BFRL GOAL--FIRE LOSS REDUCTION

REDUCED RISK OF Fire Spread Program

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NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

SOME U.S. STATISTICS

2005 (NFPA J.):

1,602,000 fires

511,000 in structures with 78 % in residences

3675 fire deaths

(3055 residential, 50 non-residential)

17,925 fire injuries

(13,825 in residences)

$10.7 billion in property losses

($9.2 B in structures, $6.9 B in residences)

OBJECTIVE

To develop effective strategies for cost-effectively reducing the Nation's fire losses (both human and financial) based on strategies for limiting fire growth and spread in and to residences. Two areas, reduction of the risk of flashover in residences and reduction in the probability of building ignition during urban/wildland interface fires, have been identified as targets providing opportunities for significant short-term reductions in fire losses. These efforts contribute directly to the BFRL Goal on *Fire Loss Reduction*.

FLASHOVER IMPLICATIONS

- Eliminating flashover could reduce U.S. fire deaths by 80% and injuries by 50%.
- Eliminating flashover could reduce direct U.S. fire property losses by 80%.
- Improved understanding of flashover will allow more effective testing and cut time-to-market for new products.
- Trade implications. Examples are ISO 9705 and European Single Burning Item (SBI) test.

Flashover

PRINCIPAL MEANS FOR LIMITING THE RATE OF HEAT RELEASE

Reducing the fire spread and growth rates is crucial

Passive

- Control fuels (e.g., wall linings and contents) and/or ventilation.

Active

- Early detection followed by manual intervention.
- Early detection followed by automatic suppression.

Wildland/Urban Interface Fires

- Frequency and severity of WUI fires is increasing.
- Factors: Increased construction in WUI areas, build up of wildland fuels, and a persistent draught in parts of the US. Addition of high winds creates very dangerous conditions.

- In October, 2003 a series of fires destroyed over 3,300 dwellings in Southern California with a loss exceeding $2,000,000,000.

- Understanding of these fire is limited. Subject falls between traditional studies of building and wildland fires.

FY07 STRS Projects

REDUCED RISK OF FLASHOVER IN RESIDENCES

Detection (1)

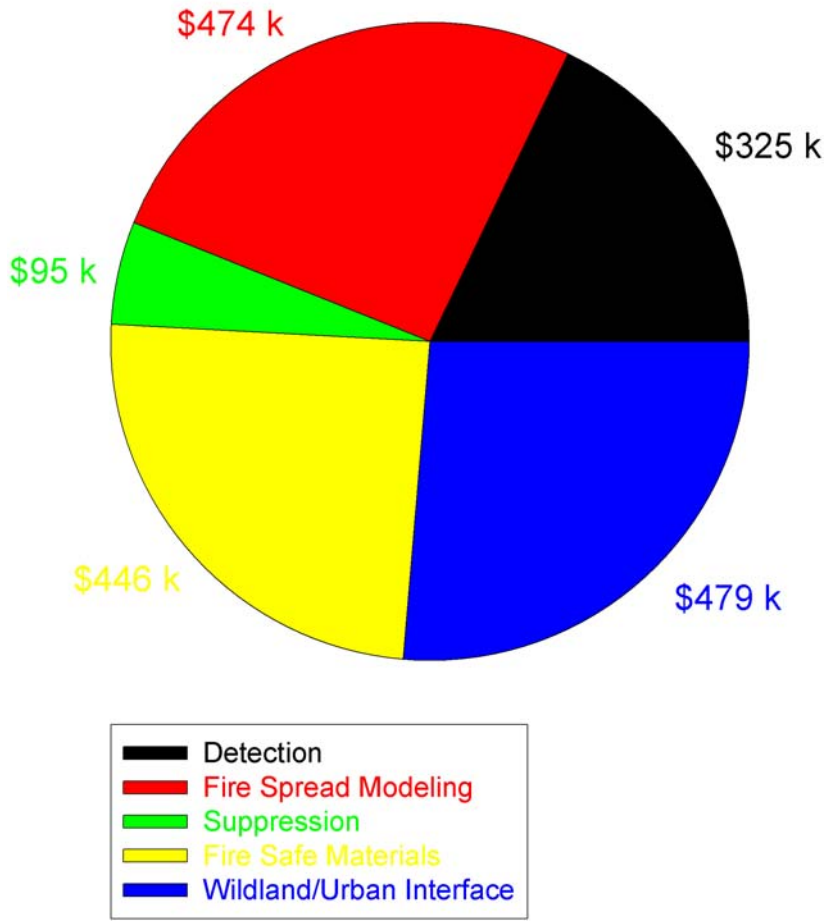
Suppression (2)

Fire Safe Materials (3)

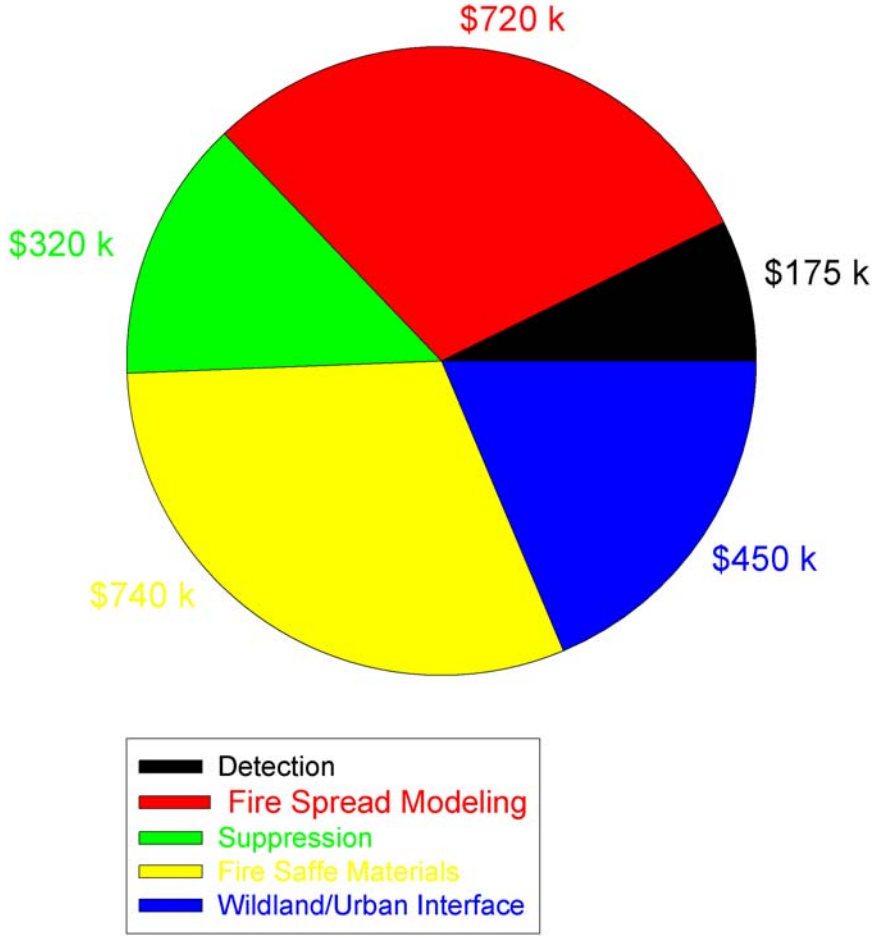
Fire Growth and Spread Model (4)

URBAN/WILDLAND INTERFACE FIRES (1)

FY05 Funding Profile
Total Funding: $1819 k



FY07 Funding Profile
Total Funding: $2410 k



Summary Table: Reduced Risk of Fire Spread Program

Project Title	PI	FY 2007 Allocation
Fault-Free Detection Test Methods and Standards	Cleary	175
Fire Suppression Test Method Development	Madrzykowski Hamins	137.9 97.1
Sprinkler Decision Tool For Communities	Brown	90
Fire Retarded Polyurethane Foam Flammability	Gilman	235
Nanoadditive Flame Retardants for Polyurethane Foam	Gilman	305
High Performance Barrier Materials for Mattresses and Furniture	Gilman	200
Fire Growth and Spread on Thermoplastic Objects	Ohlemiller	225
Modeling Melt Flow using Particle Methods	Butler	100
Fire Growth and Spread on Real Objects	Pitts Nyden	110 85
Mass Pyrolysis and Degradation of Flammable Objects	Prasad	200
Community Fire Spread	Mell	450
Total		**2410**

Fault-Free Detection Test Methods and Standards

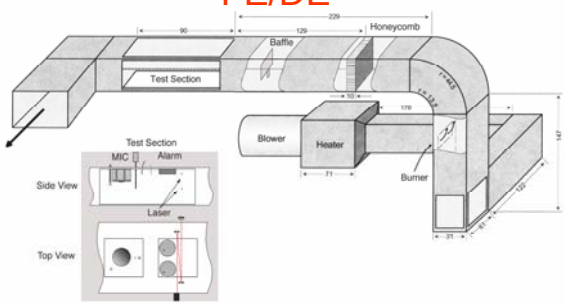
PI: Thomas Cleary

Objectives

1) To develop new test procedures to simulate realistic early fire conditions and common nuisance sources, which are capable of discriminating between existing fire alarm technologies.
2) To work with Codes and Standards organizations to encourage adoption of standards based on the enhanced testing capabilities by 2008.

Characterizing fire sources in the small room

Reproducing fire sources in the fire emulator/detector evaluator FE/DE



Smoldering, flaming and thermal degradation smoke sources were examined in the small test room. Gas species, temperature, smoke extinction and smoke concentration and size distribution data were gathered. The data extends recent work by UL to characterize smokes from materials used in a range of residential products.

Reproducing the early fire/smoke signatures in the FE/DE will allow for testing of fire alarm technologies to a wide range of early fire conditions.

FIRE SUPPRESSION TEST METHOD DEVELOPMENT

Principal Investigators: Dan Madrzykowski, Anthony Hamins

Objective: To develop a test method to examine the performance of automatic fire suppression and control systems for kitchen stovetop residential applications.

Funding Level: $232 k STRS; $120 k USFA

Approach:

- Develop an understanding of the kitchen fire problem and stakeholder's needs
- Examine the fire suppression performance of current technologies in stovetop experiments
- Based on experimental results, provide recommendations toward an improved test method
- Participate in appropriate standards organizations

Recent Highlights:

- NIST SP 1066 - *Residential Fire Suppression Research Needs: Workshop Proceedings*
- Experiments incorporating aspects of UL300A, are underway. Both "listed" and proto-type systems are being used in the experiments.
- A variety of various suppression technologies are being examined including a residential sprinkler, water mist, self-contained dry and wet chemical systems and dry and wet chemical hand held extinguishers.

Acknowledgement: To the U.S. CPSC for their partnership on this project.

Sprinkler Decision Tool For Communities

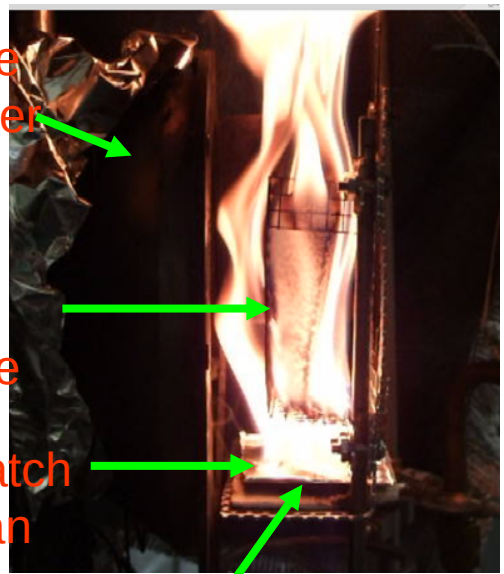
Investigators: *Hayden Brown & Priya Lavappa*

Objective: *to develop a community-centered economic benefit-cost model, enabling decision makers to assess the benefits and costs of community-wide fire sprinkler installation.*

- Funding: $90K
- FY07 Major Milestone: Identify parameters and develop the community-focused benefit-cost model using selected user-input variables.
- FY07 Deliverables: Benefit cost model and software requirements document.
- Recent highlights: the magnitude of benefits to the community depends upon the probability of fire in the community, which can be affected by geography, such as proximity to the wildland- urban interface.

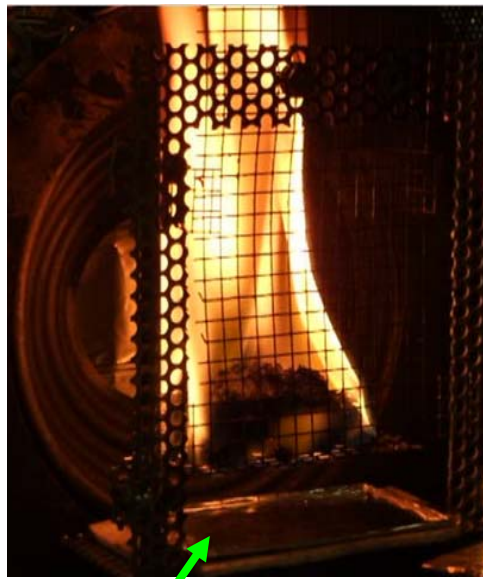
Nanoadditive Flame Retardants for Polyurethane Foam

BFRL GOAL: Fire Loss Reduction
BFRL PROGRAM: Reduced Risk of Fire Spread
Principal Investigator: Jeffrey Gilman, Co-Investigators: Tom Ohlemiller, Richard Harris, J. Randy Shields, Mauro Zammarano (GR), Roland Krämer (GR)
Funding: $235K (866-5013)
Objective: To evaluate the effectiveness of nanoadditive based flame retardants in reducing the flammability of flexible foams used in furniture
Accomplishments: Developed methods to control viscosity to allow foaming with nano additives. Designed and purchased automated liquid handling apparatus. Found Carbon Nano-fibers in foam prevent the formation of pool fire.



Pool-fire

(PU FR-foam control)



PU FR-foam + 4% Carbon Nano-Fibers: no Pool-fire

Milestones:

- 6/06 Specified and purchased automated liquid handling apparatus.
- 7/06 Evaluated processing conditions and Tign/flux and HRR for POSS in foam.
- 1/07 Evaluated processing conditions and Tign/flux and HRR for LDH and CNT in foam
- 8/07 Scale-up foam and evaluate flame spread properties.
- 1/08 Scale-up CNT foam and evaluate flame spread properties
- 8/08 Final report with recommended nanoadditive/CFR systems for foam.

Fire Retarded Polyurethane Foam Flammability

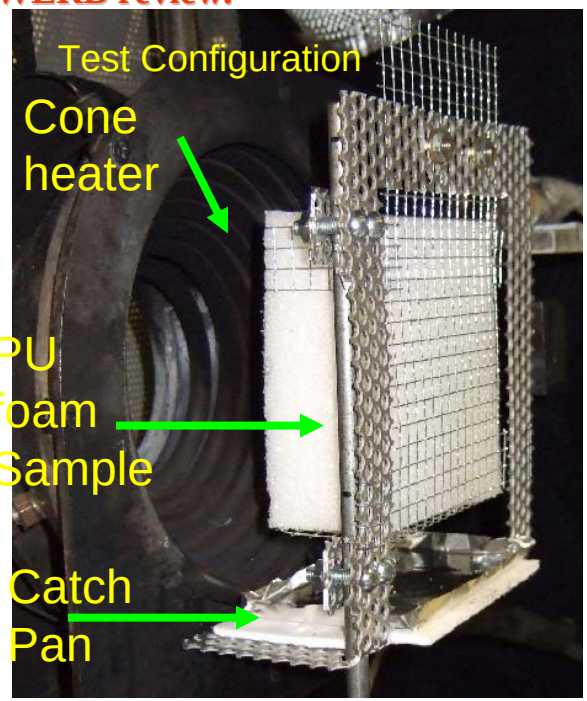
BFRL GOAL: Fire Loss Reduction

BFRL PROGRAM: Reduced Risk of Fire Spread**Principal Investigator: Jeffrey Gilman, Co-Investigators: Tom Ohlemiller, Richard Harris, J. Randy Shields, Mauro Zammarano, Roland Krämer**

Funds:$300 k (866-5237)

Objective: The objectives are to develop high throughput flammability measurement methods for fire safe foams, to further study the flammability characteristics of PU foams, and to provide input data to the fire growth modeling efforts in 866-5234.

Accomplishments: New small and medium scale tests developed for screening the heat release and dripping of melt during foam combustion. Added 2 new members to Consortium (Air Products, Barrier Dynamics, Bayer Material Science, Boeing, Dow, Foamex, Multina, Sasol, So. Clay Products), Report on foam flammability in WERB review.



Milestones:

- 11/05 Completed first stage of work with CPSC.
- 05/06 Acquire more complete set of foams from consortium members.
- 08/06 Completed spectrum of bench-scale flammability tests of foams.
- 11/06 Completed work with CPSC on furniture flammability.
- 03/07 Delivered preliminary database on foam flammability and report to WERB
- 04/07 Completed initial radiant panel/cone feeder flammability testing.
- 12/07 Deliver final database on foam flammability.
- 5/08 Complete final report

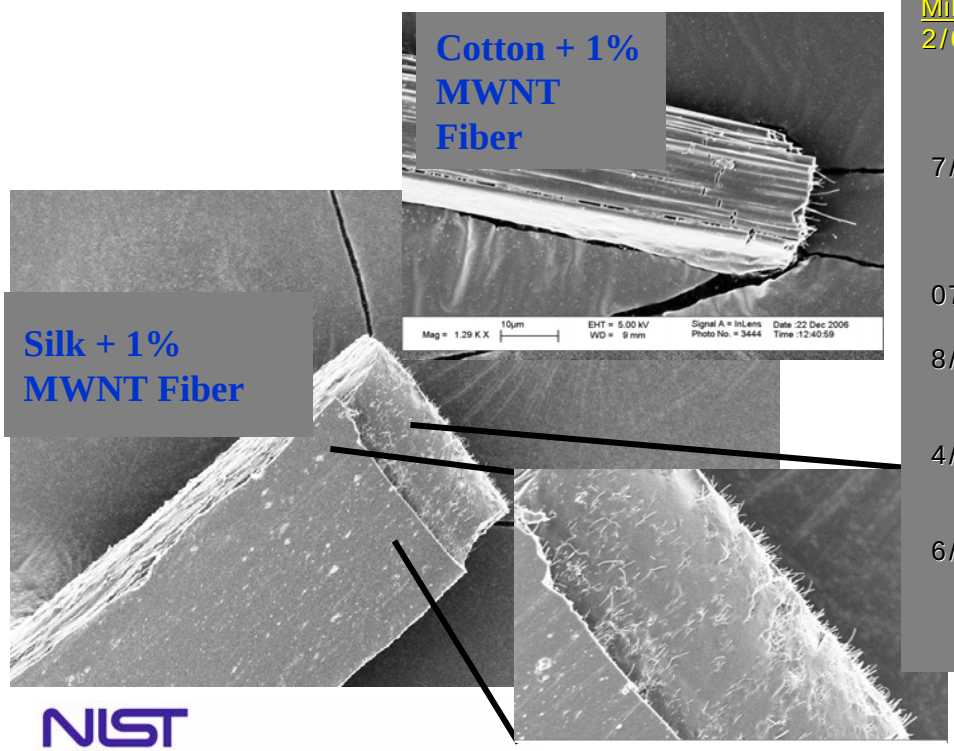
High Performance Barrier Materials for Mattresses and Furniture

BFRL GOAL: Fire Loss Reduction
BFRL PROGRAM: Reduced Risk of Fire Spread
Principal Investigator: Jeffrey Gilman, Co-Investigator(s): Tom Ohlemiller, Richard Harris, J. Randy Shields, Sameer Rahatekar (GR) Prof. Satish Kumar (grantee –Ga Tech)

Funding: $200 k STRS

Objective: To improve the ability of barrier fabrics to prevent flame spread in mattresses and furniture

Accomplishments: Prepared cotton and silk carbon nanotube composite fibers using wet spinning and green solvents (ionic liquids).



Milestones:

2/07 – evaluated image analysis of digital images taken during RG, or after burning (in radiant panel and Cone) as a method of evaluating shrinkage and cracking behavior using current PAN barrier materials.

7/07 – construct apparatus and evaluate flame sweep test over small samples, using TB603 burner as a method of evaluating shrinkage and cracking behavior using current barrier materials.

07/07 - prepare PAN, and novoloid PCNs using twin-screw extruder and electro-spinning .

8/07 - evaluate PAN PCNs flammability and char shrinkage behavior in RG apparatus, radiant panel, flame sweep, or Cone tests.

4/08 - evaluate novoloid PCNs flammability and char shrinkage behavior in RGA, radiant panel and Cone tests.

6/09 - evaluate promising PCN fabrics for effectiveness in medium scale furniture and mattress mock-up flammability tests.

Fire Growth on Thermoplastic Objects

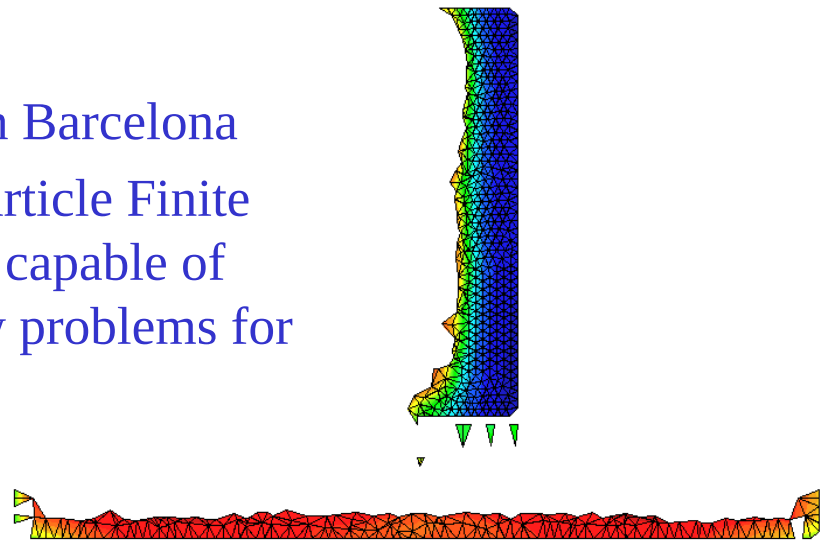
PI: Tom Ohlemiller

- Objective: A combination of models and test methods that clarify & quantify the role of polymer melt flow in fire growth, particularly for polyurethane foam-based objects
- Funding: $225K
- FY 07 Milestones focus on choice between two modeling approaches for the condensed phase and on verifying a medium-scale test method for polyurethane foam
- Recent results have demonstrated that melt flow can have a widely varying role in fire growth, depending on its properties and on the physical set-up.

Modeling Melt Flow Using Particle Methods

PI: Kathy Butler

- **Funding Level:** $100 k
- **Objective:** To determine whether new computational techniques, specifically designed to model large shape changes, are capable of modeling objects that melt and drip in a fire
- **Milestones:**
  - 5/07 Complete visit to CIMNE in Barcelona
  - 7/07 Demonstrate whether the Particle Finite Element Method (PFEM) is capable of efficiently solving melt flow problems for thermoplastic objects in fire
  - 9/07 Complete report



- **Progress:**
  - Flow for three steady heat fluxes
  - Gasification added and verified
  - Dripping into catch pan with mass conservation
  - Demonstration of 3D capability

Fire Growth and Spread on Real Objects

CO-PIs: William M. Pitts and Marc Nyden

FY 07 Funding: $195 k

Objective: Provide validated submodels for incorporation into the Fire Dynamics Simulator that predict fire growth and spread on a single object and remote ignition of a second object by a nearby burning item.

FY 07 Milestone: Complete expanded sets of fire spread experiments on polyurethane.

FY 07 Milestone: Compare global HRRs obtained from the model to experimental values for horizontal flame spread on wallboard and polyurethane.

Flame Spread on Wallboard

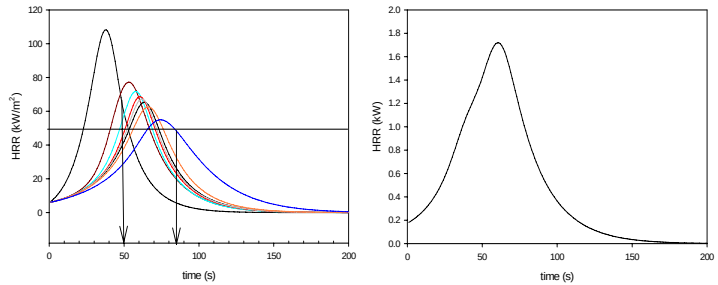
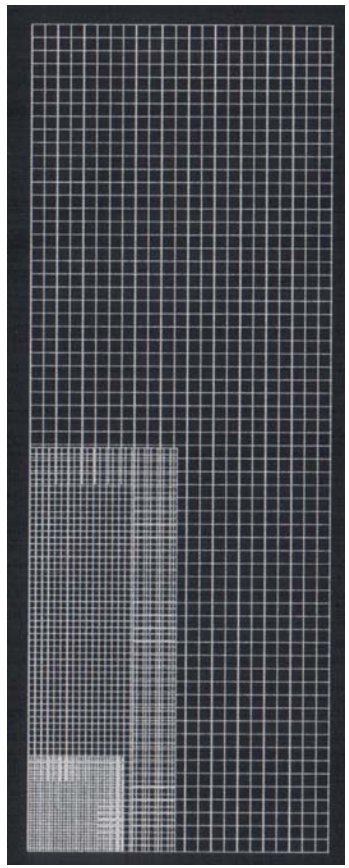


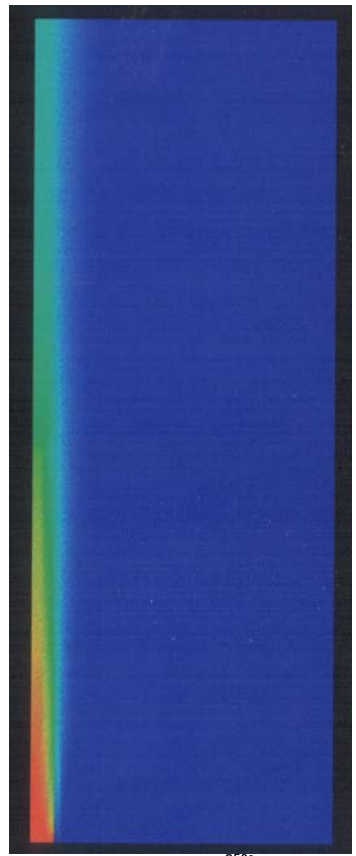
Figure 4. Heat release rate curves from the individual burning regions (right) and global heat release rate or fire growth curve for a 0.23 m x 0.13 m piece of wallboard.

Mass Pyrolysis and Degradation of Flammable Objects

PI: Kuldeep Prasad
FY 07 Funding: $200 k

- Simplified modeling of condensed phase (thermoplastics) materials.
- Use of multiblock methods for gas phase as well as condensed phase.
- Analysis and modeling of experiments on full scale structures under fire loading (China).





Community Fire Spread

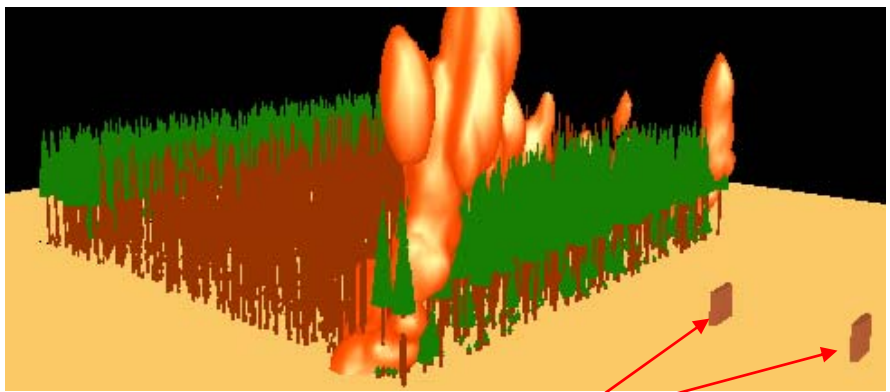
Objective: Develop tools that assess and predict the risk of communities and structures to wildland-urban interface fires.

FY07 allocation: $930 K

Current Major Milestones:

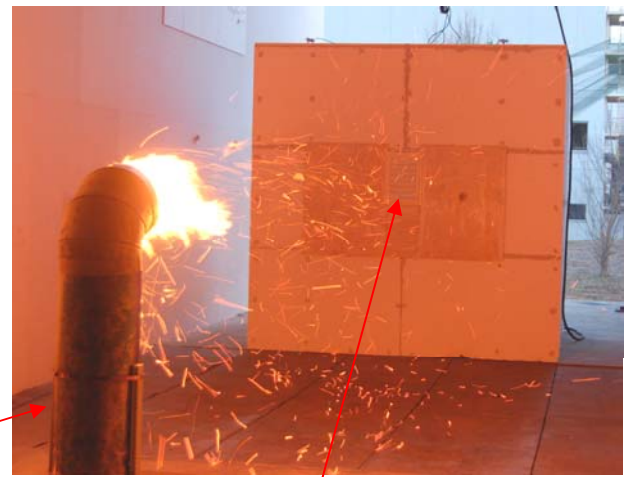
1. First stage of experiments on structural ignition via firebrands (NIST, BRI, Waterloo)
2. First stage of computer models for fire spread over complex terrain and firebrand transport.

WFDS case of International Crown Fire experiment



mock structures

Structural Ignition - Firebrand Penetration Through Vents



Unique NIST Firebrand Generator

Vent