevant data on the right pane. During the HWII

scene, each behavior model is selected and briefly displayed to better familiarize the viewer.

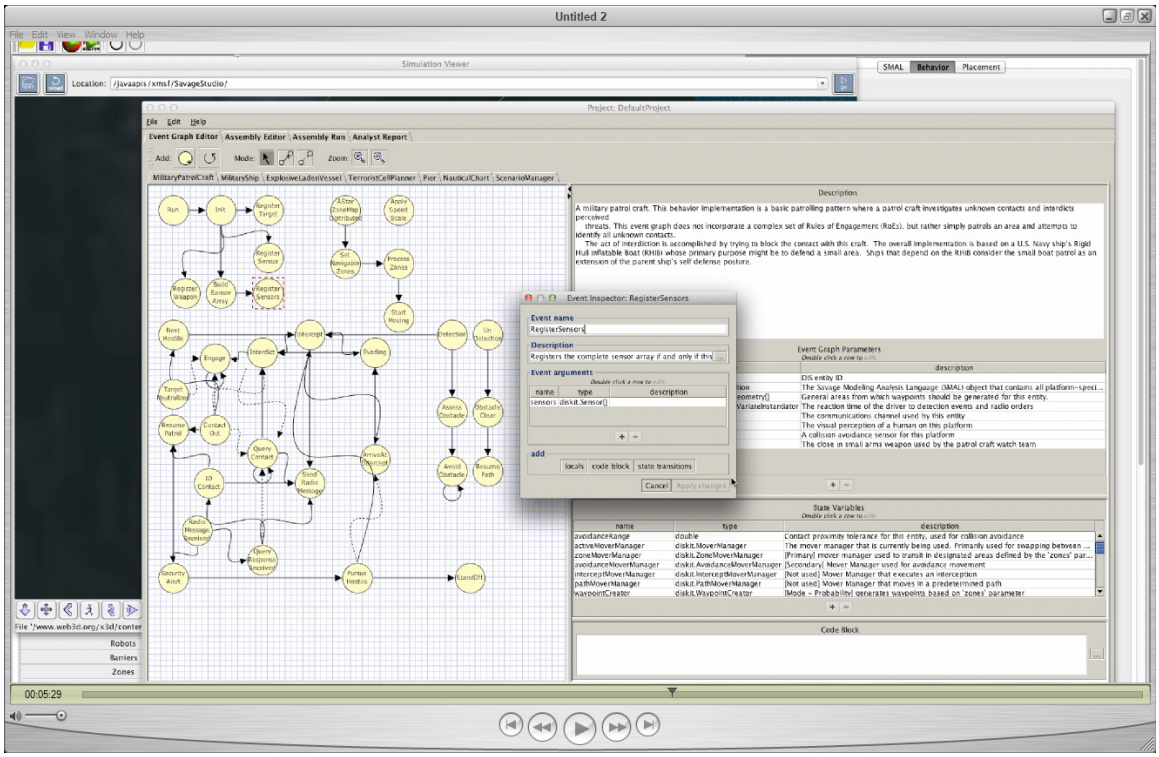

Figure 25. Example of a Behavior Model.

15. Event Scheduling

Event Scheduling conditions occur when scheduled events are completed, after predefined conditions are met, or when events are self-scheduled. Thus, they occur many times, or never again. As seen in Figure 25, Scheduling edges are depicted as solid lines on the Event Graph.

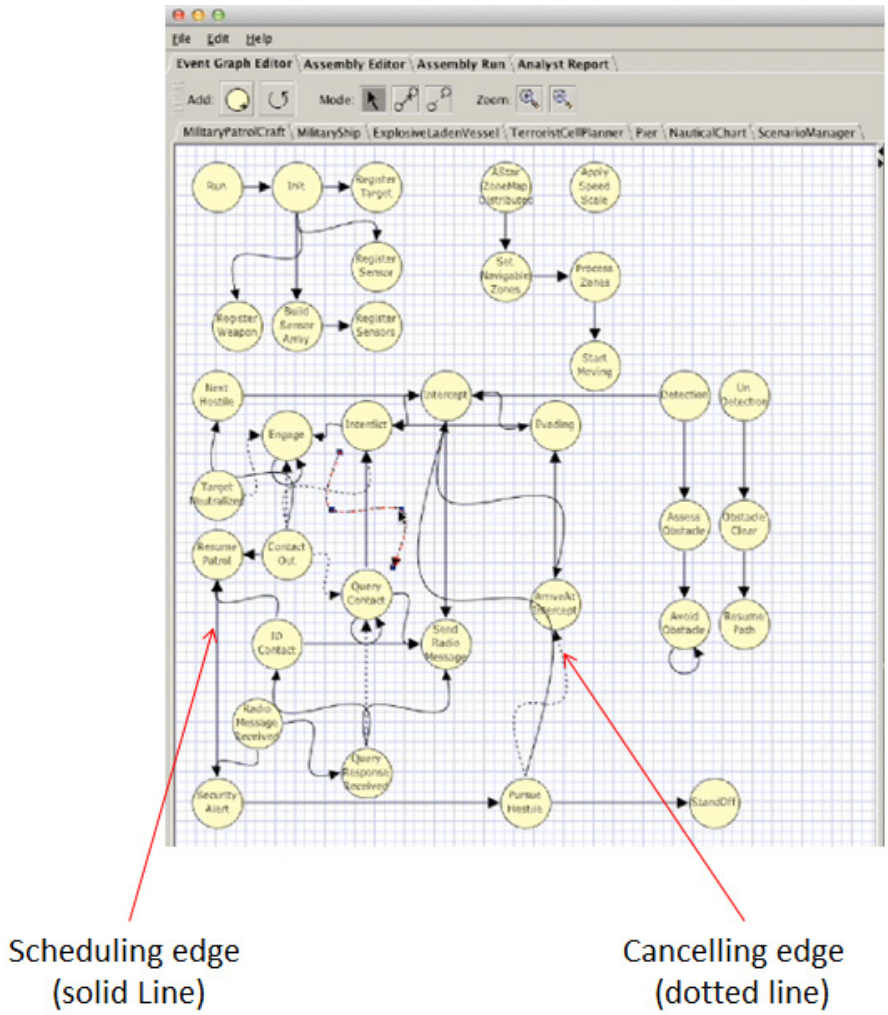

Figure 26. Example of of Scheduling edge and cancelling edge, where a behavioral state changes schedules (or overides) a planned future occurrence in the event queue.

16. Event Canceling

Event Canceling conditions occur when scheduled events are cancelled after predefined conditions are met, or when events are self-cancelling, so they occur once and never again. As seen in Figure 25, Canceling edges are depicted as dotted lines on the Event Graph. Users can access Event Graphs to cancel desired events by scrolling through available tabs. There are eight Event Graph tabs in the HWII scene; MilitaryPatrolCraft, MilitaryShip, ExplosiveLadenVessel, TerroristCellPlanner, Pier, NauticalChart, and ScenarioManager.

During the segment of HWII scene and as shown in Figure 26, green concentric circles represent the maximum (max) effective visual sensor range that crew members aboard each respective vessel are able to detect objects. SAVAGE Studio gives users the ability to fine-tune the effective visual sensor range. For example, when watchstanders are using tools such as binoculars or radar, the effective visual sensor range can be extended. Conversely, users can attenuate the effective visual sensor range to account for environmental factors like rain, fog, or nighttime operations. The HWII scene affords watchstanders optimal visibility as it is based on a clear day, at approximately midday, with sunny conditions. The inner circle is the max effective visual sensor range for watchstanders on the RHIB. The outer circle is the max visual sensor range for watchstanders on the submarine.

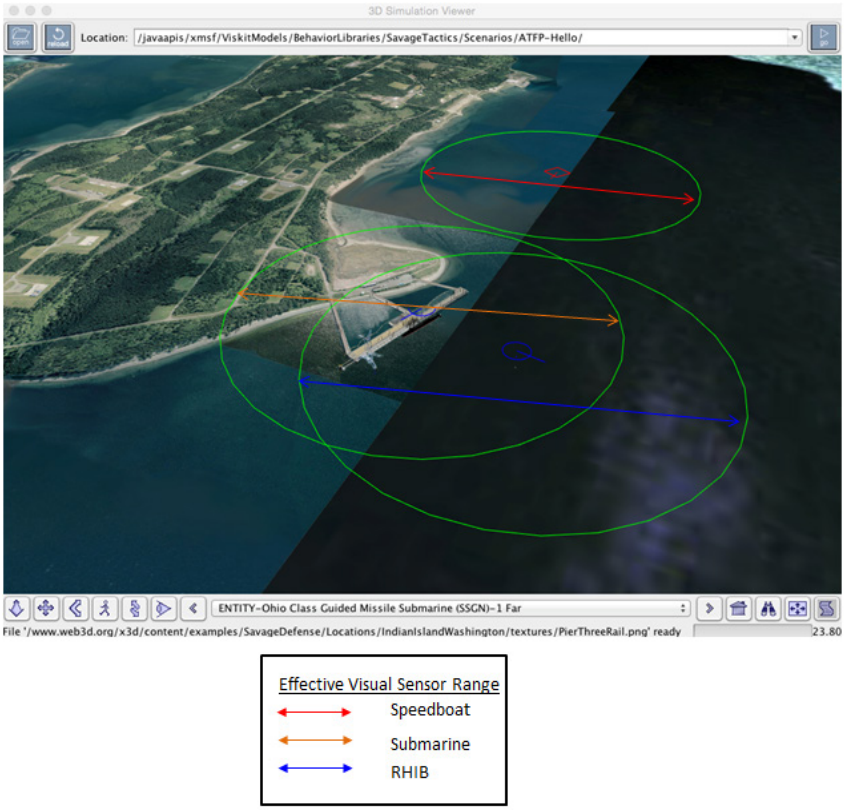

Figure 27. Visual depiction of the effective visual sensor ranges of the speedboat, submarine, and RHIB.

As previously discussed, Live X3D Graphics gives users the ability to view high-quality 3D scenes but users can get stunning results from running simulations with the 3D visualization effects turned off. Users can turn off visualization effects and invoke analytical tools via the screen shown in Figure 27. By turning these features off, users can run multiple replications or clusters, in a fraction of the time. For example, one of the lab computers was able to run fifty HWII simulations in less than 5 seconds with these feature disabled. By running hundreds or thousands of clusters, multiple data points can be rapidly derived from each simulation. By reviewing the results, users can easily recognize and then interrogate outliers to identify contributing factors, potential processes weaknesses, possible equipment shortfalls, and other previously unknown shortcomings. Simkit produces a unique seed number to identify each simulation separately. In addition to reviewing the data, users can use the seed number to select any individual simulation, then reactivate 3D visualization, reconstruct the scene, and ultimately pin-point deficiencies visually.

The green concentric circle surrounding the red diamond (Bad Actor) in Figure 26, shows that Bad Actors also have a visual sensor range. In the HWII scene, the Bad Actor is first detected by watchstanders aboard the submarine when its sensor intersects with the Bad Actor's speedboat. The submarine takes on a security alert posture the moment the speedboat is detected. Once the speedboat intersects with the RHIB's sensor, it detects the Bad Actor and changes its behavior from patrolling to security alert. The RHIB immediately takes action and intercepts the patrol boat (Figure 27).

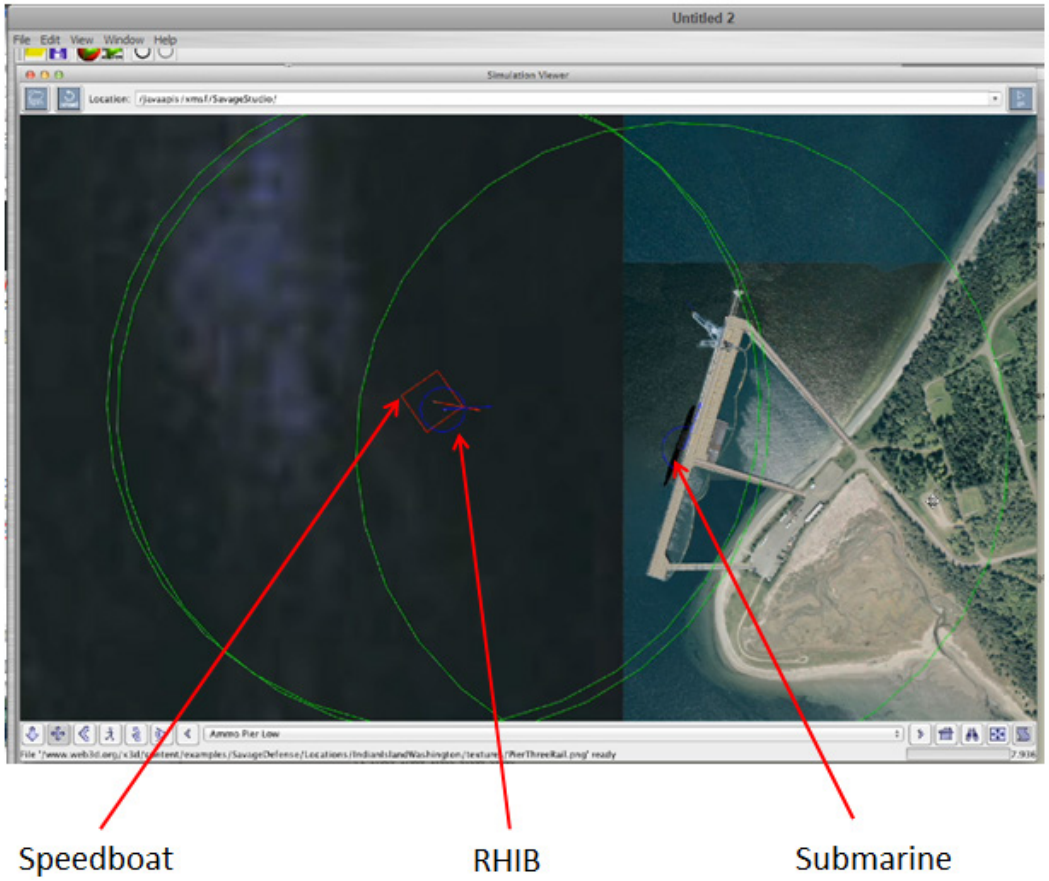

Figure 28. An overhead view of the attacking speedboat (red diamond symbol) being intercepted by the defending RHIB (adjacent blue circle symbol).

17. Analysis Report Generation

At the conclusion of each simulation, Viskit generates a plain text Analyst Report and alerts the user (Figure 28). Analysis Reports are another powerful feature of Viskit which gives users instant access to information about the simulation. After preparing a scene, and running the predetermined number of simulations, users are able to view the results on auto-generated Analyst Reports. Users can further customize Analysts Reports from the Analyst Report Panel shown on the left of Figure 28. The Assembly Run panel is "the location where the simulation is initiated and its control settings adjusted" (Seguin, 2007). Table 1 clearly lists the description of each setting in the Assembly panel.

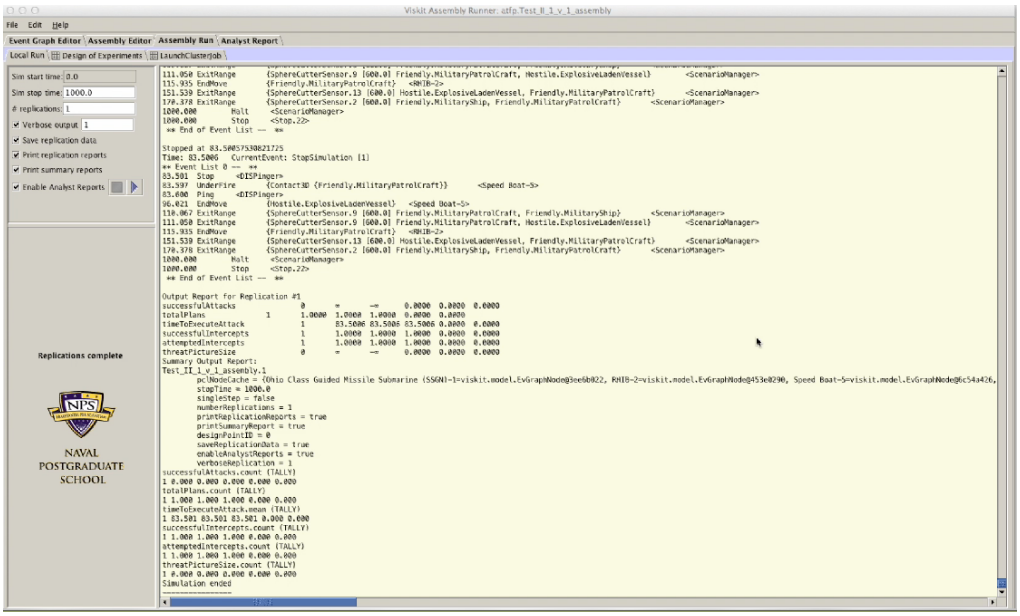

Figure 29. An image of plaintext analytics, plus options for selecting Verbose output and enabling the generation of an Analyst Report.

Setting	Description
Sim Stop Time	Determines when the simulation will stop. Simulation can also be stopped programmatically based on preset events.
# Replications	Determines the amount of replications the simulation will complete. This automatically allows for computation of confidence intervals for stochastic simulations.
Verbose Output	Determines how much information is written to the output panel on the upper right. Primarily used for simulation debug purposes. If verbose is selected, every entry in the event list is written to the output panel.
Save Replication Data	Determines if the statistical data output of the simulation is written to file. This file is in XML format and is used in generation of the Analyst Report.
Print Replication Reports	Determines if the statistical replication data output of the simulation is written to the output panel.
Print Summary Reports	Determines if the summary report is written to the output panel.

Table 1. Assembly Run panel settings and descriptions (from Seguin, 2007).

During the HWII demonstration “Verbose output” and “Enable Analyst Reports” are checked and the number of replications is increased to “30” prior to beginning the simulation run (REF Figure 28). After acknowledging the notification that the report is ready then selecting the “Analyst Report Tab,” six editable tabs appear. Some fields, like “Report Classification,” give users the ability to select from drop-down menus, as seen in Figure 29. Tabs and their associated fields can be used to further tailor the Analyst Report. After completing each tab, users can follow the steps A and B as illustrated in Figures 30 and 31 to generate an HTML formatted Analyst Report.

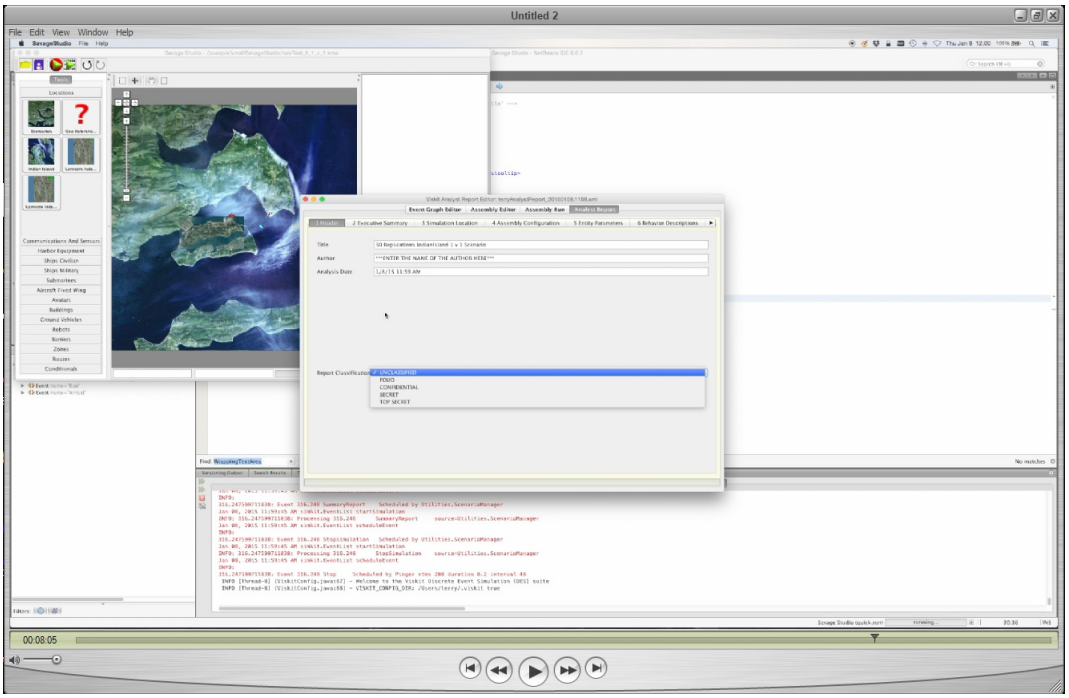

Figure 30. A snapshot of the Report Classification menu options. Reference Chapter V, Table 3 for a complete desciption of each section of the Analysis Report.

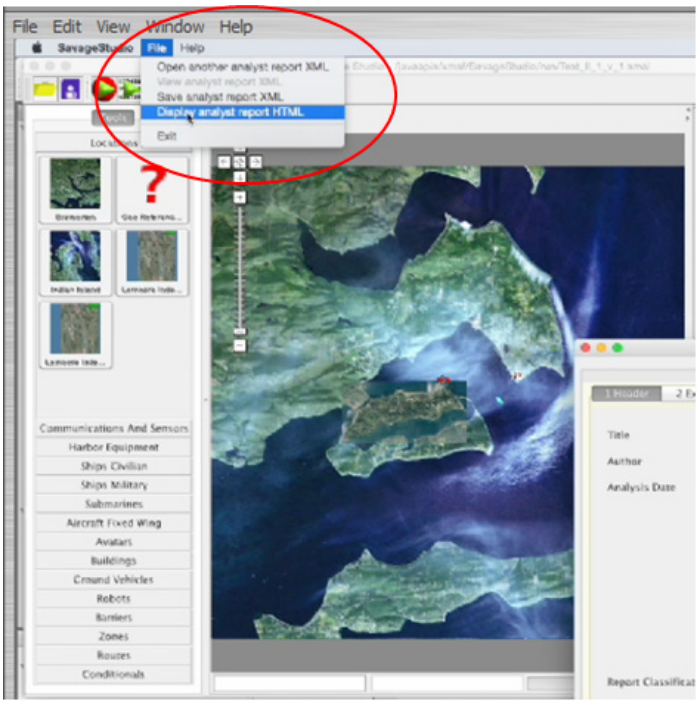

Figure 31. Step A for generating formatted Analyst Report.

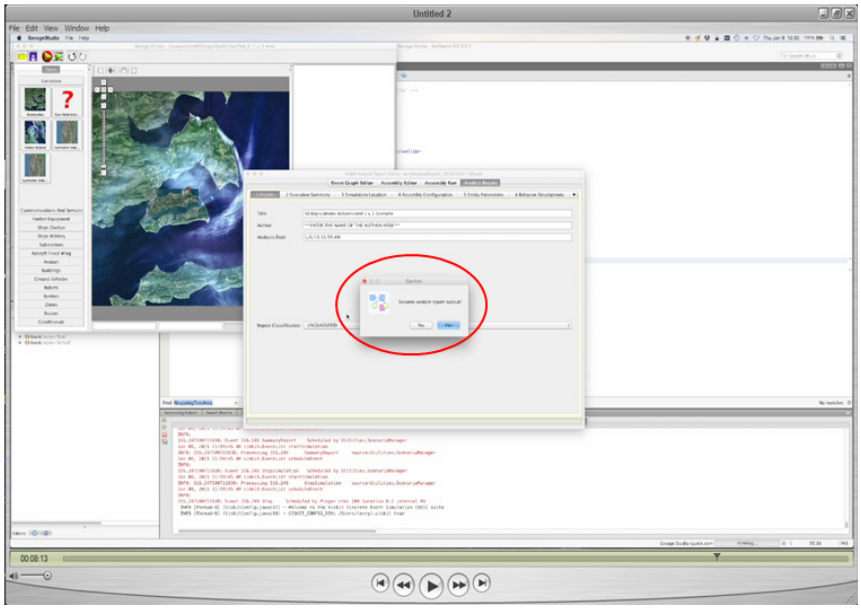

Figure 32. Step B for generating formatted Analyst Report.

18. Hyperlinked Sections

Following a simulation run an Analyst Report complete with Hypertext Markup Language (html) links are automatically generated, containing pre-populated sections such as snapshots from the scene, Measures of Performance (MoP), and Measures of Effectiveness (MoE). As shown in Figure 32, each Analyst Report contains active hyperlinks which users can swiftly and easily use to access targeted sections of the document, such as: a table of each entity and associated information, each event graph with pertinent information, and scatterplots and histograms of formatted metrics for each Statistical Listener (Figures 33 and 34). The Analyst Report can be immediately saved as a (Portable Document Format) PDF file or as a Microsoft PowerPoint presentation, and then used a preliminary after-action report, prior to in-depth analysis. There are also sections of the report that can be manually updated by user. For example, users can describe experimental intent in the header section and add their findings, conclusions, and recommendations in the summary section of the final report. Refer to Chapter V, Table 3 for a list and description of each section of an Analysis Report. Appendix A.C of this thesis also contains a sample of an Analysis Report, to provide a sense of how a basic report looks before the text fields are filled out by the user.

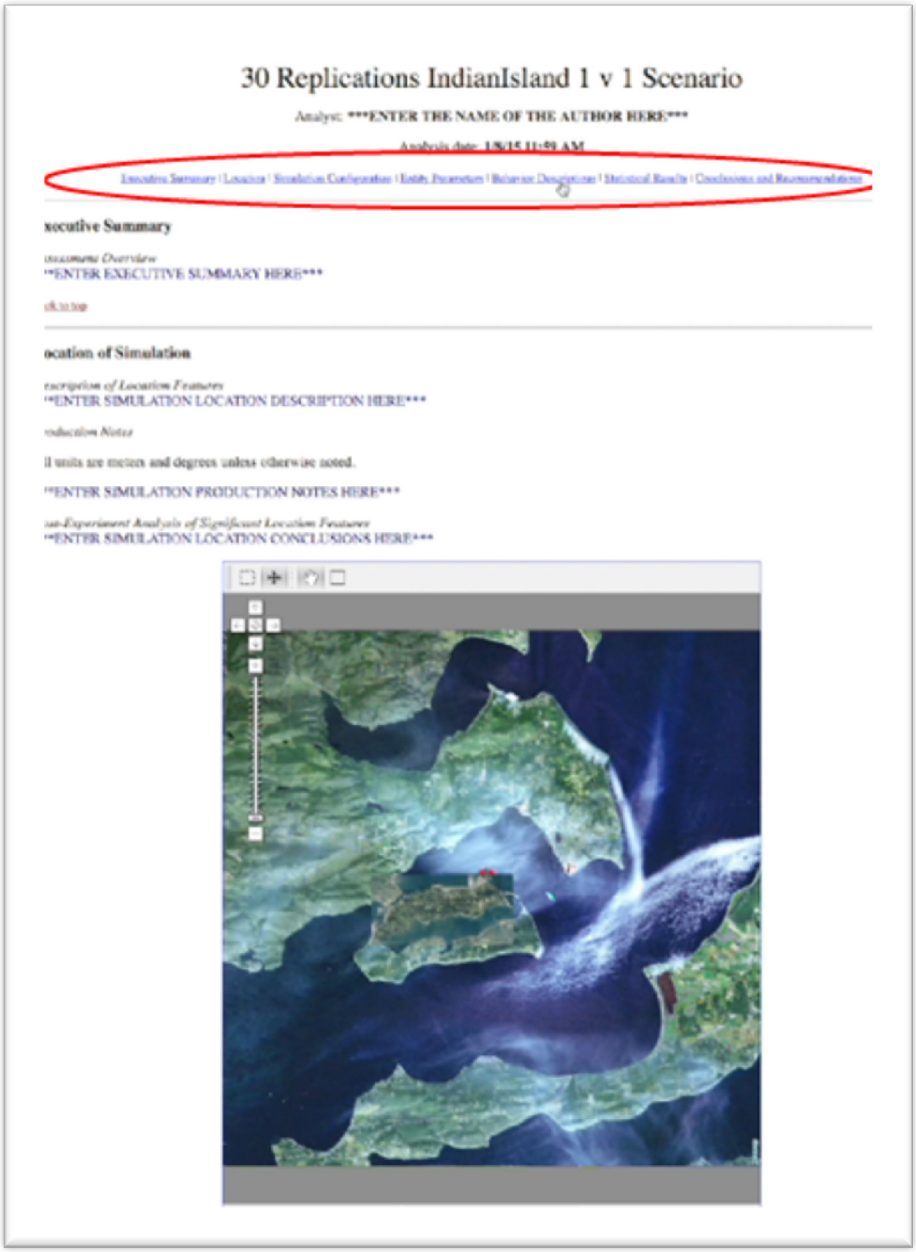

Figure 33. Example of the hyperlinked sections of the Analysis Report, featuring a snapshot from the HWII scene.

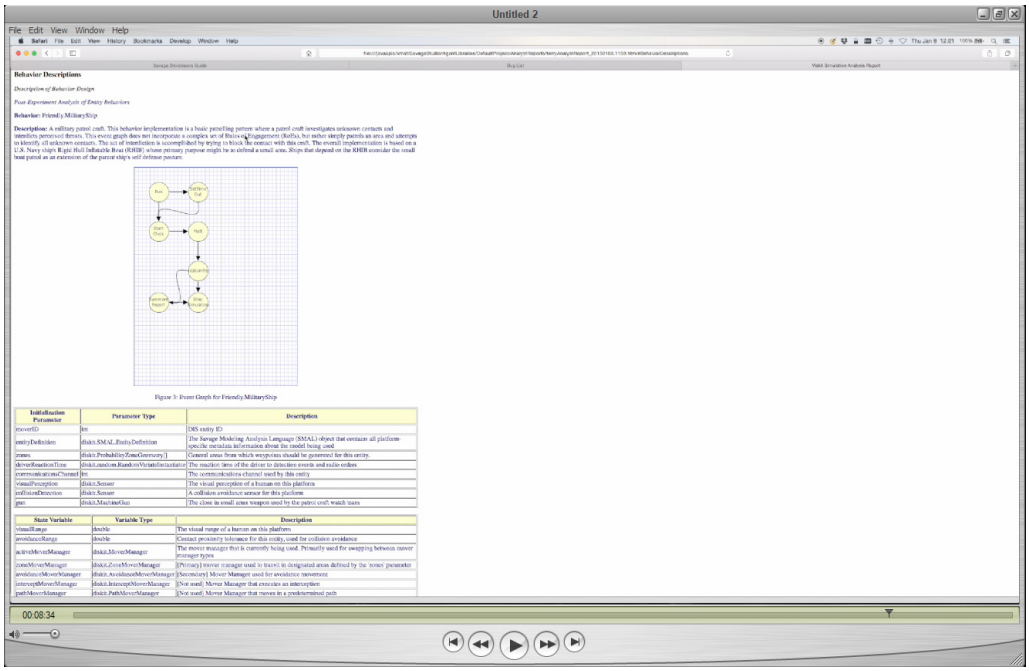

Figure 34. Example of an Analyst Report featuring Event Graph and associated information.

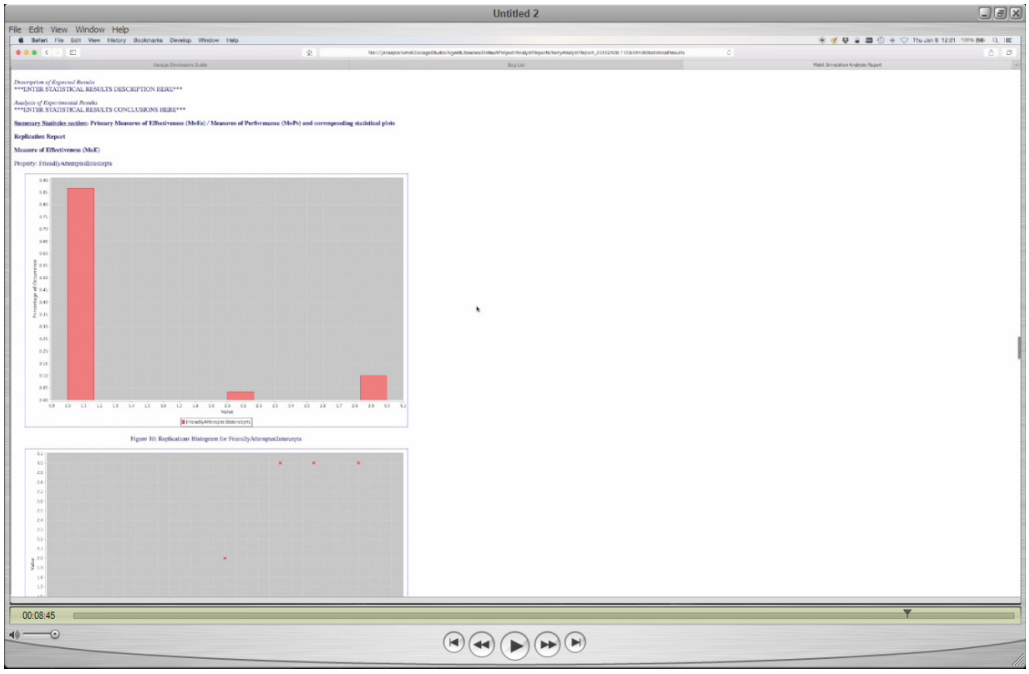

Figure 35. Example of an Analyst Report featuring a histogram and scaterplot.

D. SAVAGE STUDIO'S ADVANTAGES AND DISADVANTAGES

SAVAGE Studio is a powerful open source tool that enables users with basic computer skills to rapidly generate detailed 3D experiments. It is estimated that users with basic computer skills can create the HWII scene in approximately five to ten minutes by leveraging SAVAGE Studio. Comparatively, it would take a resident computer programmer an estimated four hours to manually create the same scene. This assumes the programmer makes use of some available models, creates *xml* coding, builds a wrapper for metadata, and creates a necessary assembly for the scene models. This section provides an unbiased summary of some of the advantages and disadvantages of using SAVAGE Studio.

Open source software is royalty-free alternative to procuring traditional license-burdened, proprietary software. Unlike traditional software, many open source platform give users unimpeded flexibility, giving them the ability to make subtle tweaks or in some cases major modifications to the baseline code. Open source software is readily available to virtually anyone via the world-wide web (www) and many open source platforms offer their community access to libraries containing and array of compatible products. The integrity of well-managed open source libraries is maintained by a group of reputable professionals who scrutinize the library's content, and in so doing maintains a stable and healthy ecosystem for its user-base. SAVAGE Studio benefits from the aforementioned advantages. The Savage Developers Guide includes a section "Free as in Freedom" which outline the advantages accompanying an open-source strategy. Of note is that such an approach can be fully compatible with providing commercial support for high-reliability software packages.

One of the drawbacks of working with the code base for graphical user interface (GUI) is programmers can easily make changes to one line of code, for the purposes of routine maintenance or improvement, that undoes another line of code and in so doing, negatively affect some of the GUI's functionality. Tools exist that allow for some automated testing, primarily for logic-based parameters. Parameters that are not logic-based require manual testing, which becomes more complex with each line of code. Unless the programmer manually tests every parameter after making changes, the full

gravity of severed connections can go unnoticed for quite some time. SAVAGE Studio is not immune from this trait, and as a result a few features were offline and unavailable for testing.

SAVAGE Studio is also subject to shortcomings common to many applications that rely on open source code-base. By agreeing to the terms and conditions of many open source products prior to downloading, users absolve developers of practically all of the standard protections contained in traditional software. Lack of dedicated technical support from the development team is a common aspect of open source software, leaving the user to trouble-shoot the root-cause of unexpected software issues, no matter how complex. The requirement for ensuring open source software architecture is compatible with the latest security patches, operating system (O/S) software releases, anti-virus protection, and other features aimed at protecting users from software exploitation commonly vanishes when users agree to open source software terms and conditions. Open source software is "free" and without funding to pay formal technical writers, open source software is often free of formally documented content many users take for granted, such as user manuals. This presents challenges for some user-level features and may even result in a sharp learning curve for seasoned developers seeking to modify features or debug problems. SAVAGE Studio is encumbered by the aforementioned disadvantages.

E. MASSIVE MULTIPLAYER ONLINE WARGAME LEVERAGING THE INTERNET (MMOWGLI) CROWDSOURCING RESOURCE

The Massive Multiplayer Online Wargame Leveraging the Internet (MMOWGLI) was used to expand on current work by examining how M&S capabilities described in this thesis can inform crowdsourcing gameplay. The objective is to design follow-on MMOWGLI game where SSP, USCG, and a wide variety of mission partners can candidly explore how they can further collaboration effectively during exercise or crisis response situations.

1. Overview

MMOWGLI is an online text-based discussion forum developed and hosted by the Naval Postgraduate School. MMOWGLI war games are used to obtain broad input on virtually any topic. The process is initiated when users present an idea card. Anyone who sees the idea card and cares to comment can do so, or simply follow the communication string without providing remarks. Though war games are generally open to the at large MMOWGLI community, the idea card's initiator has the option of restricting access to a select audience. For an added layer of security, MMOWGLI developers are in the process of integrating secure user authentication through the PKI (public key infrastructure) and the digital signatures embedded in federal Common Access Cards (CAC). This is one method of ensuring only vetted users participate in private MMOWGLI discussion boards. For more information about MMOWGLI see Appendix D or visit https://portal.mmowgli.nps.edu (last accessed May 15, 2015).

As a further extended example, previous thesis work in 2012–2013 (Hutchins 2013) demonstrated how the MMOWGLI platform can be used for crowd-sourced brainstorming of strategic options for counter-piracy, yielding valuable action plans that can be modeled, simulated, and analyzed to make strategic decisions. Hutchins stated, "Three highly rated Action Plans from the 2012 Piracy MMOWGLI game were then modeled and simulated using Discrete Event Simulation (DES). Simulation analysis suggests that the amount of ocean is not a factor if coalition navies aggressively patrol the Somali coast, either directly off shore from active pirate camps or by the use of a naval quarantine" (Hutchins, 2013).

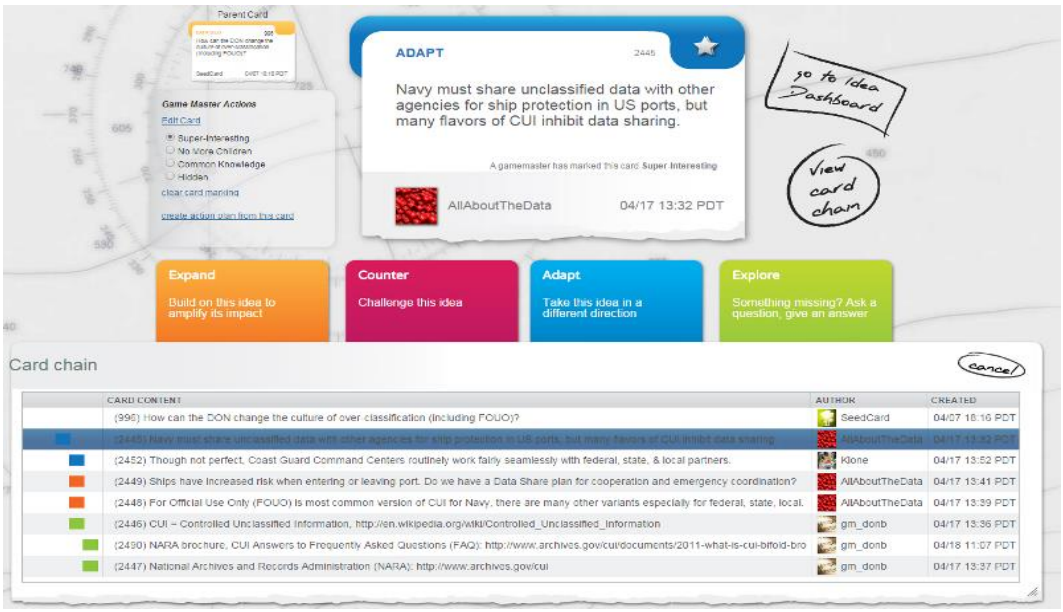

Figure 36. Screenshot of MMOWGLI Idea Card.

2. Using Idea Cards to Discuss Communication Restrictions

This research effort leveraged MMOWGLI's crowdsourcing capabilities to briefly explore the topic of communication. Communications are a crucial component during daily operations and contingency crisis response. An idea card titled, *Need common policies for sharing CUI unclassified data with other government agencies in order to better protect Navy*, was created to stimulate thought and discussion. The discussion string for this topic is located on Idea Card #996.

Since communications often degrade during operations and exercises, MMOWGLI was used to demonstrate how the USN or USCG can leverage existing tools to get input from a large community of professionals on how communications amongst our partner agencies could be improved. Idea Card #2445 was active from late Friday through Monday afternoon, when user activity was expected to be low, but still attracted valuable user comments. At the end of the discussion, the user can export the discussion thread and any associated images or video for further analysis in the form of an Action Item. Action Item #22 resulted from Idea Card #2445. Figure 35 shows a screenshot of a MMOWGLI Idea Card.

a. USCG

Though inter-agency communications can always be improved, the USCG routinely works with industry partners, law enforcement agencies, and representatives from the local, state, and federal government. Improved inter-agency communication is one of the positive byproducts the USCG enjoys as a result of constant engagement and interaction with its port partners.

b. USN

There is a natural tendency for the DOD to be less transparent with un-vetted personnel, which includes the vast majority of the civilian population. Some of the questions and comments from Idea Card #2445 suggested that the USCG was more nimble at communicating with the maritime public than the USN. MMOWGLI allows participants to pose questions and get feedback during the discussion session but non-participants can also benefit from reading the discussion logs.

F. SUMMARY

3D tools have the potential to have a positive and immediate impact on training and readiness. The HWII demonstration illustrates how military organizations can integrate 3D technology into the exercise or test cycle to uncover valuable information about potential vulnerabilities, without spending money on travel, fuel, meals, lodging, or pulling the workforce away from their normal duties to train. MMOWGLI offers a structured online environment that enables broad-scale cooperative exploration of a wide variety of topics. This is yet another collaborative tool that users can leverage to access a diverse and expanding group of professionals.

The tools discussed in this chapter are still evolving. It should be noted that these tools are geared heavily towards research, and though they can be used for commercial applications, they are not designed for commercial consumption. Naval Postgraduate School Researches work diligently to improve these tools and users who experience software-related performance issues are encouraged to contact the SAVAGE Research Group at Savage@nps.edu for further information.

V. SIMULATION RESULTS AND EXPERIMENTAL ANALYSIS

A. INTRODUCTION

This chapter lists research assumptions, offers a review the experiment's scenario, and provides a description of the 3D simulation experiment's design. This chapter also covers the results from a series of tests, followed by a complete analysis of the experiment.

B. OVERVIEW AND MOTIVATION

This chapter presents observations and supporting analytics from a controlled simulation. The experiment was designed to demonstrate how researchers can use Modeling and Simulation (M&S) to create a scenario to gain a better understanding of how altering select parameters can lead to broader understanding and potentially drive operational decisions. In order to establish a common use of terminology for members of the U.S. Coast Guard (USCG) Contingency Preparedness and Exercise (CPE) community, the following words can be used interchangeably: experiment and exercise; researcher and planner; or user and planner.

This experiment is based on a scenario involving three actors: a naval submarine, a naval rigid hull-inflatable boat (RHIB), and a speedboat. Four parameters include the analysis are; combat level, detection range, maximum (max) speed, and ammunition (ammo) count. The experiment was designed to determine which tested configuration of theses parameters is most effective at preventing successful attacks on moored submarines.

The experiment uses methodology described in Chapter IV and was constructed using modeling (M&S) tools designed to capture a variety of possible outcomes. During the experiment, a baseline simulation was established and then slight alterations were introduced to compare various outcomes. This chapter includes a list of research assumptions, a description of the scenario, an explanation of how the experiment was constructed, a summary of the results, and a detailed analysis of the experiment.

C. RESEARCH ASSUMPTIONS

The findings contained in this thesis are based on the following assumptions concerning Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) Studio, the 3D M&S tool used to design this experiment and collect the data:

- The 3D tools used in this experiment are "bug-free" and functioning as designed.
- The dimensions and characteristics of the entities used in this experiment accurately reflect the physical dimensions and characteristics of their real-world counterparts.
- The model behaviors used in this experiment are complete and correct, such that they closely emulate their real-world counterparts.
- The data from the Analysis Report is accurate.

D. SCENARIO DESCRIPTION

The experiment's scenario is similar to Hello World Indian Island (HWII) demonstration discussed in Chapter IV. The location of the simulation is Indian Island, Washington. The list of entities involved in this simulation include an Ohio-class Guided Missile Submarine (SSGN), a standard U.S. Navy (USN) RHIB, a speedboat, and a Terrorist Cell Planner (TCP). Friendly forces are depicted by the moored submarine and RHIB, which is equipped with an M-60 crew-served weapon. Hostile forces are portrayed by the TCP and the speedboat, which is laden with an explosive payload. As a reminder, the TCP works with the hostile forces embarked on the speedboat by serving as a forward deployed scout and reporting the visible actions of Friendly agents, but the TCP does not control hostile force aboard the speedboat, giving the attacking force a degree of autonomy, and thus freedom to choose an attack vector.

The objective of the RHIB is to protect the submarine from attack. The speedboat's objective is to penetrate the RHIB's defenses and then ram the submarine, triggering the detonation of its explosive cargo, a technique reminiscent of the widely

publicized attack on the U.S.S. Cole. The speedboat is programmed to always detonate its cargo, even if intercepted by the RHIB.

E. DESIGN OF EXPERIMENT (DOE)

By using 3D M&S tools, this experiment examines what effect modifying four parameters had on reducing or preventing attacks on naval submarines. These variable parameters were combat level, detection range, max speed, and ammo count. Combat level defines the boat coxswain's skill level and gunner's marksmanship abilities. Detection range describes the max effective visual sensor range of the crew members. Max speed identifies the top speed of the vessel. Finally, ammo count delineates the number of bullets the RHIB has aboard.

This experiment employed the One-Factor-at-a-Time (OFAT) analytical method, in which one factor is changed while all others are held constant (Czitrom, 1999). This approach is also known as controlled experimentation. The OFAT method is an iterative process that allows the researcher to focus on the impact a singular variable has on the entire experiment. The four variable parameters were modified using the OFAT method during the experiments. All other parameters are considered controlled parameters since they remained constant throughout the entire experiment.

A total of eight experimental configurations were used to examine what effect changing the four variable parameters would have on the outcome. As seen in Table 2, each configuration was achieved by modifying parameters on the RHIB or the speedboat. A sample size of fifty simulation runs was obtained from each of the eight configurations by running fifty simulation replications following each OFAT modification.

Within SAVAGE Studio, Statistical Listeners are nodes that monitor activities in the 3D scene for specific items of interest, while disregarding other events. Statistical Listeners were activated for the following items of interest: *Friendly Attempted Intercepts, Friendly Successful Intercepts, Line Of Demarcation, Successful Attacks, Number Of Attackers*, and *Attack Time*. These items appear under the statistical column labeled "MoE / MoP" (Measures of Effectiveness / Measures of Performance) for every Table in the Simulation Results and Analysis section of this thesis.

Configuration	Entity Modified
Baseline	None
Friendly Ammo Count	RHIB
Friendly Combat Level Intermediate	RHIB
Friendly Combat Level Advanced	RHIB
Friendly Max Speed	RHIB
Friendly Surface Detection Range	RHIB
Hostile Max Speed	Speedboat
Hostile Surface Detection Range	Speedboat

Table 2. The experimental configurations and its modified entity.

F. ANALYSIS REPORT

As discussed in Chapter V, SAVAGE Studio produces formatted Analysis Reports containing a map of the simulated area, data, tables, charts, and text fields that can be customized for each simulated experiment. Table 3 contains a description of the eight sections of the Analysis Report. The *Friendly Surface Detection Range* configuration Analysis Report located in Appendix A.C of this thesis provides a sense of how a basic report looks, before the text fields are filled out by the user.

Section	Description
Executive Summary	An available text field that allows users to write an overview of the experiment, the motivation for developing the experiment, and/or a summarization of the expanded report.
Location	An available text field that allows users to identify the location of the scene and why the area was selected. Viskit automatically places an image of the map in this section of the Analysis Report.
Simulation Configuration	An available text field that allows users to document how they went about selecting the entities. This is also a good place to orient the report recipient with any relevant features included in the scene. Viskit automatically places a table that lists the entities used during the simulation, their associated behavior, and an Event Graph in this section of the Analysis Report.
Entity Parameters	This section contains a text field for the user to document the rationale used for using default parameters or customizing the entity's parameters. Viskit automatically places a table for each entity, lists parameters such as its classification, physical constraints, and tactical constraints in this section of the Analysis Report.
Behavior Descriptions	This section contains a text field for the user to document the rationale used for assigning behaviors to entities in the scene. Viskit automatically places Event Graphs and a detailed description of each entity's assigned behavior in this section of the Analysis Report.
Statistical Results	This section contains a text field for the user to identify the Statistical Listeners they activated for the experiment and their rational for using those Statistical Listeners. Viskit automatically tabulates statistical measurements (Min, Max, Mean, Standard Deviation, and Variance) for each active Statistical Listener and places them in charts and also creates a Summary Report of all the data tables in this section of the Analysis Report.
Conclusions and Recommendations	This section contains a text field for the user to identify facts, significant findings, and the outcome of the experiment in addition to recommendations for future research.

Table 3. A description of each section in the Analysis Report.

G. SIMULATION RESULTS

This experiment was created using SAVAGE Studio, a 3D M&S graphical user interface (GUI). SAVAGE Studio also compiled simulation data, performed the initial statistical computations, and produced formatted Analysis Reports for each of the eight experimental configurations. The supporting data was derived from a replication set of fifty simulations for each experiment. The data covered in this section of the thesis was derived from the Analysis Report. This section of the thesis contains further details concerning the steps used during each configuration of the experiment, provides the results of the *Baseline* configuration, and compares the results of all other configurations to the *Baseline*.

1. Baseline

A *Baseline* simulation run was used to establish the successful attack rate with all parameters set to default values. After running fifty replications and examining the Analysis Report, that data shows that the hostile force was able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. To reiterate, the hostile force does not have to ram the submarine for the attack to be successful, but instead simply needs to get close enough to the submarine for the explosive arc to cause damage to the submarine. Table 4 shows the statistical results from the *Baseline* configuration.

Baseline							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50	0.000	1.000	0.360	0.485	0.235
RHIB	FriendlyAttemptedIntercepts	50	1.000	3.000	1.660	0.895	0.800
Map	LineOfDemarcation	50	0.000	1.000	0.920	0.274	0.075
Planner	SuccessfulAttacks	50	1.000	1.000	1.000	0.000	0.000
Planner	NumberOfAttackers	50	1.000	1.000	1.000	0.000	0.000
Planner	AttackTime	50	65.377	350.994	196.178	98.986	9798.166

Table 4. Statistical results from the *Baseline* configuration of the experiment.

2. Friendly Ammo Count

After returning all parameters to the default setting, *Friendly Ammo Count* was increased from 15 rounds to 500 rounds. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter had no effect on any of the experiment's statistical measurements. The hostile force was still able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. Figure 36 displays the formula used to calculate the difference between the results from variable configurations and the results from the *Baseline* configuration. Table 5 shows the computational difference between the statistical results of *Friendly Ammo Count* and *Baseline* configurations. Zero indicates no change.

A = *Baseline Results*
B = *Variable Configuration Results*
C = *Delta*

Formula: $B - A = C$

Figure 37. Formula used to calculate the difference between the results from variable configurations and the results from the *Baseline* configuration.

Baseline vs Friendly Ammo Count							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50	0.000	0.000	0.000	0.000	0.000
RHIB	FriendlyAttemptedIntercepts	50	0.000	0.000	0.000	0.000	0.000
Map	LineOfDemarcation	50	0.000	0.000	0.000	0.000	0.000
Planner	SuccessfulAttacks	50	0.000	0.000	0.000	0.000	0.000
Planner	NumberOfAttackers	50	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	50	0.000	0.000	0.000	0.000	0.000

Table 5. Difference between the results of the *Baseline* and *Friendly Ammo Count* experiment configurations.

3. Friendly Combat Level Intermediate

After returning all parameters to the default setting, *Friendly Combat Level* was increased from *Beginner* to *Intermediate*. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter had no effect on any of the experiment's statistical measurements. The hostile force was still able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. Table 6 shows the computational difference between the statistical results of *Friendly Combat Level Intermediate* and *Baseline* configurations. Zero indicates no change.

Baseline vs Friendly Combat Level Intermediate							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50	0.000	0.000	0.000	0.000	0.000
RHIB	FriendlyAttemptedIntercepts	50	0.000	0.000	0.000	0.000	0.000
Map	LineOfDemarcation	50	0.000	0.000	0.000	0.000	0.000
Planner	SuccessfulAttacks	50	0.000	0.000	0.000	0.000	0.000
Planner	NumberOfAttackers	50	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	50	0.000	0.000	0.000	0.000	0.000

Table 6. Difference between the results of the *Baseline* and *Friendly Combat Level Intermediate* experiment configurations.

4. Friendly Combat Level Advanced

After returning all parameters to the default setting, *Friendly Combat Level* was increased from *Beginner* to *Advanced*. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter had no effect on any of the experiment's statistical measurements. The hostile force was still able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. Table 7 shows the computational difference between the statistical results of *Friendly Combat Level Advanced* and *Baseline* configurations. Zero indicates no change.

Baseline vs Friendly Combat Level Advanced							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50	0.000	0.000	0.000	0.000	0.000
RHIB	FriendlyAttemptedIntercepts	50	0.000	0.000	0.000	0.000	0.000
Map	LineOfDemarcation	50	0.000	0.000	0.000	0.000	0.000
Planner	SuccessfulAttacks	50	0.000	0.000	0.000	0.000	0.000
Planner	NumberOfAttackers	50	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	50	0.000	0.000	0.000	0.000	0.000

Table 7. Difference between the results of the *Baseline* and *Friendly Combat Level Advanced* experiment configurations.

5. Friendly Maximum Speed

After returning all parameters to the default setting, *Friendly Max Speed* was increased from *35 miles per hour (mph)* to *45 mph*. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter had a favorable effect on several statistical measurements. The number of attempted intercepts, successful intercepts, and the line of demarcation increased slightly. *Attack Time* was lowered. Lower *Attack Times* that do not result in damage to submarine is a desired outcome but in cases where the submarine is damaged, higher *Attack Times* are also desired, since this delays the attacker from meeting their objective. The RHIB was unable to thwart the speedboat's attack by using *Friendly Max Speed* configuration, as the hostile force was able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. Table 8 shows the computational difference between the statistical results of *Friendly Max Speed* and *Baseline* configurations. Zero indicates no change.

Baseline vs Friendly Max Speed							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50	0.000	2.000	0.180	0.161	0.182
RHIB	FriendlyAttemptedIntercepts	50	0.000	1.000	0.160	0.109	0.208
Map	LineOfDemarcation	50	0.000	2.000	0.040	0.176	0.127
Planner	SuccessfulAttacks	50	0.000	0.000	0.000	0.000	0.000
Planner	NumberOfAttackers	50	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	50	-2.624	37.900	-5.997	3.099	623.214

Table 8. Difference between the results of the *Baseline* and *Friendly Max Speed* experiment configurations.

6. Friendly Surface Detection Range

After returning all parameters to the default setting, *Friendly Surface Detection Range* was increased from 600 meters (m) to 750 m. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter had a positive effect on several statistical measurements. The number of successful intercepts and line of demarcation experienced subtle increases. This change also resulted in the RHIB preventing one attack out of fifty, though the hostile force was able to penetrate the RHIB's defenses enough to inflict damage on the submarine 98% of the time. Table 9 shows the computational difference between the statistical results of *Friendly Surface Detection Range* and *Baseline* configurations. Zero indicates no change.

Baseline vs Friendly Surface Detection Range							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	0.000	0.000	0.000	0.320	-0.014	-0.013
RHIB	FriendlyAttemptedIntercepts	0.000	0.000	0.000	0.120	0.080	0.151
Map	LineOfDemarcation	0.000	0.000	0.000	-0.220	0.189	0.139
Planner	SuccessfulAttacks	0.000	-1.000	0.000	-0.020	0.141	0.020
Planner	NumberOfAttackers	0.000	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	0.000	-2.090	1.238	0.787	1.221	243.180

Table 9. Difference between the results of the *Baseline* and *Friendly Surface Detection Range* experiment configurations.

7. Hostile Maximum Speed

After returning all parameters to the default setting, *Hostile Max Speed* was increased from *35 miles per hour (mph)* to *45 mph*. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter affected several statistical measurements. The number of attempted intercepts and the line of demarcation decreased but the number of successful intercepts displayed a marginal increase. Enhancements to the speedboats speed resulted in a sharp decrease in attack time and the hostile force was able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. Table 10 shows the computational difference between the statistical results of *Hostile Max Speed* and *Baseline* configurations. Zero indicates no change.

Baseline vs Hostile Maximum Speed							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50.000	0.000	0.000	0.160	0.020	0.020
RHIB	FriendlyAttemptedIntercepts	50.000	0.000	0.000	-0.140	-0.056	-0.096
Map	LineOfDemarcation	50.000	0.000	0.000	-0.220	0.189	0.139
Planner	SuccessfulAttacks	50.000	0.000	0.000	0.000	0.000	0.000
Planner	NumberOfAttackers	50.000	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	50.000	-15.834	-75.715	-25.566	-21.212	-3749.417

Table 10. Difference between the results of the *Baseline* and *Hostile Maximum Speed* experiment configurations.

8. Hostile Surface Detection Range

After returning all parameters to the default setting, *Hostile Surface Detection Range* was increased from 600 meters (m) to 750 m. By subsequently running fifty replications and examining the Analysis Report, the data shows that modifying this parameter had no effect to any of the experiment's statistical measurements. The hostile force was still able to penetrate the RHIB's defenses enough to inflict damage on the submarine 100% of the time. Table 11 shows the computational difference between the statistical results of *Hostile Surface Detection Range* and *Baseline* configurations. Zero indicates no change.

Baseline vs Hostile Surface Detection Range							
Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
RHIB	FriendlySuccessfulIntercepts	50.000	0.000	0.000	0.000	0.000	0.000
RHIB	FriendlyAttemptedIntercepts	50.000	0.000	0.000	0.000	0.000	0.000
Map	LineOfDemarcation	50.000	0.000	0.000	0.000	0.000	0.000
Planner	SuccessfulAttacks	50.000	0.000	0.000	0.000	0.000	0.000
Planner	NumberOfAttackers	50.000	0.000	0.000	0.000	0.000	0.000
Planner	AttackTime	50.000	0.000	0.000	0.000	0.000	0.000

Table 11. Difference between the results of the *Baseline* and *Hostile Surface Detection Range* experiment configurations.

H. ANALYSIS

For the purpose of data analysis, the statistical mean was used exclusively because it was the most consistent measurement. This section will identify the variable parameters that had the greatest effect on the outcome, by closely monitoring their influence on the MoEs/MoPs. Though all MoEs/MoPs are relevant, the most significant factor for this experiment was *Successful Attacks*. Since this experiment involves only one speedboat, the *Number of Attackers* will remain constant. Table 12 contains statistical data from the eight configurations used during this experiment and is referenced throughout this analysis.

A close analysis of the experiment results revealed a potential flaw in the way Viskit calculates the MoE/MoP *Line of Demarcation*. For the tactical models used in this experiment, the *Line of Demarcation* is considered the range in which defenders were expected to sense and potentially react to hostile contacts. The Line of Demarcation may also be considered a security zone and is expected to be a fixed value. However, three experiment configurations prompted this number to change. The prevailing theory is one or more of the inputs used to determine the *Line of Demarcation* is being influenced by a random variate, instead of being held constant, and thereby introducing some uncertainty. Consequently, configurations that resulted in *Line of Demarcation* changes are flagged as "Uncertainty" in Table 12. SAVAGE Studio developers are aware of this anomaly and plan to investigate the matter further.

Summary Analysis Using Statistical Mean								
MoE / MoP	Baseline	Friendly Ammo Count	Friendly Combat Intermediate	Friendly Combat Advanced	Friendly Max Speed	Friendly Surface Detection	Hostile Max Speed	Hostile Surface Detection
Friendly Attempted Intercepts	1.66	1.66	1.66	1.66	1.82	1.78	1.52	1.66
Friendly Successful Intercepts	36%	36%	36%	36%	54%	68%	52%	36%
Line Of Demarcation	0.92	0.92	0.92	0.92	0.96	0.7	0.7	0.92
Successful Attacks	100%	100%	100%	100%	100%	98%	100%	100%
Number Of Attackers	1	1	1	1	1	1	1	1
Attack Time	196.178	196.178	196.178	196.178	190.181	196.965	170.612	196.178
Neutral	Good	Bad	Uncertainty					

Table 12. An analysis of experimental data using the statistical mean.

1. Ineffective Modifications: Friendly

This research illustrates how investments or modifications that appear to provide a tactical advantage are not always beneficial. Government agencies routinely explore improvements that promise new levels of efficiency or provide a tactical advantage. The results in Table 12 show that three friendly force modifications had no effect on the targeted MoEs/MoPs. In fact, the statistical data from the *Friendly Ammo, Friendly Combat Intermediate, and Friendly Combat Advanced* configurations were identical to the *Baseline* configuration. Changes to those variable parameters had no effect on the RHIB's ability to prevent the speedboat from successfully attacking the submarine 100% of the time.

2. Ineffective Modifications: Hostile

Hostile forces also have the ability to upgrade their equipment or make modifications that will give them a tactical advantage. To explore this in greater detail, the *Hostile Surface Detection* parameter was improved then evaluated to see what effect this change would have on the outcome. The data in Table 12 shows that increasing this parameter had no effect on the outcome. The statistical data from the *Hostile Surface*

Detection configuration was identical to the *Baseline* configuration and the speedboat's attack on the submarine was successful 100% of the time.

3. Effective Modifications: Hostile

The *Hostile Max Speed* configuration proved to be an extremely effective modification. Table 12 shows that increasing this variable parameter affected four MoEs/MoPs. *Friendly Attempted Intercepts, Friendly Successful Intercepts,* and the *Line of Demarcation* were reduced. Although the hostile force still successfully attacked the submarine 100% of the time, they were able to damage the submarine 13% faster: the most drastic reduction on the *Attack Time* MoE/MoP. Furthermore, increasing *Hostile Max Speed* resulted in the hostile force detonating the explosives more quickly, thus reaching their objective of a *Successful Attack* sooner, a conclusion supported by the lowest *Attack Time* of the experiment.

4. Effective Modifications: Friendly

Table 12 shows MoEs/MoPs were influenced by two friendly configurations: *Friendly Max Speed* and *Friendly Surface Detection*. Using the *Friendly Max Speed* configuration resulted in the highest number of *Friendly Attempted Intercepts* during this experiment. *Friendly Successful Intercepts* and the *Line of Demarcation* also increased under the *Friendly Max Speed* configuration. *Attack Time* on the other hand, experienced a decrease, when compared to the *Baseline*. Though the RHIB was able to respond to threats more quickly and successfully intercept the speedboat more often by increasing the *Friendly Max Speed* configuration, the hostile force was still able to get close enough to cause the submarine damage 100% of the time.

Table 12 illustrates that *Friendly Surface Detection* was the most effective configuration tested for preventing attacks on submarines in this experiment. This configuration had a desirable effect on all variable MoEs/MoPs. *Friendly Surface Detection* stopped one attack out of fifty attempts but was the only configuration that prevented a successful attack on the submarine. This configuration also resulted in the second highest *Friendly Successful Intercepts. Friendly Surface Detection* also recorded the highest number of *Successful Intercepts*, the largest *Line of Demarcation*, and the

longest *Attack Time*. Longer *Attack Times* are preferred as this allows additional time to activate more defensive measures, to include land-based, surface, or aerial reinforcements.

5. Comprehensive Analysis

Researchers can use the statistical data in Table 12 to draw broader conclusions. For instance, since the hostile force was able to damage the submarine all but once over a series of 400 simulation runs, the security zone may be expanded to create a greater stand-off distance.

Assuming the decision-maker could only purchase one enhancement due to fiscal constraints, the data in Table 12 suggests purchasing equipment in support of the *Friendly Surface Detection* configuration would be the most effective singular upgrade. On the surface, the data may also seem to suggest that if the budget allows for another enhancement, *Friendly Max Speed* would be a logical choice. Instead of arriving at this conclusion simply by looking at the existing data, it would be more beneficial to create a new experiment using the *Friendly Surface Detection* as the new baseline then running a similar experiment. Since the procedures outlined in this experiment are repeatable and rapid, the researcher can use them to evaluate the outcome and quickly determine the most effective combination. Lastly, the *Hostile Max Speed* configuration used in this experiment highlights the benefits of also planning for hostile forces. The data suggests that the RHIB must minimally be able to match the hostile force's speed to increase the probability of attempted intercepts and to allow enough time to activate other security measures.

I. SUMMARY

This experiment demonstrated how researchers can use 3D simulations to explore functional solutions, then use observations and supporting analytics to support operational decisions. Using the analytic component for statistical assessment removes conjecture, forming a strong basis for decision making. The process is iterative, making experiments fairly easy to duplicate or modify. 3D M&S tools offer a great degree of flexibility, making it possible for users to create small-scale experiments or scale-up to

more complex simulations. This experiment also revealed how 3D simulations can be used to validate or disprove the level of effectiveness that proposed solutions may provide. This capability is extremely valuable prior to costly investment and illustrates which configurations result in either no change, an advantage for friendly forces, or an advantage for hostile opponents.

VI. CONCLUSIONS AND RECOMMENDATIONS

This chapter of the thesis describes why this thesis is important, what this thesis accomplished, and shapes the way ahead. This chapter also provides a brief summary of the key findings from this research and a list of recommendations for future work.

A. CONCLUSIONS AND RESULTS

This thesis uses maritime security as a central theme to highlight a firm mission-oriented connection between the U.S. Navy (USN) Strategic Systems Program (SSP), the U.S. Coast Guard (USCG) Marine Force Protection Unit (MFPU), and the USCG Contingency Preparedness and Exercise (CPE) Branch. This thesis also illustrates how SSP and the MFPU can effectively influence wide-scale maritime security improvements, while boosting security during submarine escorts by collaborating with CPE. Further, this thesis uses an experiment to provide evidence that CPE can utilize modeling and simulation (M&S) to design exercises and use analytic results for a more scientific approach to decision making. Maritime security can be propelled to the next level when SSP, MFPU, CPE or USCG M&S Center takes the first step to explore this topic with the other.

1. Contingency Preparedness and Exercises

Currently, USCG contingency plans are tested during drills, exercises, and real-world events. Incorporating 3D M&S tools into the U.S. Coast Guard (USCG) CPE community has merit. USCG doctrine acknowledges that M&S tools would enhance the overall exercise experience, is expected to reduce the number of personnel needed to support traditional exercises, and can guide decision making. The USCG's CPE Branch oversees a wide range of contingency focus areas, and thus targeted use of 3D M&S tools has the potential of benefitting numerous Coast Guard mission areas and a wide range of exercise partners throughout the continental U.S., its territories, and commonwealths. The recent launch of the USCG M&S Center gives CPE access to M&S professionals that can help to identify existing 3D M&S technology or develop an in-house solution. SA

2. Strategic Systems Program (SSP) and the U.S. Coast Guard (USCG) Marine Force Protection Unit (MFPU)

SSP and the MFPU will benefit from the effects of CPE's adoption of M&S tools. SSP and the MFPU work in tandem to ensure the safe transit of submarines in littoral waterways. Though SSP and the MFPU seldom interact with USCG contingency planners, both units would benefit from CPE-driven improvements in maritime security. CPE's adoption of M&S tools has the potential to change the maritime security landscape by giving contingency planners the ability to assess a bevy of security factors in a level of detail previously unattainable. CPE's large constituency of port partners are also expected to absorb lessons from well-crafted 3D simulation exercises, thus strengthening additional links in the maritime security chain. Through collaboration SSP and the MFPU may be able to assist CPE and the USCG M&S Center to more rapidly adopt M&S tools, and consequently reap the benefits of improved maritime security more quickly.

3. SAVAGE Studio

SAVAGE (Scenario Authoring and Visualization for Advanced Graphical Environments) Studio is not production ready or designed for operational use but holds promise for exploring and analyzing scenarios of interest.

B. RECOMMENDATIONS FOR FUTURE WORK

1. Apply 3D Visualization to the Coast Guard Maritime Security Risk Analysis Model (MSRAM)

The USCG Maritime Security Risk Analysis Model (MSRAM) is a risk assessment tool used by the Federal Maritime Security Coordinator(s) (FMSC), typically a Coast Guard Captain, to assess all of the Critical Infrastructure and Key Resources (CK/IR) in their area of responsibility (AOR). MSRAM uses data inputs to produce risk scores and recommendations to buy-down risk but lacks a 3D visualization interface that can help Port Security Planners to validate numeric guidance. Research aimed at unlocking MSRAM's hidden potential by integrating 3D simulation with existing risk-based models and scenarios may lead to deeper insights and broader maritime security improvements.

For more information about MSRAM visit http://aapa.files.cms-plus.com/PDFs/MSRAMBrochureTrifold.pdf (accessed June 10, 2015).

2. Department of Homeland Security (DHS) Port Security Grants

The USCG serves as a proxy for the Department of Homeland Security (DHS) Ports Security Grant Program. In Fiscal Year 2014, DHS awarded $100,000,000 to promote viable risk-based projects focused on improving maritime security by protecting CI/KR. The USCG reviews grant proposals and recommends the approval of investment justifications that buy down the greatest risk. Research focused on how the USCG can leverage 3D simulation to more thoroughly substantiate Port Security Grant investments justifications through supported M&S analysis would be extremely beneficial. Further, M&S tool should be versatile enough to be seamlessly integrated with the aforementioned MSRAM research initiative.

3. Submarine Transits Through Oil Slicks

The USCG and USN should consider using M&S tools to determine the implications of military submarines transiting through a channel following an oil spill. Man-made and natural disasters can lead to large scale oil spills. Since there are barges, oil refineries, oil container farms, and other potential sources for oil spills in every major port in the U.S., the possibility of spills occurring in the littoral waterways that experience naval submarine traffic exists. Since the USCG is the lead federal agency for maritime oil spills, this is another area that requires close coordination between the USCG and USN. It would also be beneficial for the USN to determine the impact various types of petroleum products in the AOR will have on the submarine's performance after it transits through the oil slick.

4. Network COVE-based Simulators

Research is needed to explore the benefits of intra/inter-service COVE-based simulator networking. The USCG and USN rely heavy on COVE-based simulation as a training tool. Expanding the existing capabilities to allow simulators to establish a network connection would add a new dimension to the training experience. This

proposed networked configuration opens up new possibilities for expanded training by immersing operators from different units, locations, and even from different branches of service into a single virtual training environment. This approach should also be considered for future simulators.

5. Develop Business Case Analysis Feature

SAVAGE Studio's analytic capabilities are ample for guiding decisions but more complex problems may require additional tools. Users would also benefit from a business case analysis module that could determine how much money proposed changes would save over a period of time. It would also be advantageous if the business case solution could perform a side-by-side comparison of projected costs (or cost savings) of multiple solutions. Integrating this feature into SAVAGE Studio would provide a more comprehensive tool for guiding decision making.

6. Expand the SAVAGE Defense Libraries for X3D models and Tactical Behaviors

The SAVAGE (Scenario Authoring and Visualization for Advanced Graphical Environments) Defense Library contains a large inventory of military vehicles but lacks X3D models of USCG assets and associated SMAL (SAVAGE Modeling and Analysis Language) metadata. By updating SMAL metadata, and importing or creating the appropriate behaviors, better support for simulated scenarios involving joint operations would be realized.

7. Hello World Indian Island (HWII) Voice-over

The Hello World Indian Island (HWII) demonstration satisfies the need for an introductory video and Chapter IV of this thesis satisfies the need for a written narrative. Finding a pleasant voice to merge the two is the next logical step in the evolution. Use the information provided in Chapter VI of this thesis to create voice over narration of the Hello World Indian Island (HWII) scene.

8. Use Massive Multiplayer Online Wargame Leveraging the Internet (MMOWGLI) to Stem Concerns of Human Research Protection Programs

Many learning institutions rely on Institutional Review Boards (IRB) to ensure research does not violate the school's Human Research Protection Program, which is designed to protect rights, welfare, and anonymity of those who participate in research. Since the Massive Multiplayer Online Wargame Leveraging the Internet (MMOWGLI) is designed to safeguard user identity, more work should be done to determine how the Naval Postgraduate School, and perhaps other institutions, can benefit from more broad scale usage of this tool to generate anonymous input for research question.

C. CULTURAL SHIFT IN FEDERAL COLLABORATION

The final take away from this thesis is there needs to be a cultural shift in the federal government for greater collaboration and distributive sharing of intellectual property throughout the M&S community. The greater M&S community would greatly benefit from access to tools and solutions currently isolated on islands of excellence.

Prior to an initial investment in M&S tools, business rules should be established to require the benchmarking of existing M&S tools from other branches of the military and the broader federal government. It is quite possible that other U.S. military units or federal government agencies have invested large quantities of time and financial resources to develop complete or partial solutions to another agency's problems. To that end, the USCG and other federal agencies should consider the following recommendations:

- There appears to be willingness to share M&S tools and techniques among the service components but no structured forum for facilitating formal or informal sharing.
- The use of such a forum has the potential of eliminating duplication of effort and maximizing the return on research effort and research spending. Additional research is needed to determine how to best share M&S tools and

techniques among the service components initially, then throughout the federal government.

- Since the U.S. Coast Guard (USCG) likely shares the strongest synergies with the U.S. Navy (USN), evaluate which USN M&S and 3D tools can be repurposed for USCG implementation with little or no modification.
- The Department of Defense (DOD) as a whole has made significant investments in M&S & 3D technologies. As such, the greater DOD and it's service components, should be evaluated to determine which tools can be adopted for use in the USCG.

More collaboration can lead to reduced waste, greater efficiencies, more interoperability, and truly help agencies to do measurably more with less, in any economy. Though this thesis focuses on maritime security and M&S, the prevailing philosophy contained in this section of the thesis translates well to other functional areas and disciplines in the federal government, thus broad application is encouraged.

APPENDIX A. HOW TO OBTAIN SOFTWARE MODELS

The following Manual Installation Instructions details how to acquire software models from both the SAVAGE and SAVAGE Defense libraries.

-------- Manual Installation Instructions --------

To begin with, the latest versions of both Apache Ant: http://ant.apache.org/bindownload.cgi and Java(tm) Development Kit (JDK): http://www.oracle.com/technetwork/java/javase/downloads/index.html are required to build and run (it also helps to have your machine's environmental variables set for command line interface (CLI) invocations for both of these basic development tools).

Provided here are the Subversion (SVN) and download URLs (these are the absolute known minimum resources needed for successful SavageStudio Suite building and operation). TortoiseSVN http://tortoisesvn.net/downloads is a most useful GUI type tool for PCs to checkout each resource. The latest NetBeans IDE (8.0+) http://www.netbeans.org/downloads/index.html is also equipped to accommodate SVN operations; either tool is sufficient for repository checkout. Note: TortoiseSVN is for PCs only.

Instructions for SavageStudio checkout via SVN anonymously: http://sourceforge.net/svn/?group_id=86243:

svn co https://xmsf.svn.sourceforge.net/svnroot/xmsf SavageStudio

Be sure to checkout ViskitModels/BehaviorLibraries/SavageTactics and ViskitModelsFOUO/BehaviorLibraries/SavageDefenseTactics to the base directory of where you place SavageStudio (these are the agent behavior libraries). The SavageStduio build process will be looking for these to be there. Use the below listed URLs for each of these agent library repositories. You will also need the 3D model libraries from both Savage and SavageDefense.

https://savage.nps.edu/svn/nps/ (URL for both Savage and ViskitModels/BehaviorLibraries/SavageTactics modules)
https://savagedefense.nps.navy.mil/svn/nps/ (URL for both SavageDefense and ViskitModelsFOUO/BehaviorLibraries/SavageDefenseTactics modules).
user/password required for any module on savagedefense.nps.navy.mil (can be requested from Don Brutzman)

<mailto:brutzman@nps.navy.mil?subject=Request%20savagedefense.nps.navy.mil%20access>.
Place both of the 3D model archives (Savage and SavageDefense) at the root of the main drive your machine: /www.web3d.org/x3d/content/examples

svn co https://savage.nps.edu/svn/nps/Savage to /www.web3d.org/x3d/content/examples

svn co https://savagedefense.nps.navy.mil/svn/nps/SavageDefense to /www.web3d.org/x3d/content/examples

svn co https://savage.nps.edu/svn/nps/ViskitModels/BehaviorLibraries/SavageTactics to <your path to SavageStudio>

svn co https://savagedefense.nps.navy.mil/svn/nps/ViskitModelsFOUO/BehaviorLibraries/SavageDefenseTactics to <your path to SavageStudio>

http://sourceforge.net/svn/?group_id=51343 (for /www.web3d.org/x3d/tools/CreateContentCatalog and /www.web3d.org/x3d/examples/Basic/development):

svn co https://x3d.svn.sourceforge.net/svnroot/x3d/www.web3d.org/x3d/tools/CreateContentCatalog to /www.web3d.org/x3d/tools/CreateContentCatalog

svn co https://x3d.svn.sourceforge.net/svnroot/x3d/www.web3d.org/x3d/content/examples/Basic/development to /www.web3d.org/x3d/content/examples/Basic/development

The “to” points to where the files should be placed.

A. EXTENSIBLE 3D (X3D) GRAPHICS

Extensible 3D (X3D) Graphics is the royalty-free open standard for publishing, viewing and archiving interactive 3D models on the Web.

Lengthy tool list follows. This suite of content-creation tools is used to build and maintain the components used in this work.

X3D-Edit is an open-source Extensible 3D (X3D) Graphics authoring tool for simple error-free authoring, editing, import/export, validation and viewing of X3D scenes.
https://savage.nps.edu/X3D-Edit

X3D Resources support both X3D Graphics and its compatible predecessor, the Virtual Reality Modeling Language (VRML).
http://www.web3d.org/x3d/content/examples/X3dResources.html

X3D Scene Authoring Hints provide collection of style guidelines, authoring tips and best practices to improve the quality, consistency and maintainability of Extensible 3D (X3D) Graphics scenes.
http://www.web3d.org/x3d/content/examples/X3dSceneAuthoringHints.html

Numerous conversion tools are available for the various encodings of X3D and VRML.
http://www.web3d.org/x3d/content/examples/X3dResources.html#Conversions

X3D Quality Assurance (QA) identifies errors and warnings in order to make X3D scene content more portable and reliable.
http://www.web3d.org/x3d/content/examples/X3dResources.html#QualityAssurance

X3D Validator provides a server-based suite of tests to help ensure the quality of X3D scenes and metadata.
https://savage.nps.edu/X3dValidator

Xj3D is an open-source Java viewer and application codebase for X3D graphics scenes. Xj3D is used in Savage Studio and X3D-Edit.
https://savage.nps.edu/Savage/developers.html#Xj3D

Savage Developers Guide describes system configuration supporting various software projects by the NPS MOVES Savage Research Group.
https://savage.nps.edu/Savage/developers.html

SavageDefense Developers Guide (FOUO access only) describes client-side and server-side system configuration for SavageDefense software projects.
https://savagedefense.nps.navy.mil/developers.html

X3D Examples Archives demonstrate how X3D nodes and scenes work, providing thousands of scenes in all X3D encodings. These open-source archives include the Savage (open access) and SavageDefense (FOUO access only) which are used by the SavageStudio tool.
http://www.web3d.org/x3d/content/examples/X3dResources.html#Examples
https://savage.nps.edu/Savage
https://savagedefense.nps.navy.mil/SavageDefense

Multiple Discrete Event Simulation (DES) tools are also integrated.
https://savage.nps.edu/Savage/developers.html#DES

- Simkit is a Java package for creating Discrete Event Simulation (DES) models in source code.
- Diskit is a Java package for adding the IEEE Distributed Interactive Simulation (DIS) protocol to Simkit models.
- Viskit is a visual programming tool to create, run and analyze Simkit models.
- SavageStudio is a drag+drop scenario-authoring tool that uses the Savage archives for X3D models and Viskit behaviors to construct agent-based discrete-event simulation (DES) scenarios.

D. SIMULATION ANALYSIS REPORT

The *Friendly Surface Detection Range* configuration Analysis Report located in this section of the appendix provides a sense of how a basic report looks, before the text fields are filled out by the user. The analysis report begins on the next page.

*** THIS REPORT IS: **UNCLASSIFIED** ***

ENTER REPORT TITLE HERE

Analyst: ***ENTER THE NAME OF THE AUTHOR HERE***

Analysis date: **5/22/15 10:57 AM**

Executive Summary | Location | Simulation Configuration | Entity Parameters | Behavior Descriptions | Statistical Results | Conclusions and Recommendations

---

Executive Summary

Assessment Overview
ENTER EXECUTIVE SUMMARY HERE

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Location of Simulation

Description of Location Features
ENTER SIMULATION LOCATION DESCRIPTION HERE

Production Notes

All units are meters and degrees unless otherwise noted.

ENTER SIMULATION PRODUCTION NOTES HERE

Post-Experiment Analysis of Significant Location Features
ENTER SIMULATION LOCATION CONCLUSIONS HERE

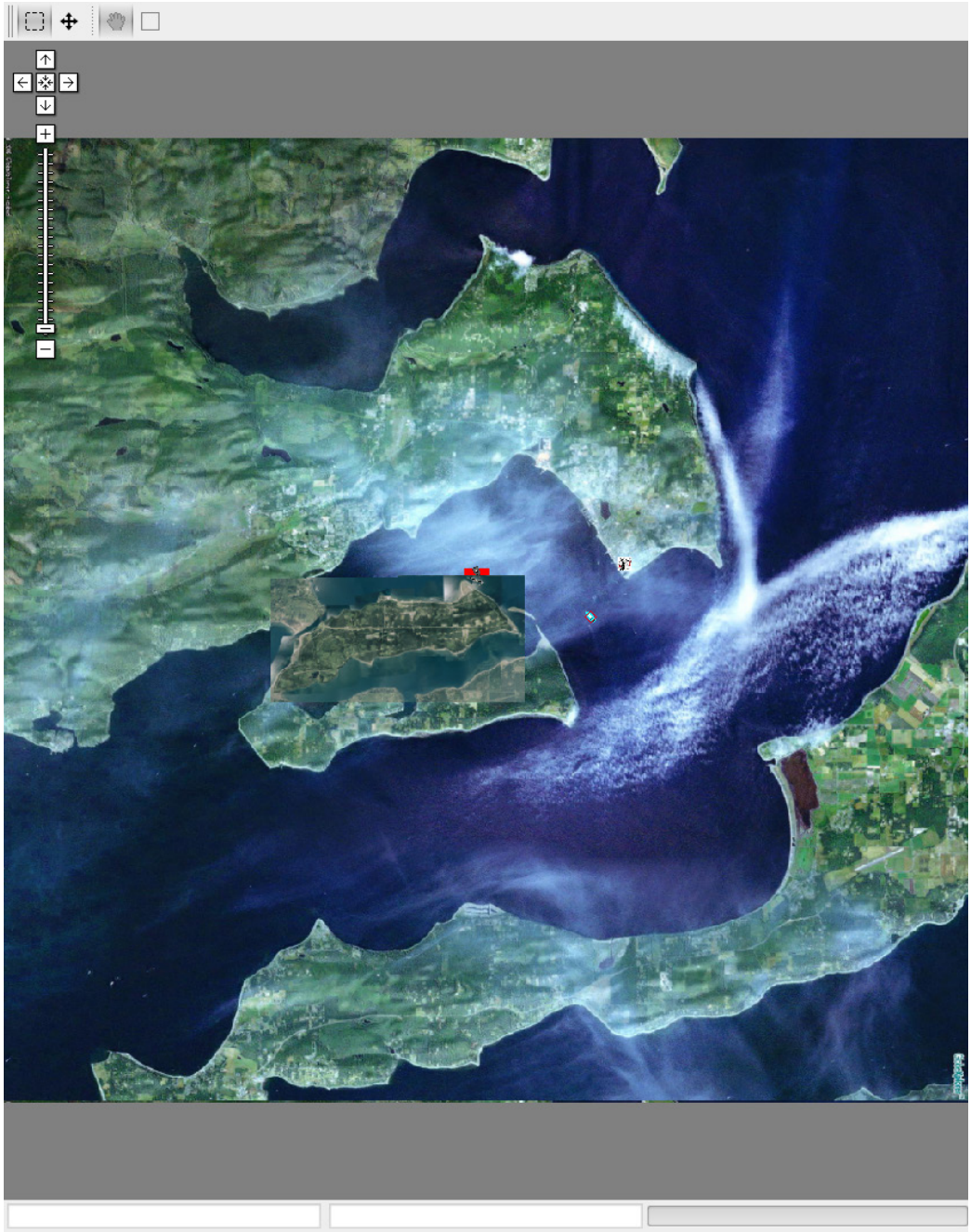

Figure 1: 2D Overview of Simulation Study Area

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Simulation Configuration: Viskit Assembly

The simulation is defined by the Viskit Assembly which collects, lists, initializes and connects all participating entity models within a single scenario. The assembly is then ready for repeated simulation replications, either for visual validation of behavior or statistical analysis of Measures of Effectiveness (MoEs).

Assembly Design Considerations
ENTER ASSEMBLY CONFIGURATION DESCRIPTION HERE

Production Notes

All units are meters and degrees unless otherwise noted.

ENTER ASSEMBLY CONFIGURATION PRODUCTION NOTES HERE

Post-Experiment Analysis of Simulation Assembly Design
ENTER ASSEMBLY CONFIGURATION CONCLUSIONS HERE

Summary of SMAL Defined Simulation Entities

Simulation Entity	Behavior Definitions
Ohio Class Guided Missile Submarine (SSGN)-1	Friendly.MilitaryShip
RHIB-2	Friendly.MilitaryPatrolCraft
Speed Boat-5	Hostile.ExplosiveLadenVessel
Planner	Hostile.TerroristCellPlanner

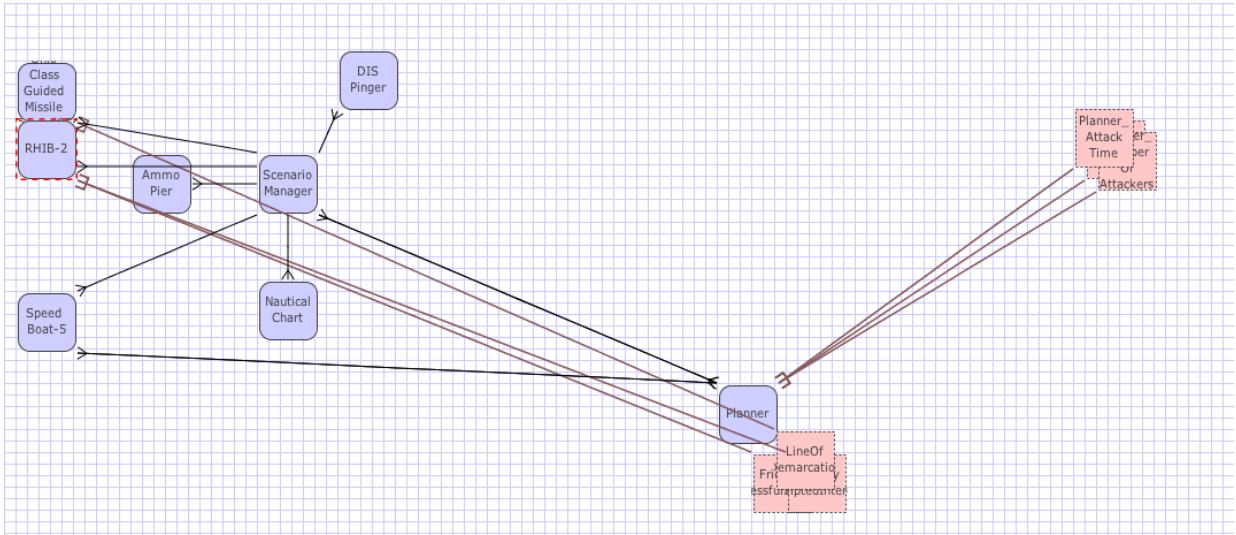

Figure 2: Simulation Assembly Combining all Simulation Entities for this Scenario Experiment

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Entity Initialization Parameters for this Simulation Assembly

Initialization parameters are applied to individualize generic behavior models. These parameters customize the event-graph models.

Entity Parameters Overview
ENTER ENTITY PARAMETER DESCRIPTION HERE

Initialization Parameters for Simulation Entity **Ohio Class Guided Missile Submarine (SSGN)-1**

Classification		Candidate Factor
level	UNCLASSIFIED	
reference	http://www.fas.org/man/dod-101/sys/ship/index.html	
rationale	All values in this model are derived from an online, public source	

Identification		
name	Friendly Military Ship	
Physical Constraints		
height	10.06	
width	10.06	
length	170.69	
draft	6.4	
grossWeight	17009713	
Dynamic Response Constraints		
maximumSpeed	46.3	
cruiseSpeed	36.8	
maximumDepth	1000	
cruiseDepth	800	
Tactical Constraints		
maximumAirThreatRange	1	
maximumSurfaceThreatRange	250	
maximumSubsurfaceThreatRange	1	
maximumAirDetectionRange	1	
maximumSurfaceDetectionRange	600	
maximumSubsurfaceDetectionRange	1	
maximumDamage	200	

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Initialization Parameters for Simulation Entity **RHIB-2**

Classification		Candidate Factor
level	UNCLASSIFIED	
reference	http://www.fas.org/man/dod-101/sys/ship/rhib.htm	
rationale	All values in this model are derived from an online, public source	
Identification		
name	Friendly Military Patrol Craft	
Physical Constraints		
height	2	
width	3.407	

length	7	
draft	.2	
Dynamic Response Constraints		
maximumSpeed	25	
cruiseSpeed	10	
maximumAcceleration	1.3	
maximumFuelCapacity	40	
Tactical Constraints		
maximumAirThreatRange	1	
maximumSurfaceThreatRange	150	
maximumSubsurfaceThreatRange	1	
maximumAirDetectionRange	1	
maximumSurfaceDetectionRange	600	
maximumSubsurfaceDetectionRange	1	
maximumDamage	20	

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Initialization Parameters for Simulation Entity **Speed Boat-5**

Classification		**Candidate Factor**
level	UNCLASSIFIED	
reference	http://www.fas.org/irp/congress/1998_hr/s980224w.htm	
rationale	All values in this model are derived from an online, public source	
Identification		
name	Hostile Explosive Laden Vessel (ELV)	
Physical Constraints		
height	2	
width	5	
length	18	
draft	.5	
Dynamic Response Constraints		
maximumSpeed	35	
cruiseSpeed	20	
Tactical Constraints		
maximumAirThreatRange	1	

maximumSurfaceThreatRange	150	
maximumSubsurfaceThreatRange	1	
maximumAirDetectionRange	1	
maximumSurfaceDetectionRange	600	
maximumSubsurfaceDetectionRange	1	
maximumDamage	20	

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Initialization Parameters for Simulation Entity **Planner**

Classification		Candidate Factor
level		
reference		
rationale		
Identification		
name	Terrorist Cell Planner	

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Behavior Descriptions

Description of Behavior Design

Post-Experiment Analysis of Entity Behaviors

Behavior: Friendly.MilitaryPatrolCraft

Description: A military patrol craft. This behavior implementation is a basic patrolling pattern where a patrol craft investigates unknown contacts and interdicts perceived threats. This event graph does not incorporate a complex set of Rules of Engagement (RoEs), but rather simply patrols an area and attempts to identify all unknown contacts. The act of interdiction is accomplished by trying to block the contact with this craft. The overall implementation is based on a U.S. Navy ship's Rigid Hull Inflatable Boat (RHIB) whose primary purpose might be to defend a small area. Ships that depend on the RHIB consider the small boat patrol as an extension of the parent ship's self defense posture.

Figure 3: Event Graph for Friendly.MilitaryPatrolCraft

Initialization Parameter	Parameter Type	Description
moverID	int	DIS entity ID
entityDefinition	diskit.SMAL.EntityDefinition	The Savage Modeling Analysis Language (SMAL) object that contains all platform-specific metadata information about the model being used
zones	diskit.ProbabilityZoneGeometry[]	General areas from which waypoints should be generated

		for this entity.
driverReactionTime	diskit.random.RandomVariateInstantiator	The reaction time of the driver to detection events and radio orders
communicationsChannel	int	The communications channel used by this entity
visualPerception	diskit.Sensor	The visual perception of a human on this platform
collisionDetection	diskit.Sensor	A collision avoidance sensor for this platform
gun	diskit.MachineGun	The close in small arms weapon used by the patrol craft watch team

State Variable	Variable Type	Description
visualRange	double	The visual range of a human on this platform
avoidanceRange	double	Contact proximity tolerance for this entity, used for collision avoidance
activeMoverManager	diskit.MoverManager	The mover manager that is currently being used. Primarily used for swapping between mover manager types
zoneMoverManager	diskit.ZoneMoverManager	[Primary] mover manager used to transit in designated areas defined by the 'zones' parameter
avoidanceMoverManager	diskit.AvoidanceMoverManager	[Secondary] Mover Manager used for avoidance movement
interceptMoverManager	diskit.InterceptMoverManager	[Not used] Mover Manager that executes an interception

pathMoverManager	diskit.PathMoverManager	[Not used] Mover Manager that moves in a predetermined path
waypointCreator	diskit.WaypointCreator	[Mode - Probability] generates waypoints based on 'zones' parameter
obstacleQueue	diskit.ObstacleQueue	Collection of obstacles for this entity to negotiate
speedScale	double	A scalar variable which is applied to the speed of this entity. Variation in the speed scale is set for all entities by the diskit.ScenarioManager. This allows for simulation wide speed-up and slow-down functionality
nauticalChart	diskit.AStarZoneMap	The nautical chart object received from the scenario manager
targetQueue	diskit.TargetQueue	Stores and sorts targets based on proximity
contactPicture	diskit.ContactPicture	List of all contacts in this entities contact picture
successfulIntercepts	int	[DATA] Total number of successful intercepts
speed	double	[DATA] Used to collect speed statistics for this entity
contactIDs	int	[DATA] Total number of contacts ID'd
distanceFromMissedAttacker	double	[DATA] Distance from attacker at time of successful attack
radioCommunication	diskit.RadioCommunication	A radio communication template used to construct and transmit radio messages through the scenario manager

responseFromContact	boolean	Whether or not a contact that has been called on the radio has answered
timeSpentIntercepting	double	[DATA] The time it takes to intercept a contact
driverResponseTime	double	[DATA] The response time of the driver
collisionSensor	diskit.Sensor	A collision avoidance sensor for this platform
visualSensor	diskit.Sensor	The visual acuity of a human watchstander on this platform
currentContact	diskit.Mover3D	the current contact
atSecurityAlert	boolean	Whether or not this entity is at security alert
machineGun	diskit.MachineGun	The close in weapon used by this patrol craft's watchteam during a security alert
attemptedIntercepts	int	A patrol craft's attempt at intercepting an inbound hostile during a security alert

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Behavior: Friendly.MilitaryShip

Description: A Military Ship is a SimEntity that, when moving, has four active sensors (surface, subsurface, air, and the visual perception of humans on the ship). When not moving, the ship has only one sensor, the human lookout. Currently this EventGraph does not take into account the difference in line of sight of a human on watch in port and a human on watch on the bridge. A Military Ship can detect impending collisions with other objects in order to take action to avoid such collision as best it can. Upon detecting a threat, the Friendly Military Ship can move to security alert status to prepare its defensive posture via the ship's quick reaction forces. This SimEntity can also communicate radio messages to direct its security forces and to direct damage control teams assessing and combating any sustained battle damage.

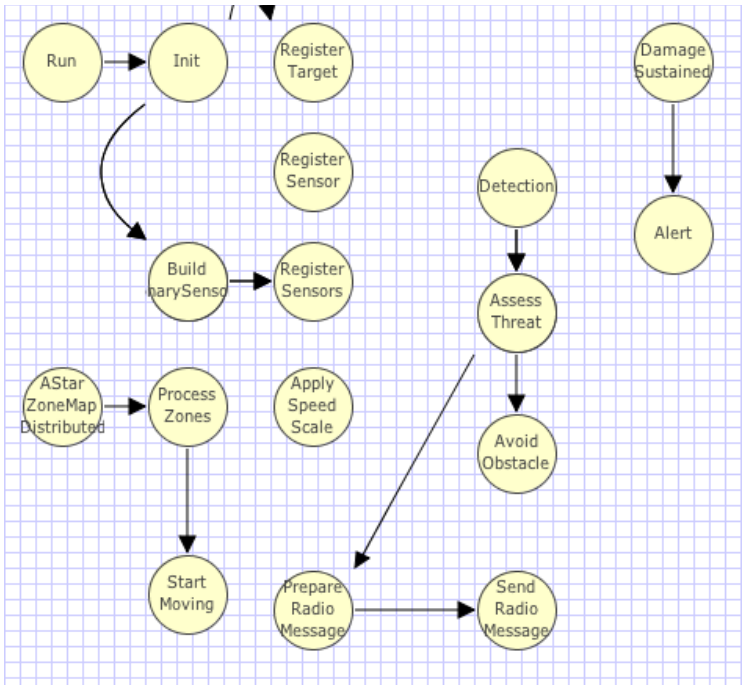

Figure 4: Event Graph for Friendly.MilitaryShip

Initialization Parameter	Parameter Type	Description
moverID	int	DIS entity specific ID
entityDefinition	diskit.SMAL.EntityDefinition	The Savage Modeling Analysis Language (SMAL) object that contains all platform-specific metadata information about the model being used
zones	diskit.ProbabilityZoneGeometry[]	General areas from which waypoints can be generated for this entity
visualSensor	diskit.Sensor	The human watchstander serving as a lookout on the bridge, or another vantage point on the ship
surfaceRadarSensor	diskit.Sensor	The Surface Search radar, a shipboard sensor, used to detect, classify and track surface targets
airSearchRadarSensor	diskit.Sensor	The Air Search radar, a shipboard sensor, used to

		detect, classify, and track airborne targets
sonarSensor	diskit.Sensor	The Underwater sonar, a shipboard sensor, used to detect, classify, and track subsurface targets
collisionSensor	diskit.Sensor	A detection of an impending collision with an object by the reporting bridge lookout (human) watchstander by visual, or CIC Surface Search radar sensor
lineOfDemarcationSensor	diskit.Sensor	The zone, specified as a nominal radius from either a ship underway, moored, or at anchor, in which an unknown, or identified hostile entity will be fired upon in self defense

State Variable	Variable Type	Description
visualRange	double	The visual range of a human on this platform
surfaceRadarRange	double	The maximum range of the surface search radar on this platform
airSearchRadarRange	double	The maximum range of the air search radar on this platform
sonarRange	double	The maximum range of the sonar on this platform
avoidanceRange	double	Contact proximity tolerance for this entity, used for collision avoidance
radioCommunication	diskit.RadioCommunication	An object used to transmit radio traffic
visualPerception	diskit.Sensor	The digital camera on this platform
lineOfDemarcationDetection	diskit.Sensor	The line of demarcation crossing detected

surfaceRadar	diskit.Sensor	The surface radar on this platform
airSearchRadar	diskit.Sensor	The air search radar on this platform
sonar	diskit.Sensor	The sonar on this platform
collisionDetection	diskit.Sensor	A collision avoidance sensor for this platform
threatPicture	diskit.ContactPicture	List of all contacts in this entities contact picture
activeMoverManager	diskit.MoverManager	The mover manager that is currently being used. Primarily used for swapping between mover manager types
zoneMoverManager	diskit.ZoneMoverManager	[Primary] mover manager used to transit within and amoung designated areas defined by the 'zones' parameter
avoidanceMoverManager	diskit.AvoidanceMoverManager	[Secondary] Mover Manager used for avoidance movement
interceptMoverManager	diskit.InterceptMoverManager	[Not used] Mover Manager that executes an interception
pathMoverManager	diskit.PathMoverManager	[Not used] Mover Manager that moves in a predetermined path
waypointCreator	diskit.WaypointCreator	[Mode - Probability] generates waypoints based on 'zones' parameter
obstacleQueue	diskit.ObstacleQueue	Collection of obstacles for this entity to negotiate
speedScale	double	A scalar variable which is applied to the speed of this entity. Variation in the speed scale is set for all entities by the diskit.ScenarioManager. This allows for

		simulation-wide speed-up and slow-down functionality
nauticalChart	diskit.AStarZoneMap	The nautical chart object, created for this simulation, used by all moving entities for navigation and collision avoidance with static objects
threatPictureSize	int	size of threatPicture container, works around collection size listener bug

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Behavior: Hostile.ExplosiveLadenVessel

Description: Terrorist that starts from a point randomly within ProbabilityZoneGeometry objects. Terrorist will proceed towards the harbor, scans the area for potential targets and attacks the targets in order of proximity and order in which detected. TODO: Add booleans to the constructor for attack Friendly, attack HVU

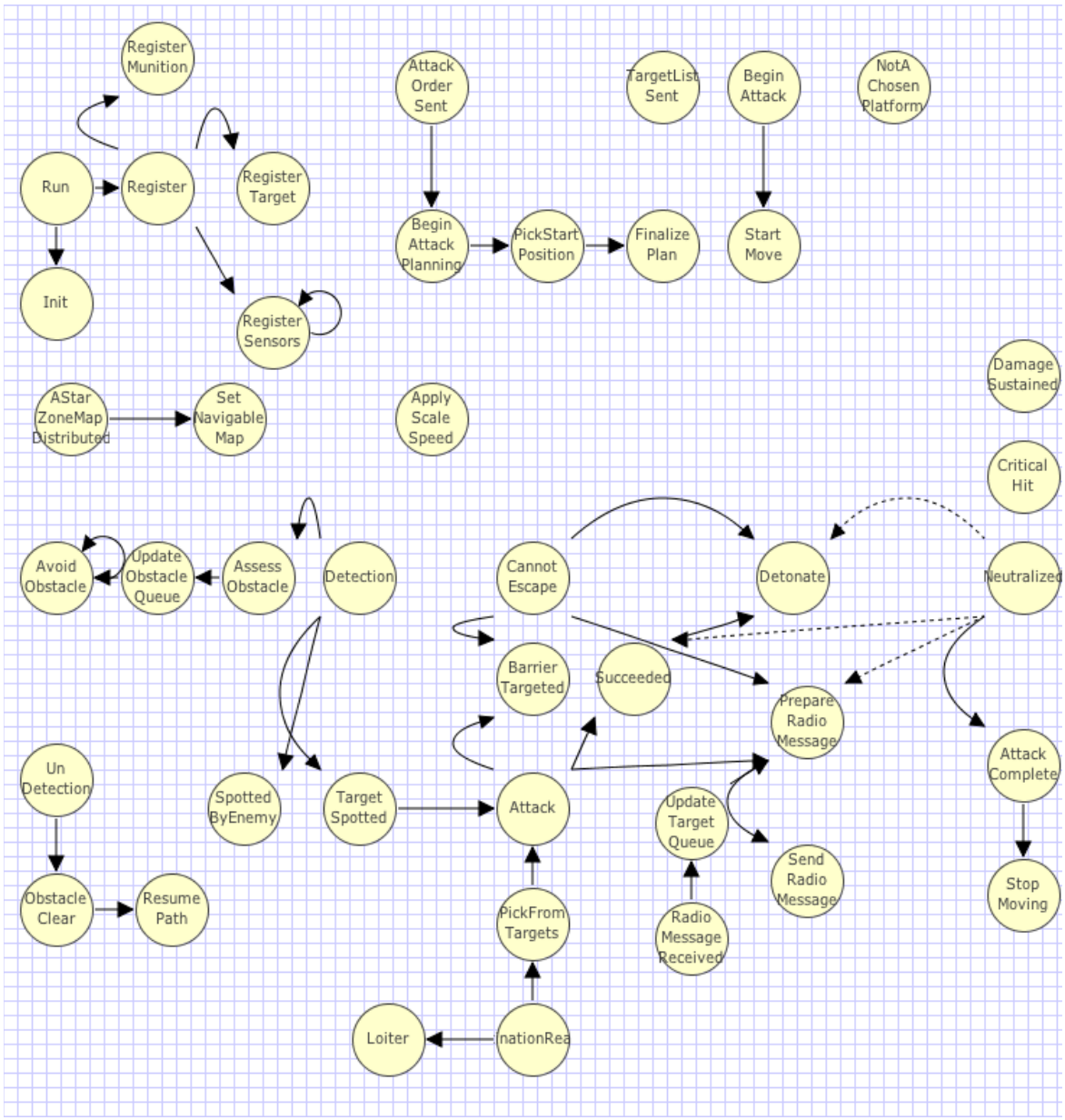

Figure 5: Event Graph for Hostile.ExplosiveLadenVessel

Initialization Parameter	Parameter Type	Description
moverID	int	Unique DIS entity ID number
entityDefinition	diskit.SMAL.EntityDefinition	The SMAL metadata definition for this entity
visualSensor	diskit.Sensor	The visual acuity of a terrorist subject operating this vessel
collisionSensor	diskit.Sensor	A collision avoidance detection employed to avoid other moving, or stationary obstacles
detonateProximitySensor	diskit.Sensor	The sensor employed to tell this terrorist to detonate its explosive device at, or as close as possible to the HVA target
radioChannel	int	channel to listen to for attack plans

State Variable	Variable Type	Description
avoidanceRange	double	The proximity tolerance for this entity
visualPerception	diskit.Sensor	Sensor object that processes all targets in the state space before attacking
waypointCreator	diskit.WaypointCreator	The utility that creates waypoints based on the arguments passed
targetQueue	diskit.TargetQueue	The queue of active targets for this entity
collisionAvoidance	diskit.Sensor	Sensor that implements collision avoidance
obstacleQueue	diskit.ObstacleQueue	The active list of obstacles that this entity is concerned with. Special class that organizes the queue based on the proximity of the obstacles
detonateProximity	diskit.Sensor	Sensor that determines if the contact is close enough to kill
visualRange	double	Visual range for this entity
plasticExplosives	diskit.Explosive	Explosives that this entity is carrying

blastRadius	double	The radius of the explosives
harborChart	diskit.AStarZoneMap	A map of the environment that contains the collection of search nodes for path finding
primaryTarget	java.lang.String	The primary target for this entity
aStarSearch	diskit.AStarSearch	The A* search implementation that is used for path finding
tactic	diskit.Tactic	The tactic that has been ordered for this terrorist
startZone	diskit.AStarZoneGeometry	The zone from which the terrorist should start
goalZone	diskit.AStarZoneGeometry	The area where this terrorist should head towards to execute it's tactics
attackAuthorized	boolean	A flag to indicate whether or not the cell planner has authorized the execution of the attack plan
planFinalized	boolean	A flag that indicates that this entity has processed it's attack order and is ready to attack
zoneMoverManager	diskit.ZoneMoverManager	The primary mover for this entity, moves using A* search zone geometry
attackStartWaypoint	diskit.Vec3d	The waypoint selected to start the attack
chosenToAttack	boolean	Flag that is set to true when this entity has been selected to attack
arrivedAtGoal	boolean	Flags when the entity has reached it's destination
speedScalar	double	The default speed scale for this entity
attackSuccess	java.lang.String	String report of the result of the attack
destroyedTarget	diskit.Mover3D	The mover that was destroyed

terroristLeader	simkit.SimEntity	The entity that is giving the orders to this terrorist
attackDelay	double	The amount of time from when an order is received
timeUndetected	double	The amount of time from simulation start before this attacker was detected by a friendly force
commsChannel	int	The radio channel for this entity
radioMsg	diskit.RadioCommunication	The communication object that this entity uses to send messages
evasiveManeuver	boolean	Whether this entity is performing evasive maneuvers
avoidanceMoverManager	diskit.AvoidanceMoverManager	avoid detected obstacles
activeMoverManager	diskit.MoverManager	currently active mover manager
self	ExplosiveLadenVessel	be able to use “this” methods as state variable calls

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Behavior: Hostile.TerroristCellPlanner

Description: This object connects to a Nautical Chart SimEntity and uses that information to develop and adjust attack plans. It passes attack plans to the entities that are listed as potential terrorist platforms. These entities must be listening to this object to get the information. Starting positions are selected from the perimeter zones of the Nautical Chart. Terrorists report back to this object as to whether or not they were successful. Adjustments are then made and this Terrorist Cell Planner (TCP) will issue new attack orders based on its evaluation of the success of the mission. The planner also stops a simulation run when it thinks that a complete attack is over. NOTE: Though this SimEntity is not a mover, it is instantiated as one so that it has access to the hostileForceList that is resident in the superclass diskit.HostileForce. It is important to have the starting position of this entity definition so far from the environment (e.g. 10000 meters below where all other entities are) so that it will not be detected by any of the movers in a simulation run.

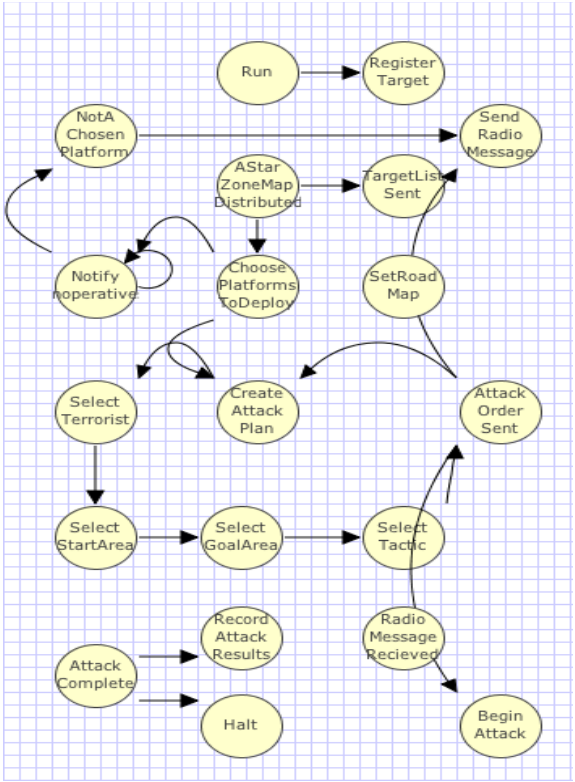

Figure 6: Event Graph for Hostile.TerroristCellPlanner

Initialization Parameter	Parameter Type	Description
entityID	int	Unique DIS entity ID number
entityDefinition	diskit.SMAL.EntityDefinition	The SMAL metadata definition for this entity
terroristIDs	int[]	The moverID numbers for all entities that can be used as a terrorist platform
targetPriorityList	java.lang.String[]	The types of entities that can be targets listed in the array in the order of priority (e.g., index[0] is the highest priority)
initialAssignments	java.lang.String[]	An array of all

		AStarZoneGeometry names that are potential destinations for a terrorist (e.g. 'go to this zone and find a target'). This array is checked against the nautical chart. Any zones that are not part of the chart are ignored
tacticalOptions	diskit.Tactic[]	A list of the possible tactics that the cell may choose to employ
attackStartDelay	diskit.random.RandomVariateInstantiator	The distribution of delay times for this object to use
communicationsChannel	int	The communication channel for this entity

State Variable	Variable Type	Description
harborChart	diskit.AStarZoneMap	A chart of all of the areas where an agent can travel
planIndex	int	Control variable for plan creation
aStarSearch	diskit.AStarSearch	The A* search algorithm for path finding
rn	diskit.random.Generator	A pseudorandom number generator for selecting attack plan components
terroristID	int	The id of the terrorist whose plan is being created
attackPlanStartZone	diskit.AStarZoneGeometry	The area from which the start position for the attack plan being created
attackPlanGoalZone	diskit.AStarZoneGeometry	The zone that's the goal
selectedTactic	diskit.Tactic	The selected Tactic for the current attack plan
totalPlans	int	The total number of plans that are generated for a single simulation run
completedAttacks	int	Number of attacks that have been

		completed
replicationNumber	int	Number of simulation iterations to run on the scenario
mapReceived	boolean	This is a special case filter that prevents multiple scheduling of the 'doAStarZoneMapDistributed' event as a result of the bi-directional listener between this object in terrorists. Without this flag multiple events would be scheduled (one from the scenario manager and one for each connected terrorist)
radioCommunication	diskit.RadioCommunication	The communication object used to send/display messages in this simulation
attackStartTime	double	The time chosen for an attack to start
successfulAttacks	int	Number of successful attacks for this run
timeToExecuteAttack	double	The amount of time that it took to execute the attack

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Behavior: Obstacles.Pier

Description: A Pier without berths specified. This event graph serves as a container object when other objects are on the pier (e.g., obstacles, brows, buildings) that need to be handled.

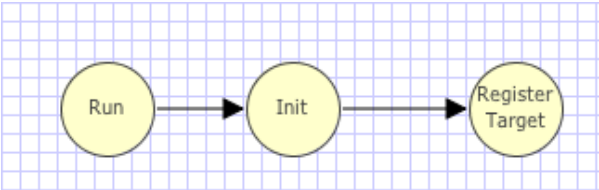

Figure 7: Event Graph for Obstacles.Pier

Initialization Parameter	Parameter Type	Description
moverID	int	Unique ID number for this object
center	diskit.Vec3d	Center point of the pier
length	double	length of the pier
width	double	width of this pier
height	double	Height in meters above the waterline
rotation	diskit.Vec4d	Orientation in radians about the (Z DIS axis (Y for X3D)) example: 0 0 1 1.57

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Behavior: Utilities.NauticalChart

Description: This object is used to collect and transmit all information that one could derive from a Nautical Chart. Accordingly, this graph includes adapter functionality (e.g. RegisterTargetByAdapter) to allow relay objects to register through the chart. The primary component of the chart is an array of type diskit.AStarZoneGeometry which define the navigable zones of the water space. Additionally, buoys, perimeter zones, piers, etc, should all pass through this class to allow other event graphs the opportunity to extract the information they need from the chart.

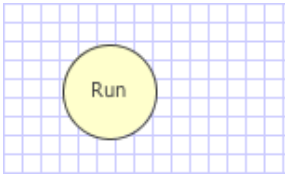

Figure 8: Event Graph for Utilities.NauticalChart

Initialization Parameter	Parameter Type	Description
navigableWaterZones	diskit.AStarZoneGeometry[]	The collection of zones that represent general areas of navigable water
waterFrontAreas	diskit.AStarZoneGeometry[]	The areas of the waterfront that can be used by crafts for launching or water access

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Behavior: Utilities.ScenarioManager

Description: The central manager for all SimEntities in an assembly which provides additional statistics such as start time, stop time and number of replications.

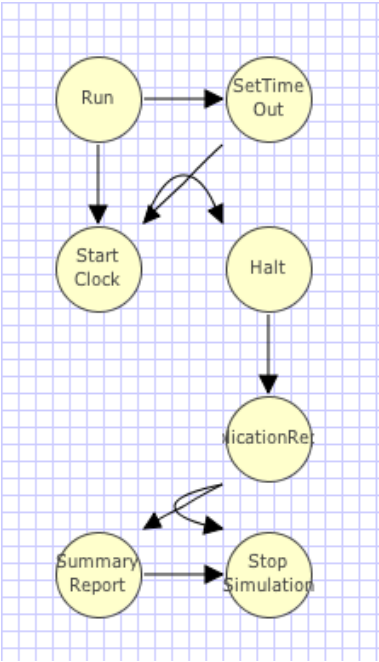

Figure 9: Event Graph for Utilities.ScenarioManager

Initialization Parameter	Parameter Type	Description
speedScale	double	A property to either speed up, or slow down the time steps of a simulation for the 3D visualization mode
clearOnReset	boolean	Boolean flag to denote clearing out all cached information before next simulation iteration
mulicastIPAddress	java.lang.String	The multi-cast network IP address to trasmit DIS packets to
port	int	The multi-cast network IP port to trasmit DIS packets to
siteID	int	Specific ID for the simulation's scenario location
appID	int	Specific ID for the simulation's application
numberOfReplications	int	can either be set by parameter, or accessor

		method pre-run
State Variable	**Variable Type**	**Description**
count	int	Since count doesn't have a state transition at the run, it won't be reset each replication. It can be used to count up and decide when the Stop is the last Stop in the simulation.
timeOut	double	maintains the original timeout

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Statistical Results

Description of Expected Results
ENTER STATISTICAL RESULTS DESCRIPTION HERE

Analysis of Experimental Results
ENTER STATISTICAL RESULTS CONCLUSIONS HERE

Summary Statistics section: Primary Measures of Effectiveness (MoEs) / Measures of Performance (MoPs) and corresponding statistical plots

Replication Report

Measure of Effectiveness (MoE)

Property: FriendlyAttemptedIntercepts

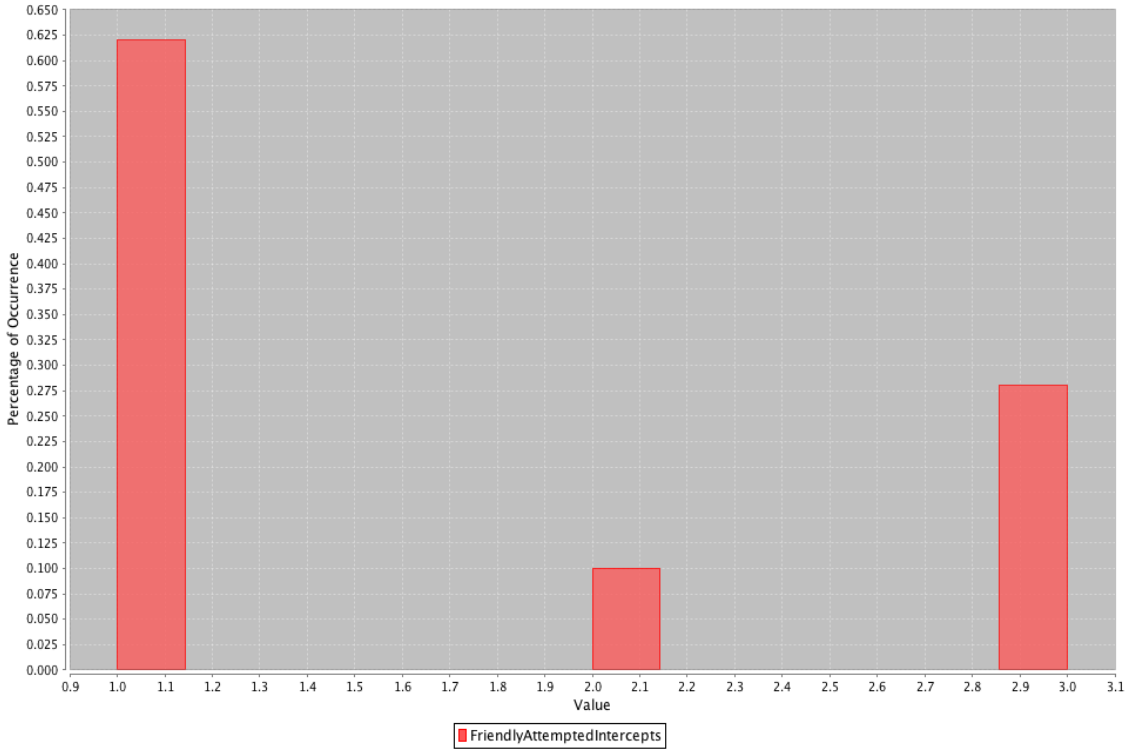

Figure 10: Replications Histogram for FriendlyAttemptedIntercepts

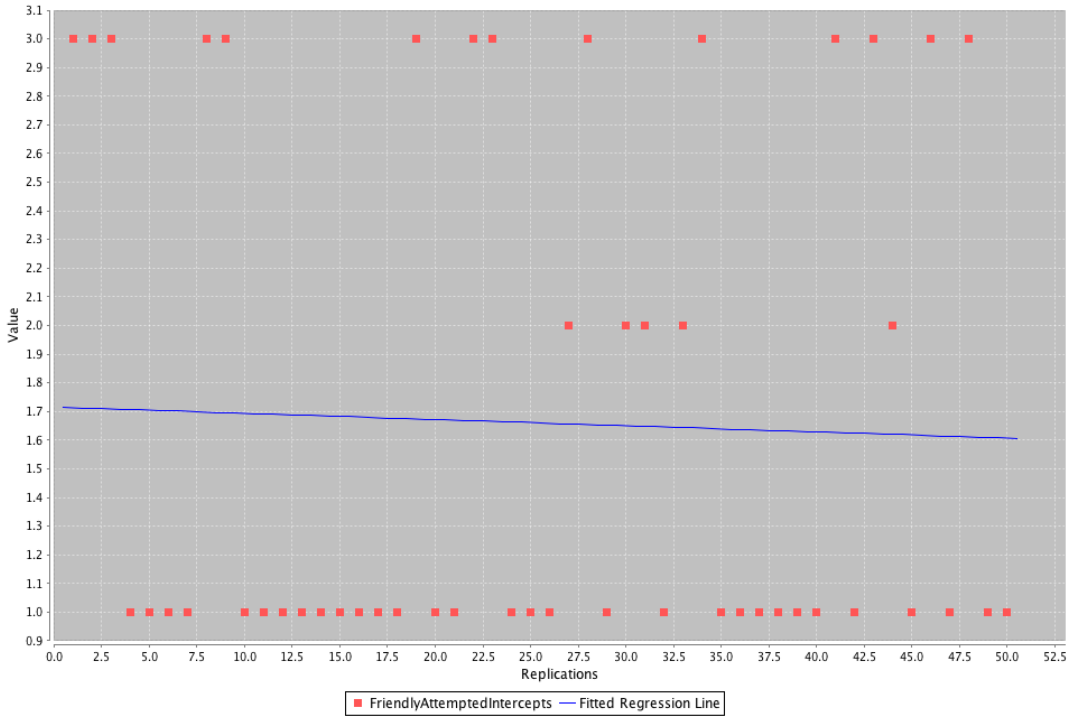

Figure 11: Replications Regression Plot for FriendlyAttemptedIntercepts

Replication #	FriendlyAttemptedIntercepts	Min	Max	Mean	StdDev	Variance
1	1			1.000		
2	1			1.000		
3	1			1.000		
4	1			1.000		
5	3	1.000	3.000	2.000	1.000	1.000
6	3	1.000	3.000	2.000	1.000	1.000
7	3	1.000	3.000	2.000	1.000	1.000
8	1			1.000		
9	3	1.000	3.000	2.000	1.000	1.000
10	3	1.000	3.000	2.000	1.000	1.000
11	1			1.000		
12	3	1.000	3.000	2.000	1.000	1.000
13	3	1.000	3.000	2.000	1.000	1.000
14	3	1.000	3.000	2.000	1.000	1.000
15	1			1.000		
16	3	1.000	3.000	2.000	1.000	1.000
17	1			1.000		
18	1			1.000		
19	3	1.000	3.000	2.000	1.000	1.000
20	1			1.000		
21	3	1.000	3.000	2.000	1.000	1.000
22	1			1.000		
23	1			1.000		
24	3	1.000	3.000	2.000	1.000	1.000
25	3	1.000	3.000	2.000	1.000	1.000
26	1			1.000		
27	3	1.000	3.000	2.000	1.000	1.000
28	3	1.000	3.000	2.000	1.000	1.000
29	2	1.000	2.000	1.500	0.707	0.500
30	1			1.000		
31	1			1.000		
32	1			1.000		

33	1			1.000		
34	1			1.000		
35	3	1.000	3.000	2.000	1.000	1.000
36	1			1.000		
37	1			1.000		
38	1			1.000		
39	1			1.000		
40	1			1.000		
41	1			1.000		
42	1			1.000		
43	1			1.000		
44	1			1.000		
45	3	1.000	3.000	2.000	1.000	1.000
46	3	1.000	3.000	2.000	1.000	1.000
47	1			1.000		
48	3	1.000	3.000	2.000	1.000	1.000
49	1			1.000		
50	1			1.000		

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Replication Report

Measure of Effectiveness (MoE)

Property: LineOfDemarcation

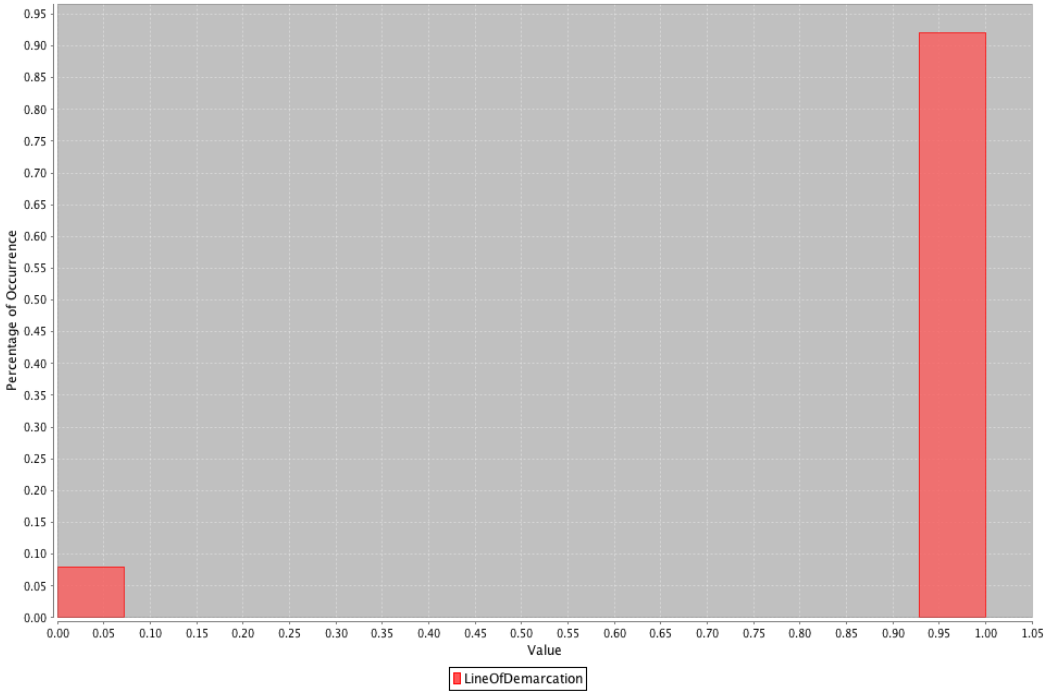

Figure 12: Replications Histogram for LineOfDemarcation

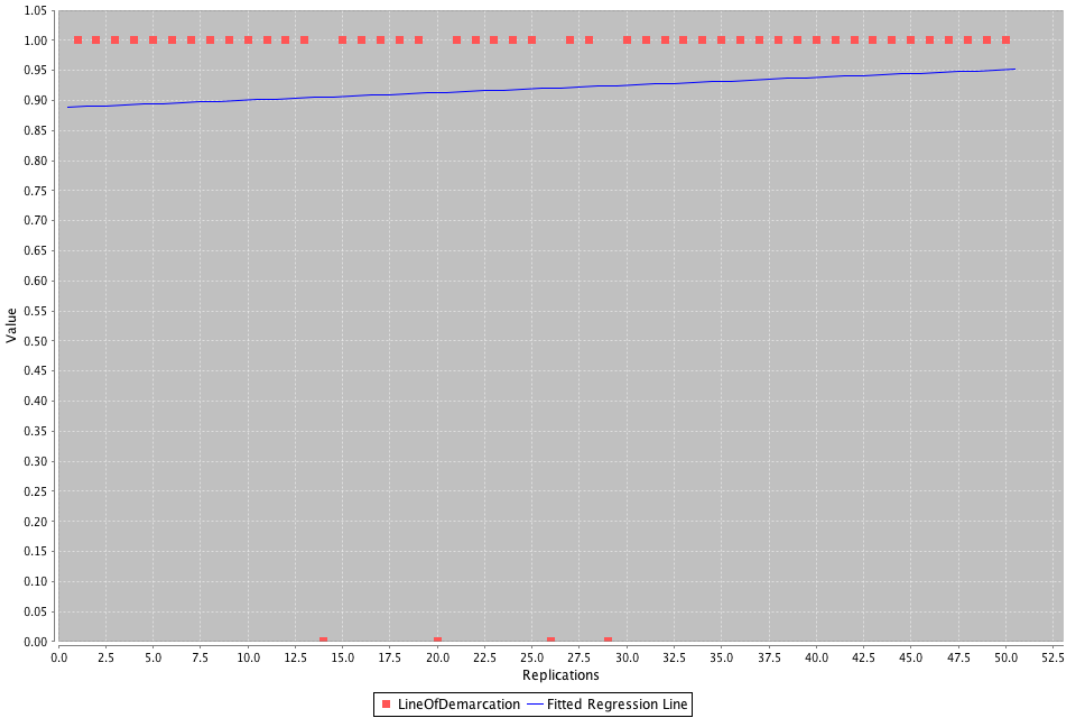

Figure 13: Replications Regression Plot for LineOfDemarcation

Replication #	LineOfDemarcation	Min	Max	Mean	StdDev	Variance
1	0					
2	0					
3	0					
4	0					
5	1			1.000		
6	1			1.000		
7	1			1.000		
8	1			1.000		
9	1			1.000		
10	1			1.000		
11	1			1.000		
12	1			1.000		
13	1			1.000		
14	1			1.000		
15	0					
16	1			1.000		
17	0					
18	0					
19	1			1.000		
20	0					
21	1			1.000		
22	1			1.000		
23	1			1.000		
24	1			1.000		
25	1			1.000		
26	1			1.000		
27	1			1.000		
28	1			1.000		
29	1			1.000		
30	0					
31	0					
32	1			1.000		

33	1			1.000		
34	1			1.000		
35	1			1.000		
36	0					
37	1			1.000		
38	0					
39	0					
40	1			1.000		
41	1			1.000		
42	0					
43	1			1.000		
44	0					
45	1			1.000		
46	1			1.000		
47	1			1.000		
48	1			1.000		
49	1			1.000		
50	1			1.000		

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Replication Report

Measure of Effectiveness (MoE)

Property: FriendlySuccessfulIntercepts

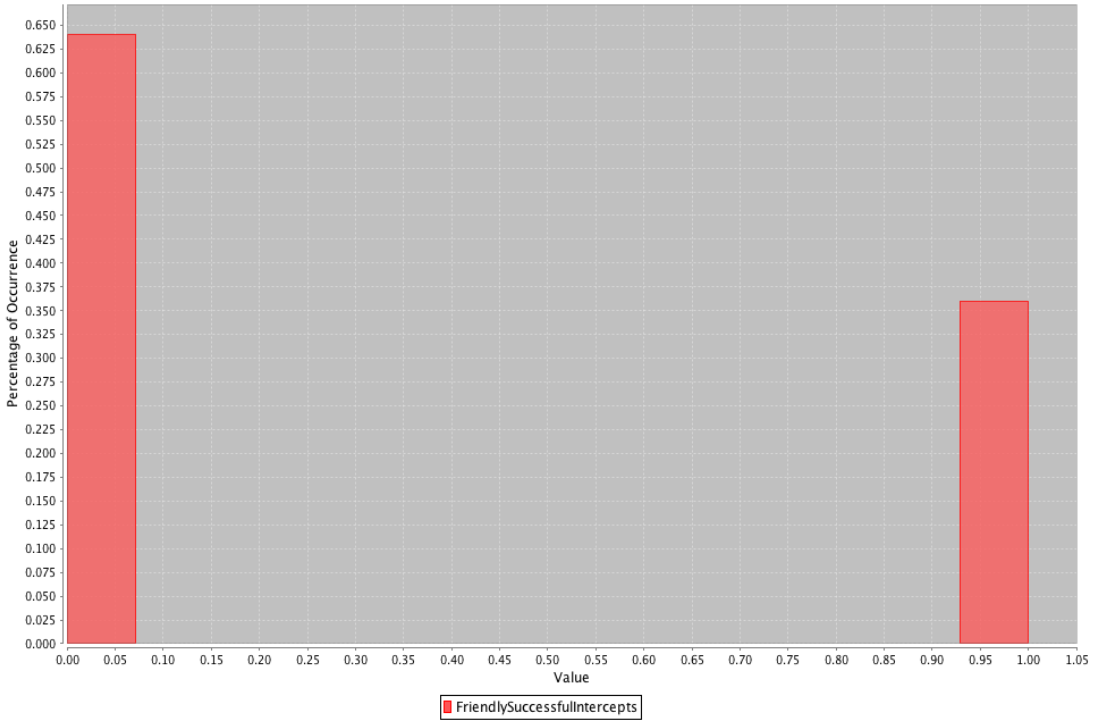

Figure 14: Replications Histogram for FriendlySuccessfulIntercepts

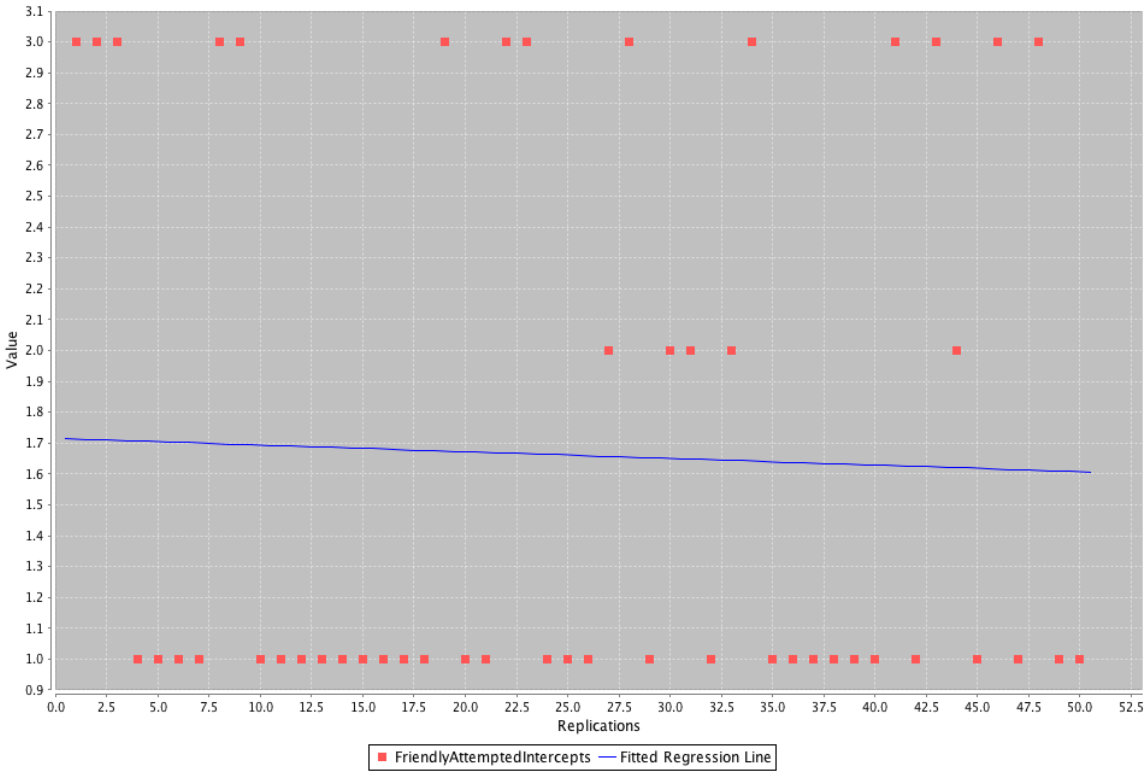

Figure 15: Replications Regression Plot for FriendlySuccessfulIntercepts

Replication #	FriendlySuccessfulIntercepts	Min	Max	Mean	StdDev	Variance
1	1			1.000		
2	1			1.000		
3	1			1.000		
4	1			1.000		
5	1			1.000		
6	1			1.000		
7	1			1.000		
8	0					
9	1			1.000		
10	1			1.000		
11	0					
12	1			1.000		
13	1			1.000		
14	1			1.000		
15	1			1.000		
16	1			1.000		
17	1			1.000		
18	1			1.000		
19	1			1.000		
20	1			1.000		
21	1			1.000		
22	0					
23	0					
24	1			1.000		
25	1			1.000		
26	0					
27	1			1.000		
28	1			1.000		
29	0					
30	1			1.000		
31	1			1.000		
32	0					

33	0					
34	0					
35	1			1.000		
36	1			1.000		
37	0					
38	1			1.000		
39	1			1.000		
40	0					
41	0					
42	1			1.000		
43	0					
44	1			1.000		
45	1			1.000		
46	1			1.000		
47	0					
48	1			1.000		
49	0					
50	0					

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Replication Report

Measure of Effectiveness (MoE)

Entity: Planner

Property: SuccessfulAttacks

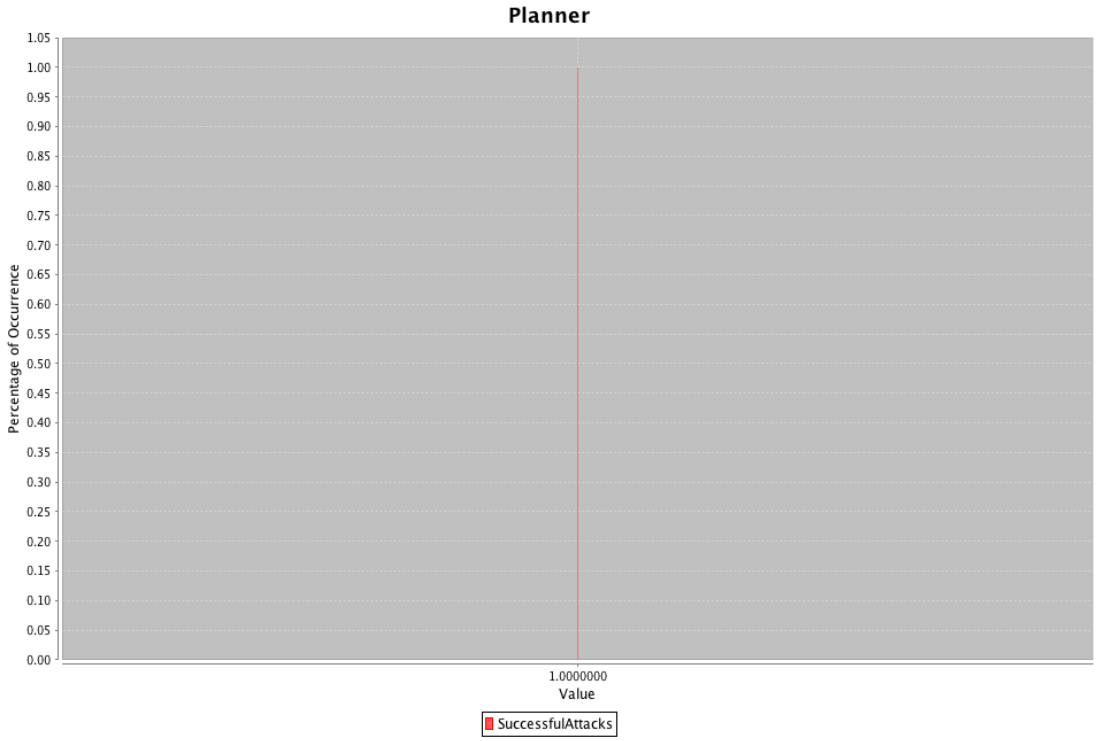

Figure 16: Replications Histogram for SuccessfulAttacks

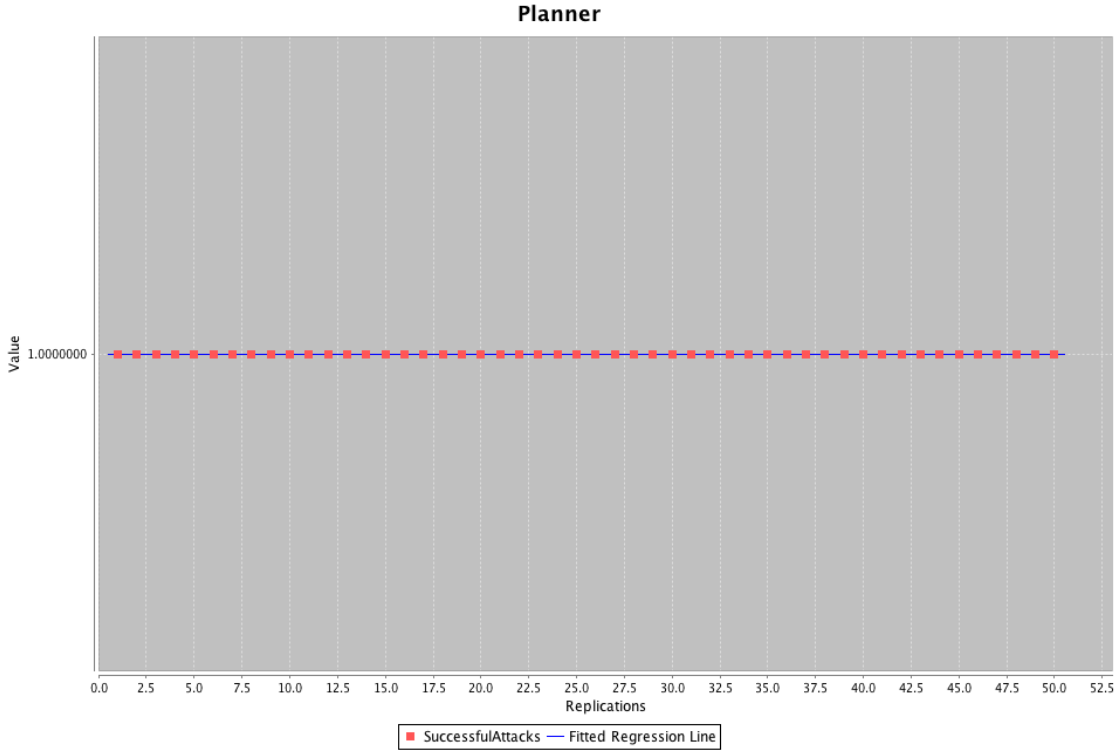

Figure 17: Replications Regression Plot for SuccessfulAttacks

Replication #	SuccessfulAttacks	Min	Max	Mean	StdDev	Variance
1	0					
2	1			1.000		
3	1			1.000		
4	1			1.000		
5	1			1.000		
6	1			1.000		
7	1			1.000		
8	1			1.000		
9	1			1.000		
10	1			1.000		
11	1			1.000		
12	1			1.000		
13	1			1.000		
14	1			1.000		
15	1			1.000		
16	1			1.000		
17	1			1.000		
18	1			1.000		
19	1			1.000		
20	1			1.000		
21	1			1.000		
22	1			1.000		
23	1			1.000		
24	1			1.000		
25	1			1.000		
26	1			1.000		
27	1			1.000		
28	1			1.000		
29	1			1.000		
30	1			1.000		
31	1			1.000		
32	1			1.000		

33	1			1.000		
34	1			1.000		
35	1			1.000		
36	1			1.000		
37	1			1.000		
38	1			1.000		
39	1			1.000		
40	1			1.000		
41	1			1.000		
42	1			1.000		
43	1			1.000		
44	1			1.000		
45	1			1.000		
46	1			1.000		
47	1			1.000		
48	1			1.000		
49	1			1.000		
50	1			1.000		

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Replication Report

Measure of Effectiveness (MoE)

Entity: Planner

Property: NumberOfAttackers

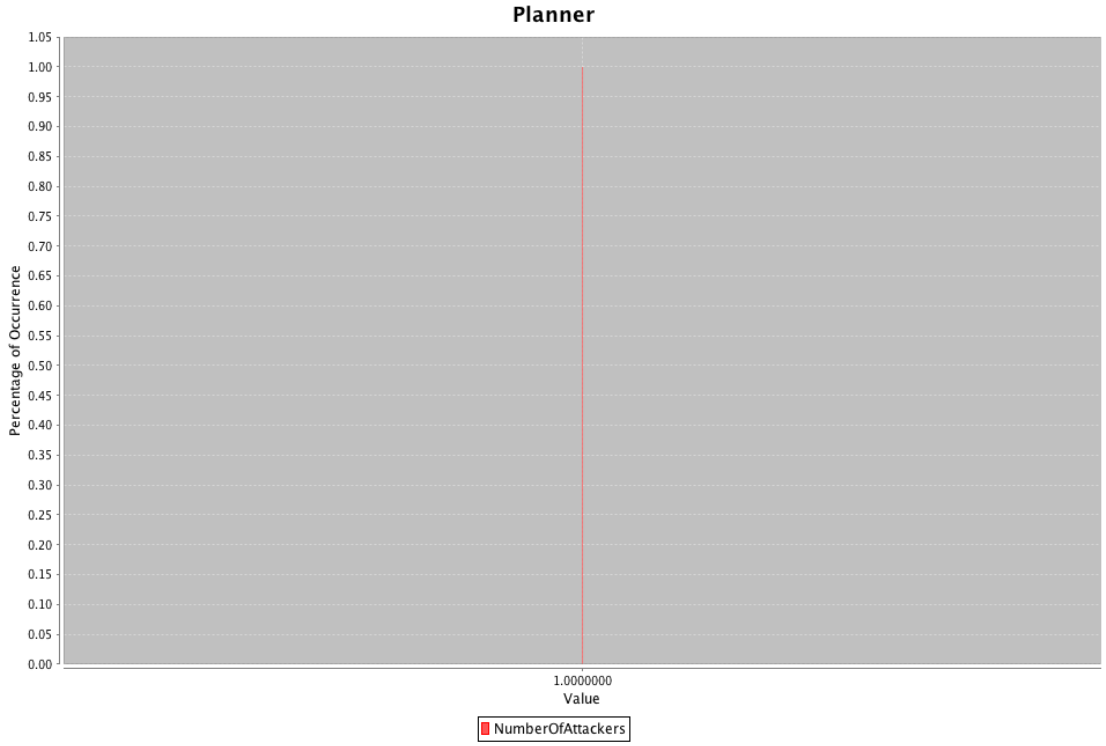

Figure 18: Replications Histogram for NumberOfAttackers

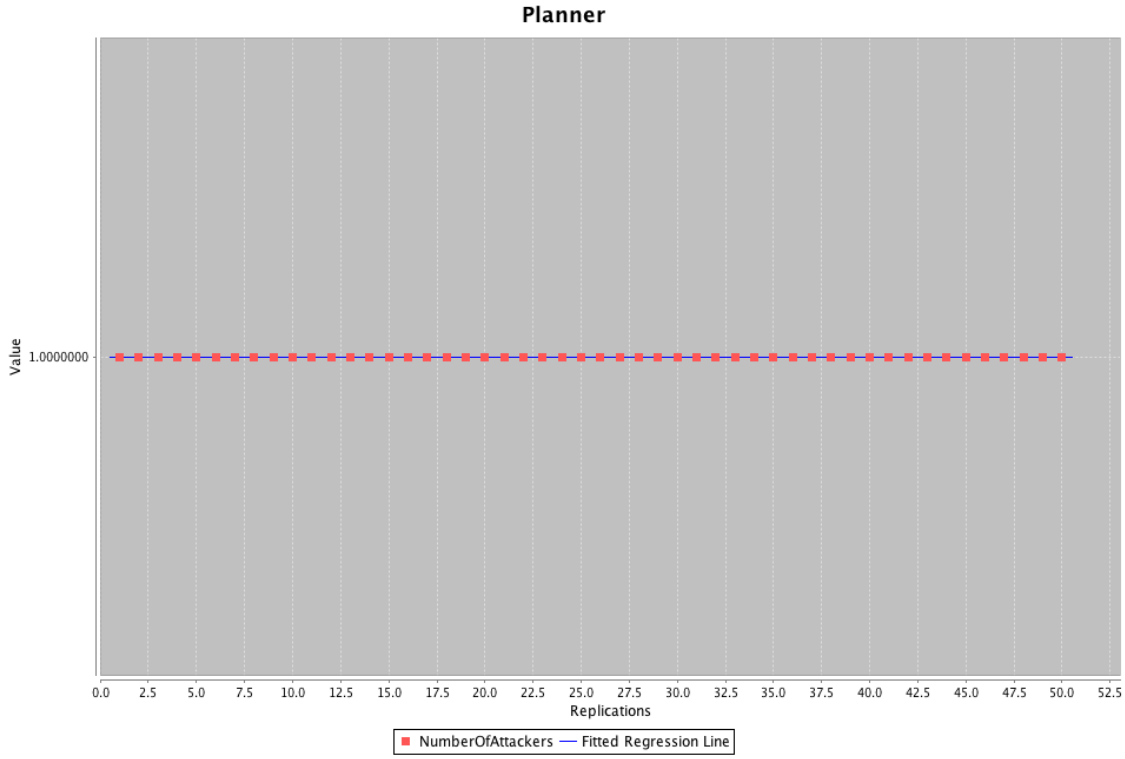

Figure 19: Replications Regression Plot for NumberOfAttackers

Replication #	NumberOfAttackers	Min	Max	Mean	StdDev	Variance
1	1			1.000		
2	1			1.000		
3	1			1.000		
4	1			1.000		
5	1			1.000		
6	1			1.000		
7	1			1.000		
8	1			1.000		
9	1			1.000		
10	1			1.000		
11	1			1.000		
12	1			1.000		
13	1			1.000		
14	1			1.000		
15	1			1.000		
16	1			1.000		
17	1			1.000		
18	1			1.000		
19	1			1.000		
20	1			1.000		
21	1			1.000		
22	1			1.000		
23	1			1.000		
24	1			1.000		
25	1			1.000		
26	1			1.000		
27	1			1.000		
28	1			1.000		
29	1			1.000		
30	1			1.000		
31	1			1.000		
32	1			1.000		

33	1			1.000		
34	1			1.000		
35	1			1.000		
36	1			1.000		
37	1			1.000		
38	1			1.000		
39	1			1.000		
40	1			1.000		
41	1			1.000		
42	1			1.000		
43	1			1.000		
44	1			1.000		
45	1			1.000		
46	1			1.000		
47	1			1.000		
48	1			1.000		
49	1			1.000		
50	1			1.000		

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Replication Report

Measure of Effectiveness (MoE)

Entity: Planner

Property: AttackTime

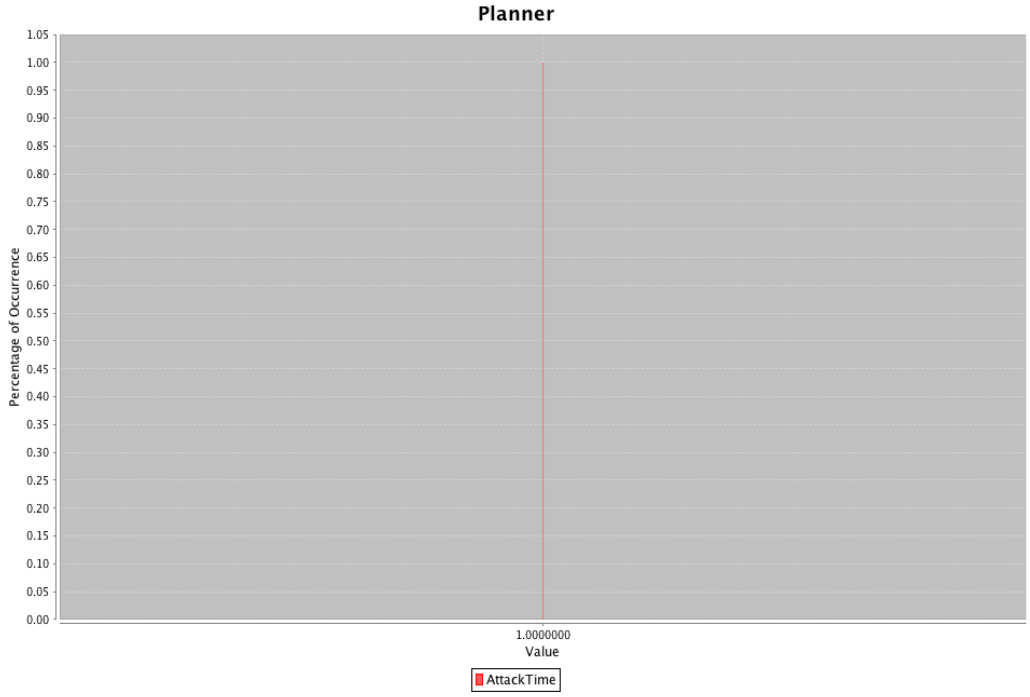

Figure 20: Replications Histogram for AttackTime

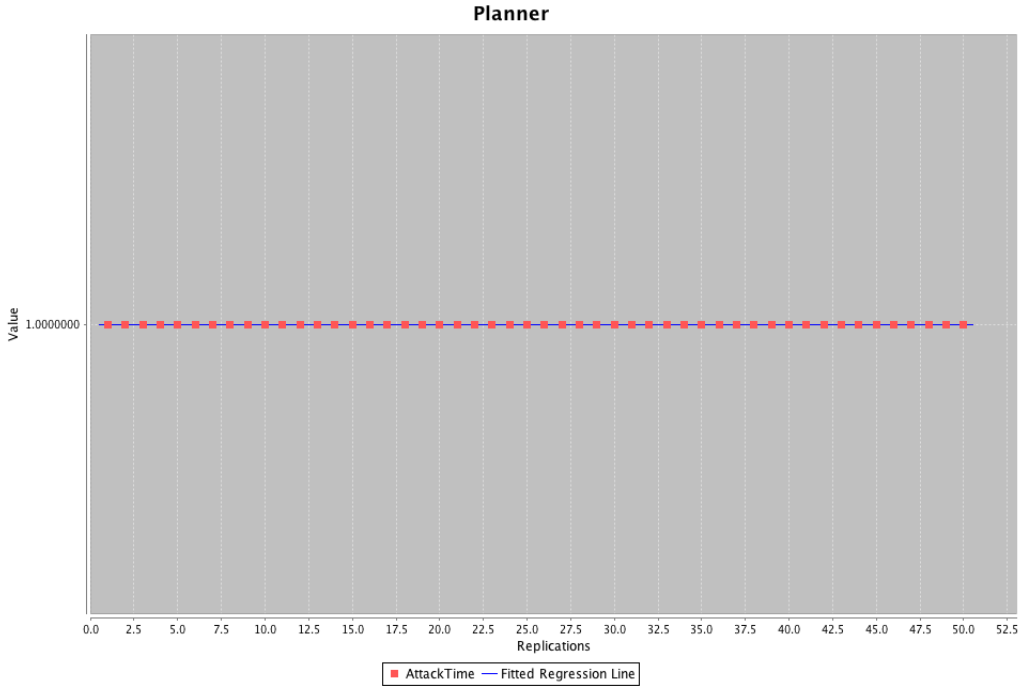

Figure 21: Replications Regression Plot for AttackTime

Replication #	AttackTime	Min	Max	Mean	StdDev	Variance
1	1			226.413		
2	1			226.340		
3	1			65.230		
4	1			218.091		
5	1			232.069		
6	1			68.661		
7	1			76.701		
8	1			319.110		
9	1			234.256		
10	1			80.109		
11	1			317.839		
12	1			70.893		
13	1			223.552		
14	1			76.447		
15	1			227.006		
16	1			72.480		
17	1			83.836		
18	1			220.011		
19	1			79.332		
20	1			214.980		
21	1			66.047		
22	1			312.877		
23	1			352.232		
24	1			213.679		
25	1			217.543		
26	1			309.383		
27	1			92.293		
28	1			224.340		
29	1			75.067		
30	1			217.872		
31	1			63.287		
32	1			314.603		

33	1			343.049		
34	1			315.810		
35	1			77.923		
36	1			212.875		
37	1			331.467		
38	1			216.930		
39	1			218.236		
40	1			306.268		
41	1			308.998		
42	1			81.884		
43	1			314.516		
44	1			229.434		
45	1			84.170		
46	1			82.947		
47	1			321.604		
48	1			67.178		
49	1			229.653		
50	1			312.705		

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Summary Report

Entity	MoE / MoP	# Replications	Min	Max	Mean	StdDev	Variance
	FriendlySuccessfulIntercepts	50	0.000	1.000	0.680	0.471	0.222
	FriendlyAttemptedIntercepts	50	1.000	3.000	1.780	0.975	0.951
	LineOfDemarcation	50	0.000	1.000	0.700	0.463	0.214
Planner	SuccessfulAttacks	50	0.000	1.000	0.980	0.141	0.020
Planner	NumberOfAttackers	50	1.000	1.000	1.000	0.000	0.000
Planner	AttackTime	50	63.287	352.232	196.965	100.207	10041.346

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Conclusions and Recommendations

Conclusions
ENTER ANALYST CONCLUSIONS HERE

Recommendations for Future Work
ENTER RECOMMENDATIONS FOR FUTURE WORK HERE

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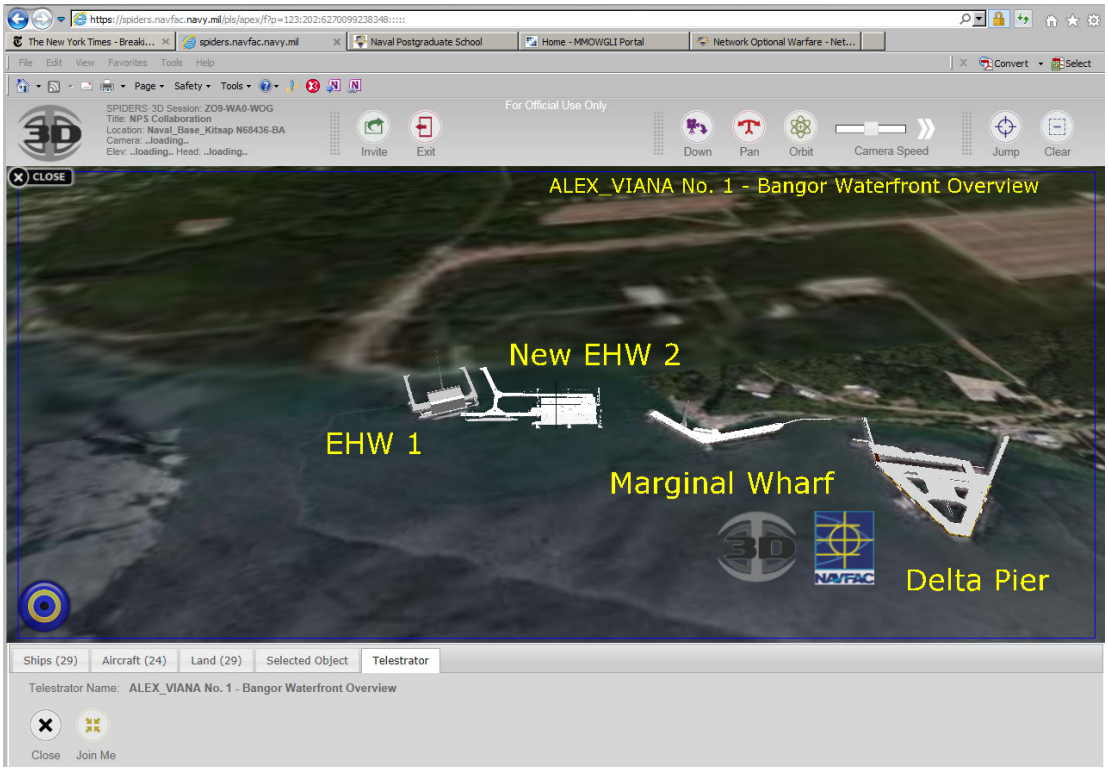
This report was autogenerated by the Viskit Event Graph and Assembly modeling tool using Simkit discrete-event simulation (DES) libraries. Online at https://diana.nps.edu/Viskit and https://diana.nps.edu/Simkit.

E. SPIDERS3D

Menneken Undersea Warfare Academic Group USWAG Demonstration
Thursday 21 May 2015, 12–1300, Spanagel 602

SPIDERS3D Navy Port Visualization Worldwide using X3D GraphicsLive Web-based Collaboration between NAVFAC and NPS



Abstract. The Navy has a requirement to assess acquisition risk for weapon system acquisition. Effective system interface design for the shore is a key element in life cycle supportability and a driver of Total Ownership Cost (TOC). The ability to efficiently harmonize shore interface design through simplified collaborative processes between system designers and Navy acquisition teams, shore maintainers, shore planners and Fleet operators is the impetus to the development and deployment of a web-based 3D product model and scene visualization capability on the world's largest intranet - Navy Marine Corps Intranet (NMCI).

In partnership with NPS MOVES staff and industry technologists, NAVFAC led the implementation of SPIDERS 3D to evolve technical collaboration among the Naval SYSCOMs and improve the pace and quality of decision making processes. The Oracle, Java and X3D based tool is a functional module of NAVFAC's Enterprise Business System for management of the Navy and MARCOR's ocean and waterfront infrastructure assets. The premise of SPIDERS 3D is web-based, real time, interactive multi-user product model interaction and scene visualization. The open standard X3D based tool is the Navy's portal to the 3D virtual as-built environment and allows for a common view of multiple disparate product models to be staged and evaluated in accurate geospatial context. The tool provides users with over 100 virtual installation scenes with simple click-drag-and-drop functionality to create ad hoc platform-shore interface scenarios, and provides functional telestration capabilities to annotate, capture, and share knowledge real time across the Navy's 300,000 NMCI computer seats across the world. SPIDERS 3D is currently supporting shore interface design evaluation for many of the Navy's weapon system acquisition programs such as the FORD Class aircraft carrier, OHIO Replacement and VIRGINIA Class submarines and the Littoral Combat Ship (LCS).

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APPENDIX B. OPERATIONAL SYMBOLS OF MILITARY UNITS

A. FRAMES DEPICTING STANDARD IDENTITIES AND DIMENSIONS

MIL-STD-2525D

TABLE I. Frames depicting standard identities and dimensions.

DIMENSION / STANDARD IDENTITY	UNKNOWN	SPACE	AIR	LAND UNIT	LAND EQUIPMENT AND SEA SURFACE	LAND INSTALLATION	SUBSURFACE	ACTIVITY/ EVENT
PENDING (YELLOW)								
UNKNOWN (YELLOW)								
FRIEND (CYAN)								
NEUTRAL (GREEN)								
HOSTILE (RED)								
ASSUMED FRIEND (CYAN)								
SUSPECT (RED)								

Note: Frames displayed with solid lines or alternating black and white dotted lines, as shown above, indicate status as present, i.e., the object exists at the location identified. See table IV for examples of frames depicting planned or anticipated status.

F. EXERCISE FRAMES

MIL-STD-2525D

TABLE II. Exercise frames.

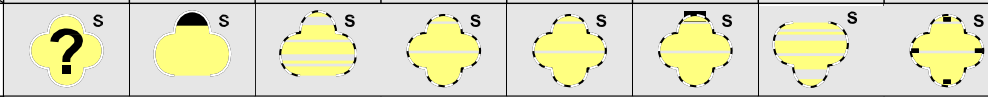
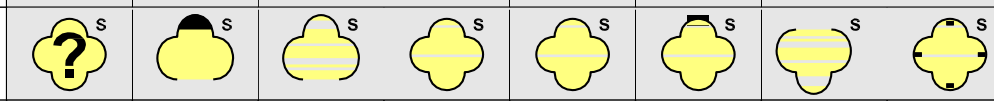
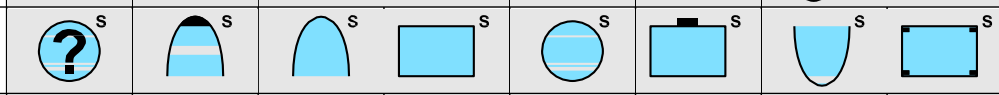
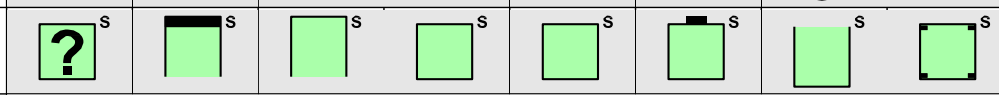
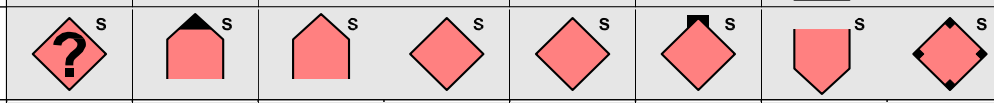
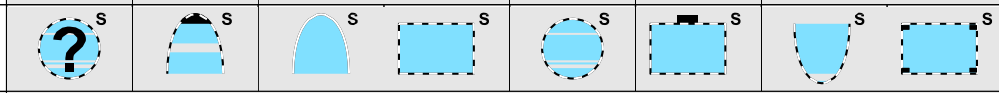
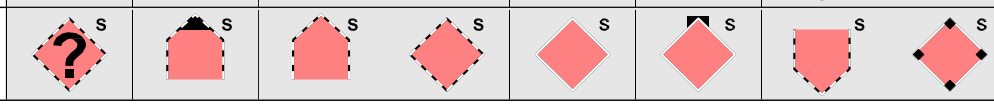
DIMENSION / STANDARD IDENTITY	UNKNOWN	SPACE	AIR	LAND UNIT	LAND EQUIPMENT AND SEA SURFACE	LAND INSTALLATION	SUBSURFACE	ACTIVITY/ EVENT
EXERCISE PENDING (YELLOW)								
EXERCISE UNKNOWN (YELLOW)								
EXERCISE FRIEND (CYAN)	N/A							
EXERCISE NEUTRAL (GREEN)	N/A							
EXERCISE ASSUMED FRIEND (CYAN)	N/A							
JOKER (RED)	N/A							
FAKER (RED)	N/A							

Note: Frames displayed with solid lines or alternating black and white dotted lines, as shown above, indicate status as present, i.e., the object exists at the location identified. See table IV for examples of frames depicting planned or anticipated status.

G. SIMULATION FRAMES

MIL-STD-2525D

TABLE III. Simulation frames.

DIMENSION / STANDARD IDENTITY	UNKNOWN	SPACE	AIR	LAND UNIT	LAND EQUIPMENT AND SEA SURFACE	LAND INSTALLATION	SUBSURFACE	ACTIVITY/ EVENT
SIMULATED PENDING (YELLOW)								
SIMULATED UNKNOWN (YELLOW)								
SIMULATED FRIEND (CYAN)								
SIMULATED NEUTRAL (GREEN)								
SIMULATED HOSTILE (RED)								
SIMULATED ASSUMED FRIEND (CYAN)								
SIMULATED SUSPECT (RED)								

Note: Frames displayed with solid lines or alternating black and white dotted lines, as shown above, indicate status as present, i.e., the object exists at the location identified. See table IV for examples of frames depicting planned or anticipated status.

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APPENDIX C. MASSIVE MULTIPLAYER ONLINE WARGAME LEVERAGING THE INTERNET (MMOWGLI)

A. MMOWGLI QUICK LOOK

This Appendix provides a relatively comprehensive overview about MMOWGLI in a quick look format. The quick look provides an overview of design elements, role of the Game Master, shares information on past games, and offers insight on ways MMOWGL can be applied to solve problems. Quick Look begins on the next page.

mmowgli

massively multiplayer online war game leveraging the internet

MMOWGLI

https://portal.mmowgli.nps.edu

About MMOWGLI

A New Kind of War Game

MMOWGLI, Massive Multiplayer Online War Game Leveraging the Internet, is a message-based game that encourages innovative thinking about some of the world's most wicked problems. The MMOWGLI project is sponsored by the Office of Naval Research (ONR) for the United States Navy (USN). The goal of the project is to explore the potential of MMOWGLI, with a variety of themes to expand engagement in military and non-military strategy development for complex geopolitical problems. MMOWGLI is designed to support large number of distributed global players working together on idea generation and action planning, with an eye towards surfacing innovative outlier strategies. To date, seven MMOWGLI games have been executed in a variety of contexts.

MMOWGLI was developed jointly by the Institute for the Future (IFTF) and the Naval Postgraduate School (NPS). IFTF expanded the goals of its successful gaming platforms, Signtific Lab and Foresight Engine, designing extensions that create a robust multimedia environment for collaborative strategic planning by networks of people who may be complete strangers. NPS drew upon its broad knowledge of worldwide Naval operations as well as its deep capacity in computer science to develop the gaming software and Web-based architecture, building a platform that can test the limits of new online environments. For more information on MMOWGLI, please visit the MMOWGLI Portal at https://portal.mmowgli.nps.edu

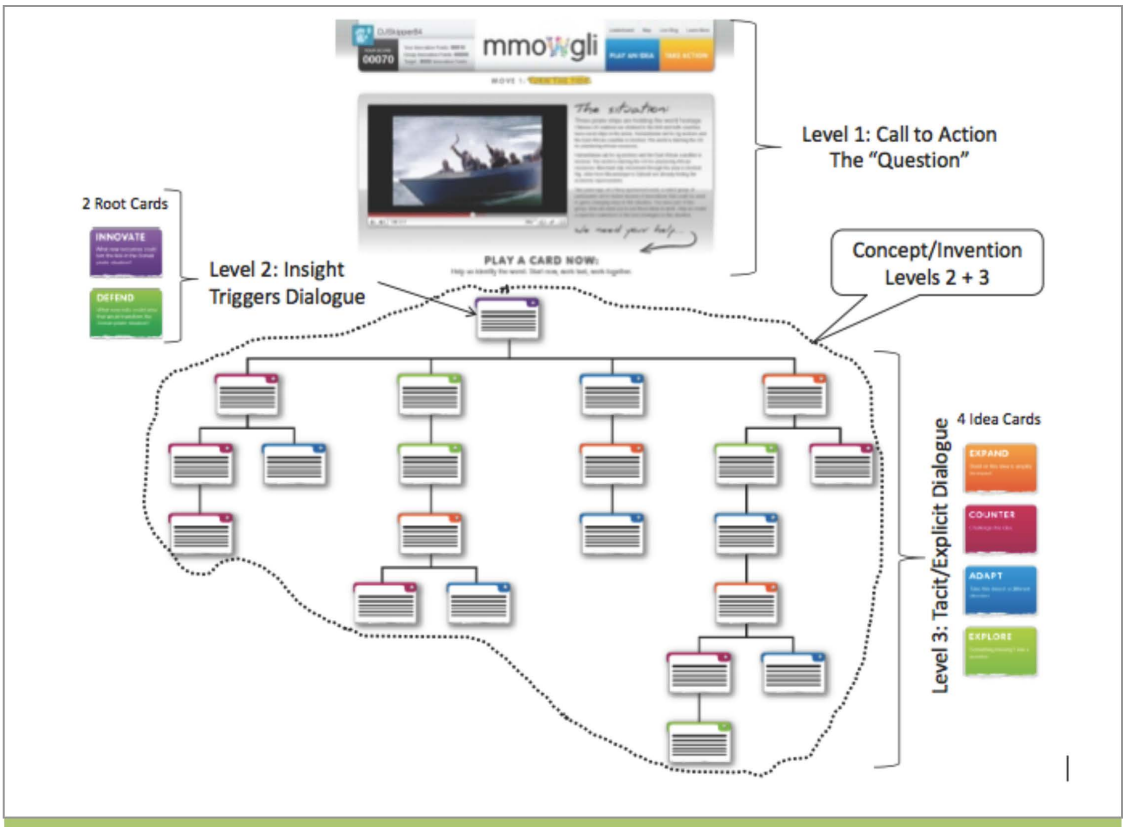
Game Design Elements:

Inside the MMOWGLI Game

Call to Action. The Call to Action video lays out the challenge presented to players. It provides the motivation to players to being engaging in dialogue to explore how best so solve a problem or overcome a challenge. The Call to Action video is simply uploaded via YouTube and can range in production value from as simple as a Power Point presentation to as high resolution as an HD film.

Root Cards. Root Cards are "the environment "in which the MMOWGLI game dialogue will grow. During the game design phase, game designers propose insights on how to address the question posed in the Call to Action. By customizing the two, top-level Root Cards, game designers can trigger a range of ways to think about or call into focus the "two sides of the story" conveyed in the Call to Action. Beneath Root Cards, players and/or game designers enter Seed Cards. In essence, the Seed Cards are just what the name implies, seeds from which the dialogue within MMOWGLI will grow.

Idea Cards. The first stage of the game for players is playing ideas—coming up with hundreds of micro-strategies that can add up to breakthrough strategies. Each "micro-strategy", or Idea Card, is 140 characters of your best thinking about how to meet this challenge. Players scan the cards that others are playing and respond with ideas that build on theirs. Players can choose to Expand, Counter, Adapt or Explore any card within the game. The goal of card play is to develop a conversation, or Idea Chain, where lots of micro-strategies add up to new breakthrough strategies. As people build on each other's ideas, Knowledge Trees begin to emerge.



MMOWGLI: From Insight to Innovation

Innovation is the generation and propagation of new knowledge. The MMOWGLI platform facilitates the tacit/explicit dialogue that builds new knowledge. The structured card chains form a network of related insights fleshing out concepts that can rise to the level of invention. Equally important it identifies a community of talented and motivated people that can create an action plan to begin the process of moving from insight to innovation.

Level 1: At level one is the Call to Action. This video is a rich narrative that describes the challenge – the burning question that must be answered. It gives the game designer the ability to set the context of the challenge in a manner that communicates to and motivates the participants.

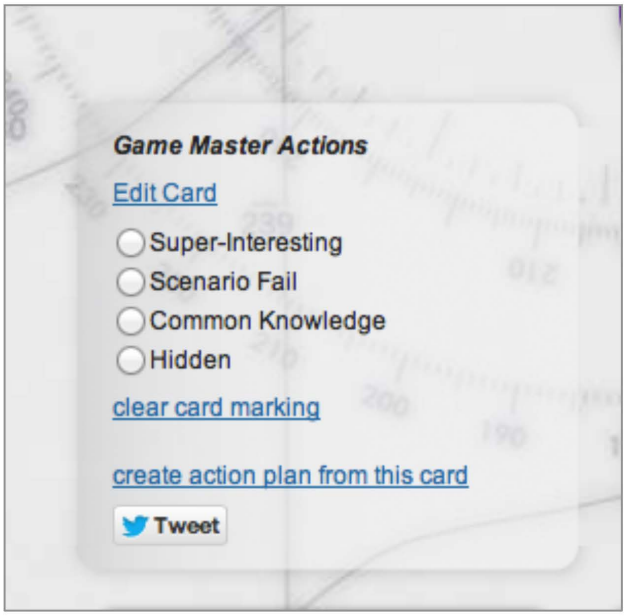
Level 2: The context of the dialogue is structured within the two top-level Root Cards. These cards can be customized to suit the challenge by the game designers who provide insights on how to address the question posed in the Call to Action. They can be used to trigger synergistic thinking. Beneath the Root Cards players will find Seed Cards. A Seed Cards trigger the dialogue within MMOWGLI. Seed Cards can either be inserted prior to game play by the game designers or kept completely open for players to spark the discussion dialogue on their own. Each option produces different raw outputs. In either case, the more Seed Cards played the more dialogues that unfold.

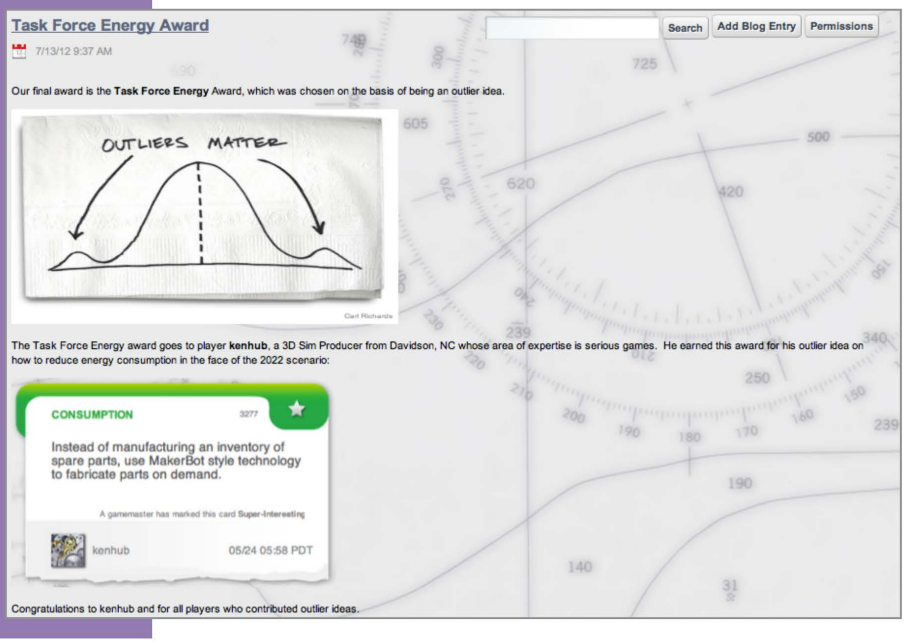
Level 3: At level three in the diagram participants can comment on the insight contained in a Seed Card by playing one or more of four Idea Cards as many times as they like. At this level a deeper exchange of knowledge develops a promising insight into a more complete "concept" (dotted line). Equally important this level reveals a network of people who have contributed to the maturation of the concept or Card Chain. For the most promising concepts, Action Plans are created. Action Plans are the "white papers" of MMOWGLI where authors of Idea Cards in a promising Card Chain are invited to mature their innovative idea. Action Plan authors can be chosen by Game Masters or can ask to form an Action Plan via a Trouble Report. The original author of the plan can invite additional Action Plan authors to help build the plan.

4

Behind the Scenes: The Role of the Game Master

A MMOWGLI Game Master is someone with special moderator privileges on the MMOWGLI platform. A Game Master also has access to the game blog, to share their thoughts about the game in progress. The primary mission is to *hunt the good stuff*. In other words, recognize and motivate players that are engaged, keep conversations flowing and players on topic. Game Masters also find interesting ideas and interesting players, and then highlight their great work by writing about it on the blog. You can also reward players on the site with special moderator feedback.





Previous MMOWGLI Games

Seven MMOWGLI games have been successfully run with a wide range of themes, contexts and sponsors. Each game design is unique, and given careful consideration and thought during the game design phase. Other notable games not mentioned below include the public piracyMMOWGLI 2011 game, piracyMMOWGLI 2012 for invited maritime professionals only, and the evtpMMOWLGI. Information on all current and prior MMOWGLI games can be found at https://portal.mmowgli.nps.edu

*energy*MMOWGLI 2012

Over 5000 Idea Cards and 47 Action Plans were generated during the 2012 *energy*MMOWGLI game. In this game, the Navy sought to rewrite the formula for its energy future and secure the Navy's energy future--with your help. With a barrel of oil projected to cost even more than it does today over the next decade, there will be less of it to go around. As a result, the operational readiness of today's Navy could turn into operational vulnerabilities for tomorrow's Navy.

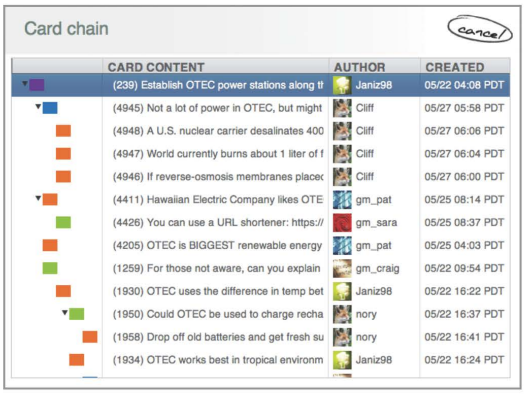
em^{2}MMOWGLI

The Navy Warfare Development Command (NWDC), the Office of Naval Research (ONR), and the Naval Postgraduate School (NPS) partnered to conduct the **Electromagnetic Maneuver MMOWGLI.** *em*^{2}MMOWGLI consisted of three rounds of game play and generated over 5600 Idea Cards and 40 Action Plans. Participation in this game was by invitation only.

*bii*MMOWGLI 2013

Business Innovation Initiative MMOWGLI game is for Navy and industry professionals exploring how best improve the Navy's new Open Systems Architecture (OSA) Strategy. Together, we're proposing and publishing new *Idea Card Chains* and *Action Plans* on how industry and the Navy can work together more effectively. Round 1 opened for players from 14-25 January 2013 and focused on *Identifying and Exploring OSA Business Challenges*. Over 900 Idea Cards were played and 12 Action Plans. Round 2 is scheduled to launch 15-26 July 2013.

With special thanks to Innovation Business Partners for their contributions to this document.



THE MOVES INSTITUTE
NAVAL POSTGRADUATE SCHOOL

Contact

Don Brutzman, Ph.D.

Phone: 831.656.2149

Code USW/Br, Naval Postgraduate School

Monterey, CA 93943-5000 USA

brutzman@nps.edu

H. IDEA CARD CHAIN 996

This section of the appendix shows the discussion string from MMOWGLI Idea Card Chain 996, which was used to openly discuss the "Need common policies for sharing CUI unclassified data with other government agencies in order to better protect Navy ships in U.S. ports." Idea Card can be found on the next page.

Data Silo	996	SeedCard: **How can the DON change the culture of over-classification (including FOUO)?**				
	Expand	1381	gen0365: To really change this, the DON must go to the lowest level, which is educating the employee on what should or should not be classified.			
	Expand	1087	* Desert Fox: Education. Again, fear of getting it wrong defaults to over-classification. Automated checklist tool to assist decision making			
		Adapt	1286	NG36B: Can we create an automatic tool to stop over classification of data?		
			Expand	1318	Desert Fox: Automate decision flows as in DOD Manual 5200.45(publicly released) Can increase user confidence or do simple classification for user	
	Expand	1162	AllAboutTheData: Decide in advance on default classification levels, criteria for each different data model/set/stream. Might be more than one level,			
		Expand	1169	AllAboutTheData: Put necessary metadata markings in XML Schema for data model, along with decision criteria expressed using Semantic Web constructs (RDF/OWL)		
		Expand	1170	AllAboutTheData: Goal metric is EASY, both for humans assisted by tools and for standalone agents, to keep classification at lowest acceptable level.		
			Explore	1174	Rodent: Issue might not be classification of initial object, but classification as attributes are added and as aggregation of data objects occurs.	
				Counter	1176	Frost M1-SW: In my experiance people overclassify to start as a way of protecting the information better.
	Expand	1291	NG36B: Require every command to have a classification guide, similar to having an EO or SAPR program.			
	Adapt	2445	* AllAboutTheData: Navy must share unclassified data with other agencies for ship protection in US ports, but many flavors of CUI inhibit data sharing.			
		Expand	2448	AllAboutTheData: For Official Use Only (FOUO) is most common version of CUI for Navy, there are many other variants especially for federal, state, local.		
		Adapt	2452	Klone: Though not perfect, Coast Guard Command Centers routinely work fairly seamlessly with federal, state, & local partners.		
		Explore	2446	gm_donb: CUI = Controlled Unclassified Information, http://en.wikipedia.org/wiki/Controlled_Unclassified_Information		
			Explore	2447	gm_donb: National Archives and Records Administration (NARA): http://www.archives.gov/cui	
			Explore	2490	gm_donb: NARA brochure, CUI Answers to Frequently Asked Questions (FAQ): http://www.archives.gov/cui/documents/2011-what-is-cui-bifold-brochure.pdf	
		Expand	2449	AllAboutTheData: Ships have increased risk when entering or leaving port. Do we have a Data Share plan for cooperation and emergency coordination?		
	Expand	1292	NG36B: Expand the secured NIPRnet with tools like Intelink. That way we can share unclassified information behind encryption.			
		Explore	1293	NG36B: Intelink = https://www.intelink.gov/		
	Explore	1231	uss social: Do we keep data classified to protect programs and people? Flattening information and sharing kills ricebowls.			
		Adapt	1633	uss social: Have a continuous review of data as per current tempo/social/poltical situation. What is classified today may not be in a new timeline		
			Explore	1637	Rodent: Concur. Classified info has a timeline for declassification. The issue usually becomes if release reveals source or source capabilities.	
		Counter	1255	NG36B: If you use classification to hide something, that is misuse and against the law.		
	Expand	1076	* 13: Make people explicitly pay for the lifecycle cost of information, including a declassification tax. Like can recycling tax			
		Counter	1389	Desert Fox: This blames the user for something that they are clearly perplexed by. It only makes them want to run from the systems		
		Explore	1081	gm_becca: How would this work?		
		Counter	1113	Frost M1-SW: wouldnt this burden certain offices more than others purely based on mission specific assignments?		
		Explore	1159	Rodent: Would this encourage people to set long time ranges for declassification? That way the tax does not affect them in the near term.		
			Expand	1391	Desert Fox: They will come up with any and every way to circumvent this systems. It will become a new cat and mouse game	
	Expand	1294	NG36B: Punish overclassifiers. After so many times of overclassifying, require written counseling of those individuals.			
	Explore	1109	Frost M1-SW: Currently what guidance is available to DON or Federal government employees that helps in classification of documents?			
	Explore	1128	gm_donb: FOUO = For Official Use Only, https://portal.mmowgli.nps.edu/fouo			
	Expand	1084	Desert Fox: People over-classify because the potential repercussions of "underclassifying" are so severe - criminal penalties, career destruction			
		Counter	1095	kkesler: Correct, if everything is classified then nothing is classified.		
		Adapt	1096	kkesler: maybe have specialist teams that are able to not only classify but also purge unnecessary items.		
	Counter	1093	kkesler: Classification guidelines are vague & work at a high-level.			
		Counter	1107	Frost M1-SW: Very often things are classified incorrectly and it leads to massive problems long term. Currently we are overclassifiying documents		
	Expand	1133	Rodent: Need to start with the Service Classification Authorities. Lower levels are typically told what classification an item is at.			
	Adapt	1195	Dobbs: Take humans out of the classification game. Create rule sets that define the correct level. Continuously monitor and automate.			
		Explore	1203	Rodent: This idea might be good candidate for development into an action plan.		
	Adapt	1094	kkesler: Maybe institute new guidelines at a functional level to help resources understand classification levels.			
		Expand	1108	Frost M1-SW: Education. I cant pretend to know everything but FEMA's Independant study courses are a great method of educating large groups about policy		
	Adapt	1230	uss social: How about getting rid of NIPRNET. Use Internet with VPNs for unclass and SIPR. Rethink networks, including the coalition mindset			
		Adapt	1259	NG36B: How do we protect information when we work with agencies (like logistics) that live solely in the NIPRnet world?		
		Counter	1258	NG36B: Getting rid of NIPRNET simply makes it more expensive, because we'll put more burden on the SIPRnet.		

I. ACTION PLAN 22

MMOWGLI Action Plan 22, which accompanies Idea Card Chain 996 from the previous section of this Appendix. Action Plan 22 was included to provide a sense how parses content from post-online discussions in a formatted report for actionable follow-up. User can also upload videos in addition posting photos. Action Plan begins on the next page.

Action Plan 22

ID

Action Plan 22 for dd Data Dilemma

Title

Need common policies for sharing CUI unclassified data with other government agencies in order to better protect Navy ships in US ports.

Rating

2.2 "thumbs up" score (range from 1 to 3) with **10** player votes received, ranking 19 out of 23 plans.

Idea Card Chain Providing Original Motivation

Idea Card Chain 2445 started by player AllAboutTheData: Navy must share unclassified data with other agencies for ship protection in US ports, but many flavors of sharing.

Co-Authors

AllAboutTheData, NG36B, Frost M1-SW, Klone, PinkPanther

Who Is Involved?

Navy, Coast Guard, Department of Homeland Security (DHS), U.S. Customs, state and local agencies, harbor masters and pilots, local law enforcement, FEMA, NO. Game, and others all need to be able to coordinate. Participation can also vary by port. National Archives and Records Administration (NARA) is federal Executive A

What Is It?

Navy must share unclassified data with other agencies for ship protection in US ports, but dozens of varieties of Controlled Unclassified Information (CUI) inhibit da Use Only (FOUO) is just one form of CUI. All are unclassified yet all have restricted access and restricted dissemination. The situation is so complex and convoluted knows what the rules really are. This confusion and the potential risk of penalty severely inhibits data sharing and re-use.

What Will It Take?

Make some sense of many different CUI categories. They typically have strict and different rules for how each is handled... but none talk about how they can be com together. So that probably means sharing is not strictly allowed, which might get everyone in trouble when an emergency or an attack occurs. It is not clear that any F authority or effective power to make decisions that other agencies will follow.

How Will It Work?

Providing cross-cutting comprehensive guidance to all Navy, Department of Defense, Federal, State and Local government agencies is a starting point. Perhaps speci granted to DHS to ensure change occurs, or perhaps White House direction is necessary to bridge bureaucratic barriers. Special effort might also be needed to figure sharing doesn't work already... Does it take an emergency or disaster to demonstrate that there is a real problem?

How Will It Change the Situation?

Navy ships will have greater security when entering, mooring or leaving ports. Routine operations are likely satisfactory already but a major terrorist attack on infrast might provoke many unforeseen consequences. In the event of a disaster or emergency, better coordination among individual entities will allow better planning, more avoid confusion.

Images

1

Controlled Unclassified Information (CUI) logo

https://mmowgli.nps.edu/dd/images/22/500px-Controlled_Unclassified_Information_Office_logo.svg.png

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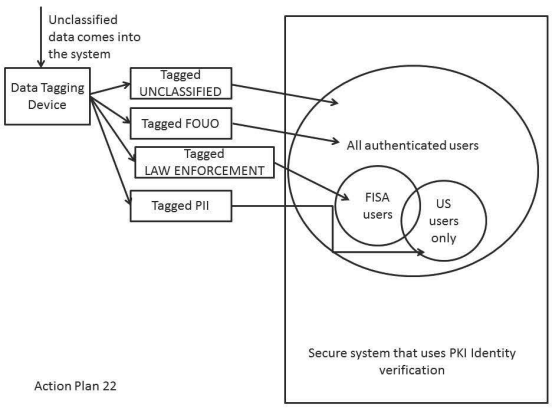
2



https://mmowgli.nps.edu/dd/images/22/AP22.jpg

Action Plan 22

3

Persian Gulf (March 8, 2006) - United States Coast Guard meml
the patrol boat USCGC Wrangell (WPB 1322) view flight opera
Nimitz-class aircraft carrier USS Ronald Reagan (CVN 76). The
came alongside the Navy's newest aircraft carrier to have a photo
take in the view of flight operations aboard the aircraft carrier. R
embarked Carrier Air Wing One Four (CVW-14) is currently on
deployment conducting Maritime Security Operations (MSO) in
participating in the global war on terrorism. U.S. Navy photo by
Mate Spike Call (RELEASED)

https://mmowgli.nps.edu/dd/images/22/Cutter_&_Carrier.jpg

4

Multi-agency training events like this is evidence of established
the military and federal/state/local partners. We are poised to bu
relationships when policies are relaxed to permit higher rates of

https://mmowgli.nps.edu/dd/images/22/USCG_USN_Partnershi

5

ATLANTIC OCEAN (Jan. 14, 2015) Maritime Enforcement Sp
Ricky Perilla, assigned to U.S. Coast Guard Law Enforcement D
engages in weapons-handling drills with members of the Cabo V
maritime law enforcement communities aboard the Military Seal
high-speed vessel USNS Spearhead (JHSV 1). Spearhead is on a
deployment to the U.S. 6th Fleet area of responsibility in suppor
collaborative capacity-building program Africa Partnership Stati
by Mass Communication Specialist 1st Class Joshua Davies/Rel

https://mmowgli.nps.edu/dd/images/22/USCG_USN_Partnershi

6

Prev | Next Close

150326-N-IG780-013 CARIBBEAN SEA (March 26, 2015) Chief Engineman Eugene Andal observes as Engineman 1st Class Timothy Golden trains on an electric plant control console during engineering drills aboard the guided-missile frigate USS Kauffman (FFG 59). Kauffman is underway in support of Operation Martillo, a joint operation with the U.S. Coast Guard and partner nations within the U.S. 4th Fleet area of responsibility. (U.S. Navy photo by Mass Communication Specialist 3rd Class Shane A. Jackson/Released)

Download High Res More Info 0

CARIBBEAN SEA (March 26, 2015) Chief Engineman Eugene
Engineman 1st Class Timothy Golden trains on an electric plant
engineering drills aboard the guided-missile frigate USS Kauffm
Kauffman is underway in support of Operation Martillo, a joint
Coast Guard and partner nations within the U.S. 4th Fleet area o
Navy photo by Mass Communication Specialist 3rd Class Shane

https://mmowgli.nps.edu/dd/images/22/USCG_USN_Partnershi

7

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150106-N-KB426-034 ARABIAN GULF (Jan. 6, 2015) U.S. Coast Guard Sailors pull alongside the guided-missile destroyer USS Dewey (DDG 105) to deliver cargo. Dewey is deployed in the U.S. 5th Fleet area of responsibility supporting Operation Inherent Resolve, strike operations in Iraq and Syria as directed, maritime security operations, and theater security cooperation efforts in the region. (U.S. Navy photo by Mass Communication Specialist 3rd Class James Vazquez/Released)

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ARABIAN GULF (Jan. 6, 2015) U.S. Coast Guard Sailors pull
missile destroyer USS Dewey (DDG 105) to deliver cargo. Dew
U.S. 5th Fleet area of responsibility supporting Operation Inhere
operations in Iraq and Syria as directed, maritime security opera
security cooperation efforts in the region. (U.S. Navy photo by
Specialist 3rd Class James Vazquez/Released)

https://mmowgli.nps.edu/dd/images/22/USCG_USN_Partnershi

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ARABIAN GULF (Jan. 6, 2015) U.S. Coast Guard Sailors pull
missile destroyer USS Dewey (DDG 105) to deliver cargo. Dew
U.S. 5th Fleet area of responsibility supporting Operation Inhere
operations in Iraq and Syria as directed, maritime security opera

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150106-N-KB426-030 ARABIAN GULF (Jan. 6, 2015) U.S. Coast Guard Sailors pull alongside the guided-missile destroyer USS Dewey (DDG 105) during a cargo delivery. Dewey is deployed in the U.S. 5th Fleet area of responsibility supporting Operation Inherent Resolve, strike operations in Iraq and Syria as directed, maritime security operations, and theater security cooperation efforts in the region. (U.S. Navy photo by Mass Communication Specialist 3rd Class James Vazquez/Released)

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security cooperation efforts in the region. (U.S. Navy photo by M
Specialist 3rd Class James Vazquez/Released)

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150124-N-JP249-063 ATLANTIC OCEAN (Jan. 24, 2015) A boarding team member from the Senegal military climbs down from the Military Sealift Command USNS Spearhead (JHSV 1) to a waiting rigid-hull inflatable boat. Spearhead is on a scheduled deployment to the U.S. 6th Fleet area of responsibility to support the international collaborative capacity-building program Africa Partnership Station. (U.S. Navy photo by Mass Communication Specialist 2nd Class Kenan O'Connor/Released)

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ATLANTIC OCEAN (Jan. 24, 2015) A boarding team member
military climbs down from the Military Sealift Command USNS
to a waiting rigid-hull inflatable boat. Spearhead is on a schedul
U.S. 6th Fleet area of responsibility to support the international
building program Africa Partnership Station. (U.S. Navy photo b
Communication Specialist 2nd Class Kenan O'Connor/Released)

https://mmowgli.nps.edu/dd/images/22/USCG_USN_Partnershi

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The U.S. Coast Guard Cutter Waesche patrols the Pacific Ocean during a deployment in June 2012.

https://mmowgli.nps.edu/dd/images/22/CGC-Waesche-patrols-tl 600x428.jpg

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USCG, USN operations

The U.S. Coast Guard Cutter Jarvis (WHEC-725) and the amphi ship USS Cleveland (LPD 7) and Landing Craft Utility (LCU) 1 Kingdom of Tonga to begin the first phase of Pacific Partnership

https://mmowgli.nps.edu/dd/images/22/800px-US_Navy_11041 046_The_U_S__Coast_Guard_cutter_Jarvis_WHEC-725_front_the_amphibious_transport_dock_ship_USS_Clevelan 600x300.jpg

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U.S. Coast Guard H-60 Jayhawk helicopter landing on the deck Wasp.

https://mmowgli.nps.edu/dd/images/22/Flickr_-_Official_U_S__U_S__Coast_Guard_helicopters_land_aboard_USS_Wasp_0.jp

Author-to-Author Chat Messages

1 Friday, 17 April 2015 14:23:55-PDT *AllAboutTheData:* wondering if there are any online images or videos that show past Navy-USCG exercises, illustrating all the differe talk together?

2 Saturday, 18 April 2015 22:24:49-PDT *NG36B:* We need better definition on unclassified data. I propose: - Unclassified - Law Enforcement, meaning it falls under FISA con it can't be posted to internet (but can be shared freely with anyone via a secure connection)

Player Comments

1 Friday, 17 April 2015 14:20:06-PDT *PinkPanther:* Commanding Officers of Navy ships will always have the last say as to whether information from the ship is shared or n retain sole authority on this point.

2 Saturday, 18 April 2015 10:49:57-PDT *gm_donb:* See card 2446 for CUI and NARA references. The MMOWGLI community portal includes several references relating to Fo (FOUO) limitations on access and distribution of unclassified government materials. https://portal.mmowgli.nps.edu/fouo

3 Saturday, 18 April 2015 10:56:57-PDT *AllAboutTheData:* Similar problems with information sharing may also occur at overseas ports. Participation by additional agencies (S Departments, intelligence community, others) is likely needed for those cases. If the Navy can get our own Data Share challenges sorte the we can likely also improve coordination internationally to further benefit the protection of Navy ships.

4	Saturday, 18 April 2015 22:35:55-PDT	*NG36B:* I'm thinking we need a PKI system for identification among government users, including coalition partners, where we post ur tagging lets us determine who can access it, then the sharing happens automatically via a good search engine.
5	Sunday, 19 April 2015 19:52:29-PDT	*Klone:* Command Center (CC) facilitates the execution all USCG missions, provides valuable information, & coordination capability t agencies and port partners. CC s operate 24x7 & perform three primary functions: C2, situational awareness, and information manager
6	Sunday, 19 April 2015 20:59:05-PDT	*KIrkster:* What about sharing the data from the local authorities and other law enforcement agencies?
7	Monday, 20 April 2015 16:12:29-PDT	*Klone:* Information flowing thru Command Centers can be desensitized when necessary then passed on to port partners. This is far fro proven to be effective. It should also be noted that some ports & LE agencies have fusion centers. This greatly enhances our ability to
8	Monday, 20 April 2015 17:08:47-PDT	*AllAboutTheData:* Card 2365 describes how regular Web browsers do not trust government website certificates. This means that if a la emergency occurs, off-duty personnel might not be able to access critical government web sites. The same problem can occur for gene trying to report important information or just find out what is going on. This situation is unsatisfactory. Government web sites (includi not be treated the same as criminal sites.

J. IDEA CARD CHAIN 2445

This section of the appendix shows the discussion string from MMOWGLI Idea Card Chain 2445, which was used to openly discuss the topic of, "Navy must share unclassified data with other agencies for ship protection in [U.S.] ports, but many flavors of CUI inhibit data sharing."

2445	* AllAboutTheData: Navy must share unclassified data with other agencies for ship protection in US ports, but many flavors of CUI inhibit data sharing.		
Explore	2446	gm_donb: CUI = Controlled Unclassified Information, http://en.wikipedia.org/wiki/Controlled_Unclassified_Information	
	Explore	2447	gm_donb: National Archives and Records Administration (NARA): http://www.archives.gov/cui
	Explore	2490	gm_donb: NARA brochure, CUI Answers to Frequently Asked Questions (FAQ): http://www.archives.gov/cui/documents/2011-what-is-cui-bifold-brochure.pdf
Expand	2449	AllAboutTheData: Ships have increased risk when entering or leaving port. Do we have a Data Share plan for cooperation and emergency coordination?	
Expand	2448	AllAboutTheData: For Official Use Only (FOUO) is most common version of CUI for Navy, there are many other variants especially for federal, state, local.	
Adapt	2452	Klone: Though not perfect, Coast Guard Command Centers routinely work fairly seamlessly with federal, state, & local partners.	

SUPPLEMENTAL

Maritime Force Protection Unit's Transit Protection Training System, Simulator Upgrade List

The Transit Protection Training System (TPTS) is the result of a close collaboration between the U.S. Coast Guard (USCG) and the U.S. Navy (USN). TPTS is based on the Conning Officer Virtual Environment (COVE), which is a dynamic ship handing simulator used by the Navy's Surface Warfare Officers School (SWOS) to provide realistic training in vessel operation, management, and shipboard tactics (Lundquist, 2013). By combining the COVE's high-end M&S technology with commercial off-the-shelf (COTS) hardware, the Navy created a tool scalable enough to permit individual training or support several teams training on multiple afloat platforms simultaneously. With relatively minor modifications to the core software, the Navy "helped adapt the COVE simulation technology to the immersive environment of the Coast Guard units that escort ballistic-missile submarines in and out of port" (Lundquist, 2013).

The MFPU maintains a list of desired upgrades for future implementation. Dissemination controls for this list is maintained at the For Official Use Only (FOUO) level.

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