Navy Fire & Emergency Services Project Spring 2012

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Sponsored by Fred Woodaman
Innovative Decisions Inc

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Where Innovation Is Tradition

Agenda

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

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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)

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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

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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

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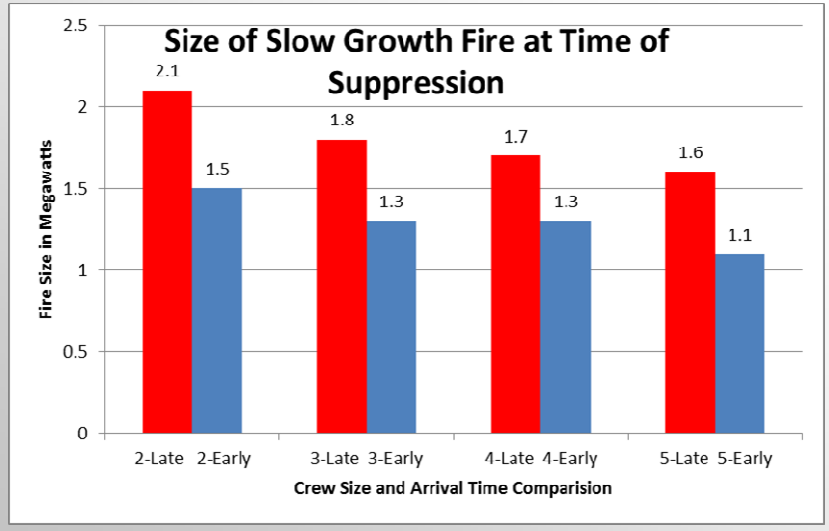
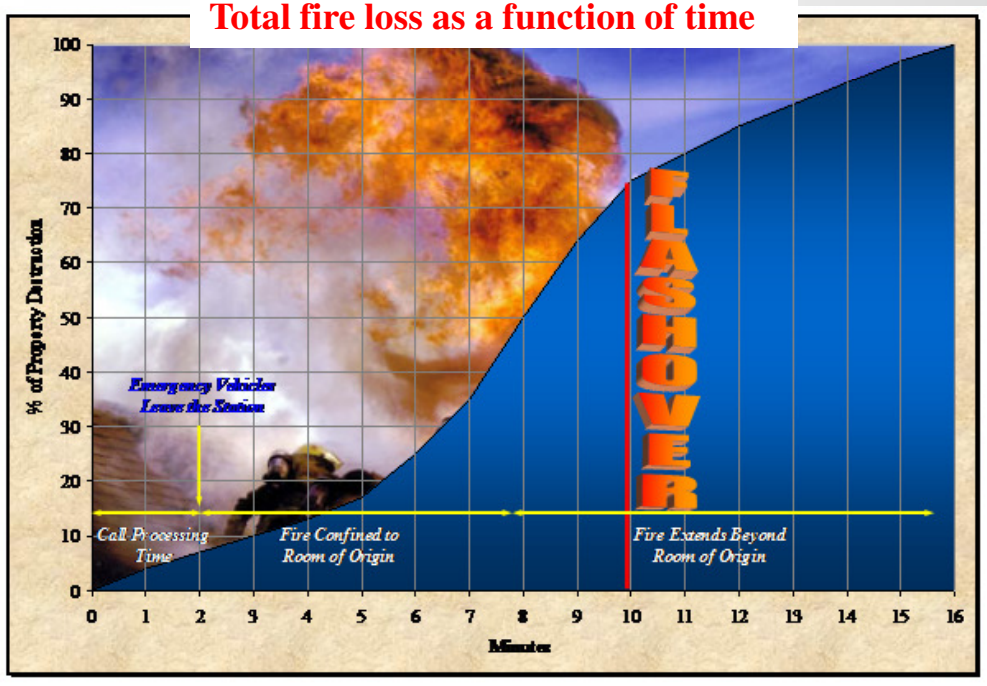
Fire Science

- 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

Total fire loss as a function of time



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

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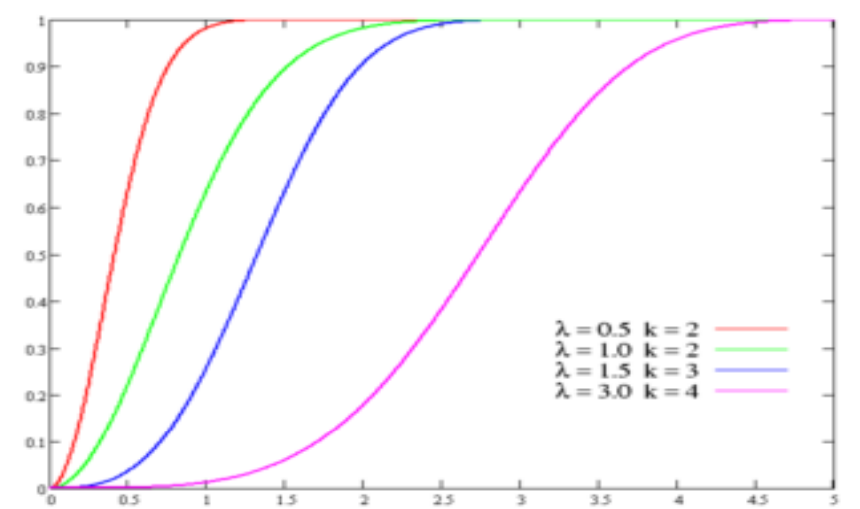
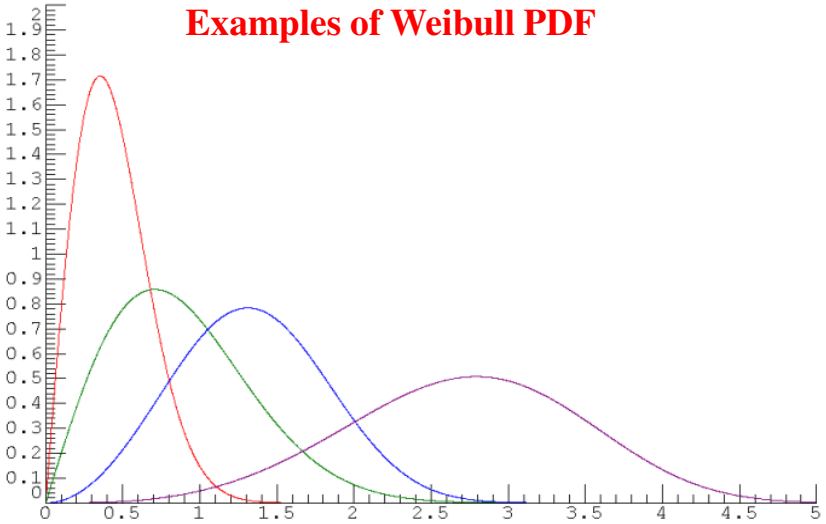
Technical Approach – Characterizing Loss

- 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.

Examples of Weibull CDF



Examples of Weibull PDF



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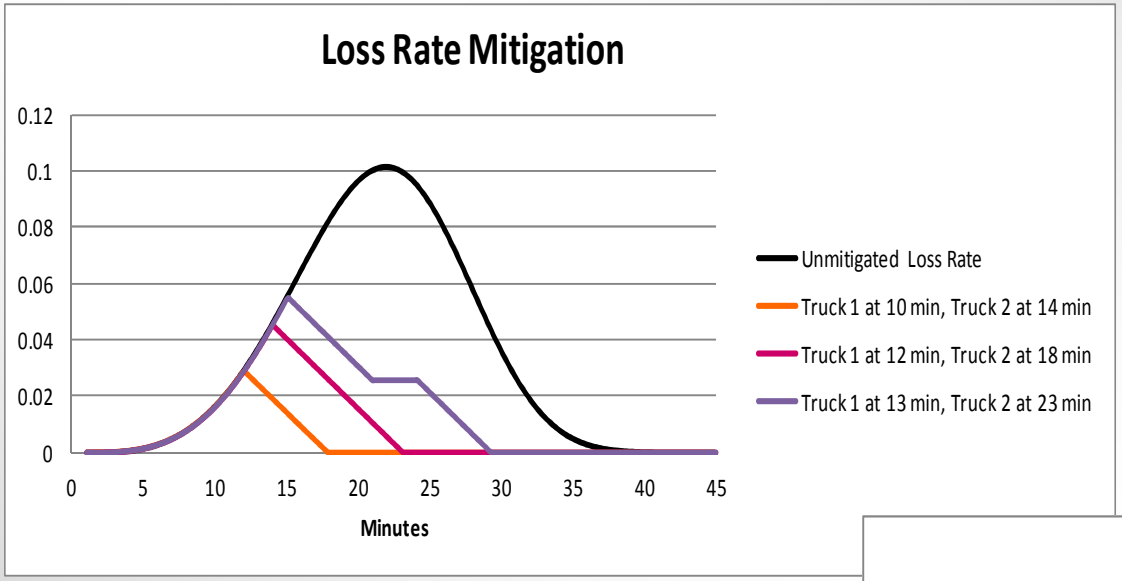
Technical Approach – Loss Mitigation



Loss Mitigation Assumptions:

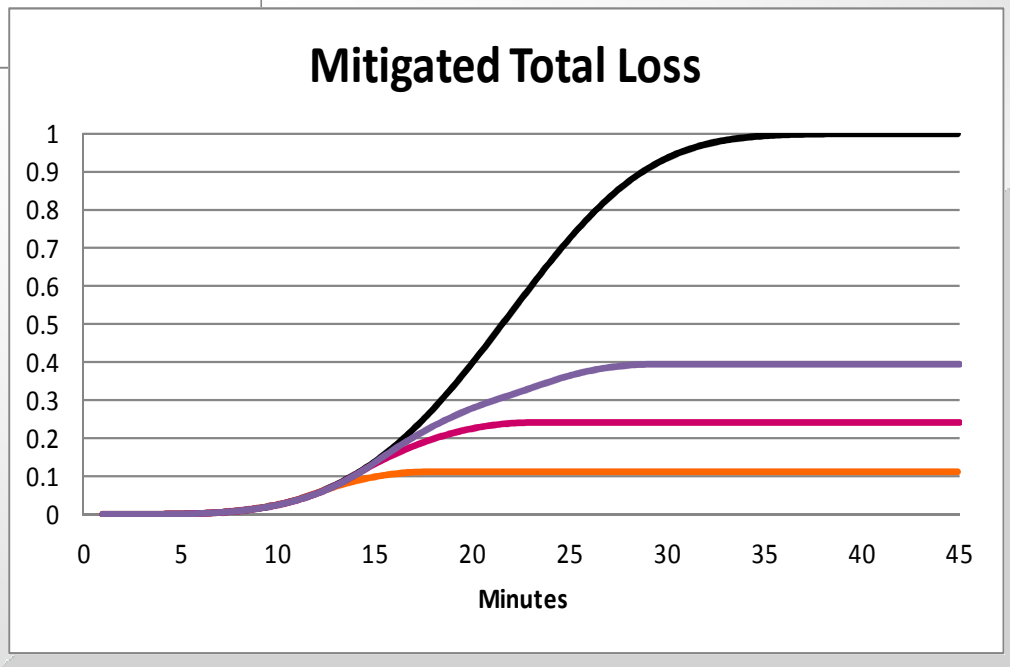
-Mitigation starts when water is applied

-1st engine crew alone can apply water for a limited time until tank empties

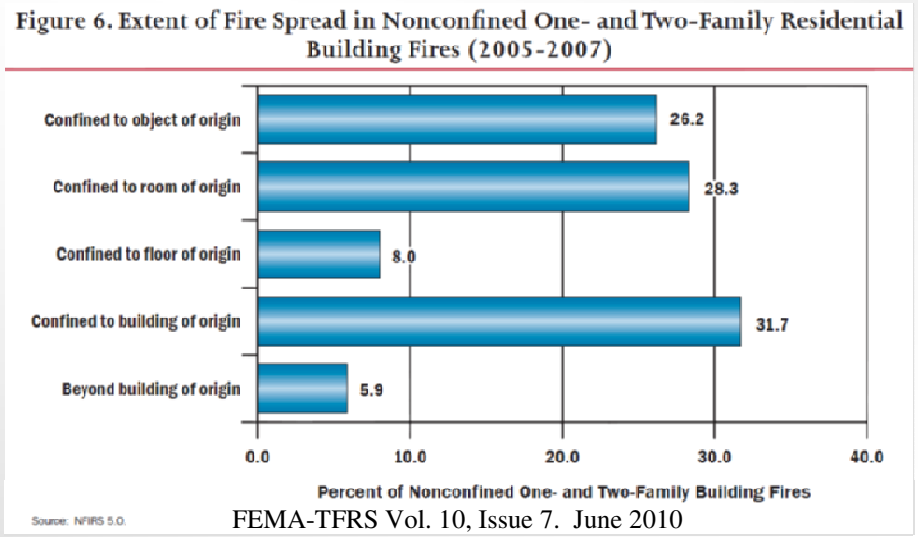
-2 minutes (4 minutes if undermanned) after response time required to start hose

-2nd engine crew connects the hydrant to the 1st engine, removing water limitations

Response times and crew staffing levels control degree of loss mitigation

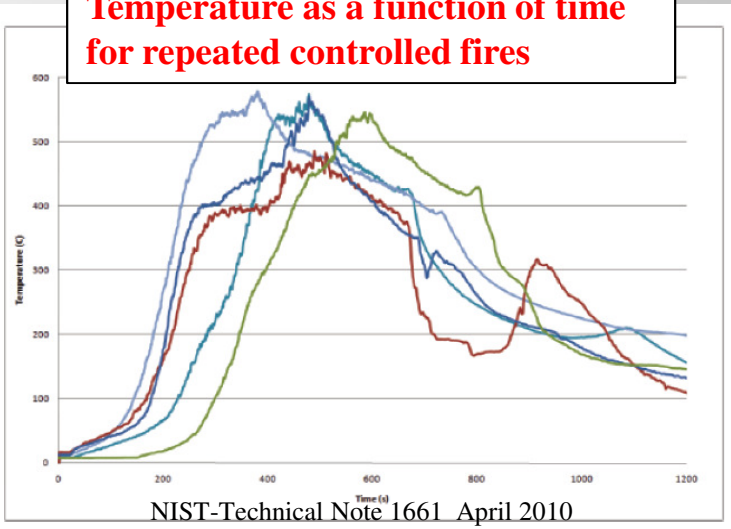


Tech Approach – Fire Spread & Variability



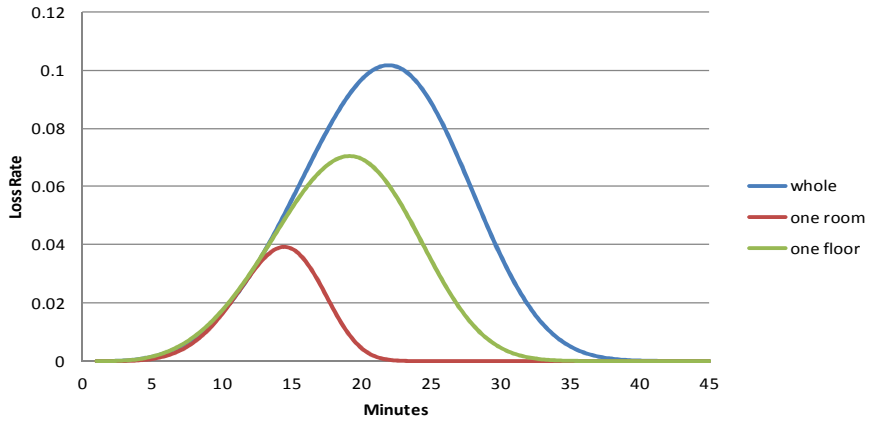
FEMA-TFRS Vol. 10, Issue 7. June 2010

Temperature as a function of time for repeated controlled fires

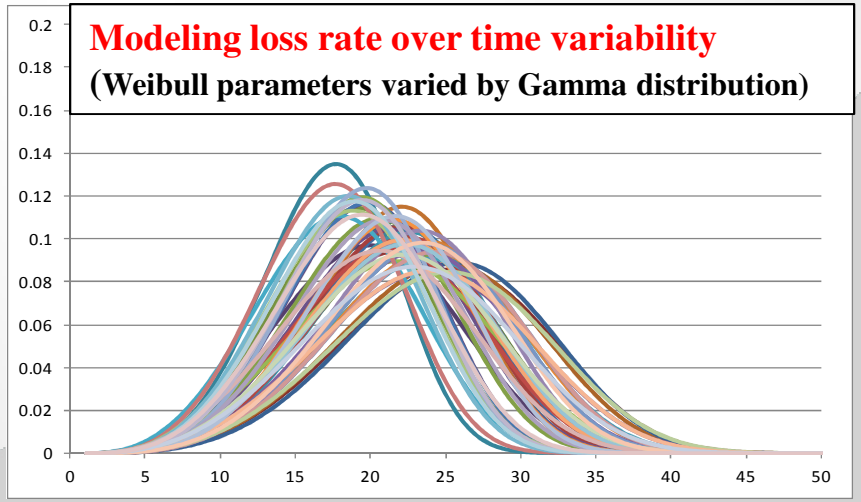


NIST-Technical Note 1661 April 2010

Examples of loss rates for various fire spread



Modeling loss rate over time variability
(Weibull parameters varied by Gamma distribution)



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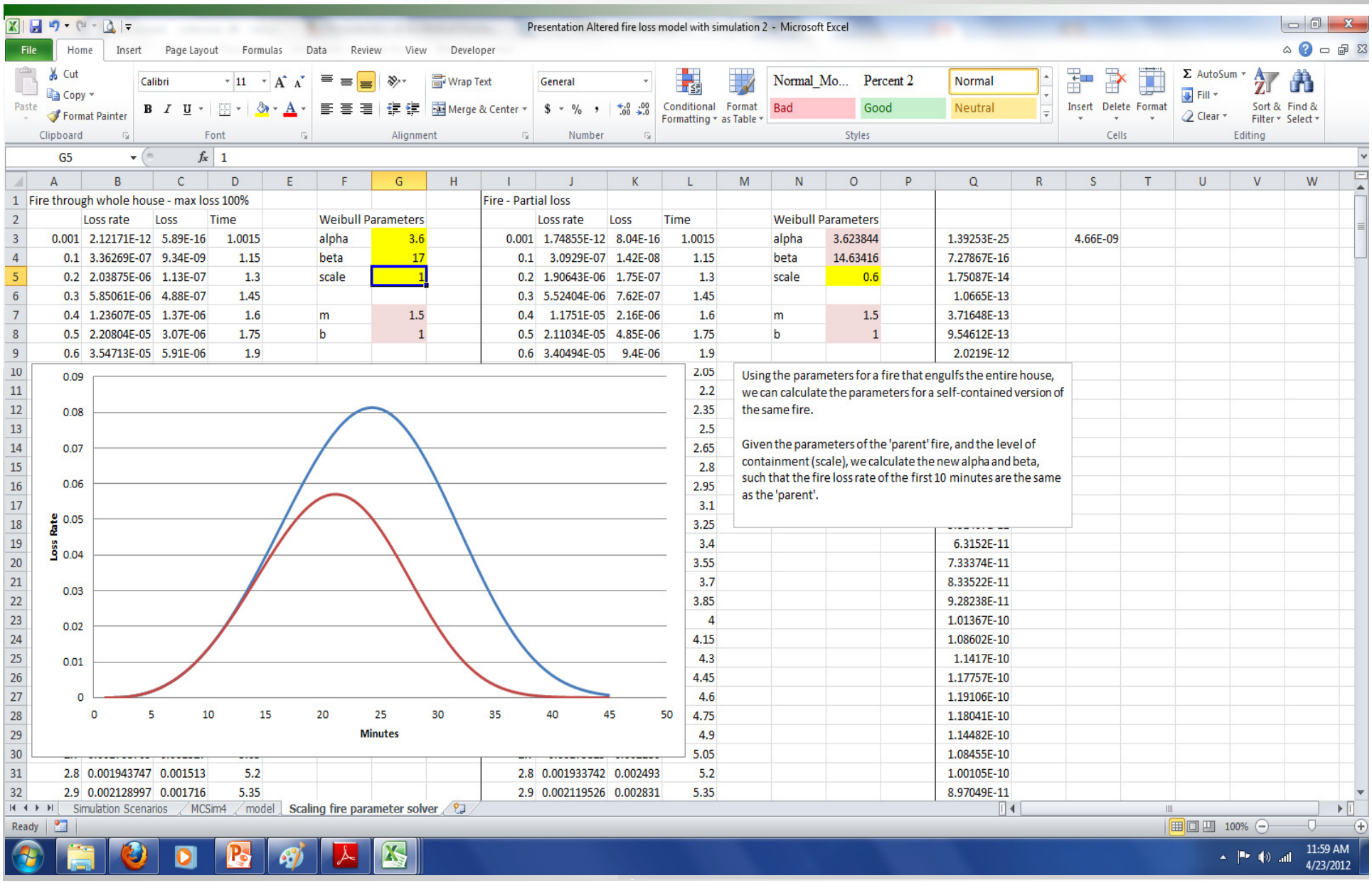
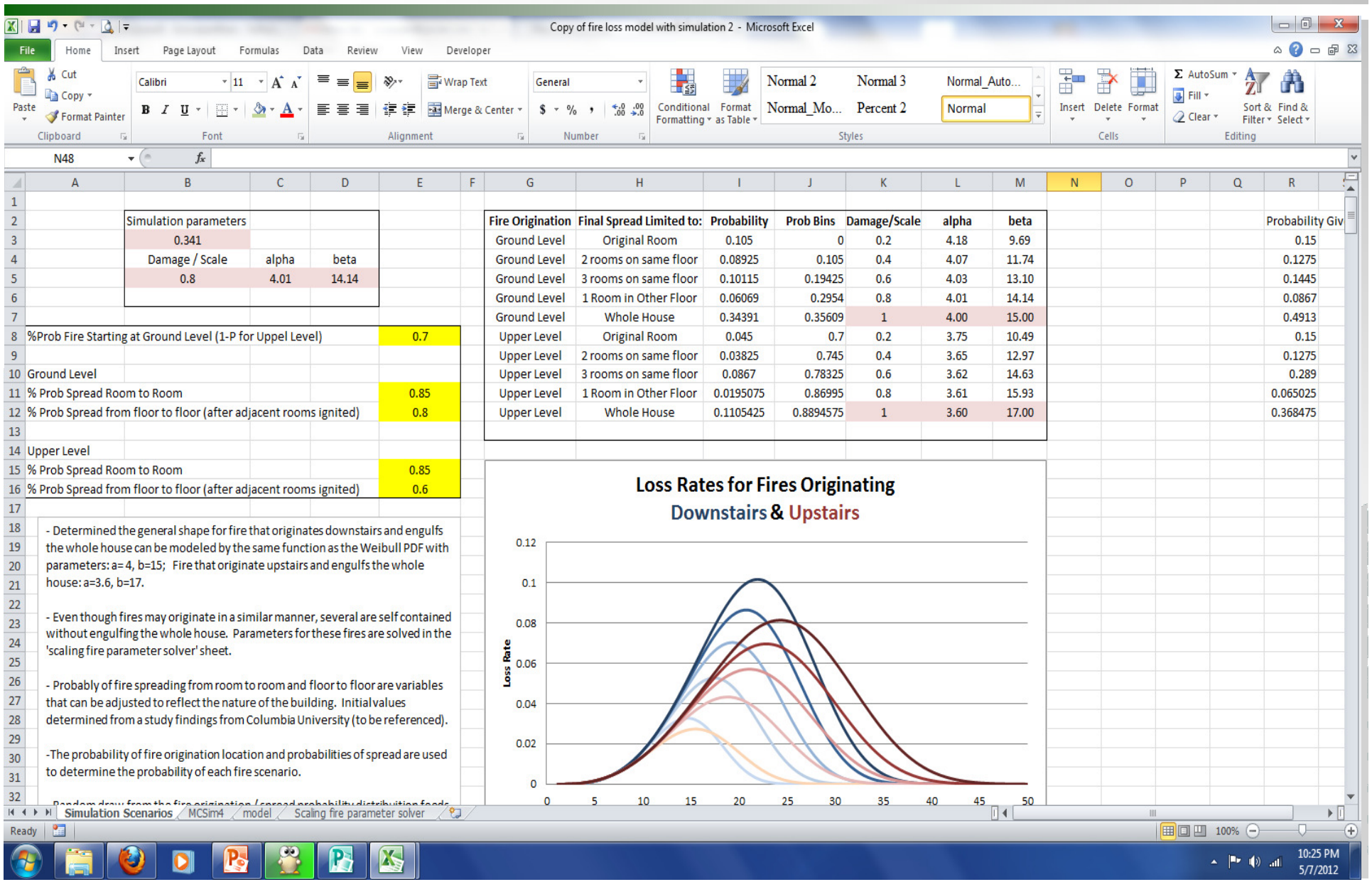
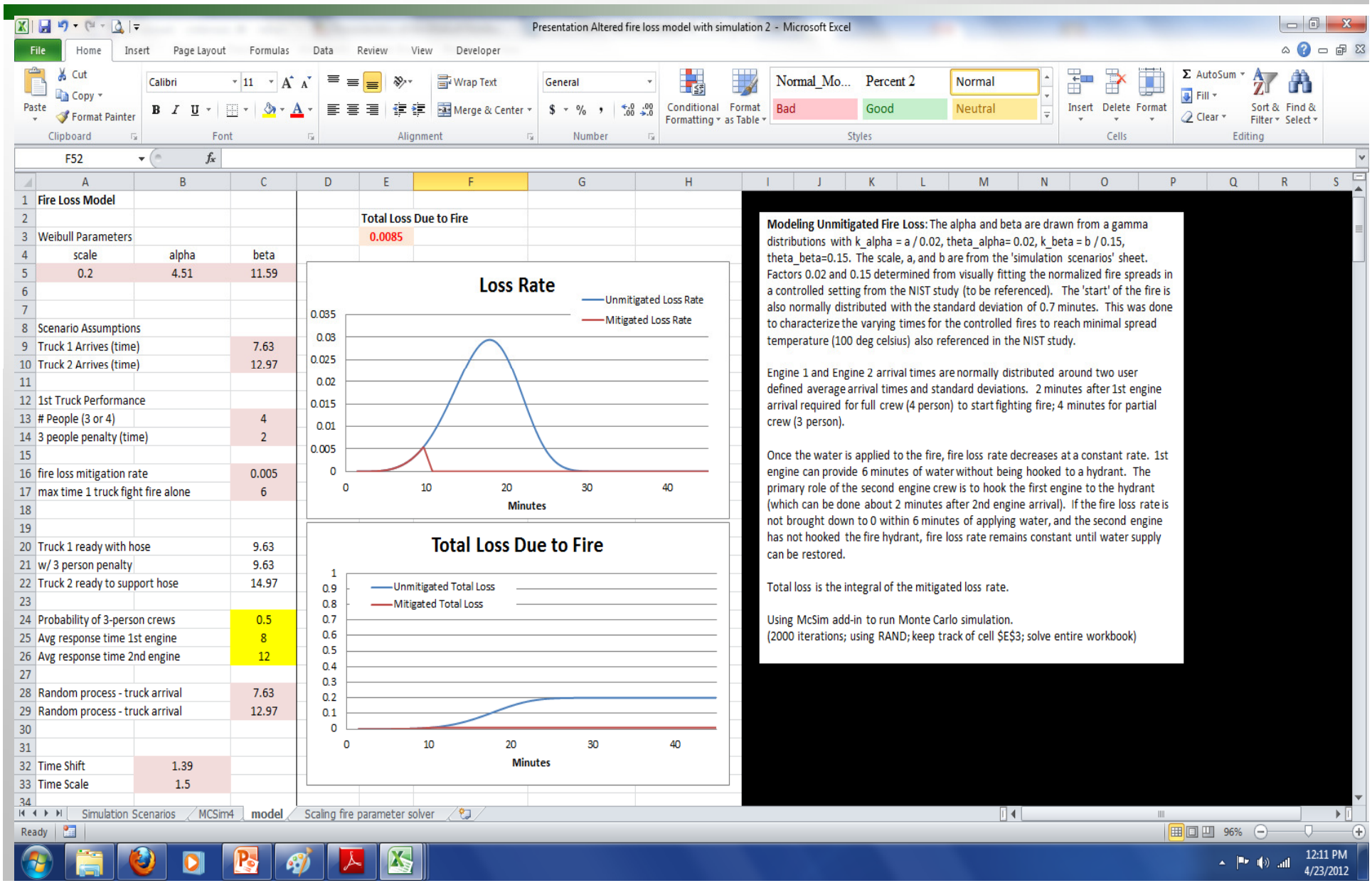
Technical Approach – Baseline Fire Types



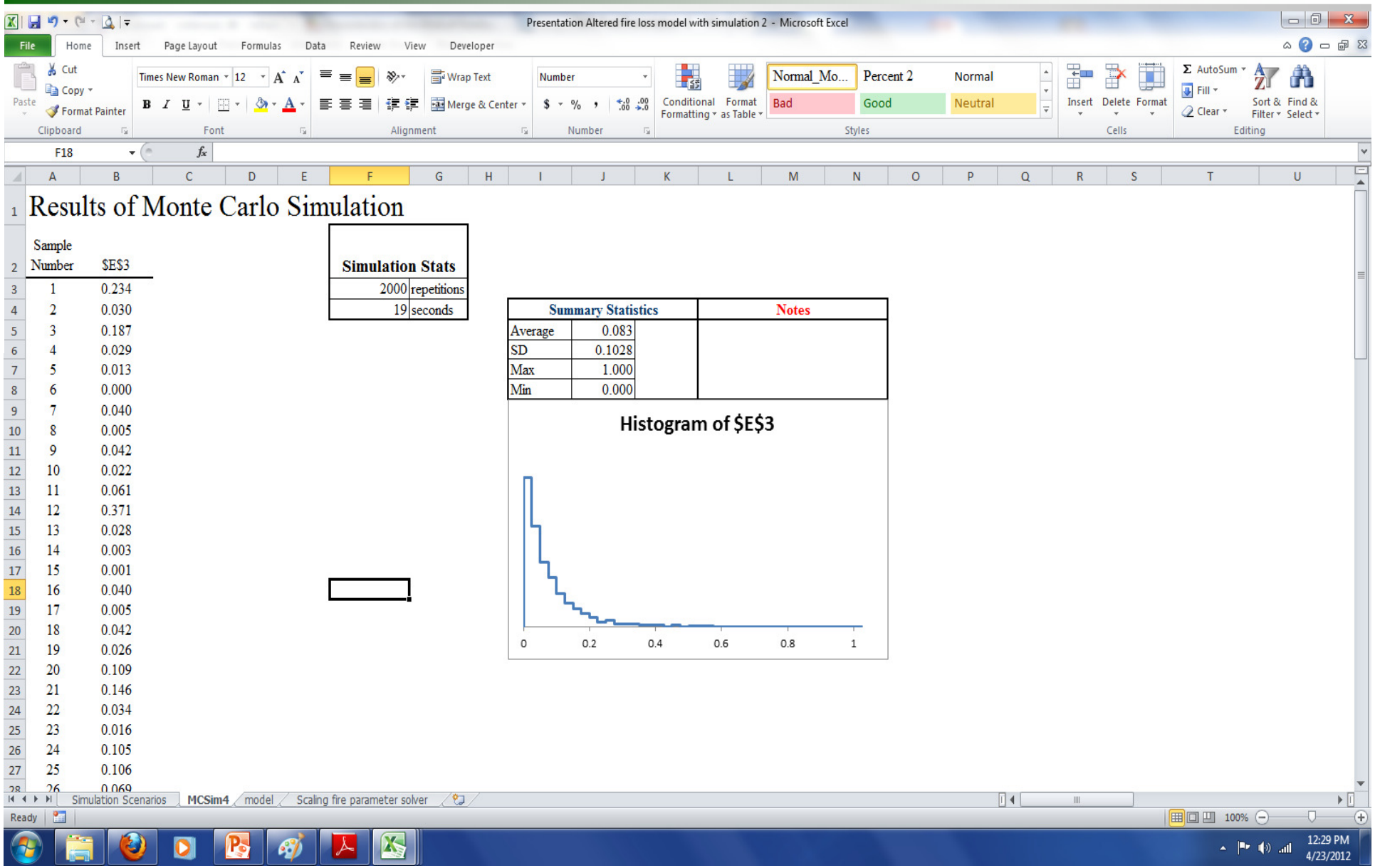
Technical Approach – Fire Spread Parameters



Technical Approach – Model Prototype



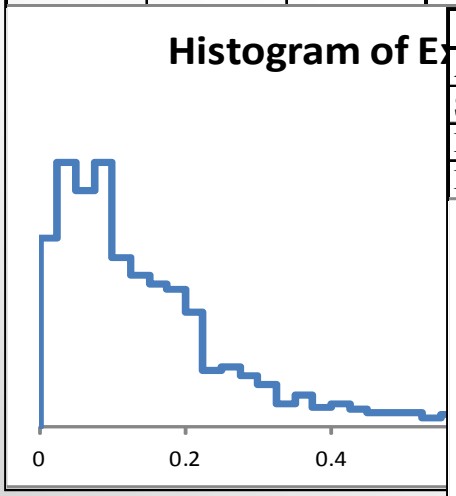
Technical Approach – Simulation



Evaluation – How to Use Tool

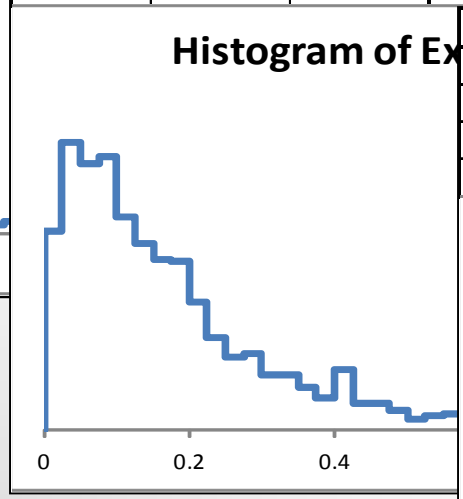
Summary Statistics	
Average	0.171
SD	0.1710
Max	1.000
Min	0.001

Notes
1st Engine Resp. Time: 10 min
2nd Engine Resp. Time: 15 min
% Small Crews: 40%



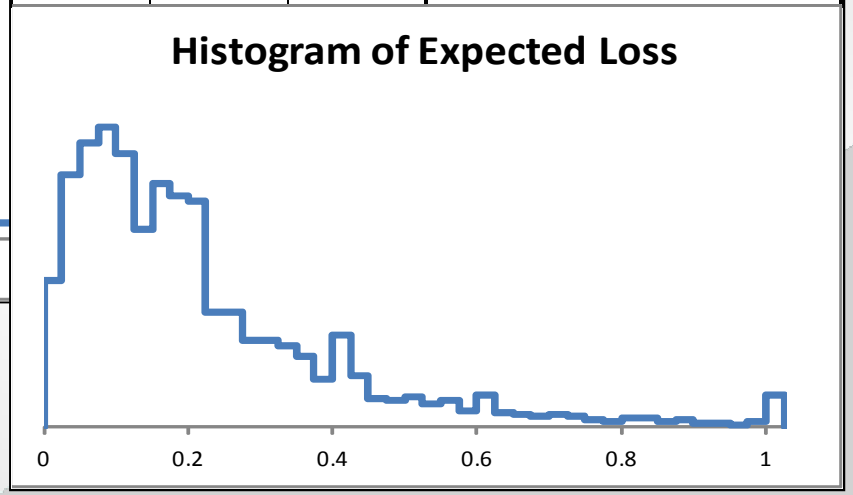
Summary Statistics	
Average	0.185
SD	0.1760
Max	1.000
Min	0.001

Notes
1st Engine Resp. Time: 10 min
2nd Engine Resp. Time: 15 min
% Small Crews: 60%



Summary Statistics	
Average	0.218
SD	0.1917
Max	1.000
Min	0.000

Notes
1st Engine Resp. Time: 11 min
2nd Engine Resp. Time: 16 min
% Small Crews: 40%



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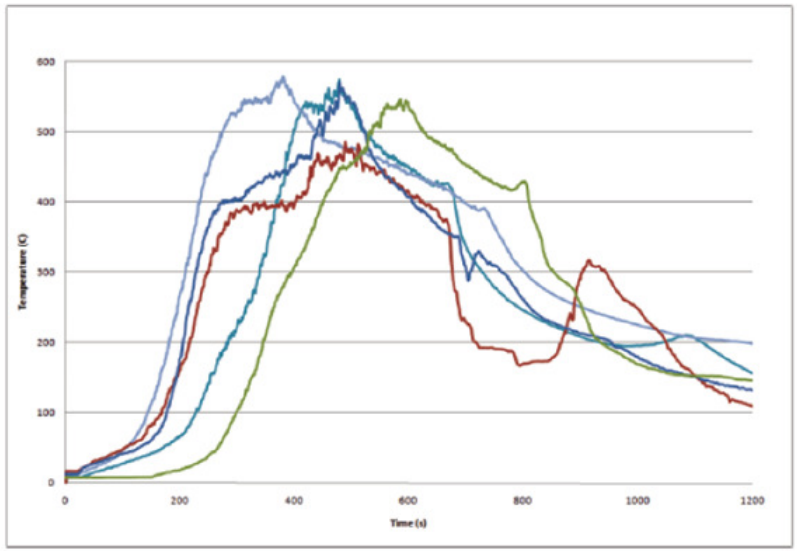
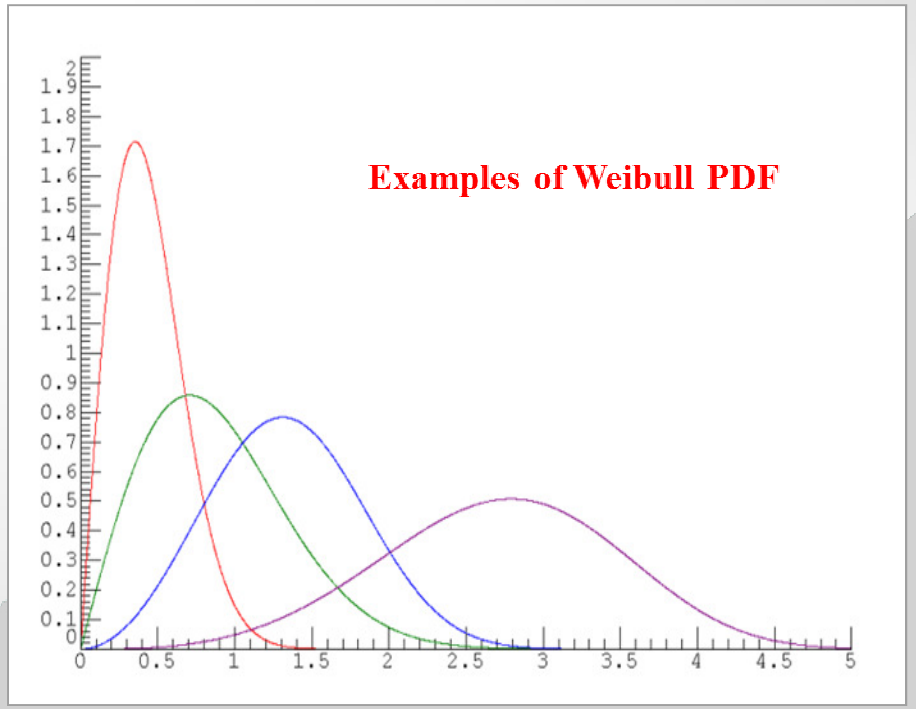
Evaluation – Model Assumptions

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

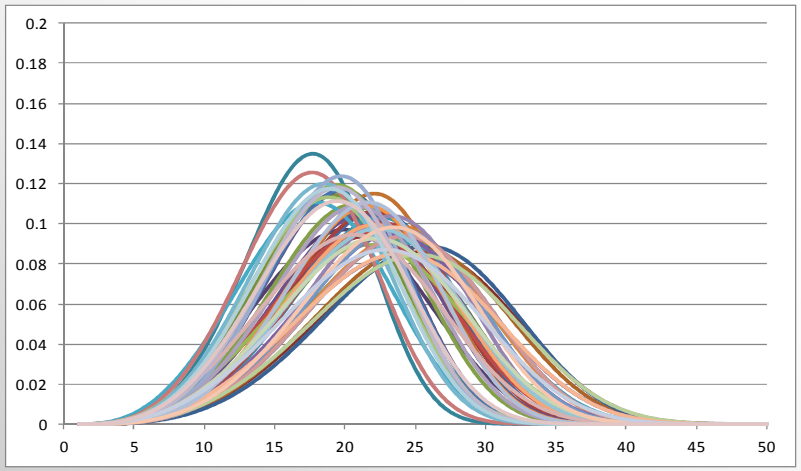
Temperature as a function of time for repeated controlled fires



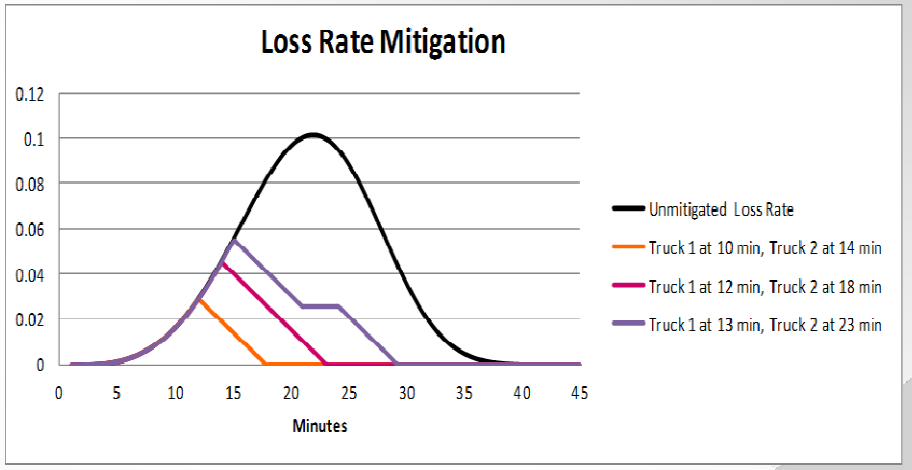


Evaluation – Model Assumptions

- 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

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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

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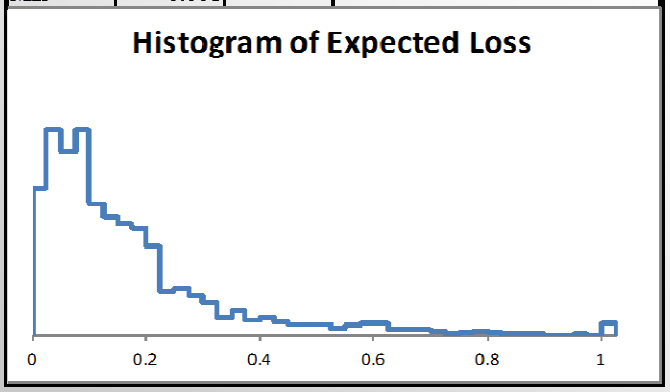
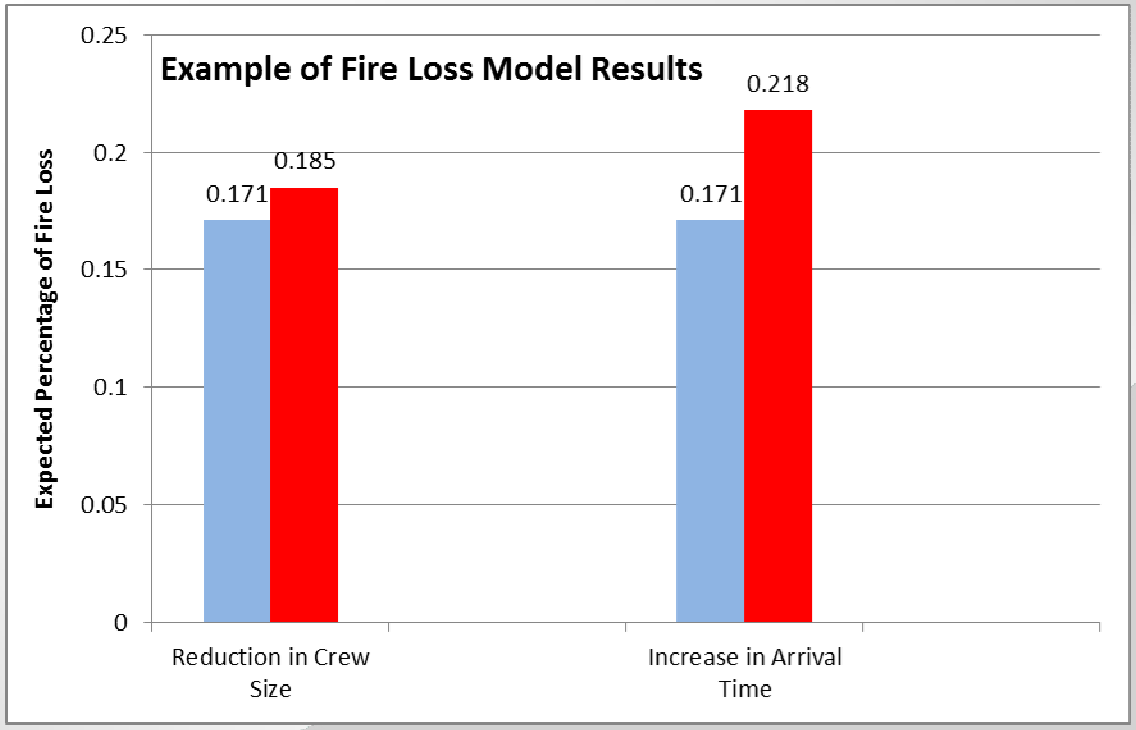
Evaluation – Analysis of Results

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

Summary Statistics		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	





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

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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.

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Acknowledgements

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- Mr. Fred Woodaman—Project Sponsor
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