



# **NAVAL POSTGRADUATE SCHOOL**

**MONTEREY, CALIFORNIA**

## **THESIS**

**THE IMPORTANCE OF ARTIFICIAL INTELLIGENCE  
FOR NAVAL INTELLIGENCE TRAINING SIMULATIONS**

by

Patricia A. Sweat

September 2006

Thesis Advisor:

Co-Advisor:

Chris Darken

Perry McDowell

**Approved for public release; distribution is unlimited**

THIS PAGE INTENTIONALLY LEFT BLANK

<b>REPORT DOCUMENTATION PAGE</b>			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.				
<b>1. AGENCY USE ONLY (Leave blank)</b>		<b>2. REPORT DATE</b> September 2006	<b>3. REPORT TYPE AND DATES COVERED</b> Master's Thesis	
<b>4. TITLE AND SUBTITLE:</b> The Importance of Artificial Intelligence for Naval Intelligence Training Simulations			<b>5. FUNDING NUMBERS</b>	
<b>6. AUTHOR(S)</b> LT Patricia A. Sweat				
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Naval Postgraduate School Monterey, CA 93943-5000			<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> N/A			<b>10. SPONSORING/MONITORING AGENCY REPORT NUMBER</b>	
<b>11. SUPPLEMENTARY NOTES</b> The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
<b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited			<b>12b. DISTRIBUTION CODE</b>	
<b>13. ABSTRACT (maximum 200 words)</b>  <p>Agent technology is widely deployed in numerous commercial areas such as networking, modeling, and software; however, this technology remains under-utilized by operational organizations within the United States Navy. This thesis will investigate the importance of artificial intelligence (AI) for military training simulations, particularly in the training of intelligence personnel in the Navy.</p> <p>The Computer Generated Forces (CGF) of the current Intelligence Team Trainer's (ITT) system initiate actions as a result of rigid scripted programming. Forces will execute the same actions regardless of what the user decides to do, resulting in highly unrealistic scenarios. For instance, in a scenario where an ARG (Amphibious Ready Group) transits the Strait of Hormuz, the response of Iranian P3 or an incoming dhow would be the same whether the battle group utilized frigate escorts or not.</p> <p>This thesis will produce very simple, but less rigid AI, which can easily be made more complex and "intelligent" in later phases. Demonstrations and assessments will validate the importance of AI integration for the ITT. Furthermore, this analysis of the requirements for the AI will assist training commands and combat information centers fleet wide with the range of realistic combat-related possibilities needed in order to ensure a fully capable 'combat ready' watch team.</p>				
<b>14. SUBJECT TERMS</b> Multi-Agent Systems, Artificial Intelligence, Naval Simulations, Combat Information Center, Air-Defense Simulation, AEGIS, CG, Human-Computer Interface (HCI), Watchstander Training, Naval Air Defense, Threat Assessment, Decision Making, Interactive Training Systems			<b>15. NUMBER OF PAGES</b> 83	
			<b>16. PRICE CODE</b>	
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified	<b>20. LIMITATION OF ABSTRACT</b> UL	

THIS PAGE INTENTIONALLY LEFT BLANK

**Approved for public release; distribution unlimited**

**THE IMPORTANCE OF ARTIFICIAL INTELLIGENCE FOR NAVAL  
INTELLIGENCE TRAINING SIMULATIONS**

Patricia A. Sweat  
Lieutenant, United States Navy  
B.S., Oregon State University, 1999

Submitted in partial fulfillment of the  
requirements for the degree of

**MASTER OF SCIENCE IN MODELING, VIRTUAL ENVIRONMENTS  
AND SIMULATION (MOVES)**

from the

**NAVAL POSTGRADUATE SCHOOL  
September 2006**

Author: Lieutenant Patricia A. Sweat

Approved by: Christian J. Darken  
Thesis Advisor

Perry McDowell  
Co-Advisor

Rudy Darken  
Chairman, MOVES Academic Committee

THIS PAGE INTENTIONALLY LEFT BLANK

## **ABSTRACT**

Artificial intelligence (“intelligent agent”) technology is widely deployed in numerous commercial areas such as networking, modeling, and software; however, this technology remains under-utilized by operational organizations within the United States Navy. This thesis will investigate the importance of artificial intelligence (AI) for military training simulations, particularly in the training of intelligence personnel in the Navy.

The Computer Generated Forces (CGF) of the current Intelligence Team Trainer’s (ITT) system initiate actions as a result of rigid scripted programming. Forces will execute the same actions regardless of what the user decides to do, resulting in highly unrealistic scenarios. For instance, in a scenario where an ARG (Amphibious Ready Group) transits the Strait of Hormuz, the response of Iranian P3 or an incoming dhow would be the same whether the battle group utilized frigate escorts or not.

This thesis will produce very simple, but less rigid AI, which can easily be made more complex and “intelligent” in later phases. Demonstrations and assessments will validate the importance of AI integration for the ITT. Furthermore, this analysis of the requirements for the AI will assist training commands and combat information centers fleet wide with the range of realistic combat-related possibilities needed in order to ensure a fully capable ‘combat ready’ watch team.

THIS PAGE INTENTIONALLY LEFT BLANK



## TABLE OF CONTENTS

<b>I.</b>	<b>INTRODUCTION.....</b>	<b>1</b>
A.	<b>PROBLEM .....</b>	<b>1</b>
B.	<b>MOTIVATION .....</b>	<b>1</b>
C.	<b>THESIS STATEMENT .....</b>	<b>3</b>
<b>II.</b>	<b>BACKGROUND INFORMATION .....</b>	<b>5</b>
A.	<b>INTRODUCTION.....</b>	<b>5</b>
B.	<b>GLOBAL COMMAND AND CONTROL SYSTEM (GCCS) .....</b>	<b>5</b>
C.	<b>MODERNIZED INTEGRATED DATABASE (MIDB) .....</b>	<b>8</b>
D.	<b>ARTIFICIAL INTELLIGENCE.....</b>	<b>9</b>
<b>III.</b>	<b>REQUIREMENTS ANALYSIS .....</b>	<b>13</b>
A.	<b>EVALUATING TRAINING GOALS .....</b>	<b>13</b>
B.	<b>THESIS SCOPE LIMITATIONS .....</b>	<b>14</b>
C.	<b>CURRENT SYSTEM FUNCTIONALITY .....</b>	<b>14</b>
D.	<b>SYSTEM DEFICITS .....</b>	<b>15</b>
E.	<b>POSSIBLE SYSTEM IMPROVEMENTS .....</b>	<b>16</b>
<b>IV.</b>	<b>SOFTWARE PROTOTYPE.....</b>	<b>17</b>
A.	<b>INTRODUCTION.....</b>	<b>17</b>
B.	<b>SYSTEM ARCHITECTURE .....</b>	<b>17</b>
C.	<b>FEATURES .....</b>	<b>18</b>
1.	<b>Graphical User Interface.....</b>	<b>18</b>
2.	<b>Modernized Integrated Database (MIDB) Structure .....</b>	<b>19</b>
3.	<b>Message Traffic Generation.....</b>	<b>20</b>
D.	<b>IMPLEMENTATION .....</b>	<b>21</b>
1.	<b>Selected Classes and Methods.....</b>	<b>21</b>
<b>V.</b>	<b>TEST SCENARIO .....</b>	<b>25</b>
A.	<b>INTRODUCTION.....</b>	<b>25</b>
1.	<b>Background Information on Scenario .....</b>	<b>25</b>
B.	<b>INITIAL SYSTEM DEMONSTRATION SETUP AND PARAMETERS.....</b>	<b>25</b>
1.	<b>Scenario Generation .....</b>	<b>26</b>
<b>VI.</b>	<b>EXPERIMENT .....</b>	<b>33</b>
A.	<b>EXPERIMENTAL SETUP TO VALIDATE THE USE OF THE SYSTEM .....</b>	<b>33</b>
1.	<b>Subjects Used to Conduct Experiment .....</b>	<b>33</b>
2.	<b>Experimental Setup .....</b>	<b>33</b>
3.	<b>Experimental Design.....</b>	<b>34</b>
B.	<b>ANALYSIS .....</b>	<b>35</b>
C.	<b>RESULTS OF EXPERIMENT.....</b>	<b>36</b>
1.	<b>Analysis of Results .....</b>	<b>37</b>

2.	Control Group	38
3.	Experimental Group.....	38
4.	Other Results	39
VII.	SUMMARY, CONCLUSIONS, AND FUTURE WORK.....	41
A.	SUMMARY .....	41
B.	CONCLUSIONS .....	41
C.	FUTURE WORK.....	42
APPENDIX A.	DEBRIEF QUESTIONNAIRE.....	43
APPENDIX B.	EXPERIMENTAL PROCEDURE.....	47
APPENDIX C.	EXPERIMENT RESULTS FOR SCRIPTED VERSION .....	51
APPENDIX D.	CONTACT SYMBOLOGY HANDOUT.....	53
APPENDIX E.	SCREEN SHOT SIMULATION HANDOUT .....	55
APPENDIX F.	SCREEN SHOT MESSAGE TRAFFIC HANDOUT .....	57
APPENDIX G.	EXPERIMENTAL RESULTS FOR SCRIPTED .....	59
APPENDIX H.	EXPERIMENTAL RESULTS.....	61
APPENDIX I.	SCREEN SHOTS OF SIMULATION .....	63
	LIST OF REFERENCES .....	65
	INITIAL DISTRIBUTION LIST .....	67

## LIST OF FIGURES

Figure 1.	SUPPLOT Team Trainer Stations (From: MOVES Institute Proposal).....	2
Figure 2.	Illustration of GCCS Elements (From: <a href="http://www.fas.org/nuke/guide/usa/c3i/gccs1.gif">http://www.fas.org/nuke/guide/usa/c3i/gccs1.gif</a> ) .....	6
Figure 3.	Mainframe IDB (From: <a href="http://www.fas.org/irp/program/disseminate/midb_build.gif">http://www.fas.org/irp/program/disseminate/midb_build.gif</a> ).....	9
Figure 4.	Architecture Diagram.....	17
Figure 5.	Screen Shot 1 of Simulation .....	19
Figure 6.	Message Traffic Generator Initial Message.....	20
Figure 7.	Message Traffic Generator .....	21
Figure 8.	Screen Shot of simulation .....	22
Figure 9.	Taiwan Strait (From: <a href="http://www.fsmitha.com">http://www.fsmitha.com</a> ) .....	26

THIS PAGE INTENTIONALLY LEFT BLANK

## LIST OF TABLES

Table 1.	Story board for scripted version.....	28
Table 2.	Story board for AI version .....	31
Table 3.	Distribution of Average Number of Anticipated Responses for Control Group .....	35
Table 4.	Distribution of Average Number of Anticipated Responses for Experimental Group.....	36
Table 5.	Table of Data Obtained from Experiment .....	36
Table 6.	Distribution of Anticipated Enemy Responses, Displaying Control Group vs. Experimental Group .....	37

THIS PAGE INTENTIONALLY LEFT BLANK

## ACKNOWLEDGEMENTS

The completion of my thesis was the product of nearly a year of intense research, development, and programming. First, I would like to acknowledge my parents, Michael and Lourdes Sweat, who both have motivated me throughout my life to further my education and have supported me in every milestone of my life. Additionally, I'd like to thank my best friend, Shawn Singletary, who has inspired me in more ways than he will ever know. The entire experience has been an enormously nourishing one for me, professionally and academically. However, this thesis, as well as the enriching experiences it has provided me, would not have been possible without the assistance and guidance of a number of exceptional individuals, all of whom I have listed below. These individuals shared their invaluable knowledge and experience with me, and I am profoundly grateful for their contribution to my academic and professional growth. Especially to Professor Darken, thank you for your support, guidance, and most of all patience. To all of you, Thank You!

*Naval Postgraduate School, Monterey California*

Chris Darken – Research Professor, Modeling Virtual Environments and Simulation (MOVES) Institute

Perry McDowell – Research Associate, Modeling Virtual Environments and Simulation (MOVES) Institute

Mike Jones – Research Professor, Naval War College

Mitch Brown – Research Professor, Naval War College

*Fleet Technical Support Center, Pacific (FTSCPAC)*

Michelle Proses – Lieutenant Junior Grade, United States Navy, FTSCPAC

Patrick Prag - Lieutenant, United States Navy, FTSCPAC

The following is a list of course that were considerably beneficial to the completion of my thesis:

CS-3310 Artificial Intelligence

MV-4015 Agent-Based Autonomous Behavior for Simulations

CS-4310 Artificial Intelligence Techniques for Military Applications

THIS PAGE INTENTIONALLY LEFT BLANK



## **I. INTRODUCTION**

### **A. PROBLEM**

In the Department's Transformation Planning Guidance, Secretary of Defense Rumsfeld stated, "We must transform not only the capabilities at our disposal, but also the way we think, the way we train, the way we exercise, and the way we fight." (Training04) Within this document we focus on how 'training' within the military and other internal components within the DoD must now prepare the force to learn, improvise, and adapt to constantly changing threats while simultaneously executing doctrine to standards. While it is obvious that training of some kind is essential in any strategic environment, the method of approach is just as vital. That is where the use of computer simulation training plays a major role in the military today. More and more computer-based training is being introduced into the military as a means to not only save money, but to allow capabilities that would otherwise be limited to the real-world and access to more than one individual at a time.

Despite many advances achieved within the fields of Modeling and Simulation (M & S) and agent technology over the past several decades, practical application of both have been highly under utilized by the operational units of the United States Navy. When such technology has been deployed with units, it has usually been developed in order to improve operator proficiency, which is also the focus of this work. Little has been created for the war fighter to run "what-if" scenarios that might aid in development of tactical planning for increased proficiency of established doctrine.

### **B. MOTIVATION**

Currently, battle group (BG) intelligence teams are required to spend a minimum of three training sessions at the Intelligence Team Trainer (ITT) at the Fleet Intelligence Training Center, Pacific (FITCPAC). This trainer is a highly realistic simulation of the various intelligence cells onboard ships and trains the teams within the different cells as well as coordination between the multiple cells of the BG. Resembling many trainers currently employed fleet wide, the trainer is not meant to train individuals about their jobs, for job competency is trained earlier and is assumed by the time the team reaches

FITCPAC. The trainer is utilized as a way to teach the team to function proficiently and that a team's value is the sum of all of its parts.

Within the ITT, operators sit at mock consoles that replicate actual seating arrangements that are utilized on deployment and all input into these systems are highly accurate. Accurate message traffic, including some that do not relate to the problem, is distributed though out the cells. See Figure 1 below.

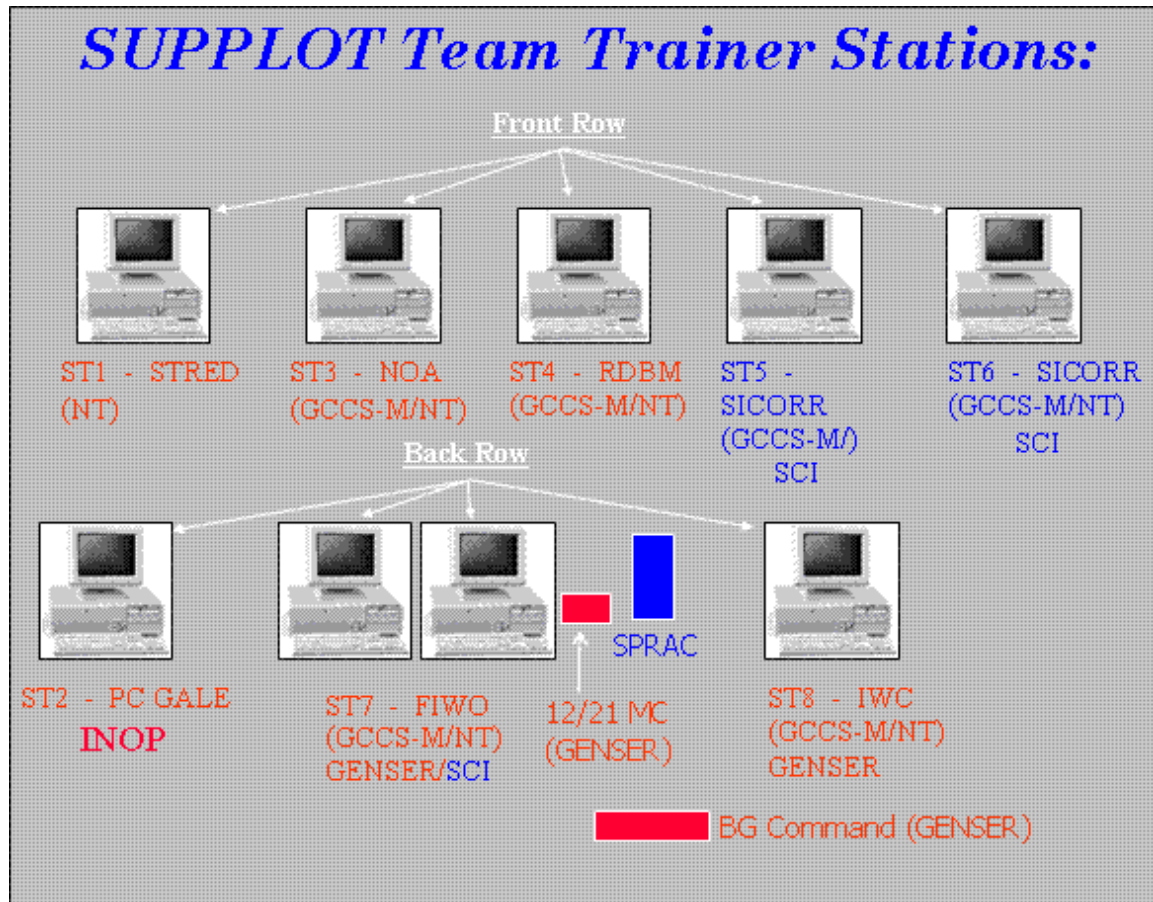


Figure 1. SUPPLOT Team Trainer Stations (From: MOVES Institute Proposal)

As intelligence analysts, the team members interpret and use this information to make a determination on the operation situation that is then passed on to BG commanders via their Watch Officer. Due to the substance of the scenarios, the details of each are tightly scripted and take a significant amount of time to design and build.

The amount of time it takes to create each scenario is one of many obstacles to the ITT. Currently, each scenario takes up to one year to build and as a result few scenarios

exist which reflect the latest conditions. This has resulted in each BG intelligence team conducting the same scenario multiple times. Without unpredictability and variation, the team's performance becomes less that of an ability of a team to function properly, but rather their ability to remember each scenario. Additionally, there is no way for the BG intelligence team's to train on scenarios based on the latest changes in the tactical, operational, or strategic situation.

### **C. THESIS STATEMENT**

This thesis describes the investigation, research, and development of a less rigid artificial intelligence (AI) which can easily be made more complex and "intelligent" in later phases. Demonstrations and assessments validate the importance of AI integration for the ITT. Furthermore, this analysis of the requirements for the AI will assist training commands and combat information centers fleet wide with the range of realistic combat-related possibilities needed in order to ensure a fully capable 'combat ready' watch team.

THIS PAGE INTENTIONALLY LEFT BLANK

## **II. BACKGROUND INFORMATION**

### **A. INTRODUCTION**

Due to the requirements of their work, intelligence professionals are not always given the opportunity to train as a team prior to a deployment. A response to this need was developing an Intelligence Team Trainer supervised by military instructors and civilian contractors that allowed these teams to not only meet fleet requirements for inspections, but to allow them to train in a manner similar to their deployed environment. The trainer establishes rigorous skill sets that build upon one another, so the end result is an effective and efficient intelligence operation that can easily communicate with other intelligence operations and teams throughout not only their own Battle Group, but through out the world's intelligence cohorts.

The intended end state of each training simulation is to expose the teams to situations that they will encounter while underway. In other words, the trainer's intention is to better prepare a sailor, allowing them have a better grasp on what to do and how to react in a timely manner for various events they will encounter in the real world. Additionally, a more general goal of this trainer is to give the Sailors the opportunity to learn how to work together as a team in an Operational setting.

### **B. GLOBAL COMMAND AND CONTROL SYSTEM (GCCS)**

The Global Command and Control System (GCCS) is an automated information system designed to support a common operation picture with the use of an integrated set of analytic tools and the flexible data transfer capabilities. GCCS is fast becoming the single C4I system to support the warfighter from foxhole to unified command posts (GCCS00).

The purpose of GCCS is to provide command centers with C5I, maintain the common operating picture (COP) for the specified area of responsibility (AOR), and provide the DoD with an open system architecture, as shown in Figure 2.



- Good to use C2PC or Intel Office to maintain
3. Message Handling and Communications Processing
    - Lines of Communication (LOC's) and IR's
  4. Track Correlation for near real-time update
    - For Force Over-the-Horizon Track Coordinator (FOTC)
    - Locator data
    - Longitude and Latitude
    - Link data (11/14/16)

In order to operate this system deployed or land-based, manning of GCCS involves two main categories of personnel: users and maintainers.

### **Users**

1. Intelligence Specialist (IS) – Tactical / Strategic Intelligence
2. Operations Specialist (OS) – FOTC
3. Electronic Warfare (EW) – Maintain radars
4. Cryptologic Technician (CT) – ELINT correlation and database

### **Maintainers**

1. Electronic Technicians (ET) – Maintain hardware
2. Information Systems Technician (IT)/ Cryptologic Technician – Communications (CTO) – software and application

The users and maintainers of the system are Navy enlisted personnel with subspecialties that qualify them to train for this system. In general, each rate has different positions within the trainer and requires a prerequisite such as a special school or qualification in order to do their job. For instance, the Intelligence Specialist (IS), if attached to a ship, must attend the Global Command and Control System Maritime Fleet-School (GCCS-M F) held at the FITCPAC center in San Diego (for West Coast personnel). Once they graduate from the school they receive a certification that qualifies them to operate the GCCS system and any application related to the system. Additionally, each piece of equipment or application in the system requires a certification from its associated training environment.

GCCS is the principal command and control system supporting the Joint Chiefs of Staff (JCS) and Commanders in Chief (CINCs) in managing military assets. GCCS

support six mission areas (operations, mobilization, deployment, employment, sustainment, and intelligence) through eight functional areas:

- Threat identification and assessment
- Strategy planning aid
- Course of action development
- Execution planning
- Implementation
- Monitoring
- Risk analysis
- Common tactical picture

### **C. MODERNIZED INTEGRATED DATABASE (MIDB)**

The Modernized Integrated Database (MIDB) is considered the worldwide general military intelligence (GMI) database for the Distributed Production Program (DPP) to provide GMI intelligence to the warfighter. MIDB is currently available through Intelink, the Sensitive Compartmentalized Information network. MIDB provides access in several different forms such as static posting, templated dynamic pull, and full MIDB access via Telnet. MIDB serves as the principal database of intelligence data for the entire United States Department of Defense (DOD) community, as well as Australia, Canada, and the United Kingdom. MIDB Order of Battle data contains all official validated graphical and textual information about enemy sites, facilities, and units. The system supports MIIDS/IDB database (military forces, installation and facilities, population concentrations, command and control structures, significant events and equipment) for retrieval and maintenance. MIDB is the MIIDS database with the addition of icons that represent the data in the database, as shown in Figure 3. Data collected from this database is extremely important to the intelligence team trainer and is pulled on a daily basis to maintain an updated operational picture of the world and, more importantly, the area of operation.



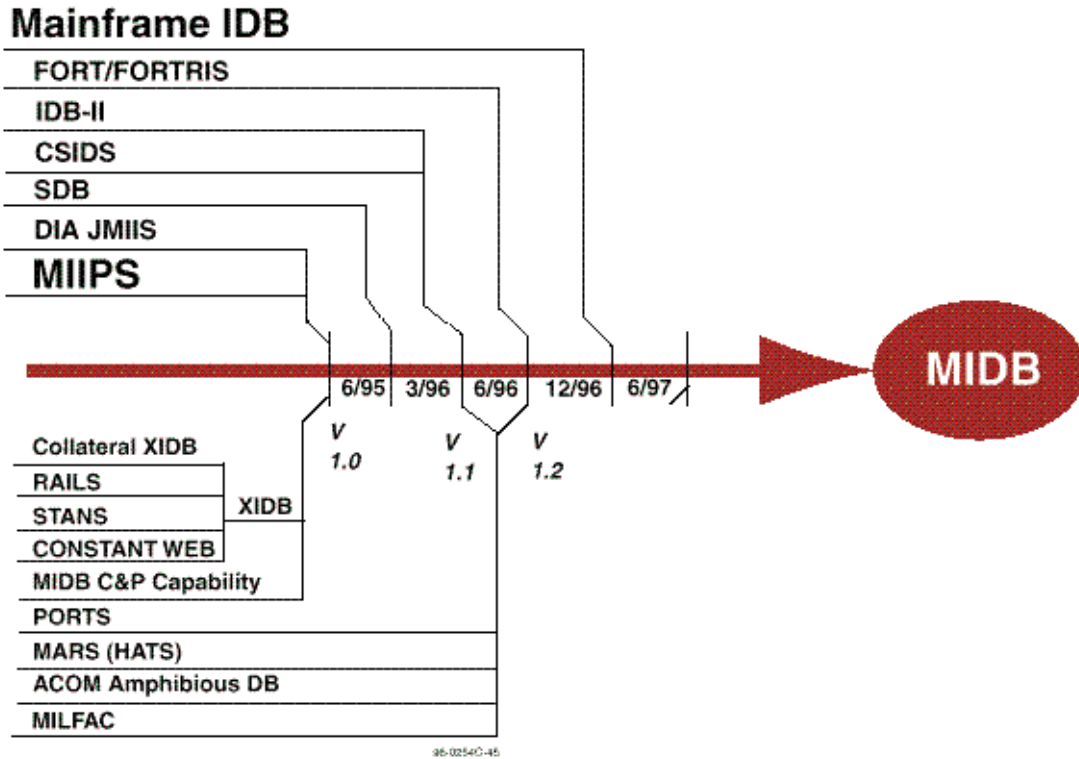


Figure 3. Mainframe IDB (From: [http://www.fas.org/irp/program/disseminate/midb\\_build.gif](http://www.fas.org/irp/program/disseminate/midb_build.gif))

MIDB is a DOD migration system and currently includes several legacy systems:

- Electronic Order of Battle Services (EOBS)
- Expeditionary Warfare
- Military Facilities File (MILFAC)
- Target Material Management (TMM)
- CENTCOM/SOCOM Integrated Data System (CSIDS)
- Force Trends database (FORT)
- Force Tracking Information System (FORTRIS)
- Space Data Base (SDB)

#### D. ARTIFICIAL INTELLIGENCE

There has been a revolution of change in game design, slowly evolving from a linear aspect, such as scripted game play to an environment of exponential

unpredictability (Tozour03). These changes have brought about numerous approaches and techniques relevant to applying variability to responding to a user's actions in order to create a more realistic training environment. Among these techniques are genetic and heuristic algorithms, scripting, state machines, A\* Path finding, and Bayesian networks. According to Paul Tozour, the most useful of these in creating a more human-like reasoning is the probabilistic inference technique of Bayesian networks (Touzour02\_1, Touzour02\_2). Additional contributions have been made by the entertainment sector, and due to advancements in hardware and software continuously become more accessible to the everyday user.

For decades the military has built computerized tools for analyzing combat such as, ATLAS, CASTFOREM, THUNDER, and TACWAR, to name a few. Recently, simulations have taken over as the foundation for computerized combat training tools (Janus, AWSIM, and JTLS). The expense of producing these computerized training tools is phenomenal. Realizing the cost involved in production and the continuing influence of producing accurate training systems, the Department of Defense (DoD) made the validation, verification, and accreditation (VV&A) of these simulations an official requirement (DOD5000, Training04).

The difficulty in conducting VV&A for a particular system is daunting and requires individuals with a great deal of experience in building and utilizing military simulations. Numerous papers have been written in this area; however, little is written on the effects of systems with rigid programming (i.e., scripted events) versus systems utilizing AI. In an article written by John E. Laird, he studies the similarities and differences in AI for computer games and AI utilized in computer generated forces. (Laird00)

In most legacy military training tools, the framework behind the system exploits scripted events. In other words, enemy actions behave the same every time the simulation is run. When a validation of the effects of these types of systems on trainee performance is conducted over a sustained period of time, performance levels of

individuals/teams continually increase. Of course, it is painfully obvious why: the individual/team knows exactly what the enemy will do each time. But this cannot be called effective training.

Many examples of practical approaches to applying AI to game-based training are available to the military. Among them is an article by John Manslow who discusses the importance of the application of using AI in order to force players to continually search for new ways to defeat the enemy AI. He provides solutions and steps in the decision processes of making an adaptive AI. (Manslow02).

The objective of many training systems is enhanced training value with no negative training. Detail or the 'fidelity' of a training system is dependent on the goal of the trainer. There are numerous papers that discuss training transfer or increasing or decreasing fidelity based on the objective of the simulation or virtual environment. For this reason, this paper will focus on performance measures and explaining how to obtain them in a system that utilizes very simple AI. The metric obtained in this analysis will demonstrate the superiority of using simple AI rather than none at all in combat training tools.

THIS PAGE INTENTIONALLY LEFT BLANK

### **III. REQUIREMENTS ANALYSIS**

#### **A. EVALUATING TRAINING GOALS**

During the researcher's visit to the Intelligence Team Trainer (ITT), instructors discussed their desired functionality in a new training system. The instructors expressed great interest in the use of AI in order to allow them to utilize time spent in the trainer to overlook the team itself, instead of typing message traffic or equivalent activities that take away from complete observation of the team. Additionally, the instructors desired pull-down menus to set-up various scenarios based on team experience and time limitations. The pull-down menus include a range of selections from areas of responsibility (AORs), time of day, weather, countries involved, etc. This will be covered in more detail in the Design Chapter.

In a meeting conducting between FITCPAC personnel and the MOVES Institute at Naval Postgraduate School, the following critical factors for a successful game-based simulation were discussed. The trainer should have all the basic functionality of the old system in addition to the following:

- The trainer should be simple enough to use so that both staff at FITCPAC and deployed personnel can utilize the trainer and produce scenarios within without special training;
- The trainer should be PC based in order for personnel to use the simulation exclusive of any access to specialized systems which might be occupied by a team or inoperative do to scenario setup. The specialized systems would include the MIDB, GCCS, and Office Intel;
- The system should be capable of training a complete intelligence team, requiring a network that allows team members to interface with one another;
- The system should be capable of training a single operator, with the other team members simulated by agents that are indistinguishable from actual humans. For instance, if one user desires to operate a PC based version of

the trainer, the individual stations not manned will be simulated by the game with responses and actions expected from an actual qualified watch stander;

- The trainer should be capable of interfacing and stimulating the systems and equipment involved in normal use by the intelligence team in order to create the same environment that is takes place while deployed;
- The trainer should be reactive, in order that the user's actions produce the enemy's actions. The system will also permit the enemy to "learn" from the user's actions so that the same user action will not produce identical results each time;
- The trainer should be entertaining and fun, so that Sailors will play the simulation outside of the work environment allowing for maximization of training.

## **B. THESIS SCOPE LIMITATIONS**

Due to time and capability limitations, this thesis provides the basic functionality of the current system's capabilities limiting itself to one scenario. Additionally, this thesis provides a simple PC based version of the trainer with a scenario generator, simple MIDB, message traffic implementation, and a graphical user interface that displays the actions of the user and the enemy's response to that action. This thesis focuses only on the issue of the reactivity of the trainer to user actions. However, one scenario will be sufficient enough to provide evidence whether utilizing artificial intelligence is an improvement over the older scripted version.

## **C. CURRENT SYSTEM FUNCTIONALITY**

The ITT utilizes the framework from GCCS, MIDB, Office Intel, and GCCS is the main operating system for the ITT simulation at FITCPAC, San Diego. Use of a modified stand-alone version is maintained at the FITCPAC facility to facilitate the realistic-scenario driven simulations conducted by the military instructors without disturbance to the real world.

Scenarios are put together by contractors with experience in scripting, doctrine, and various applications utilized in order to create realistic events. The process of

creating these scenarios is very tedious and takes two qualified contractors approximately a year to build. First, research into doctrine of the countries involved must be conducted so as to script rational results. Secondly, orders of battle must be loaded in from the stand-alone MIDB that include all countries involved which are placed in specific areas according to the research conducted by the contractors. Thirdly, event-driven scenarios are scripted one enemy reaction at a time dependent on the action of the user.

The current trainer progresses through the interaction of the watch standers and instructors based on the decisions made by the watch standers using data provided for them. The watch standers interact through chat and analyzing message traffic and visual data provided for them by display. The watch standers produce a complete intelligence picture for the Force Intelligence Watch Officer (FIWO), who in turn makes recommendations to “the staff”, which is simulated by the FITCPAC instructors who are observing the scenario. The team’s recommendations are always taken by the staff and the system runs its scripted actions.

#### **D. SYSTEM DEFICITS**

The current system’s forces initiate actions as a result of scripted programming. In other words, forces will execute the same actions regardless of what the user decides to do, resulting in highly unrealistic scenarios. For instance, in a scenario where an ARG transits the Strait of Hormuz, the response of Iranian P3 or an incoming dhow would be the same whether the battle group utilized frigate escorts or not. Because of this, scripted events are generally inferior to AI for the overall objective of FITCPAC’s Intelligence Team Trainer.

Due to the amount of time it takes to create a complete scenario, the FITCPAC facility will have only two or three scenarios available to them per training team cycle. This results in the intelligence team running each scenario approximately three times, each time with same situation and same behavior of enemy forces. Scripted events limits the amount of reaction an enemy force will have as a result of the user’s action. The team can become lethargic, simply because if they are familiar with the scenario, they can repeat previous actions with complete knowledge of what the enemy will do. The training becomes monotonous, and users will continue on with the scenario without reaching their full strategic potential.

## **E. POSSIBLE SYSTEM IMPROVEMENTS**

The best way to improve this training is to use AI to create enemy forces (often referred to as “red forces”) and U.S. forces (“blue forces”) which will react to one another. Therefore, each time the same simulation set-up is rendered, the behavior of the enemy forces will not necessarily be the same, since the actions the trainees take will change the behavior of the blue forces which will effect the behavior of the red forces. Furthermore, it is possible to introduce variation/randomness in the behavior of the enemy agents even given identical actions by the user. Adding AI like to the current system will improve the realism of scenarios for the training facility at FITCPAC. Additionally, such a system will be deployable with each shipboard intelligence team. Building a system to introduce such variability in force behavior is the aspect we focus on in this work.

Another advantage of utilizing AI within the current system is that it will significantly reduce the time spent on creating scenarios. As mentioned earlier, it takes approximately a year to generate a scripted scenario. Adding pull-down menus to establish each scenario prior to running it will significantly shorten time spent on creation. Of course, creating a system that enables a scenario to be drafted regardless of what country and area of responsibility will require a significant amount of research. This thesis covers only one scenario, involving the ongoing tensions with the arms race of China and its presumed desire of Taiwan via a situation involving the Strait of Taiwan. Details will be discussed later in Chapter IV.

Additionally, by generating message traffic with the AI the instructors will have the opportunity to be continuously present in the trainer with the team, vice at modules typing up responses. This will produce a better training environment because the instructors will have more time to critique and mentor the students. The system will also have the capability to record, stop, and replay a scenario at the instructors’ preference. This functionality will allow for the optimum training environment for the instructors to discuss with the team their decisions and how to improve their decision making process.



## IV. SOFTWARE PROTOTYPE

### A. INTRODUCTION

This chapter will provide an overview of the software developed to support the experimental investigation described later.

### B. SYSTEM ARCHITECTURE

The game-based simulator was created using NetBeans, which is an open source integrated development environment (IDE) written entirely in Java using the NetBeans Platform. NetBeans is based upon the Java language which contains the ability to provide simple graphical user interface (GUI), making it easier to develop complex behavior. Java contains modules to handle networking, rendering, movement, and complex interactions between objects. The Java code will act like a game engine as shown in the architecture diagram, Figure 4.

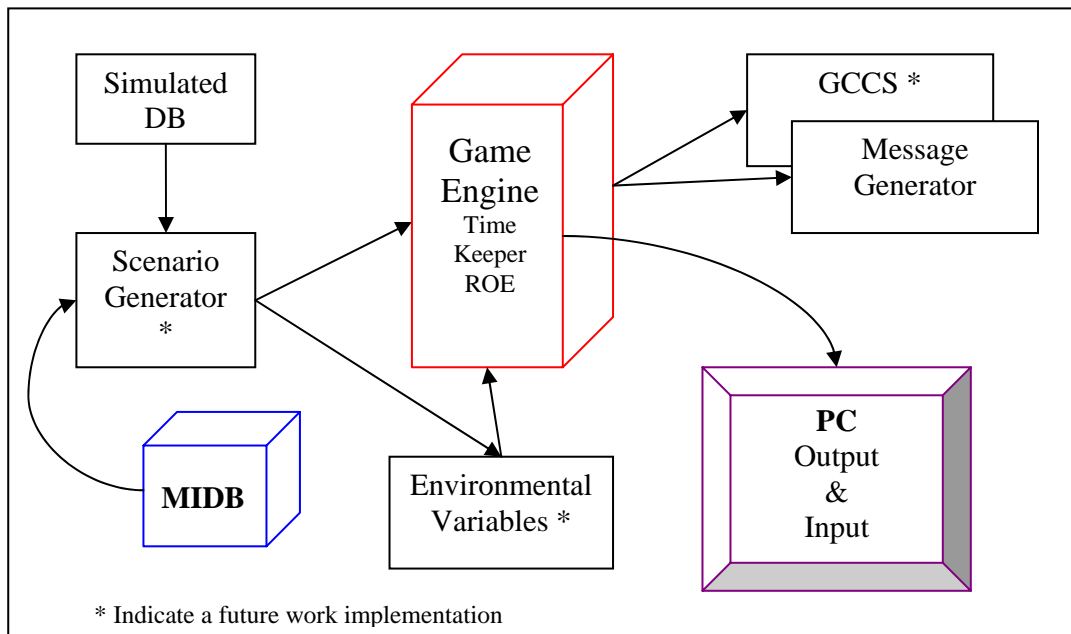


Figure 4. Architecture Diagram

The program was written utilizing various classes that control different aspects of the game-based simulator. Each class has a specific purpose within the simulation such as setup of initial variables, generating message traffic, movement of forces, and generation of the GUI.

The initial architecture designed for this thesis is limited to just the scope of the thesis. The application demonstrates for the user the distinction between a fixed-result simulation and a simulation developed with AI.

## **C. FEATURES**

In order to create a miniaturized stand-alone version of the current system, steps were taken so that all applications utilized in this test platform are as similar as possible to the real system. Miniaturized versions of systems include: the GUI, MIDB, Message Traffic Generation, and an addition to the current system which is the pull-down scenario creator ( See Figure 5).

### **1. Graphical User Interface**

All the features involved within the simulation are conducted in a GUI built within the NetBeans IDE. The opening display allows the user to setup the simulation from a series of buttons that open up separate windows with allow users to choose different preferences on how they would like to run the simulation. This allows the user to select area of operation (AO), time of day, and intensity level. Each selection determines the variables involved within each class and function that help govern the course of the simulation. A brief description of each class and its purpose within the simulation is discussed later in this chapter under Implementation.

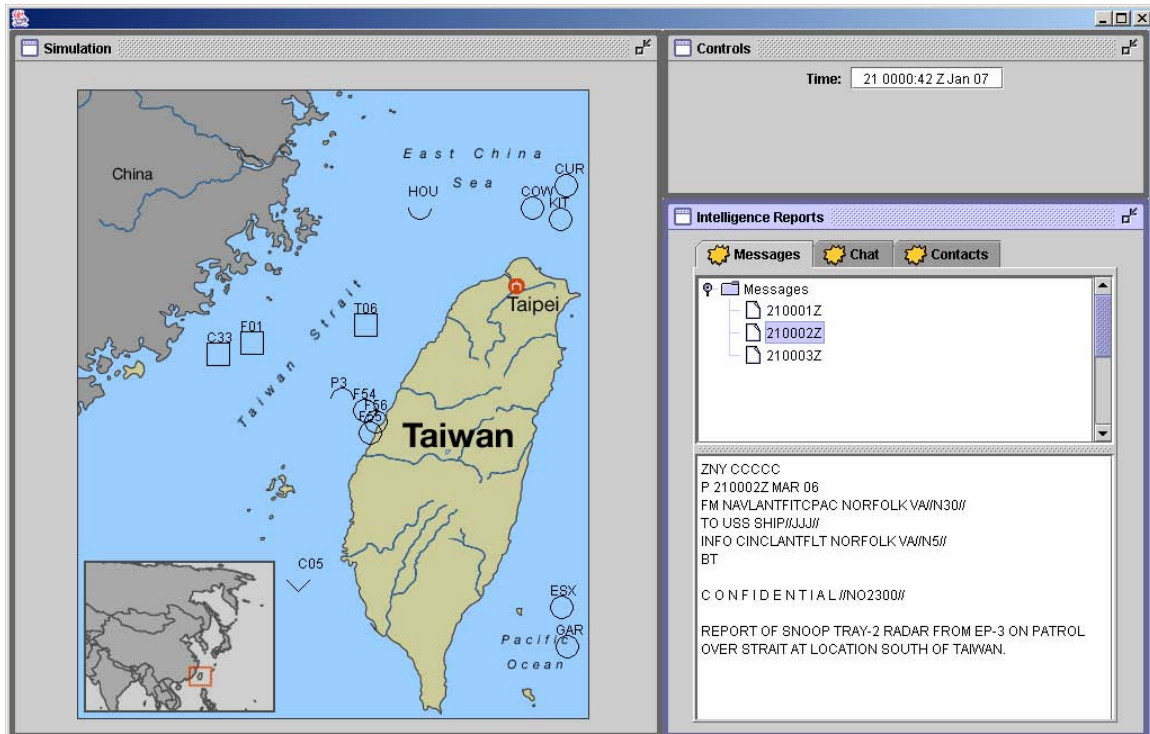


Figure 5. Screen Shot 1 of Simulation

## 2. Modernized Integrated Database (MIDB) Structure

First, research was conducted in order to analyze China's military doctrine and history of reactions to various combat situations. Additionally, Taiwan was studied in order to establish its military standing and social dependency on China. A very simple order of battle was established for China, Taiwan, Britain, Australia, Japan, and the United States. Assumptions of course were made that all parties would be involved on the influence of the United Nations and previous experience with established coalitions during Operation Enduring Freedom. The original MIDB would provide a substantial amount of intelligence data, but for the purposes of this thesis, data is limited to only data needed to conduct this experiment.

The MIDB be used in this thesis will be based on a plain text file built via the very simple and well known text editor Notepad. In future versions, Microsoft Excel or Intel Excel should be used to simplify the entry process. Notepad allows for simple extraction of the data needed to establish order of battle for red and blue forces. The data extracted will include the following:

- Military bases and facilities (i.e. port, airbases, SAM sites)
- Military units (i.e. types of ships, aircrafts)
- Weapons associated with each platform
- WMD

### 3. Message Traffic Generation

Intelligence information gathered from and transmitted via message traffic is crucial for the BG intelligence teams. Messages received via the Naval Computer and Telecommunications System (NCTS) are transmitted and disbursed throughout all U.S. Naval Ships and Shore Facilities. Information contained within each message must follow a specific format encompassing subject matter that is classified as unclassified, confidential, secret, or top secret. Format of messages are in accordance with Naval Telecommunications Procedure (NTP3(J)97) and for the purposes of this thesis, all messages' will be labeled as confidential; however, no actual confidential information will be created or used (Figure 7, Figure 8).

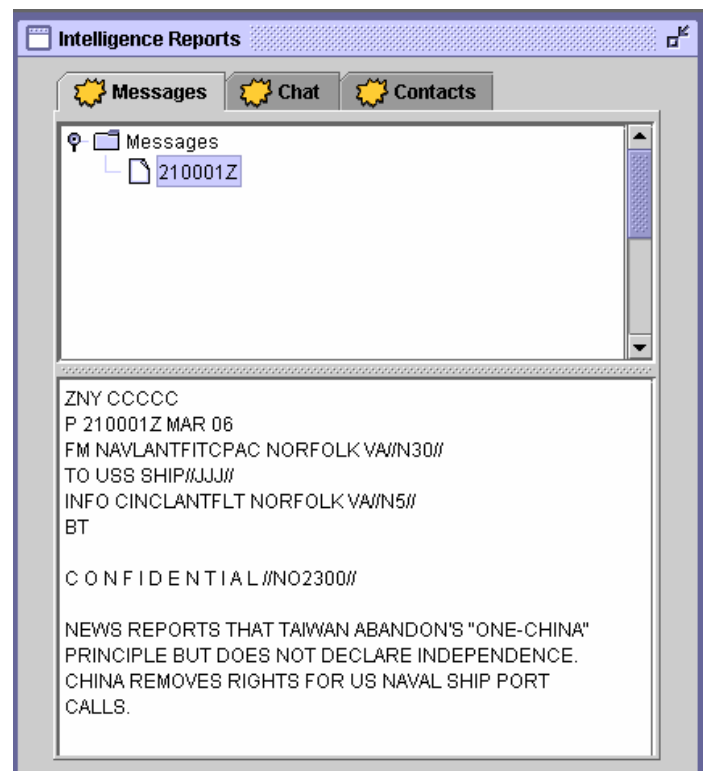


Figure 6. Message Traffic Generator Initial Message

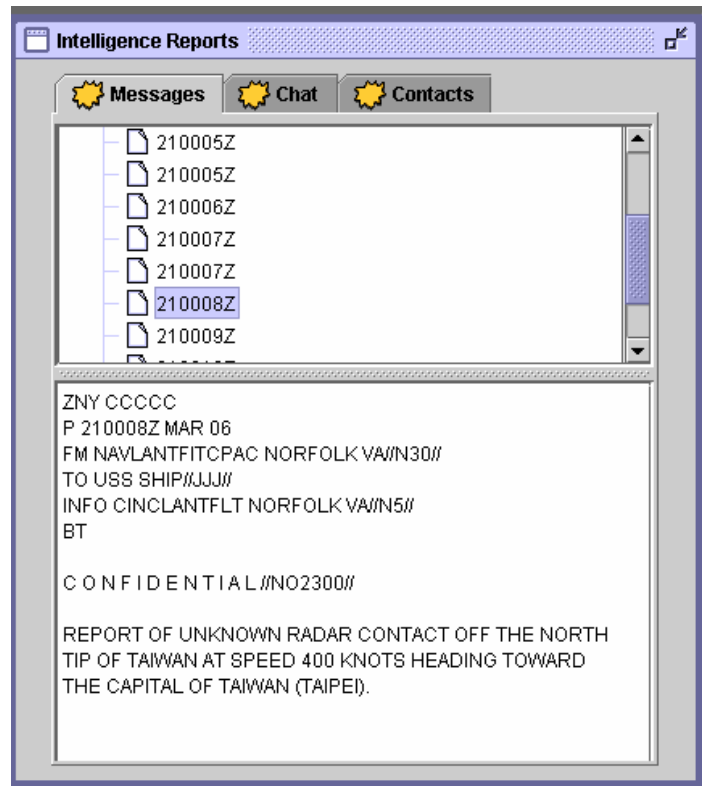


Figure 7. Message Traffic Generator

The purpose of the message traffic generation within the thesis scope is strictly confined to demonstration of the established scenario in the thesis simulation. In future work, AI should be utilized to generate messages as deemed necessary by user's actions. Messages in this simulation however, are messages that are pre-written and will emerge within the simulation at pre-determined time increments. For example, at time  $x$ , message 02 will appear; at time  $x + 1$ , message 03 will; appear and so forth.

#### D. IMPLEMENTATION

This section will describe briefly the structure of classes involved in the demonstration of this thesis.

##### 1. Selected Classes and Methods

The simulation uses the following classes and methods and a concise summary of each is shown:

Settings class. This class is the initial display which allows the user to choose various options available to determine the variables involved in the classes listed below to run the simulation. For example, time of day, area of operation, and intensity of the scenario.

Start class. This class runs the GUI to get instructor inputs that determine what happens within each time dependent portion of the simulation. Within the GUI there is the chart of the area of operation (in this case Strait of Taiwan), controls that stop and start the simulation, and the display that allows the user to scroll through message traffic available to him/her at various times throughout the demonstration. See Figure 5.

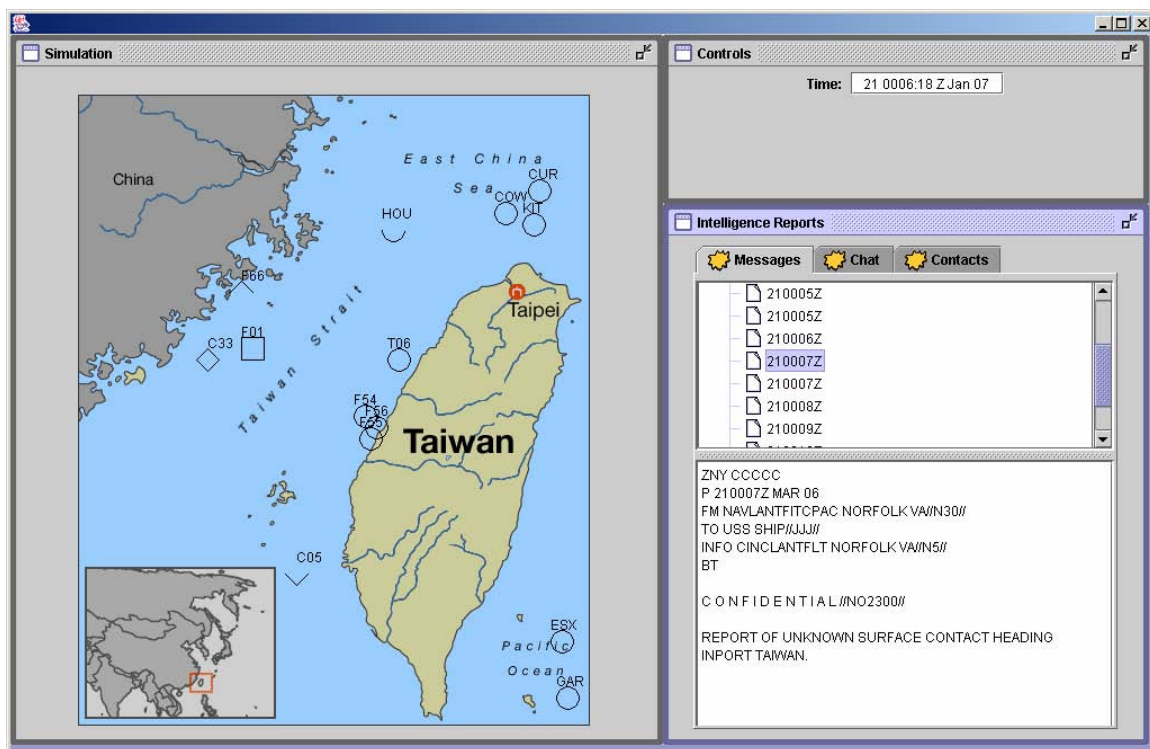


Figure 8. Screen Shot of simulation

Coordinate class. This class was written to assist in icon placement and movement throughout the 2D environment on the chart. Movement is dependent on the speed of the icon (i.e. ship, aircraft, or static shore facility) which is shown by the speed vector in the direction of movement.

MessageTree class. This class provides the message generation and message distribution of the simulation.

SimElement class. This class is an abstract class which has methods and functions that are similar to all aircraft, surface vessels, and submarines. (i.e., speed, quantity, location). Classes that implement this interface are those written to control each subclass such as AircraftElement, ShipElement, and so forth. This class was written in order to ease the complication of creating a list of objects and allowing easy movement of each regardless of the entity.

THIS PAGE INTENTIONALLY LEFT BLANK



## **V. TEST SCENARIO**

### **A. INTRODUCTION**

This chapter will provide a brief summary of the history and politics behind the chosen scenario of the Strait of Taiwan is given. Additionally, this chapter will summarize the initial system demonstration setup and parameters involved in the pilot experiment that was conducted in order to demonstrate the importance of exploiting AI technology in military training systems.

#### **1. Background Information on Scenario**

Since the presidential elections of March 2000, the world's attention is once again focused on Taiwan. There has been an ongoing and increasing concern over the island's security, in particular, whether not China will use force against Taiwan and of course, whether or not the U.S. will intervene to help defend the small island of Taiwan.

The rapid rise of the Peoples Republic of China (PRC) as a regional political and economic power with global aspirations is one of the principle elements of the emergence of East Asia. As a result of China's military expansion and the expressed political desires of the concept of "one-China", the focus of the PRC is clearly the prevention of Taiwan independence. (Studeman98) Independence has not been declared by Taiwan, but despite negotiations that been ongoing between both parties, Taiwan has made it known to the world that they will never settle on Beijing's current terms.

The likelihood of a conflict with China as a consequence of force against Taiwan is a realistic possibility. Therefore, a scenario based on this exact conflict involving the prospect of U.S. intervention with variables that would play influential roles in decision making is ideal for this investigation of AI.

### **B. INITIAL SYSTEM DEMONSTRATION SETUP AND PARAMETERS**

The generation of the scenario depends upon the selections made in the initial set up process which is conducted by the instructor in this experiment. Once the selections have been made the instructor is responsible monitoring the simulation and providing the keyboard inputs that will drive the AI of the system. The instructor's involvement will be discussed later in this chapter in detail.

## 1. Scenario Generation

As discussed in Chapter IV, the scenario chosen for this experiment is the potential threat of conflict with China if a hostile situation develops between China and Taiwan. The territory directly involved within the scenario will be the body of water called the Strait of Taiwan, as shown in Figure 9.

The graphical user interface provided by this simulation starts off with the user choosing what region of the world they would like to operate in. The setup lists other areas of the world; however, only the Strait of Taiwan will be active in this thesis. In conjunction with selecting the region of interest there will be other options as discussed in chapter IV, such as, time of day, and intensity level. All of these selections shown in the setup will display various options, but again, only the selection needed for the scenario will be active. This will allow for future implementation and provide the illusion of a complete training system.



Figure 9. Taiwan Strait (From: <http://www.fsmitha.com>)

The scenario was conducted in two versions depending on the stage of the experiment. The first version was the fixed response version; in other words, no AI involved and actions of the enemy will be simulated in pre-determined time increments. A story board, shown in Table 1, was created that illustrates the complete scenario in a table format that lists the time, event, expected action, and the contingent action of the simulation. Again, this version will be time driven and will have no independent reactions other than what is scripted.

<b>Time in (HH:MM)</b>	<b>Event</b>	<b>Expected Action</b>	<b>Contingent Action</b>
00:00	Commence Transit		
00:01	News Input	News reports that Taiwan abandons “one-China” principle but does not declare independence. China removes rights for US port calls.	Instructor make note of reaction.
00:02	Report of Snoop Tray-2 radar from EP-3 on patrol over Strait at location south of Taiwan	Match radar to platform (Kilo) Ask for HUMINT, SIGINT, and imagery operators for any information on Chinese Kilos.	Instructor make note.
00:03		Recommend vectoring P-3 supporting ESG transit to Kilo position for localization	Kilo will be located within its normal range at T +01:00
00:04		Watchstander should recognize that Chinese Kilos carry shoulder launched SAM’s with range of X NM and inform watch captain. Watchstander should recommend to watch captain that P-3 maintain safe standoff distance via USWC.	Receive report that Snoop Tray-2 Ceases Emitting and receive report of Chinese submarine exercise ongoing.
00:05	Report of local Taiwanese fishing vessels being harassed off coast of Taiwan by Chinese frigates	Watchstander should be constantly monitoring all contacts on display. If unknown contacts, should be contacting other ships near contact’s location for contact information.	Instructor make note.
00:06		Watchstander should locate Chinese frigates on display; if not, trying to correlate with contacts on display by contacting other units in area for their INTEL.	Chinese Frigate will be shown changing course in opposite direction and becoming a non threat.
00:07	Unknown surface contact heading import.	Watchstander should be interested in surface contact and identification.	P-3 will report that it is a Commercial Tanker heading in port. (will longer be an issue)

Time in (HH:MM)	Event	Expected Action	Contingent Action
00:08	Unknown radar contact off the North tip of Taiwan at speed of X knots heading toward the capital of Taiwan (Taipei).	Watchstander should have noticed the unknown contact was an aircraft from speed and already made attempt to identify through means available to him/her.	CG will report that it shows IFF of a Chinese J-6 and they are conducting a query.
00:09		Watchstander should report weapons capability of J-6 and recommend to watch captain to label contact as hostile.	CG will report that query of aircraft was ignored and they are heading in direction of CG off north coast of Taiwan.
		Watchstander should recommend diverting CAP in direction of aircraft for a visual and request of intentions and change of course.	Instructor make note.
00:10			J-6 will continue to get closer to CG and emits fire control radar.
00:10	Scenario Ends.		

Table 1. Story board for scripted version

The second version is supported by AI and the simulation will progress with the keyboard inputs of the instructor dependent on the response of the user. Similar to the fixed-version, there is a story board, shown in Table 2; however, the story board involved with the AI version tells the instructor with what key to push (1, 2, or 3) during certain time blocks in response to the user's actions. The total time for the AI version will be the same as the fixed-version, 10 minutes.

Time in (HH:MM)	Event	Expected Action	Key	Contingent Action
00:00	Commence Transit			
00:01	News input	News reports that Taiwan abandon's "one-China" principle but does not declare independence. China removes rights for US port calls.	1	If threat to level of transit is noted, scenario will continue as normal. (Note for instructor)

Time in (HH:MM)	Event	Expected Action	Key	Contingent Action
			2	Instructor dependent: Moderate Level of preferences.
			3	If this is not noted by the watchstanders as an increased threat level of transit, then scenario should become more difficult. (Note for instructor)
00:02	Report of Snoop Tray-2 Radar from EP-3 on patrol over Strait at location south of Taiwan	Match radar to platform (Kilo). Ask for HUMINT, SIGINT, and imagery operators for any information on Chinese Kilos.		
00:03		Recommend vectoring P-3 supporting ESG transit to Kilo position for localization	1	If instant reaction is: P-3 is vectored, Kilo will be located within its normal range at T +01:00
			2	Kilo will be located at T +02:00.
			3	If P-3 is not vectored, Kilo will disappear from radar and location will be unknown leaving ESG vulnerable.
00:04		Watchstander should recognize that Chinese Kilos carry shoulder launched SAM's with range of X NM and inform watch captain. Watchstander should recommend to watch captain that P-3 maintain safe standoff distance via USWC.	1	If so, receive report that Snoop Tray-2 ceases emitting and receive report of Chinese submarine exercise ongoing.
			2	Receive report that Chinese submarine exercise ceased and has intended movement towards ESG.
			3	If not, P-3 might be engaged by shoulder launched SAM and receive HUMINT relay report of Kilo-366 being loaded with torpedoes 6 days ago before departing homeport.
00:05	Report of local Taiwanese fishing vessels being harassed off coast of Taiwan by Chinese frigates	Watchstander should be constantly monitoring all contacts on display. If unknown contacts, should be contacting other ships near contact for contact information.	1	If this happens, Chinese frigate will be shown changing course in opposite direction and becoming a non threat.

Time in (HH:MM)	Event	Expected Action	Key	Contingent Action
			2	Continued harassment of fishing vessel will lead to bridge-to-bridge transmission of SOS. And frigate will cease harassment.
		Watchstander should locate Chinese frigates on display, if not, trying to correlate with contacts on display by contacting other units in area for their INTEL.	3	If this does not happen, Chinese frigate will continue to harass and Taiwanese response will elevate and could lead to shots fired toward fishing vessel.
00:06	Unknown Surface contact heading import.	Watchstander should be interested in surface contact and identification.	1	If user asks about the unknown surface contact, P-3 will report that it is a commercial tanker heading in port. (will no longer be an issue)
			2	Message that Intel received on certain shipping vessels carrying biological agents onboard and to keep look out.
			3	If not, receive report of mobilization of PLA in preparation for attack of Taiwan.
00:07	Unknown radar contact off the North tip of Taiwan at speed of X knots heading toward the capital of Taiwan (Taipei).	Watchstander should have noticed the unknown contact was an aircraft from speed and already made attempt to identify through means available to him/her.	1	If so, CG will report that it shows IFF of a Chinese J-6 and query in progress.
			2	If noticed and did nothing to find out, CG will report that query being conducted and response ongoing.
			3	If not, CG will report that query of aircraft was ignored and they are heading in direction of CG off north coast of Taiwan.
		Watchstander should report weapons capability of J-6 and recommend to the watch captain to label contact as hostile.	1	CG will report query successful and J-6 changing course.
			2	CG will conduct a 2 <sup>nd</sup> Query and warn J-6 that they will shoot to kill.
			3	J-6 will ignore query and continue heading towards CG.

<b>Time in (HH: MM)</b>	<b>Event</b>	<b>Expected Action</b>	<b>Key</b>	<b>Contingent Action</b>
		Watchstander should recommend diverting CAP in direction of aircraft for a visual and request of intentions and change of course.	1	If so, J-6 will change directions and head back in the opposite direction.
			2	If suggest something else, J-6 will come within 10 nm and turn around. CG will report this.
			3	If not, J-6 will continue to get closer to CG and emits fire control radar.
00:10	Scenario Ends.			

Table 2. Story board for AI version

THIS PAGE INTENTIONALLY LEFT BLANK



## **VI. EXPERIMENT**

### **A. EXPERIMENTAL SETUP TO VALIDATE THE USE OF THE SYSTEM**

This chapter will describe the experimental design and subjects used to conduct the experiment.

#### **1. Subjects Used to Conduct Experiment**

The experiment was conducted using students qualified in Naval Surface Warfare from the Naval Postgraduate School in Monterey, California. It is essential that the subjects have the basic knowledge and understanding of how the Global Command and Control (GCCS) display functions, experience in dealing with contacts of various entities and the threat of proximity in international waters, as well as rules of engagement (ROE) in a potential combat zone.

This experience comes from standing watch while underway onboard a combat capable ship and obtaining either the Combat Information Center Watch Officer (CICWO) or Tactical Actions Officer (TAO) qualification. The requirement for the qualification in Surface Warfare for this experiment fulfills the basic knowledge constraint, because CICWO is a prerequisite to be Surface Warfare qualified.

#### **2. Experimental Setup**

The experiments were conducted at the Naval Postgraduate School in which student volunteers, qualified in Surface Warfare, were used to determine which of the two systems used in this experiment were superior. First, the subjects were informed that the training simulation was a simple reconstruction of a current system used at FTCPAC that included the basic functionalities and are limited to one scenario each for experimental purposes. Additionally, they were instructed in how to conduct various tasks within the GUI and what they were expected to accomplish within the training simulation.

The experiment was conducted in two groups: 1) control group and 2) experimental group. The control group was made up of subjects who operated the fixed-version training simulation and the experimental group subjects were operating the AI-

version training simulation. Subjects were randomly assigned to the two groups by choosing every other one based on their arrival time.

Control group: conducted a total of three simulation runs of the fixed-version simulation.

Experimental group: conducted a total of three simulation runs of the AI-version simulation.

At the end of the test runs, there was a face-to-face debrief, which included a questionnaire for each group that was used afterward for comparison analysis. The questionnaire addressed questions for each event of the simulation, separately, in order to determine how many predictions a subject anticipated for the enemy's reactions within that particular event. (See Appendix A for the questionnaire developed for this experiment)

### **3. Experimental Design**

The purpose of this experiment is to demonstrate the importance of applying AI technology to current training simulations. The system being enhanced currently uses scripted events that carry out enemy actions independent of the user's inputs/reactions. This is extremely detrimental to overall training because it does not take into account the variability of the real world. After the first run of a particular scenario, every run thereafter is one-hundred percent predictable because the enemy will perform the same actions every time. In other words, the subject is expected to predict only one enemy response per event with the scripted version. Ironically, the current system does produce overall performance improvement between scenario runs; however, this is only because the user knows exactly what is going to happen.

The use of AI technology not only will keep the user engaged, but enhance overall combat readiness (Boldo87). This is of course important to any military branch, for the threats in the world today are much different than those a generation prior. The military today is dealing with threats that are non-conventional and unpredictable in a sense that we are operating in environments that are not familiar (e.g., urban warfare or religious persecution).

The subjects were not told what system they will be assigned to, only that they are either in system A or system B. A scripted format of steps to be taken was strictly followed in order to ensure consistency throughout the experiment. (See Appendix B)

The variable to be analyzed was the number of predictions for the enemy's response within each event, indicated by the user in the questionnaire.

The hypothesis of the experiment is: Adding AI to a training simulation causes the subject to consider more possible enemy responses per event throughout multiple runs of the simulation.

## B. ANALYSIS

Data obtained from this experiment is the number of enemy response predictions per event. Each subject answered a questionnaire which lists each event separately requiring a number that describes how many of the enemy's responses they anticipated during that event given the history of the last three runs of the simulation. In other words, if the subject ran a fourth experiment, what they would expect to be the enemy's response based off of what had happened in the last three simulation runs.

The control group responded as expected given the exact same scenario three times in a row. Because the enemy responded the same all three runs, they anticipated that the fourth run would be the same. The results are shown in Table 3.

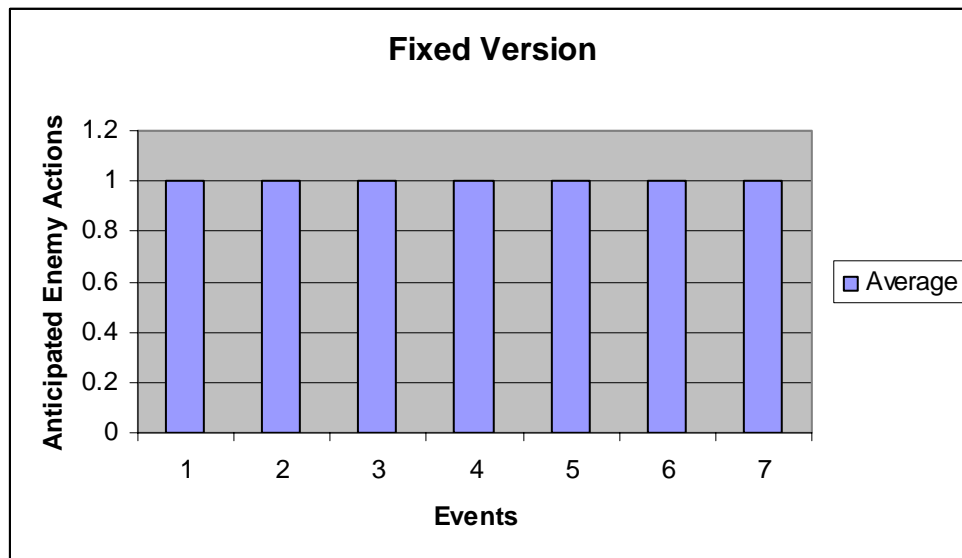


Table 3. Distribution of Average Number of Anticipated Responses for Control Group

### C. RESULTS OF EXPERIMENT

Is hypothesis correct? Adding AI to a training simulation caused the subject(s) to consider more possible enemy responses per event on the final “Test” run (See Tables 4, 5, 6).

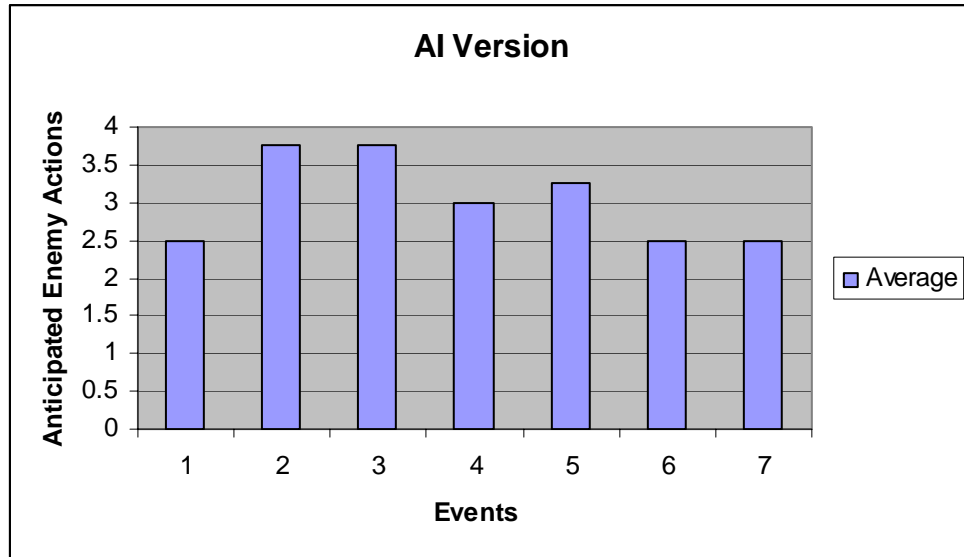


Table 4. Distribution of Average Number of Anticipated Responses for Experimental Group

Event	Fixed Version Average Number of anticipated Enemy response(s)	AI version Average Number of anticipated Enemy response(s)
Event 1	1.0	2.5
Event 2	1.0	3.75
Event 3	1.0	3.75
Event 4	1.0	3
Event 5	1.0	3.25
Event 6	1.0	2.5
Event 7	1.0	2.5

Table 5. Table of Data Obtained from Experiment

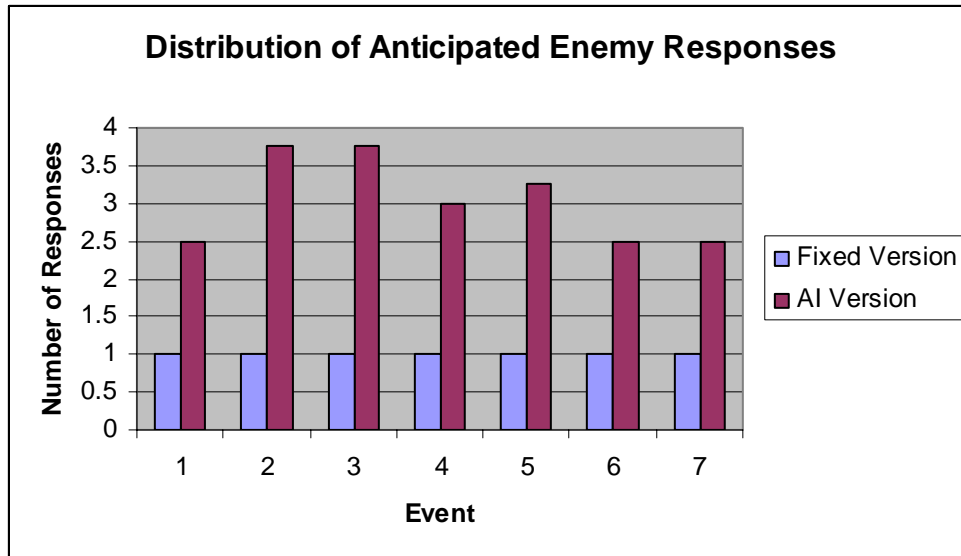


Table 6. Distribution of Anticipated Enemy Responses, Displaying Control Group vs. Experimental Group

However, while we did not perform a statistical test, the data makes clear that the null hypothesis (that the responses of control and experimental groups are from the same distribution) must be rejected, since there is almost no overlap between the two response sets. The control group uniformly responded with “1” for the number of possible enemy responses. In the experimental group, only one individual in one instance gave the response “1”. See complete data from the experiment in Appendix C.

### 1. Analysis of Results

Common sense tells us that the results of conducting an experiment with this setup will result in more predictions of anticipated enemy responses in the AI version versus the fixed version training system. However, this is dependent on the setup and consistency in which the experiment is presented to the subjects.

This approach to enhancing legacy military training systems by incorporating AI into the already existing system is very simple and will ensure that the subjects are being presented with an environment that is more realistic.

When subjects use a training tool whose objective is to increase combat readiness, how combat ready is a person whose only reference to combat is a training tool that is one hundred percent predictable?

## **2. Control Group**

All subjects who were in the control group realized that the enemy responses were fixed during the second run of the simulation. Of the four subjects who conducted the controlled experiment, the first three verbally noted that “*the enemy did the same thing last time*”, when the third event occurred in the second simulation run. While the fourth subject realized the enemy had the same reaction during the fourth event of the second simulation run. Upon realizing that the enemy’s actions were going to be the same regardless of what they did, the subjects were not as observant as in the beginning and all pursued some sort of conversation outside the area of the experiment.

Results of the control group confirmed the complacency assumption of scripted events. Basic human nature applied and subjects were not as observant of the scenario and its components when they came to understand that they did not control or effect the enemy’s reactions.

## **3. Experimental Group**

Contrary to the control group, the subjects in the experimental group understood that their actions (verbally) decided the actions of the enemy. Two subjects noted that the key strokes made during each event made them believe that their responses were being addressed and that the enemy was reacting because of the key strokes. Whether or not this was the case, the key strokes played a essential role in keeping the subjects observant during the simulation runs.

During the second run of the simulation all subjects understood that the enemy was reacting differently than the first simulation run. This was mainly due to the fact that during the first simulation run, every subject had a high intensity reaction from the enemy. This increased intensity level was set because each subject was getting use to the controls and functionality of the simulation during the first run and most tended not to be as verbal as needed by the experiment. Once each subject was settled into their own routine the second and third run went more smoothly with less and less intense reactions from the enemy.

#### **4. Other Results**

Overall the simulation runs of each group went smoothly and as perceived. However, one subject did not understand what was needed from him in the debrief questionnaire and because too much information was given to him, the answers received by this subject had to be thrown out.

THIS PAGE INTENTIONALLY LEFT BLANK



## **VII. SUMMARY, CONCLUSIONS, AND FUTURE WORK**

### **A. SUMMARY**

In the real-world, the enemy will not always react in the same way when presented with an identical situation or environment. So why should we be training our military personnel on a system that uses this antiquated approach.

Similar to the ‘Choose your own adventure’ books, a series of children’s books first published by Bantam Books from 1979 to 1998, the framework of this system requires numerous potential responses in the database. This will ensure that the user’s actions will result in a different enemy action each time the simulation is played at least more than four runs consecutively. The number of available enemy responses will be dependent on the system design and intention of training.

In a paper written by Francis Kapper in 1981, he summarizes proper use of military simulations and the potential level of validity achievable by those simulations: “The most appropriate and valid objectives for using war games and simulations within the DoD context are to: better understand complex phenomena, identify problems, evaluate alternatives, gain new insights, and broaden one’s perspectives” (Kapp81). The variability of the enemy’s responses to the user’s actions was accomplished with a very simple technique allowing the enemy to have more than one response. The three to four responses available to choose from dependent on the users actions was enough to ensure the subject was engaged and maintained continuous observation of his/her simulation environment. As mentioned earlier, scripted game-based environments tend to lose the attention of users once they realize no matter what they do, the enemy will always react the same.

### **B. CONCLUSIONS**

In recent years there has been a dramatic interest in developing simulations and virtual environments for training purposes, particularly in the military. The demands on military simulations are continually increasing, primarily motivated by fiscal necessity and secondly, due to the pressure to employ such simulations, which has led to exploration of new methods for modeling combat activities. Billions of dollars are spent

producing simulations for combat training; unfortunately, little is spent on validating the products and even fewer spent on the effects of utilizing artificial intelligence (AI) to enhance legacy military training systems.

The purpose of conducting this experiment in such a manner as described above is to demonstrate the importance of applying AI technology to current combat-related training systems, despite the simplicity of the AI. This work demonstrates that simple AI is better than no AI.

Again, most legacy combat-related training tools use scripted events that carry out enemy actions dependent of the user's inputs/actions. This is extremely detrimental to overall training because it does not take into account the variability of the real world. After the first run of a particular scenario in a scripted system, every run thereafter is one-hundred percent predictable because the enemy will react the same way every time. In other words, the subject is expected to predict only one enemy response per event with the scripted version. Ironically, these systems will produce overall, performance growth; however, this is only because the user knows exactly what the enemy will do.

### **C. FUTURE WORK**

A recommended extension of the experiment would be to execute a total of four, simulation runs with subjects in both the control and experimental group. The fourth simulation run would be carried out with a completely different scenario utilizing AI for both groups. The reaction time of each user could be recorded to determine performance levels based on the experience obtained during the first three runs within their own group. This could establish the application of AI in determining the efficiency of training when presented with a completely new scenario.

Further research and development of techniques in application of AI in combat training tools is highly encouraged, for the reason that it can greatly contribute to the combat fighting proficiency of our future Sailors. In particular, in order create a more useful training tool for military intelligence team trainers; AI for chat capabilities with other entities in the Battle Group should be developed.

## APPENDIX A. DEBRIEF QUESTIONNAIRE

This handout was used in order to obtain the data needed for the thesis hypothesis. The subject was told to answer the questions with respect to only the simulation and their experience with the three simulation runs. In other words, if the subject ran a fourth experiment, what they would expect to be the enemy's response based off of what had happened in the last three simulation runs.



Patricia A. Sweat  
MOVES  
Watkins Hall  
Naval Postgraduate School  
Monterey, California 93943

831-583-0988  
541-771-2782  
pasweat@nps.edu

### DEBRIEF QUESTIONNAIRE

**First Event:** (Report of Snoop Tray-2 Radar from EP-3 on patrol over Strait at location south of Taiwan)

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Once P-3 vectored, Kilo located instantly
- ☐ Kilo's exact location could not be determined.
- ☐ Kilo not located and datum disappears from radar, leaving BG and ESG vulnerable.
- ☐ List other reactions:: \_\_\_\_\_

**Second Event:** (Chinese Kilo threat determination)

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Receive report of Chinese submarine exercises ongoing.

- ☐ Receive report of Chinese submarine intended movement towards area of Battle group or ESG.
- ☐ P-3 might be engaged by shoulder launched SAM
- ☐ Receive report of Kilo-366 being loaded with torpedoes prior to departing homeport.
- ☐ List other reactions: \_\_\_\_\_

**Third Event:** (Report of Local Taiwanese Fishing vessels being harassed off coast of Taiwan from Chinese Frigates)

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Chinese Frigate change course and stop harassment.
- ☐ Continued harassment from Chinese.
- ☐ Call for help from fishing vessels over Bridge-to-Bridge.
- ☐ Continued harassment of fishing vessels lead to elevation to Taiwanese response.
- ☐ List other reactions: \_\_\_\_\_

**Fourth Event:** (Unknown Surface contact heading import)

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Identified as Chinese Naval Vessels.
- ☐ Receive report that it's a commercial shipping vessel.
- ☐ Receive report of commercial vessels carrying biological agents onboard.
- ☐ No response from surface vessel leading to concern of threat to Taiwan.
- ☐ List other reactions: \_\_\_\_\_

**Fifth Event:** (Unknown radar contact off the North Tip of Taiwan at speed of X knots heading toward the capital of Taiwan – Taipei).

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Report of IFF and contact identified.
- ☐ Report that contact Chinese aircraft and query in progress.
- ☐ Report that query is in progress with contact and no response.
- ☐ Air contact heading towards ESG.
- ☐ List other reactions: \_\_\_\_\_

**Sixth Event:** (Query of Air contact in progress)

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Report that query successful and aircraft changing course.
- ☐ Report first query successful however, aircraft not changing course and second query ongoing questioning intentions.
- ☐ Report that queries ignored and preparing for Battle Stations.
- ☐ List other reactions: \_\_\_\_\_

**Seventh Event:** (Air craft movement in progress)

How many reactions of the enemy did you anticipate given the current situation?

- ☐ Aircraft will change course and head in opposite direction.
- ☐ Aircraft will continue on course towards Battle Group getting close enough to upset, but turn around in time not to be shot at.
- ☐ Aircraft will continue on course towards Battle Group and emits fire control radar.

☐ List other reactions: \_\_\_\_\_

During any time in the experiment did you believe that there was a sense of variability with the enemy's actions? (i.e. did the enemy react in response to your actions, or did the enemy react regardless of what you chose to do or say). Briefly explain your answer.

☐ Yes

☐ No

Any comments or recommendations.

---

---

---

**Thank you for your time, have a great day!**

## **APPENDIX B. EXPERIMENTAL PROCEDURE**

Note: The quoted paragraphs are what was said verbatim in order to maintain consistency throughout the experiment.

“I will be reading from a script in order to maintain consistency among the participants and to ensure that no detail is left out which might be devastating to the overall results of this experiment.”

1. Subject will walk in and sit down.
  - a. Subject will be given the Participant Consent Form and Minimal Risk Statement for signature

“First, I will be giving you a Participant Consent Form & Minimal Risk Statement for signature and for IRB and my records. The purpose of this experimental study will be used to improve the use of advanced techniques to enhance future military training simulations. Certain details will be left out in order not to affect the experiment, however, please feel free to ask after the experiment is completed. There will be three phases in this experiment: 1) this 5 minute brief which will be used to familiarize you with the training system 2) training and execution phases lasting approximately 5 minutes per simulation, during which you will be expected to accomplish a number of tasks related to identifying, interpreting data, and making recommendations based on data collected, and 3) 5 minute debrief which will consist of a questionnaire.”

Second, I need to ensure that you understand that this project does not involve any reasonably foreseeable risks or hazards greater than those encountered in everyday life.

Additionally, I must tell you that all recodes of this study will be kept confidential and that your privacy will be safeguarded. No information will be publicly accessible which could identify you as a participant, and you will be identified only as a code number on all research forms.

All records of your participation will be maintained by NPS for five years, after which they will be destroyed. Your participation is strictly voluntary, and if you agree to participate, you are free to withdraw at any time without prejudice.”

- b. Subject will sign consent form.
- 2. Subject will be briefed on what the current trainer at FITCPAC accomplishes.
  - a. Trainer for Carrier BG Intelligence cells.
  - b. Assists FITCPAC instructors in analysis of individual interpretations of intelligence information.
- 3. Subject will be introduced to the functionality of the simulation provided by the GUI.
  - a. Subject will be given visual aid document with useful symbology for reference through out the simulation runs.
  - b. What each symbol represents (i.e. aircraft, surface, sub-surface, unknown, friendly, hostile).

(Symbology Sheet) – “This sheet should be used as a reference for understanding the symbology used in this experiment. These symbols are similar to those seen in a Combat Information Center on ACDS screen and/or on GCCS screen. Feel free to refer to this sheet throughout the experiment.”

- c. How to use the message traffic box

(Screen Shot Sheet) – “This is a screen shot of what the simulation will look like during the experiment. The tabbed marked ‘Messages’ will be where you check messages that are generated that contain reports from various Intelligence sources. In order to read the content of the messages you need to click once on each line item that shows up at specific times throughout the simulation.

It’s important to constantly check if new messages have arrived. Messages contain information on correlation of contacts and intelligence that will help you decided what to do next.”

- d. How to identify various entities on the chart provided by the GUI, (i.e. the GCCS display portion)

(Screen Shot Sheet) – “This is a screen shot of what is the initial contact information. As you can see there are some contacts that are labeled ‘unknown’.



These are the contacts that you need to correlate with by reading the message traffic and analyzing the reports from the Intelligence sources.”

4. Subject will be told what is expected of them and how to accomplish the tasks; via voice or the GUI.

“During the experiment, you will be expected to verbalize your thoughts, i.e. verbalize your explanation for your decision-making. What you wondering about, what you think certain entities are or could be, and concerns with certain entities and there location in regards to the Battle Group or ESG.”

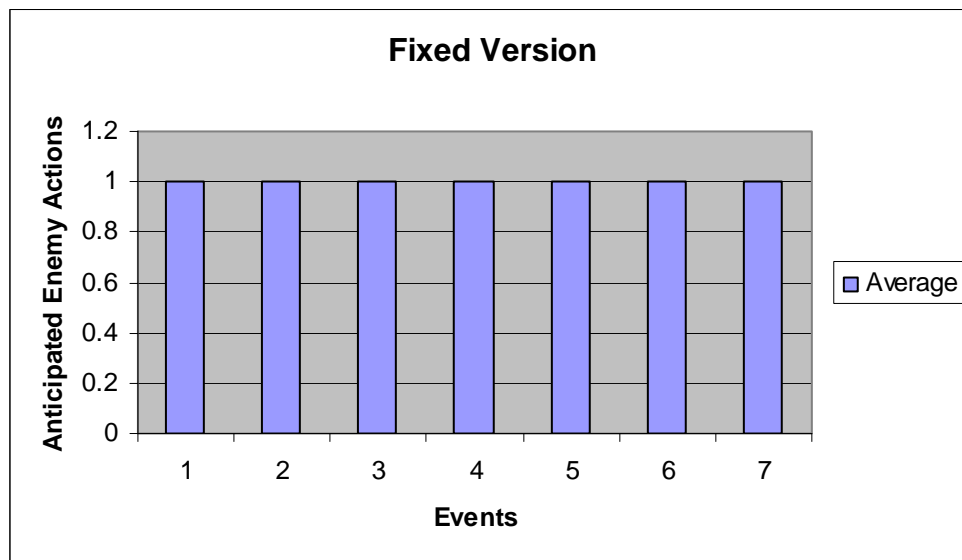
- a. Information gathering techniques (i.e. messages, voice comms)
  - b. Interpretation of data and how to make recommendations to the watch captain
  - c. How voicing opinion and recommendations is important to the progression of the simulation
5. Once subject understands the tasks involved, the simulation will start.
  - a. Subject will conduct four simulation runs overall
  - b. Each run will be approximately 5 minutes each
6. Once all runs of the simulation is over, debrief will commence.
  - a. Subject will be given questionnaire.
  - b. Explain the questionnaire to the subject and how accurate and correct answers are important to the analysis.

“When answering this questionnaire, please keep in mind that the answers should be directing related to the simulation, in other words, what the simulation provided to you as a user. When asked how many reactions of the enemy did you anticipate given the current event, the answer should be what the simulation allowed you to anticipate.”

THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX C. EXPERIMENT RESULTS FOR SCRIPTED VERSION

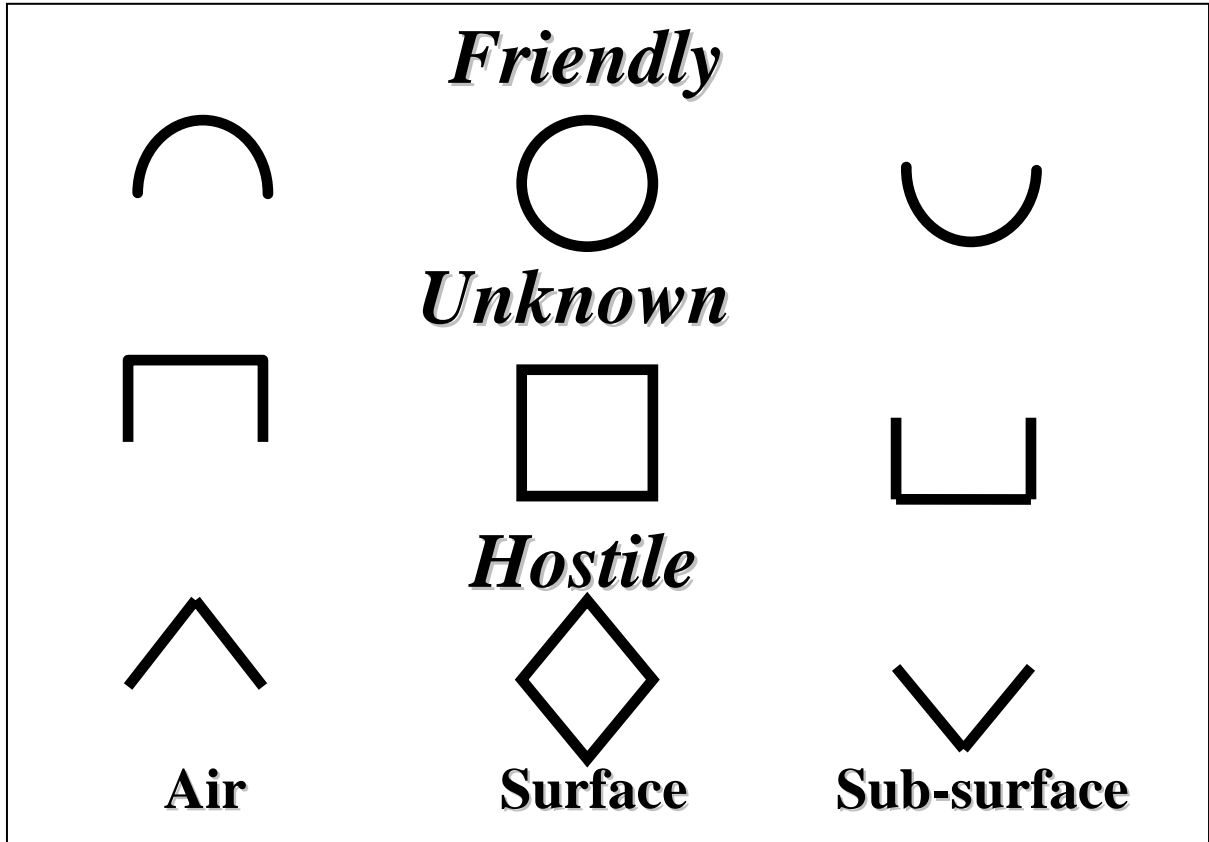
Events	1	2	3	4	5	6	7
Subject 1	1	1	1	1	1	1	1
Subject 2	1	1	1	1	1	1	1
Subject 3	1	1	1	1	1	1	1
Subject 4	1	1	1	1	1	1	1
Average	1	1	1	1	1	1	1



THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX D. CONTACT SYMBOLOGY HANDOUT

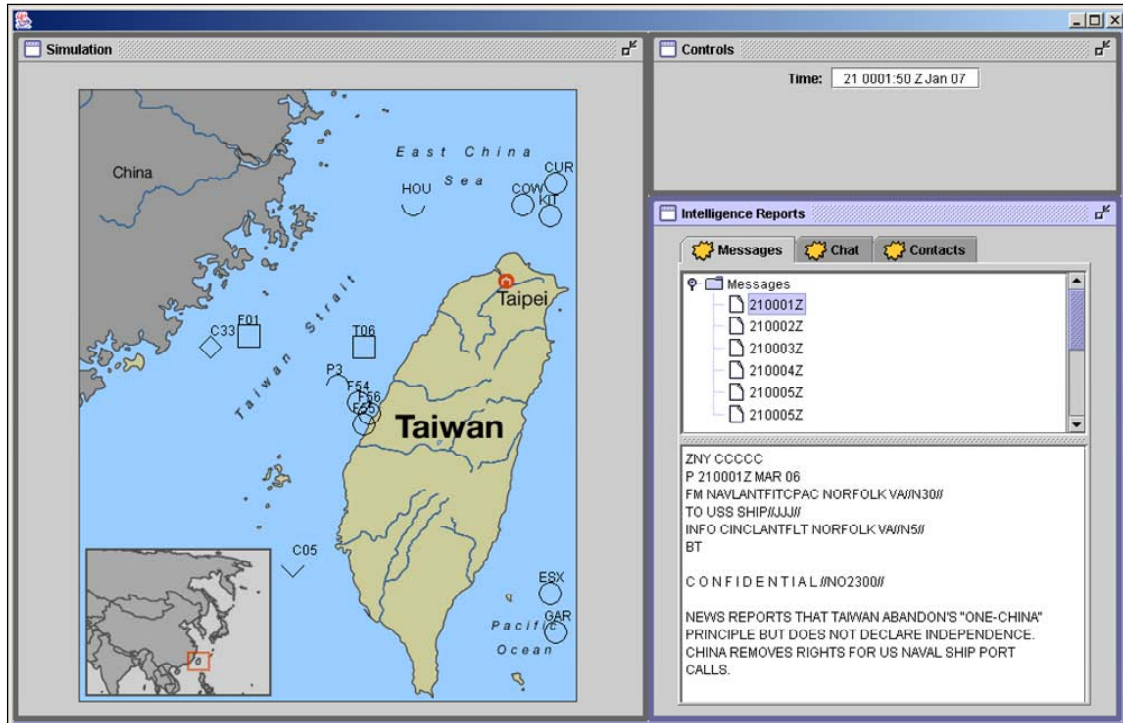
This handout was used as a reference for symbology used in the simulation. Even though all subjects were students at Naval Postgraduate School with Combat Information Center experience; certain details are forgotten after being away from the environment for a long period of time.



THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX E. SCREEN SHOT SIMULATION HANDOUT

This handout was used in order to illustrate what the simulation would look like as well as explain the functionality of the message traffic and how to access the messages' content by clicking on the icon.

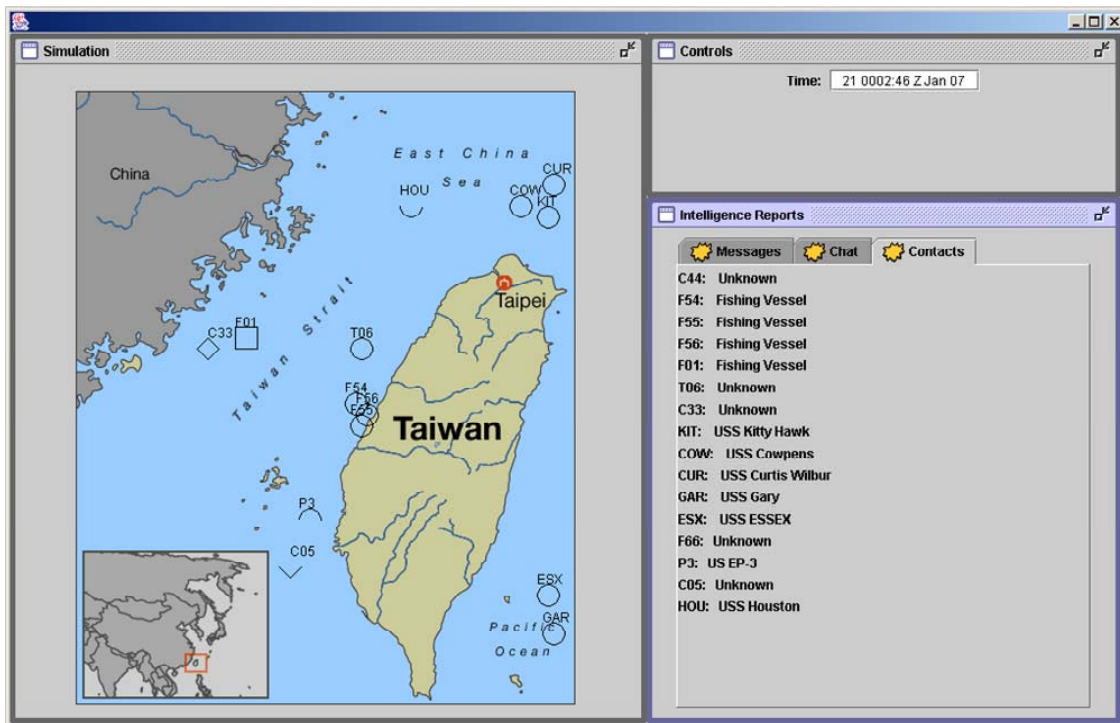


THIS PAGE INTENTIONALLY LEFT BLANK



## APPENDIX F. SCREEN SHOT MESSAGE TRAFFIC HANDOUT

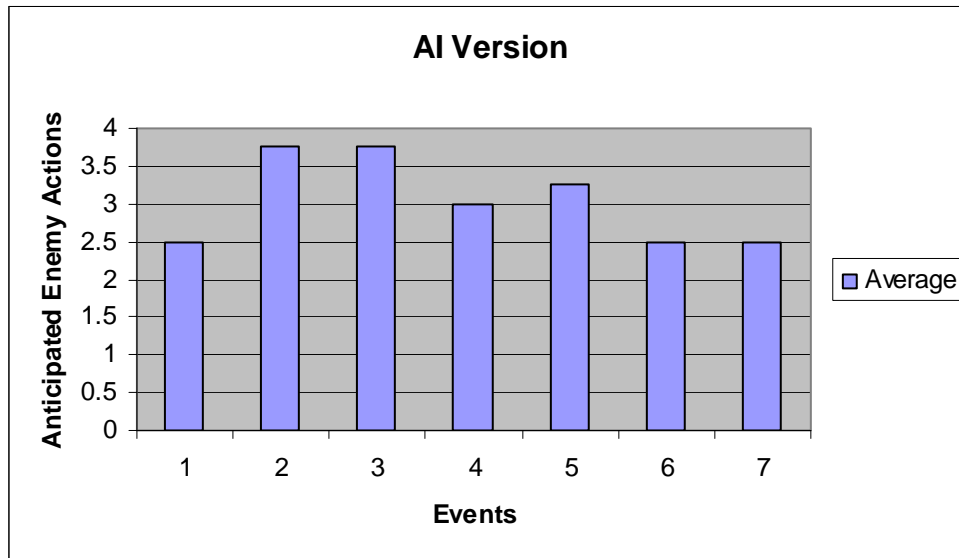
This handout was used to illustrate the initial contact identification correlated with icons shown on the chart. If for some reason the user forgot what certain contacts were, the tab marked 'Contacts' was what needed to be clicked to refresh her/his memory.



THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX G. EXPERIMENTAL RESULTS FOR SCRIPTED

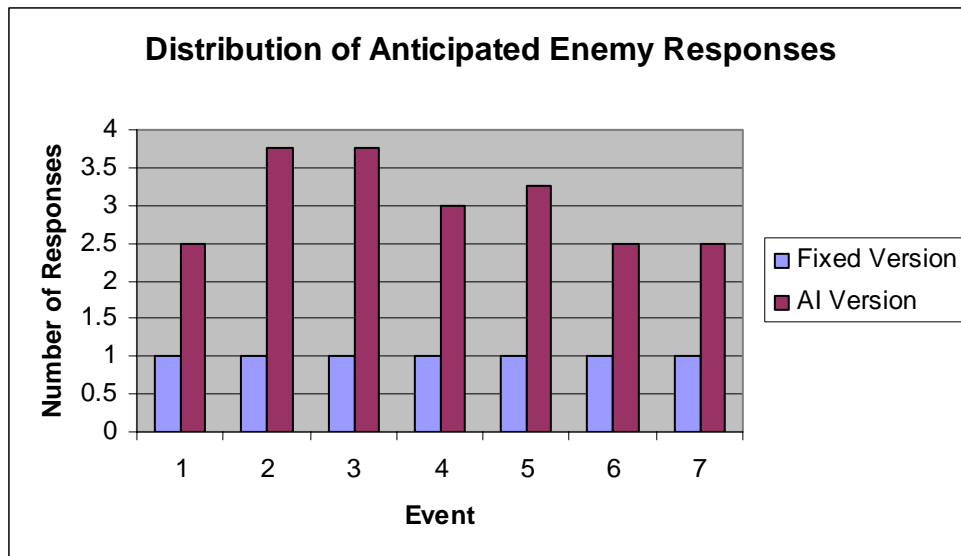
Events	1	2	3	4	5	6	7
Subject 1	3	4	4	4	4	3	3
Subject 2	1	4	4	2	2	2	2
Subject 3	3	3	3	3	4	2	2
Subject 4	3	4	4	3	3	3	3
Average	2.5	3.75	3.75	3	3.25	2.5	2.5



THIS PAGE INTENTIONALLY LEFT BLANK

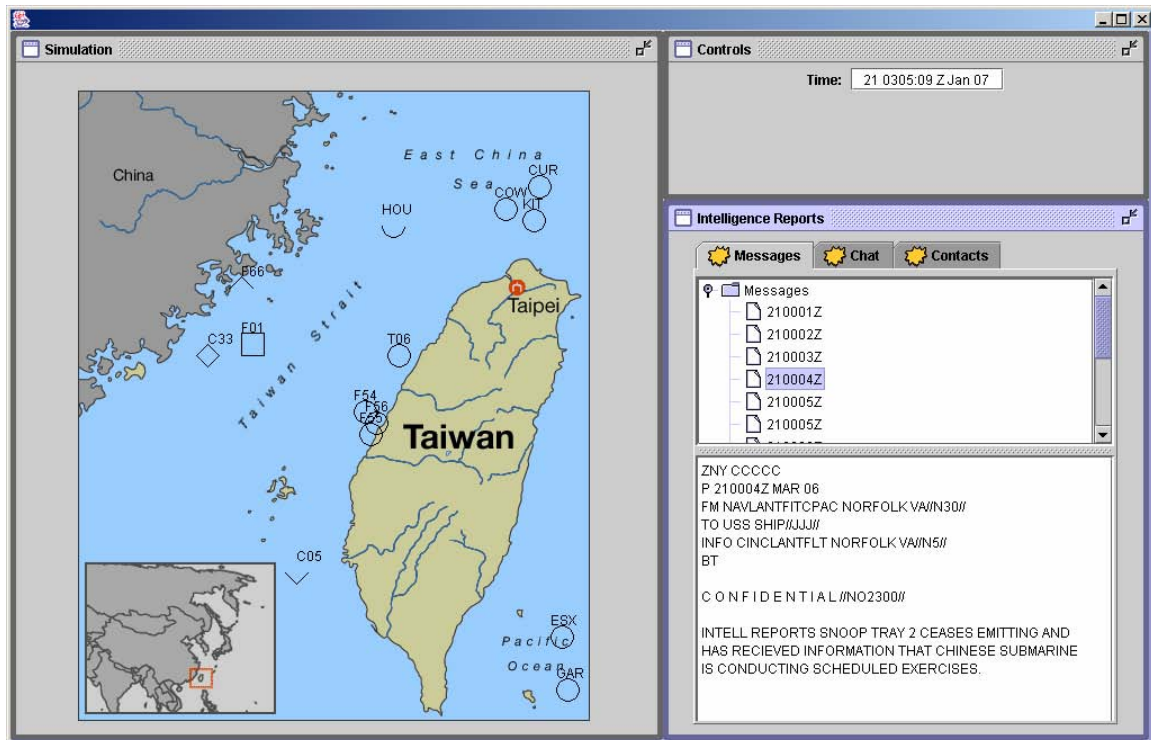
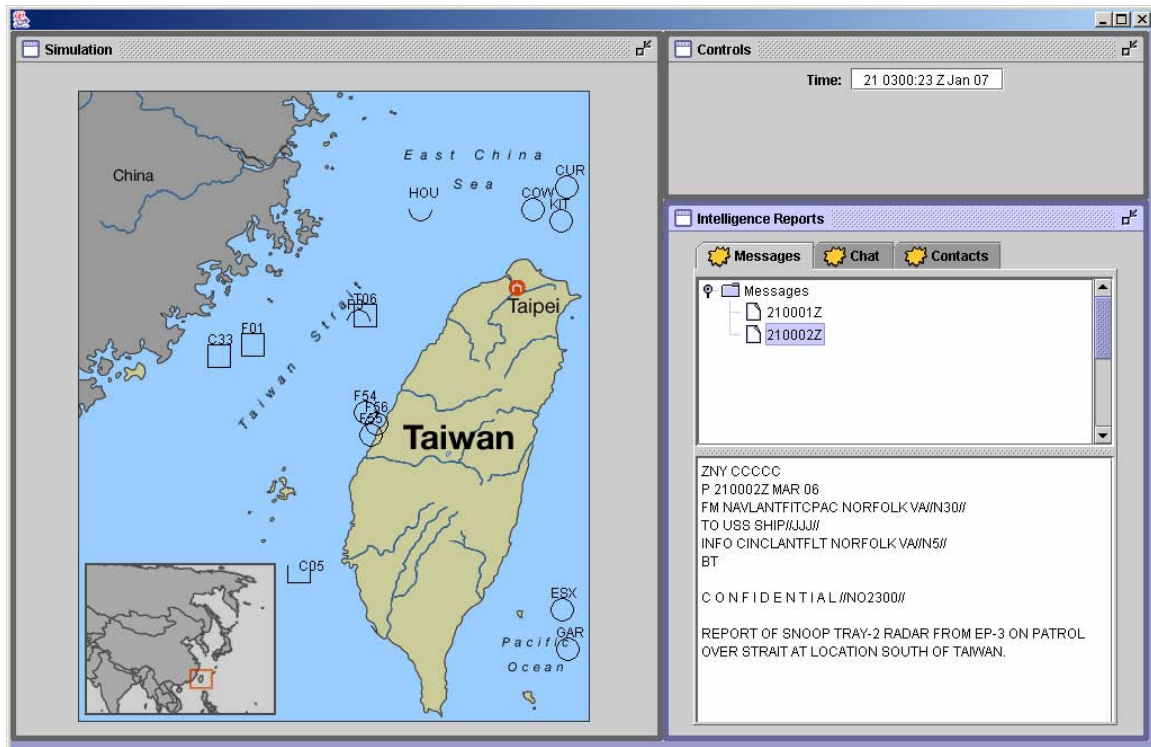
## APPENDIX H. EXPERIMENTAL RESULTS

Event	Fixed Version	AI Version
Event 1	1	2.5
Event 2	1	3.75
Event 3	1	3.75
Event 4	1	3
Event 5	1	3.25
Event 6	1	2.5
Event 7	1	2.5



THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX I. SCREEN SHOTS OF SIMULATION



THIS PAGE INTENTIONALLY LEFT BLANK



## LIST OF REFERENCES

- Boldo87      Boldovici, John, A. "Measuring Transfer in Military Settings." *Transfer of Learning: Contemporary Research and Applications*. Academic Press, 1987.
- DOD5000      DODD 5000.1. Department of Defense. Directive 5000.1.
- GCCS00      <http://www.fas.org/irp/program/disseminate/gccs.htm>, last accessed 14 July 2006
- Kapp81      Kapper, Francis, B. *Wargaming I: The Simulation of Crisis*. Arlington, VA. American Forces Information Service. Defense/81, May 1981.
- Laird00      Laird, John E. *An Exploration into Computer Games and Computer Generated Forces*. University of Michigan. 2000.
- Manslow02      Manslow, John. "Learning and Adaptation in Games." *AI Game Programming Wisdom*, 2002.
- MIDB00      <http://www.fas.org/irp/program/disseminate/midb.htm>, last accessed 14 July 2006
- NTP3(J)97      Telecommunications Users Manual. Naval Telecommunications Procedure. Washington DC, 1997.
- Scott02      Scott, Bob. "Architecting a Game AI." *AI Game Programming Wisdom*, 2002.
- Studeman98      Studeman, Michael. *Calculating China's Advances in the South China Sea, Identifying the Triggers of "Expansionism."* Master's Thesis, Naval Postgraduate School, 1998.
- Tozour02\_1      Tozour, Paul. "Introduction to Bayesian Networks and Reasoning Under Uncertainty." *AI Game Programming Wisdom*, 2002.
- Tozour02\_2      Tozour, Paul. "Building an AI Diagnostic Toolset." *AI Game Programming Wisdom*, 2002.
- Tozour03      Tozour, Paul. "A Flexible Tagging System for AI Resource Mangement." *AI Game Programming Wisdom*, 2003.
- Training04      Director, Readiness and Training Policy and Programs, "Department of Defense Training Transformation Implementation Plan," 2004.

THIS PAGE INTENTIONALLY LEFT BLANK

## **INITIAL DISTRIBUTION LIST**

1. Defense Technical Information Center  
Ft. Belvoir, Virginia
2. Dudley Knox Library  
Naval Postgraduate School  
Monterey, California
3. Commander  
Fleet Technical Support Center, Pacific (FTSCPAC)  
San Diego, California
4. Commander  
Naval Sea Systems Command  
Washington, D.C.