# Navy Fire & Emergency Services Project Spring 2012

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> Sponsored by Fred Woodaman Innovative Decisions Inc





Where Innovation Is Tradition

# Agenda

- Introduction and Background
- Objectives and Bottom Line
- Fire Science
- Technical Approach
- Evaluation
- Future Development
- Acknowledgements
- Questions



## Introduction & Background

- The US Navy would like a tool developed to simulate Fire & Emergency events within its worldwide installations
- Fall 2011 capstone developed Excel-based "FESEBLE"
  - But the loss sustained due to a scenario was not quantified
  - Loss due to an event was binary (all or none)





# Objectives

- Accurately model the behavior of the fire and expected loss given varying response parameters
- Provide a capability for this model to simulate expected loss at a customer installation





## Bottom Line

- Created a novel loss function along with a working model and accompanying simulation capability
- It allows for quantitative comparison of expected losses with respect to management metrics.
- These metrics can in turn be tied to resource allocation
- Scope
  - Single family residence fires only
  - Measures fractional asset "loss" without regard to specifying property or dollars





## Fire Science

- When left unchecked, fire loss generally starts slowly, then accelerates, and then decelerates once the fuel begins to be exhausted.
- Research shows the most important factors in loss mitigation are the staffing levels and response times of the first two engine companies that arrive at the scene



Data Compiled NIST Technical Note 1661, April 2010

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Graphic taken from http://iaff266.com/flashover

## Technical Approach – Characterizing Loss

- The total loss over time has a similar shape to CDFs particularly the highly adaptable Weibull CDF.
- And since the derivative of a CDF is a PDF, the Weibull PDF can characterize the rate of loss over time.





## Technical Approach – Loss Mitigation



#### **Loss Mitigation Assumptions:**

-Mitigation starts when water is applied -1<sup>st</sup> engine crew alone can apply water for a limited time until tank empties -2 minutes (4 minutes if undermanned) after response time required to start hose -2<sup>nd</sup> engine crew connects the hydrant to the 1<sup>st</sup> engine, removing water limitations

Response times and crew staffing levels control degree of loss mitigation





## Tech Approach – Fire Spread & Variability









### Technical Approach – Baseline Fire Types

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## Technical Approach – Fire Spread Parameters

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5	0.8	4.01	14.14		Ground Level	3 rooms on same floor	0.10115	0.19425	0.6	4.03	13.10				0.14	45
6				· · · · · ·	Ground Level	1 Room in Other Floor	0.06069	0.2954	0.8	4.01	14.14				0.08	67
7					Ground Level	Whole House	0.34391	0.35609	1	4.00	15.00				0.49	13
8 %Prob Fire Starti	ing at Ground Level (1-P fo	r Uppel Lev	rel)	0.7	Upper Level	Original Room	0.045	0.7	0.2	3.75	10.49				0	15
9					Upper Level	2 rooms on same floor	0.03825	0.745	0.4	3.65	12.97				0.12	75
10 Ground Level					Upper Level	3 rooms on same floor	0.0867	0.78325	0.6	3.62	14.63				0.2	89
11 % Prob Spread Room to Room 0.85				Upper Level	1 Room in Other Floor	0.0195075	0.86995	0.8	3.61	15.93				0.0650	25	
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## Technical Approach – Model Prototype

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9 Tru	ick 1 Arrives (time	)	7.63	0.03		$\land$				t	temperature (100 deg celsius) also referenced in the NIST study.															
10 Tru	ick 2 Arrives (time	)	12.97	0.025																						
11				0.02	0.02						defined average arrival times and standard deviations. 2 minutes after 1st engine arrival required for full crew (4 person) to start fighting fire; 4 minutes for partial crew (3 person).															
12 1st	Truck Performan	ce		0.015	0.015																					
13 # P	eople (3 or 4)		4	0.01	0.01																					
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16 fire	loss mitigation ra	ite	0.005							e	engine can provide 6 minutes of Water Without being hooked to a hydrant. The primary role of the second engine crew is to book the first engine to the hydrant															
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### Technical Approach – Simulation



## Evaluation – How to Use Tool



#### **Evaluation – Model Assumptions**

Fire loss rate at any given time is approximated by the temperature and amount of energy released at that moment Weibull function shape is sufficient to approximate temperature behaviors for accurate extraction of quantitative losses



#### **Evaluation – Model Assumptions**

• Varying Weibull parameters via a Gamma Distribution produces a representative sample of loss rate curves



 Reduction of the fire loss rate by responders occurs linearly and responders are assumed to be fully trained and competent



• Fraction of loss incurred is then equal to the area under the loss rate curve



## Evaluation – Analysis of Results

- A simulation using this model can be used for reliable, quantitative comparisons of expected structure loss across different resource availability levels
  - Fire behavior is modeled accurately based on previous studies and discussions with SMEs
  - Fire response and mitigation is based on researched policies, tactics, and performance levels



## Evaluation – Analysis of Results

• The magnitude of the difference in expected loss can vary significantly through adjustments to customizable parameters

Sur	nmary Stati	stics	Notes
Average	0.171		1st Engine Resp. Time: 10 min
SD	0.1710		2nd Engine Resp. Time: 15 min
Max	1.000		% Small Crews: 40%
Min	0.001		

#### Histogram of Expected Loss







## Recommendations

- Refinement of fire ignition point and type of spread data percentages
- Analyze available data within Department of Defense Fire Incident Reporting System (DFIRS) as to fire types and frequency differences from national data to adjust probability segments within Naval installations.
- Suggested additions to this model
  - Additional building types (offices, apartment buildings)
  - Affects of built in fire mitigation devices
  - Additional scenarios and effects of simultaneous incidents



## Future Development

- Develop and examine the impact of loss of life or injury on model recommendations
- Assign future GMU project teams to develop new functionalities desired by Navy F&ES and the sponsor
- Integrate these efforts into a single tool to produce the desired comprehensive analysis.



## Acknowledgements

- Dr. Kathryn Laskey—Project Advisor
- Mr. Fred Woodaman—Project Sponsor
- Mr. Dan Hunt—Prince George County volunteer and Federal Firefighter
- Mr. Patrick Cantwell– Systems Engineering Doctoral Candidate George Washington and Stafford County, VA volunteer firefighter

