Navy Fire & Emergency Services Loss Modeling

OR 699/SYST 699 Project Proposal

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Sponsored by:

Innovative Decisions, Inc.

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1. Introduction

1.1 Background

Navy Fire & Emergency Services (F&ES) protects 70+ installations worldwide via four functions: Fire Protection, Fire Prevention, EMS Transport, and Aircraft Rescue & Fire Fighting. However, in a fiscally constrained era, the Navy is required to more carefully budget and trim their resources and the F&ES are not exempt. In order to make decisions regarding a reduction in assets and services, the Navy needs to be able to quantify the risk of loss of infrastructure, property, and lives.

In the Fall 2011 semester, a team of students from George Mason University (GMU) developed an Excel-based simulation of a generic installation with a simplistic loss function driven by historical call data. This model uses loss as a measure of the ability of F&ES assets to reach the location of an emergency. To expand on this model, a second team of GMU student developed a probabilistic loss model of the residential fire scenario during the Spring 2012 semester. This model provides a more realistic simulation of a two story single-family dwelling fire.

1.2 Problem Statement

The two previously built models provide a basis for quantifying loss on an installation given a reduction in F&ES assets. However, they are currently disconnected and simplistic. The Navy needs a unified tool that can realistically quantify loss.

1.3 Sponsor

The sponsor for this study is Mr. Fred Woodaman, Principal Analyst at Innovative Decisions Inc.

1.4 Objectives

The Fall 2012 GMU team is committed to the following objectives:

- To construct a model of a generalized installation that can be made specific given simple data for a particular installation.
- To build an efficient simulation model that will calculate expected losses using probabilistic loss models of various emergencies.
- To include and expand on the residential fire probabilistic loss model.
- To provide an interface to allow for simple addition of new probabilistic loss models for other emergency scenarios.

In summary, the study team intends to create a simulation model of an installation that is based on simple facts, rather than a grid, and is capable of calculating partial loss, rather than assuming loss to be binary. This will involve combining the two previous models and making the original simulation more closely reflect reality. While the Fall 2012

GMU team will not be able to complete a probabilistic loss model for every emergency, they will provide a basis for easy integration of such models in the future.

2 Technical Approach

2.1 Scope

This study will seek to build a generalized model of an installation. The study team will confine the model to a simulation of incident mitigation based on assumptions about the composition of the installation. There will be no attempt to optimize fire station locations, specify building materials or weather, or model incident prevention.

2.2 Assumptions

The previous GMU teams used the assumptions that follow. These will form the basis for the current GMU team's analysis, however they are subject to change as necessary.

- Complex and varied Navy installations can be generalized and simplified, such that they can be described adequately by a small set of parameters.
- Loss from fire follows a Weibull distribution using a random draw for parameters of distribution and a given building size.
- First fire company to respond only uses water on truck, allowing a limited amount of fire-fighting time. Second company to respond hooks up to hydrant to assist. Third company acts as a reserve. (NFPA requires 3 companies).
- F&ES forces are relatively small, such that forces cannot necessarily be reduced by a given percentage to match a desired budgetary outcome. (i.e. One cannot reduce a fire truck by 90%.)
- Each infrastructure on an installation is within 5 minutes of a fire station.
- There are one to three fire trucks in each fire station.
- There are 4 fire fighters per company one duty at any given time.

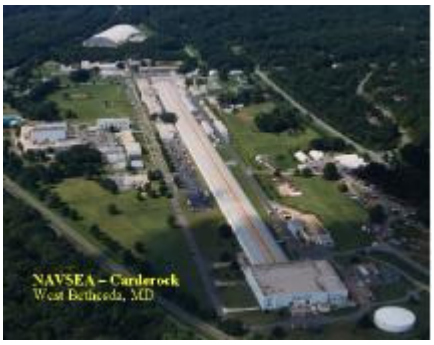
2.3 Limitations

Since the study team does not contain any subject matter experts on F&ES, it will not be able to build probabilistic loss models for all emergency scenarios that can occur on an installation within the course of the semester. Therefore, the simulation model will include an interface to connect with future scenario models.

2.4 Methodology

The study team will begin by researching the structure of Naval installations and the responsibilities of F&ES. This research will provide information for building a simulation model of a generalized installation and various emergency situations. The team also plans to explore ways to expand the Spring 2012 GMU team's residential fire probabilistic loss model to include buildings of various types. The resulting model, written in Visual Basic for Applications in Excel, will be able to provide a measure of expected losses for a given installation and its F&ES assets.

Once a simplified base layout is identified, such as the one shown in Figure 1, the team will apply loss modeling to each building based on the likelihood of a fire event occurring, driven by past service calls for that base, as derived from the Program Compliance Assessment records, such as those shown in Figure 2. Initial loss modeling will be performed by utilizing a scalable version of the Spring 2012 team's residential model (shown in Figure 3) and applying it to larger and different typed buildings. When or if new models become available, they will be substituted as appropriate.



Name	NSWC Carderock				
Location	Bethesda, MD				
Population	1000				
Total Area	0.356	sq. miles			
Buildings	20				
F&ES Stations	1				
Mutual Aid	3				

Index	BuildingID	BuildingName	Type	Floors	Floor Area (sq ft)
0	23	Security	Commercial	1	900
1	57	Visitor Office	Commercial	1	900
2	43	Mess Hall	Retail	1	2500
3	113	Tow Tank A	Warehouse	1	100000
4	117	Tow Tank B	Warehouse	1	90000
5	119	Tow Tank C	Warehouse	1	67000
6	32	Code 32	Commercial	3	3000
7	76	Lab B	Commercial	4	3500
8	78	Lab C	Commercial	2	2500
9	79	Lab A	Commercial	2	1700
10	95	Code 95	Manufacturing	1	10000
11	13	Records Room	Commercial	1	2700
12	52	Building 52	Commercial	4	6500
13	9	Steel Shop	Manufacturing	1	12000
14	102	Wood Shop	Manufacturing	1	6000
15	27	Storage A	Warehouse	1	3200
16	28	Storage B	Warehouse	3	4900
17	17	Gym	Commercial	1	6500
18	59	Medical	Commercial	2	4000
19	40	IT Routing	Commercial	1	2000
20	41	Facilities Dept	Commercial	2	2800

Index	Station	Engines	Crew/Engine	Response Time
0	Station 1	1	4	4
1	Mutual 1	1	4	9
2	Mutual 2	1	4	11
3	Mutual 3	1	4	11

Figure 1 Navy installation transformation

Summary By Incident Type

Report Period: 1/1/04 - 12/31/06

Calls By Incident Type	Frequency	Percent Of Total Calls	Mutual Aid None	Mutual Aid Given	Mutual Aid Received	Other Aid Given	Invalid Aid Flag	Exposures	Total Incidents
FIRES									
Building Fires (110-118, 120-123)	25	0.30%	16	0	9	0	0	1	26
Vehicle Fires (130-138)	8	0.10%	5	0	3	0	0	0	8
Others Fires (100, 140-173)	27	0.33%	25	0	2	0	0	0	27
Total Fires	60	0.73%	46	0	14	0	0	1	61
Overpressure Ruptures, Explosion, Overheat (200-251)	2	0.02%	2	0	0	0	0	0	2
RESCUE CALLS									
Emergency Medical Treatment (300-323)	319	3.88%	142	0	177	0	0	0	319
All Others (331-381)	37	0.45%	35	0	2	0	0	0	37
Total Rescue Calls	356	4.33%	177	0	179	0	0	0	356
Hazardous Condition Calls (400-482)	7037	85.51%	7028	0	9	0	0	0	7037
Service Calls (500-571)	43	0.52%	43	0	0	0	0	0	43
Good Intent Calls (600-671)	58	0.70%	57	0	1	0	0	0	58
Severe Weather or Natural Disaster Calls (800-815)	3	0.04%	3	0	0	0	0	0	3
Special Incident Calls (900-911)	6	0.07%	6	0	0	0	0	0	6
Unknown Incident Type (UUU)	0	0.00%	0	0	0	0	0	0	0
FALSE CALLS									
Malicious Calls (710-715, 751)	10	0.12%	10	0	0	0	0	0	10
Other False Calls (700, 721-746)	654	7.95%	652	0	2	0	0	0	654
Total False Calls	664	8.07%	662	0	2	0	0	0	664
TOTAL CALLS	8229	100.00%	8024	0	205	0	0	1	8230

Total Incidents With Exposure Fires	1	Total Fire Dollar Loss	$1,119,584
Total Exposure Fires	1	Total Dollar Loss	$1,620,048

Casualty Summary	Civilian	Fire Service
Fire Related Injuries	3	0
Non-Fire Injuries	3	0
Fire Related Deaths	1	0
Non-Fire Deaths	1	0

Page 2 of 2 NFIRS 5.0 National Reporting System 4/4/07 8:11:23 PM

Figure 2 NAS Key West Incident Reports from March 2007 PCA

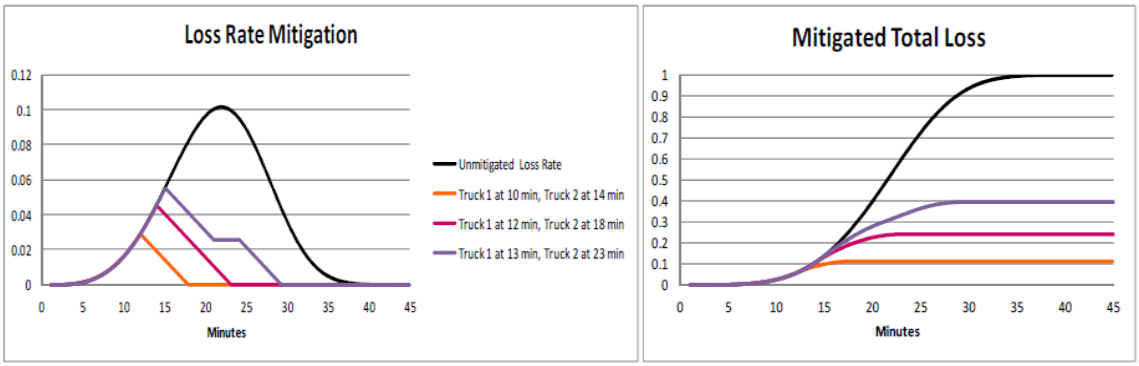


Figure 3 Residential Loss Model

3 Project Plan

3.1 Deliverables

Project Proposal and Presentation: 10/4
Status Report: 10/11
Design of Web Pages: 10/11
In Progress Review: 10/18
Draft of Final Presentation: 11/1
Project Report: 11/29
Simulation Model: 11/29
Final Website: 11/29
Final Presentation: 12/7

3.2 Work Breakdown Schedule

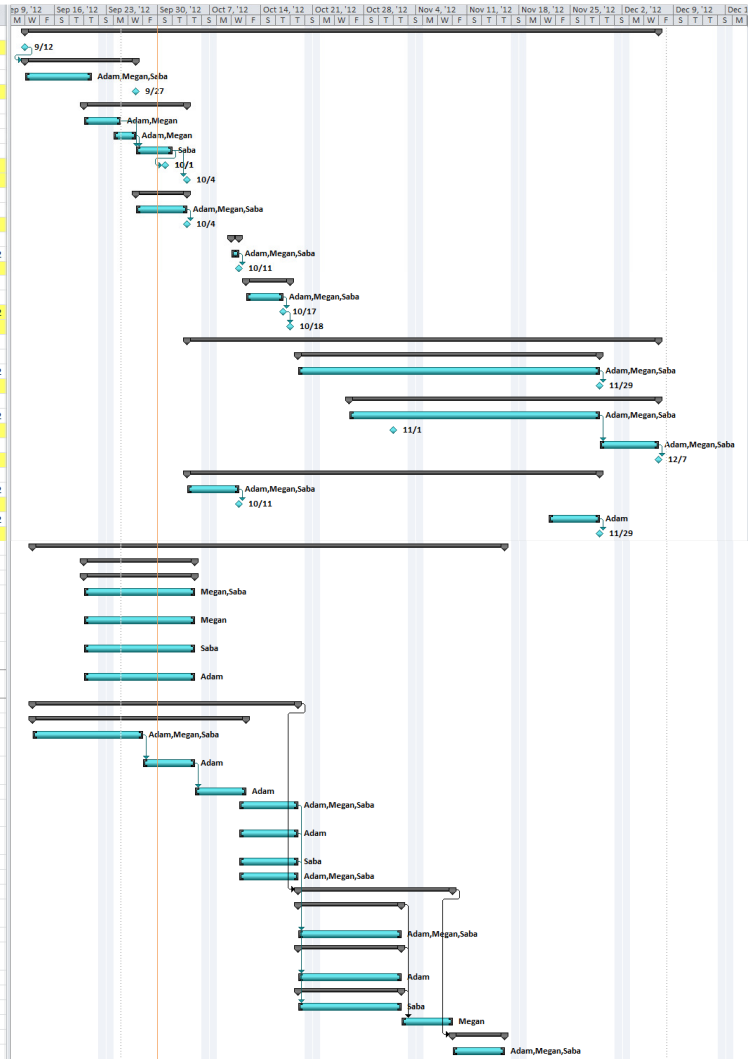
1. Project Management
    - 1.1. Project Kickoff
    - 1.2. Develop Project Definition
        - 1.2.1. Interview sponsor
        - 1.2.2. Present problem definition
    - 1.3. Develop Project Plan
        - 1.3.1. Assign tasking
        - 1.3.2. Layout project schedule
        - 1.3.3. Generate plan slides
        - 1.3.4. Submit project plan slides
        - 1.3.5. Present project plan
    - 1.4. Develop Project Proposal
        - 1.4.1. Write proposal
        - 1.4.2. Submit project proposal
    - 1.5. Prepare 1 page status update
        - 1.5.1. Write status update
        - 1.5.2. Submit status update
    - 1.6. Prepare IPR presentation
        - 1.6.1. Generate IPR slides
        - 1.6.2. Submit IPR presentation
        - 1.6.3. Present IPR
    - 1.7. Prepare final deliverables
        - 1.7.1. Prepare final report
            - 1.7.1.1. Generate final report
            - 1.7.1.2. Submit final report
        - 1.7.2. Prepare final presentation
            - 1.7.2.1. Generate final slides
            - 1.7.2.2. Submit presentation draft
            - 1.7.2.3. Dry run presentation
            - 1.7.2.4. Present project results

1.7.3. Prepare project website
1.7.3.1. Design website layout
1.7.3.2. Submit website design
1.7.3.3. Write HTML
1.7.3.4. Upload files

2. Analytic Framework Development
2.1. Conduct background research
2.1.1. Break down previous models
2.1.1.1. Identify inputs and outputs
2.1.1.2. Identify assumptions made
2.1.1.3. Identify underlying algorithms
2.1.2. Identify common installation features
2.2. Design framework
2.2.1. Capture requirements
2.2.1.1. Identify stakeholder requirements
2.2.1.2. Decompose into system requirements
2.2.1.3. Generate SRS
2.2.2. Design modular loss model interface
2.2.3. Design generic installation descriptors
2.2.4. Design data input modality
2.2.5. Design user interface
2.3. Develop framework
2.3.1. Develop modular loss model interface
2.3.1.1. Code model interface
2.3.2. Develop generic installation descriptors
2.3.2.1. Code installation handler
2.3.3. Develop data input modality
2.3.3.1. Code data handler
2.3.4. Develop user interface
2.4. Test framework
2.4.1. Develop test case from existing base information and call data

3.3. Project Schedule

	WBS	Task Name	Duratic	Start	Finish
1	**1**	Project Management	**62 days**	**Wed 9/12/12**	**Fri 12/7/12**
2	**1.1**	Project Kickoff	**0 days**	**Wed 9/12/12**	**Wed 9/12/12**
3	**1.2**	Develop Project Definition	**11 days**	**Wed 9/12/12**	**Thu 9/27/12**
4	1.2.1	Interview sponsor	7 days	Wed 9/12/12	Thu 9/20/12
5	**1.2.2**	Present problem definition	**0 days**	**Thu 9/27/12**	**Thu 9/27/12**
6	**1.3**	Develop Project Plan	**10 days**	**Thu 9/20/12**	**Thu 10/4/12**
7	1.3.1	Assign tasking	3 days	Thu 9/20/12	Mon 9/24/12
8	1.3.2	Layout project schedule	3 days	Mon 9/24/12	Wed 9/26/12
9	1.3.3	Generate slides	3 days	Thu 9/27/12	Mon 10/1/12
10	**1.3.4**	Submit project plan slides	**0 days**	**Mon 10/1/12**	**Mon 10/1/12**
11	**1.3.5**	Present project plan	**0 days**	**Thu 10/4/12**	**Thu 10/4/12**
12	**1.4**	Develop Project Proposal	**5 days**	**Thu 9/27/12**	**Thu 10/4/12**
13	1.4.1	Write proposal	5 days	Thu 9/27/12	Wed 10/3/12
14	**1.4.2**	Submit project proposal	**0 days**	**Thu 10/4/12**	**Thu 10/4/12**
15	**1.5**	Prepare 1-5 page status update	**1 day**	**Wed 10/10/12**	**Thu 10/11/12**
16	1.5.1	Write status update	1 day	Wed 10/10/12	Wed 10/10/12
17	**1.5.2**	Submit status update	**0 days**	**Thu 10/11/12**	**Thu 10/11/12**
18	**1.6**	Prepare IPR presentation	**4 days**	**Fri 10/12/12**	**Thu 10/18/12**
19	1.6.1	Generate IPR slides	3 days	Fri 10/12/12	Tue 10/16/12
20	**1.6.2**	Submit IPR presentation	**0 days**	**Wed 10/17/12**	**Wed 10/17/12**
21	**1.6.3**	Present IPR	**0 days**	**Thu 10/18/12**	**Thu 10/18/12**
22	**1.7**	Prepare final deliverables	**46 days**	**Thu 10/4/12**	**Fri 12/7/12**
23	**1.7.1**	Prepare final report	**29 days**	**Fri 10/19/12**	**Thu 11/29/12**
24	1.7.1.1	Generate final report	29 days	Fri 10/19/12	Wed 11/28/12
25	**1.7.1.2**	Submit final report	**0 days**	**Thu 11/29/12**	**Thu 11/29/12**
26	**1.7.2**	Prepare final presentation	**30 days**	**Fri 10/26/12**	**Fri 12/7/12**
27	1.7.2.1	Generate final slides	24 days	Fri 10/26/12	Wed 11/28/12
28	**1.7.2.2**	Submit presentation draft	**0 days**	**Thu 11/1/12**	**Thu 11/1/12**
29	1.7.2.3	Dry run presentation	6 days	Thu 11/29/12	Thu 12/6/12
30	**1.7.2.4**	Present project results	**0 days**	**Fri 12/7/12**	**Fri 12/7/12**
31	**1.7.3**	**Prepare project website**	**40 days**	**Thu 10/4/12**	**Thu 11/29/12**
32	1.7.3.1	Design website layout	5 days	Thu 10/4/12	Wed 10/10/12
33	**1.7.3.2**	Submit website design	**0 days**	**Thu 10/11/12**	**Thu 10/11/12**
34	1.7.3.3	Generate HTML	5 days	Thu 11/22/12	Wed 11/28/12
35	**1.7.3.4**	Upload files	**0 days**	**Thu 11/29/12**	**Thu 11/29/12**
36	**2**	Analytic Framework Development	**46 days**	**Thu 9/13/12**	**Thu 11/15/12**
37	**2.1**	Conduct background research	**11 days**	**Thu 9/20/12**	**Thu 10/4/12**
38	**2.1.1**	Break down previous models	**11 days**	**Thu 9/20/12**	**Thu 10/4/12**
39	2.1.1.1	Identify inputs and outputs	11 days	Thu 9/20/12	Thu 10/4/12
40	2.1.1.2	Identify assumptions made	11 days	Thu 9/20/12	Thu 10/4/12
41	2.1.1.3	Identify underlying algorithms	11 days	Thu 9/20/12	Thu 10/4/12
42	2.1.2	Identify common installation features	11 days	Thu 9/20/12	Thu 10/4/12
43	**2.2**	Design framework	**26 days**	**Thu 9/13/12**	**Thu 10/18/12**
44	**2.2.1**	Capture requirements	**21 days**	**Thu 9/13/12**	**Thu 10/11/12**
45	2.2.1.1	Identify stakeholder requirements	11 days	Thu 9/13/12	Thu 9/27/12
46	2.2.1.2	Decompose into system requirements	5 days	Fri 9/28/12	Thu 10/4/12
47	2.2.1.3	Generate SRS	5 days	Fri 10/5/12	Thu 10/11/12
48	2.2.2	Design modular loss model interface	6 days	Thu 10/11/12	Thu 10/18/12
49	2.2.3	Design generic installation descriptors	6 days	Thu 10/11/12	Thu 10/18/12
50	2.2.4	Design data input modality	6 days	Thu 10/11/12	Thu 10/18/12
51	2.2.5	Design user interface	6 days	Thu 10/11/12	Thu 10/18/12
52	**2.3**	Develop framework	**15 days**	**Fri 10/19/12**	**Thu 11/8/12**
53	**2.3.1**	Develop modular loss model interface	**10 days**	**Fri 10/19/12**	**Thu 11/1/12**
54	2.3.1.1	Code model interface	10 days	Fri 10/19/12	Thu 11/1/12
55	**2.3.2**	Develop generic installation descriptors	**10 days**	**Fri 10/19/12**	**Thu 11/1/12**
56	2.3.2.1	Code installation handler	10 days	Fri 10/19/12	Thu 11/1/12
57	**2.3.3**	Develop data input modality	**10 days**	**Fri 10/19/12**	**Thu 11/1/12**
58	2.3.3.1	Code data handler	10 days	Fri 10/19/12	Thu 11/1/12
59	2.3.4	Develop user interface	5 days	Fri 11/2/12	Thu 11/8/12
60	**2.4**	Test framework	**5 days**	**Fri 11/9/12**	**Thu 11/15/12**
61	2.4.1	Develop test case from	5 days	Fri 11/9/12	Thu 11/15/12



4 System Requirements

The system defined by the following requirements consists of the analysis tool, algorithms, and external interfaces that will allow expected annual loss to be computed probabilistically for various installation configurations, including variable F&ES force sizes.

1. System Objective – The system shall consist of a modular analysis tool that enables the Navy to establish an estimated annual expected loss for any given installation as a function of the level of Fire and Emergency Services available to that installation.
    - 1.1. User Interface Requirements
        - 1.1.1. System Modality - The user interface shall be in Microsoft Excel.
        - 1.1.2. Input Requirements
            - 1.1.2.1. Data file – the system shall utilize a data file describing the installation to be analyzed. The data file will include building type and size parameters.
            - 1.1.2.2. Force size – the system shall allow the user to vary the force size
        - 1.1.3. Output Requirements
            - 1.1.3.1. Expected loss – the system shall output expected annualized loss estimates for the installation as a percentage. The final total will be an aggregate of the losses from each individual building within the installation.
    - 1.2. Algorithm Requirements
        - 1.2.1. Loss Model Requirements
            - 1.2.1.1. The model shall compute expected loss for a single building for a single event.
            - 1.2.1.2. Input Requirements
                - 1.2.1.2.1. The algorithm shall use at least the following items as inputs: building size, number of floors, estimated fire team response time.
            - 1.2.1.3. Output Requirements
                - 1.2.1.3.1. The algorithm shall output the percentage loss of the building and its contents as an estimate of lost value.
        - 1.2.2. Installation Model Requirements
            - 1.2.2.1. Input Requirements
            - 1.2.2.2. Output Requirements
        - 1.2.3. Data Model Requirements
            - 1.2.3.1. The system shall utilize Program Compliance Assessment (PCA) data to establish a baseline risk profile for a given installation.
2. System Training – The project team shall provide training on usage of the system to the Navy or its representatives prior to final delivery.
3. System Maintenance – The system shall be maintained by the Navy or its representatives following delivery.