LIGHTWEIGHT DISASTER MANAGEMENT TRAINING AND CONTROL

THESIS PROPOSAL

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Abstract

Disaster management is increasingly a global enterprise for international organizations, governmental institutions, and arguably individuals. The tempo at which information is collected and disseminated during natural and man-made disasters paces the rate and effectiveness of relief efforts. As the Internet becomes a ubiquitous platform for sharing information, a browser-based application can provide disaster managers a lightweight solution for training and control. A heavyweight solution might include dedicated communications, real-time command and control software and hardware configurations, and dedicated personnel. In contrast, a lightweight solution requires trained personnel with Internet access to a server via computers or hand-held devices. TsunamiSim provides asynchronous situational awareness with an interactive, Geographic Information System (GIS). TsunamiSim is not capable of providing real-time situational awareness nor intended to replace or compete with heavyweight solutions developed for that purpose. Rather, TsunamiSim will enhance the disaster managers' abilities to train for and control disasters in regions where heavyweight solutions are impractical. For distributed training, TsunamiSim will provide deterministic and stochastic scenarios of historical and fictional disasters. TsunamiSim will be an open-source, Java application implemented for maintainability and extensibility. United States Pacific Command (PACOM) located at Camp Smith, Hawai'i, will enable TsunamiSim validation and assessment.

Glossary of Acronyms

AOR	Area of Responsibility defines the geographic region where commanders have the authority to plan and conduct operations.[1]
API	Application Program Interfaces provide software developers the ability to modularly integrate applications and create consistent user interfaces.
FEMA	US Federal Emergency Management Agency
HLA	High Level Architecture is a general-purpose architecture for simulation reuse and interoperability.
IBM	International Business Machines Corporation.
ICS	The University of Hawai'i at Manoa Information and Computer Sciences Department.
ISO	International Organization for Standardization
NGO	Nongovernmental Organization is a transnational organization of private citizens that maintain a consultative status with the United Nations. NGOs may be professional associations, foundations, multinational businesses, or simply groups with a common interest in humanitarian assistance activities.
PACOM	US Pacific Command headquartered at Camp Smith on the island of Oahu in Hawai'i.
UN	United Nations
US	United States
VV&A	Verification, Validation, and Accreditation is the process of insuring application software operates as designed, fulfills user requirements, and is approved for official use.

Chapter 1

Introduction

1.1 The Challenge of Disaster Management

Disasters on a continuum include small-scale events localized perhaps in a single neighborhood such as gas main breaks to cataclysmic events spanning international borders such as earthquakes. Although small disasters are relevant, often posing unique problems, they typically are locally mitigated. My research centers on large disasters nationally and internationally mitigated.

1.1.1 PACOM Customer, Asia-Pacific Focus

As an Army officer attending graduate school in Hawai'i, I am obligated to do research in an area germane to Army requirements. PACOM is not only my closest customer best capable of enabling verification, validation, and accreditation (VV&A); they have the most potential to benefit from TsunamiSim. PACOM's area of responsibility (AOR) is the largest consisting over more half of the earth's surface and nearly 60% of the world's population. The AOR consists of 43 countries, 20 territories and possessions, and ten US territories. A PACOM mission is to enhance security and promote peaceful development in the Asia-Pacific region by responding to crises. To accomplish this mission, PACOM's strategy is to stay engaged throughout the AOR in areas such as disaster management training and relief. From 1996 to 1998 alone, PACOM participated in 16 disaster relief operations in 12 countries and 1 US territory. Like PACOM, I am sensitive to the military connotation distracting from peaceful engagement efforts in areas like as disaster management. My intent is to sparingly use military terms and doctrine only where they are generally acknowledgeable outside the military, or to make analogies to undefined yet similar non-military artifacts. As a disclaimer, TsunamiSim is unclassified, and is not intended for combat training and operations.

1.1.2 Disasters Natural and Man-Made

Disasters are either caused by natural phenomena or human action. Natural disasters can be exacerbated by human error during reaction and mitigation. Examples of natural disasters internationally mitigated include earthquakes, volcano eruptions, severe droughts, floods, and indeed tsunamis. Examples of man-made disasters prompting an international response are the Chernobyl nuclear accident, large-scale oil spills like, and terrorist actions such as the embassy bombings in Nairobi and Dar es Salaam in 1998. My research and the scenarios used for analysis will focus on natural disasters. Since the protocol for mitigating man-made disasters and natural disasters are similar, this TsunamiSim could be extended for man-made disaster management. However, focusing on natural controls the scope of my thesis, and avoids security classification issues particularly in the case of terrorism.

1.1.3 Organized Disaster Management

Disaster management is a vast domain that includes treaties, laws, policies, equipment, and training implemented by the United Nations down to community civil defense organizations. Organizations can be characterized by their roles in disaster management such as policy making, types of disasters they respond to, funding sources and benefactors, information sharing, training and preparation, response personnel and equipment, damage assessment, response and recovery, and control. The following organizations represent those that potentially could employ TsunamiSim or provide invaluable input. I will provide details about relevant organizations based on TsunamiSim implementation and assessment.

1.1.3.1 International organizations

International organizations are staffed and resourced by member nations. Examples outside the Asia-Pacific are the European Union, Organization of American States, and Organization of African Unity. Primary Asia-Pacific disaster management organizations:

- United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA).
- United Nations Centre for Regional Development (UNCRD) Disaster Management Planning Hyogo Office in Japan.
- Asia Disaster Preparedness Center (ADPC) in Thailand.
- Asia Disaster Reduction Center in Japan.

1.1.3.2 Government organizations

Government organizations are staffed and resourced at the national level down to municipalities. Though government organizations respond primarily to disasters within their jurisdiction, they often provide outside assistance. The following government organizations influence international disaster management in the Asia-Pacific:

- US Agency for International Development Office of US Foreign Disaster Assistance (USAID/OFDA).
- Federal Emergency Management Agency (FEMA), US.
- Emergency Management Australia.
- Canadian Centre for Emergency Preparedness.
- Center of Excellence for Disaster Management and Humanitarian Assistance (COE DMHA) in Hawai'i.
- US Department of Health and Human Services Office of Emergency Preparedness, US.
- Military active, reserve, and national guard components.
- Fire departments.
- Police departments.
- Civil defense.

1.1.3.3 Nongovernmental Organizations (NGOs)

NGOs are non-profit organizations staffed and resourced nationally or internationally. NGOs that support Asia-Pacific disaster management include:

- Disaster Preparedness and Emergency Response Association (DERA) in the US.
- International Committee of the Red Cross
- Doctors Without Borders
- International Medical Corps

1.1.3.4 Online Resources

Online resources include seismic, weather, and tidal monitoring and prediction, and portals to disaster related Internet sites. The following are Asia-Pacific online disaster management resources:

- Asia Pacific Area Network, PACOM, in Hawai'i.
- HazardNet, Simon Fraser University, Canada.
- Global Disaster Information Network (GDIN) in the US.
- Pacific Disaster Center (PDC) in Hawai'i.
- Philippine Institute of Volcanology and Seismology.
- ReliefWeb, UN.
- Natural Disaster Management (NDM), UN.

1.1.3.5 Others

The media, religious organizations, schools, businesses, volunteers, and others participate in disaster management. During the assessment phase, I will document any additional organizations with relevant TsunamiSim dependencies.

1.1.4 Train and Control

Disaster management begins with preparations. Preparations range from earthquake-proof building codes to public alerts. Preparations also include training. Training not only familiarizes people with disaster management duties, but also identifies where additional preparations might be needed. US Army individual and collective training is defined by tasks, conditions and standards. The training heuristic is that personnel and organizations are *trained* if they periodically perform specified tasks under realistic conditions to a standard commensurate with success during a real event. Collective training requires evaluation in accordance with standards to be successful. Observer comments, simulation state and event logs, and after-action reviews form the basis of evaluations. Ideally, organizations should train for the types of disasters that could occur where they could occur as often as necessary for personnel to stay trained. Reality is that resources such as time and money prevent this from always happening, particularly in economically deprived Asia-Pacific regions. TsunamiSim will provide organizations the ability to conduct asynchronous distributed training requiring a fraction of the resources needed for synchronous, centralized training. In crises, trained individuals fall back on embodied skills. They also use tools at hand that they are familiar with. TsunamiSim will be a globally accessible disaster management training and control application.

1.1.5 TsunamiSim Target Audience

Disaster responders, observers, analysts, and decision makers will employ TsunamiSim. As a GIS application, TsunamiSim will provide interactive, attributed maps. Responders and observers will input and update locations of damages, mitigation efforts, and recovery assets. Analysts and decision makers will use TsunamiSim to assess disasters, manage responders and resources, and coordinate relief and recovery efforts between organizations. In military parlance, TsunamiSim provides situational awareness for operators and decision makers.

1.2 Related Approaches to Disaster Management

The TsunamiSim target audience uses a variety of approaches for disaster management training and control. However, none, to my knowledge, use an interactive, Internet-distributed GIS application capable of simulating disaster scenarios. Proprietary data protection, security, Internet access, cost, and marketability may be reasons preventing a system like TsunamiSim from being developed. For instance, although TsunamiSim is asynchronous, data could be used for targeting or hostile intelligence purposes. In the US and other western nations, we take for granted that we can use Internet maps to find a location. But publishing the location say of an unprotected refugee camp in hostile regions of the world might cause death to its inhabitants. In assessing TsunamiSim, I will address these detractors and other limitations that I discover.

For disaster management training, situational awareness depicting a scenario both analog and digitally can be used to exercise participants. Analog procedures could be as simple as having participants use a map and phone to react to scripted events. Digital procedures might be as complex as simulations portraying a disaster and participant mitigation efforts distributed in real-time across dedicated communication lines. The training should reflect the real disaster were it to occur. Ideally, if digital systems are used for control, then they should be the same systems used for training. Unfortunately, training simulations often run independently which can limit realistic training on control systems. In Chapter 3, I detail some of the digital systems used for collective disaster management training and control in order to contrast the capabilities and limitations of TsunamiSim:

1.2.1 Decision Support Systems (DSS)

A wide domain of software applications used for supporting industries from e-commerce to healthcare. Generally, decision support systems are operations research applications that use models and a knowledge base to formulate solutions to user problems. IBM's Business Intelligence (BI) Solutions is an example of DSS. BI transforms corporate and demographic data relating to sales, inventory, customers, and markets into knowledge for decision makers.[2]

1.2.2 Command and Control (C2) Systems

The military and emergency response organizations use synchronous communication and situational awareness applications to plan for and conduct disaster management operations. Global Command and Control System (GCCS) used by the US Military is an example of a C2 system. GCCS integrates service and allied C2 systems to provide synchronous, coherent situational awareness throughout an area of operations.[3]

1.2.3 Simulations

Disaster management training is often conducted with the use of localized and distributed simulations. For example, Science Applications Information Corporation (SAIC) develops Consequence Assessment Toolset (CATS) for military and civil organizations to conduct disaster management training.[4]

1.2.4 GIS

As computer processing speed becomes cheaper and cheaper, GIS is becoming the industry approach to organizing and maintaining not only geographic information, but any data that can be spatially organized such as gnome research. REMAPS was prototyped as a GIS system with many similarities to TsunamiSim, and deserves scrutiny.[5]

1.3 TsunamiSim in a Nutshell

TsunamiSim is multi-tier application that will be implemented to run on nearly any host machine. TsunamiSim will have user interfaces for the disaster managers, administrators, and developers. TsunamiSim will be developed to support sustained maintenance and enhancements. TsunamiSim will be secure and protect intellectual property rights such as GIS data.

1.3.1 TsunamiSim is Lightweight

A lightweight collaborative training and control application is one that does not require specialized, proprietary software. Specifically, TsunamiSim clients will run on newer versions of Internet browsers, (Microsoft Internet Explorer and Netscape 4.0 or higher). Military and government organizations often use heavyweight, collaborative training and control applications. Applications such as simulations, and command and control systems typically require specialized software and hardware configurations. Heavyweight solutions may be preferable and more capable, but they are not easily and rapidly fielded to civil organizations and austere regions. A lightweight application accessible to anyone is needed when heavyweight applications cannot be deployed to everyone.

1.3.2 TsunamiSim is Web-based.

The demand for web-based applications for internationally distributed disaster management training and control will grow as the Internet continues global proliferation. A browser-centric approach is advantageous because:

- Dedicated communications not required.
- Rearward compatibility and interoperability.
- Low cost to no cost startup and maintenance for end-users.
- Simplicity to learn and use.

1.3.3 TsunamiSim is a Geographic Information System

GIS integrates maps and databases into spatially oriented layers. In other words, GIS provides intelligent maps. The advantages of GIS are:

- Geographically organizes all types of information.
- Static and dynamic content management.
- Enable sophisticated queries, analysis, and prediction.
- Create interactive layers and attributes "on the fly."
- Availability of data and transformation tools.
- Efficiently binds status reporting to location.

1.3.4 TsunamiSim Implementation

My goal with TsunamiSim is to produce an implementation that provides empirical evidence to my thesis. I intend to follow best software engineering practices and procedures so that TsunamiSim might survive and grow beyond my thesis. As such, I plan to follow Extreme Programming (EP). Decidedly, since I am doing my own implementation, I will not do pair programming as called for by EP.

1.3.4.1 Adhere to Military Simulation Standards

The US Army mandates that all simulations be verified, validated, and accredited (VV&A) for official use.[6] Although the regulation does not apply to graduate school research, TsunamiSim will have a VV&A plan for its usefulness, and to make TsunamiSim more adaptable for official use. Verification is the process of insuring that the application does what it is designed to do. In Extreme Programming, this is the process of building iterations according to the release plan. Validation is the process of insuring what the application does is appropriate in the target domain. In Extreme Programming, this is acceptance testing. Lastly, accreditation is the process of approving an application for a specific, official use. In Extreme Programming, this is customer approval of small releases.

The US Department of Defense mandates that simulations used for official use be High Level Architecture (HLA) compliant.[7] Again, TsunamiSim will implement the HLA API to make it more readily adaptable for official military use.

1.3.4.2 Geographic Data Issues

Whereas the Web community looks to the World Wide Web Consortium (W3C) for technologies to promote reuse and interoperability, GIS technologies are fragmented around vendor specifications. Geographic data standardization issues have not gone unnoticed as evidence by Dr. Werner Kuhn's white paper presented to the ISO.[8] Though I plan to research GIS standards and interoperability issues as they relate to TsunamiSim, use of GIS vendor data extensions is nonetheless unavoidable. Since Environmental Services Research Institute (ESRI) Shapefile (.shp extension) is documented, it has become a de facto industry standard that TsunamiSim principally will use.[9]

1.3.4.3 Component Reuse

TsunamiSim will integrate server-side, transformation, and client-side components where available from existing GIS applications. Initially, I plan to leverage the following applications:

- **JShape** is a Java implementation and API for publishing GIS on the Web available free for non-commercial use.[10]
- **ESRI** provides a suite of development tools including ArcInfo, ArcView, and ArcIMS for GIS development and Web publishing.

1.3.4.4 Prioritized Implementation Goals

- Map browser user interface
- GIS map server
- User account management
- Interactive thematic layers and icons
- User and thematic navigation
- Administration user interface
- Embedded files and attributes
- Dynamic data
- Deterministic and stochastic simulation
- Hand-held device integration

1.4 Thesis Statement

A GIS-based collaborative map application accessible with an Internet browser is a feasible and effective way for diverse and geographically distributed organizations to train for and conduct disaster management training and control.

1.5 Case Study: A Compilation of Disasters

A scenario depicting realistic and historical natural disaster conditions potentially mitigated will be used for validation. Ideally, validation will be done in two stages beginning with a Hawai'ian hurricane followed by foreign natural disaster. Starting with a Hawai'ian scenario will facilitate rapid implementation and validation due to the availability of GIS data and subject matter expertise. General phased scenario outline:

Phase I: Hurricane Season Preparation

- Review policies and standard operating procedures (SOPs)
- Conduct C2 operational tests
- Configure and train with TsunamiSim
- Assess state of preparedness

Phase II: Hurricane Watch

- Warn citizens
- Do predictive modeling with TsunamiSim

Phase III: Hurricane Warning

- Implement emergency operation procedures
- Maintain situational awareness with TsunamiSim

Phase IV: Hurricane Approaches

- Conduct evacuations
- Manage utilities and transportation
- Deploy responders
- Maintain situational awareness with TsunamiSim

Phase V: Hurricane Hits

- Prioritize and manage response
- Maintain situational awareness with TsunamiSim

Phase VI: Hurricane Passes

- Prioritize and manage response and initiate recovery
- Maintain situational awareness with TsunamiSim

Phase VII: Recovery

- Complete recovery plan
- Conduct after action review

1.6 TsunamiSim Results

TsunamiSim validation will consist of conducting interviews and acceptance testing. Civil and military disaster managers will provide validation of TsunamiSim by detailing how their respective organizations operate, how TsunamiSim could enhance their operations, and by doing TsunamiSim acceptance testing. Organizations in Hawai'i will be the principle source of validation, and where possible, I will acquire mainland and foreign validation. Accreditation will be accomplished by deploying TsunamiSim for use in a distributed environment as part of a disaster management exercise or a course of instruction.

1.7 Roadmap to the Rest of the Thesis

Chapter 2: Related Work

2.1 Decision Support Systems
2.2 Command and Control Systems
2.3 Simulations
2.4 GIS

Chapter 3: TsunamiSim Specification

3.1 Disaster Management User Stories
3.2 TsunamiSim Design
3.3 TsunamiSim Implementation Plan

Chapter 4: Evaluation

4.1 Verification: Peer Review
4.2 Validation: Subject Matter Experts
4.3 Accreditation: TsunamiSim Exercise
4.4 Analysis

Chapter 5: Post-Thesis Goals

5.1 Maintenance
5.2 Enhancements

1.8 Research Plan

June:	Thesis Proposal
July:	Design and Implementation
August:	Verification and Validation
September:	Accreditation
September 14:	*Fall Term Graduation Application Deadline*
October:	Analysis and Draft Completion
October 26:	*Thesis Defense Deadline*
November 13:	*Thesis Submission Deadline*

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[1] AOR and other military terms are further defined in "Field Manual (FM) 101-5, Operational Terms and Graphics," Headquarters, Department of the Army, Washington, DC, September 1997.
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[2] "Introduction to Business Intelligence," IBM, Armonk, NY, May 2000.
http://www-4.ibm.com/software/smb/pdf/introductiontobusinessintelligence.pdf

[3] "Global Command and Control System," US Defense Information Agency Fact Sheet, Headquarters, Department of Defense, Washington, DC, March 2001. Available online at: http://www.disa.mil/info/gccs-mar01.doc

4 Consequence Assessment Toolset (CATS) simulation for disaster management training is developed by Science Applications International Corporation (SAIC), San Diego, CA, under the direction of FEMA. http://cats.saic.com/

[5]Relief Emergency Mapping System (REMAPS) is a prototype of a disaster management GIS application developed by VISTA for Global Disaster Information Network and the United Nations ReliefWeb. According to VISTA, REMAPS was not developed due to a lack of funding. http://www.gdin-international.org/proj_remaps.html

[6] "Department of the Army Regulation 5-11, Management of Army Simulations," Headquarters, US Army, Washington, DC, July 1997.
http://www.usapa.army.mil/pdffiles/r5_11.pdf

[7] HLA memorandum of agreement was signed by the US military services to promote simulation reuse and interoperability in November 2000. The Defense Modeling and Simulation Office (DMSO) in Alexandria, VA, is the Department of Defense proponent for HLA. HLA was approved as an open standard through the Institute of Electrical and Electronic Engineers (IEEE) - IEEE Standard 1516.
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[8] "Liaison contribution from OGC: Toward Implemented Geoprocessing Standards: Converging Standardization Tracks for ISO/TC 211 and OGC," by Dr. Werner Kuhn, October 1997 presented to the ISO/TC 211, Geographic Information/Geomatics, 5th Plenary in Oxford, UK, October 1997. Available online at:
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[9] "ESRI Shapefile Technical Description," ESRI, Redlands, CA, July 1998. Available online at: http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf

[10] JShape terms of use, downloads, and documentation are available online at
http://www.jshape.com/