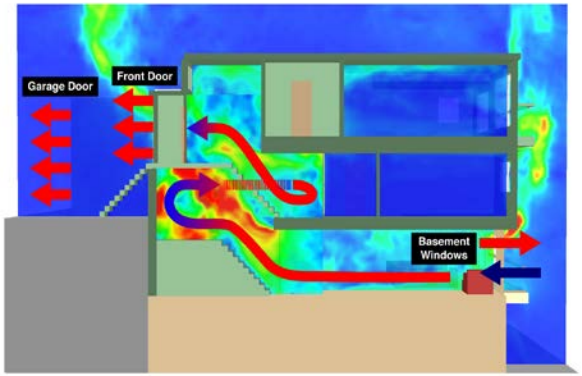
Update on Fire Research at NIST



Nelson Bryner
Fire Research Division
Engineering Laboratory

Federal Fire Working Group
November 5, 2015

Overview

- Update on Fire Research at NIST
  - Flow Path Related LoDDs -
  - Wind-driven fire studies -

- Updating Other Fire Events
  - Fire Chiefs White House Roundtable on Climate Change and Impact on WUI (11/9)
  - National Fire Service Research Needs Symposium (11/16-19)
  - Single Vision for First Responders – IAB, DHS, DOJ, NIOSH, & NIST (ongoing)
  - Next Gen Wildland Fire Fighter Shelter- NFPA, US Forest Service, DHS, & North Carolina State (ongoing)

Recent Flow Path related LoDDs

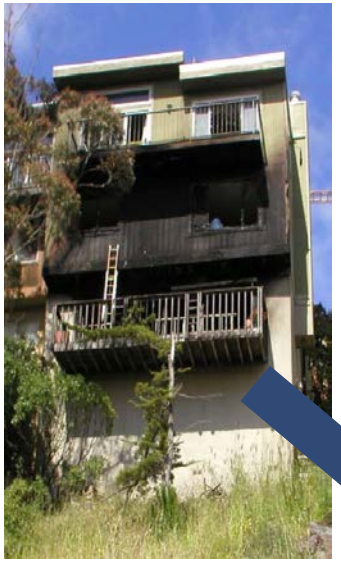
NIOSH Report No.	No. of LODDs/LODIs	Flow Path Details	
99-F01	3 LODDs	From apartment into hallway on 10th floor of high-rise apartment building	
99-F21	2 LODDs 2 LODIs	Basement to 1st floor	Washington DC, 1999
F2000-04	3 LODDs 3 civilian deaths	1st floor to 2nd floor	Keokuk, 1999
F2000-16	1 LODD 1 LODI 1 civilian death	2nd floor hallway through 2nd floor apartment	
F2000-23	1 LODD 2 LODIs	From ground level to 1st floor then to 2nd floor, flow exited through ceiling	
F2000-43	1 serious LODI 2 other LODIs	1st floor to 2nd floor	
F2004-02	1 LODD	1st floor to basement	
F2005-02	1 LODD 4 LODIs	Rear to front of the building	
F2005-04	1 LODD 9 LODIs	Basement to 1st floor	
F2007-09	1 LODD 2 LODIs	3 story training burn - flow through all levels	
F2007-35	4 LODIs	1st floor to 2nd floor	
F2009-11	2 LODDs	Rear to front of the building	Houston, 2009
F2011-13	2 LODDs	Lower level up stairs and through entry door and garage	San Francisco, 2011
F2011-31	1 LODD	Fire extended from lower level apartment	
F2012-28	1 LODD 1 LODI	Attic fire extended into closed porch and then into 2nd floor	Chicago, 2012

NIST's Fire Dynamics Simulator (FDS)

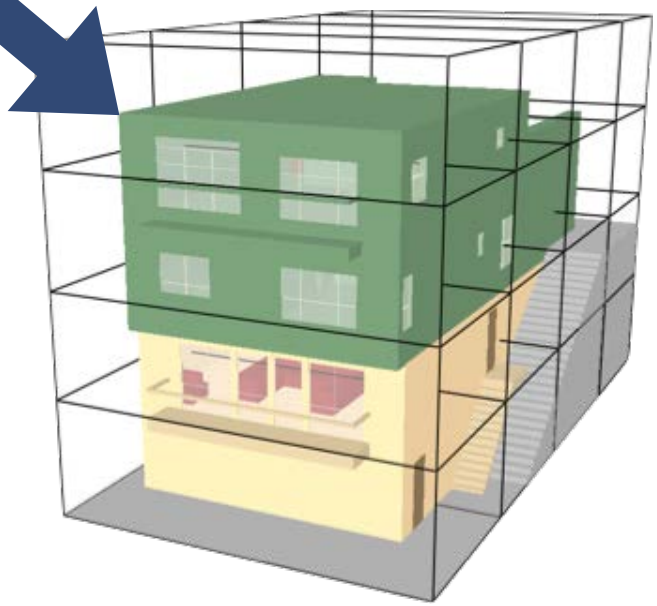
- Computational fluid dynamics software that is designed to transport heat and smoke from fire
- Open-source code that is rigorously verified (nightly) and validated (for every minor release)
- Available here:
  - http://firemodels.github.io/fds-smv/

Important Scenario Parameters

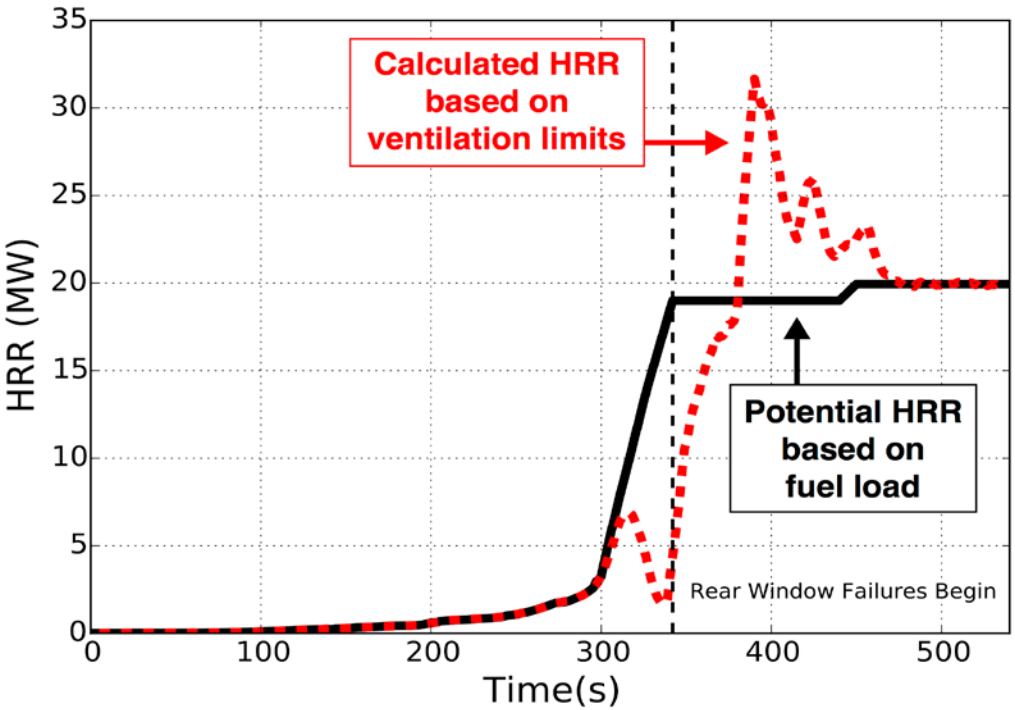
- Building geometry and relevant compartments
- Interior and exterior ventilation openings
- Documentation of fire dama (photographs)
- Detailed timeline
- Relevant weather



Post incident image from San Francisco to FDS model of structure.

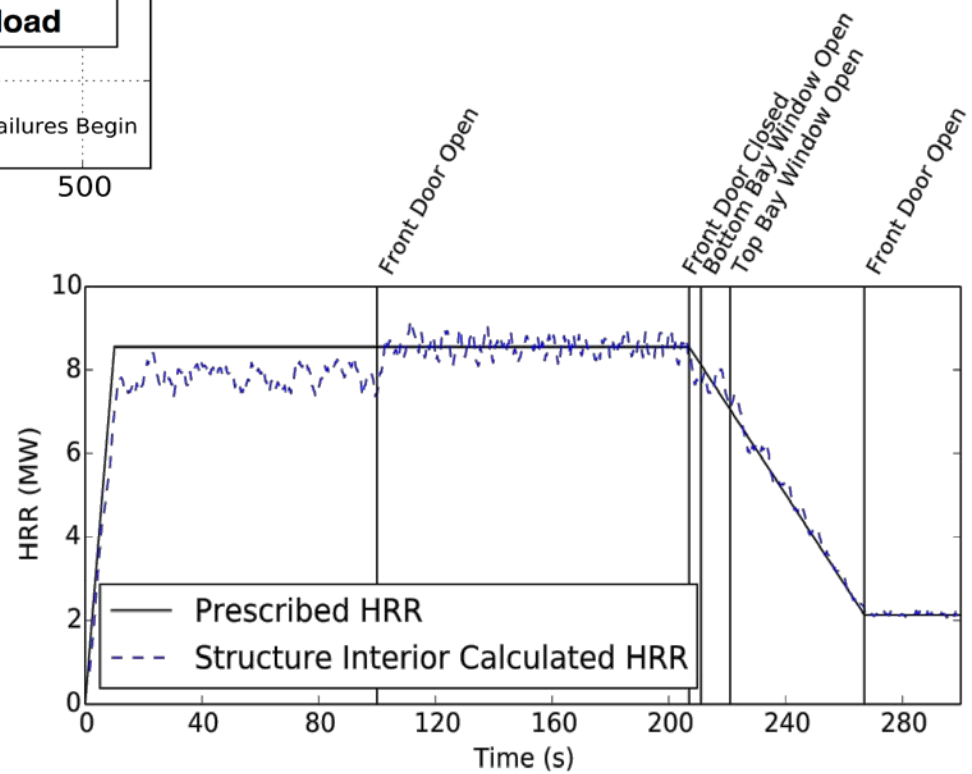


Simulated Fire Development

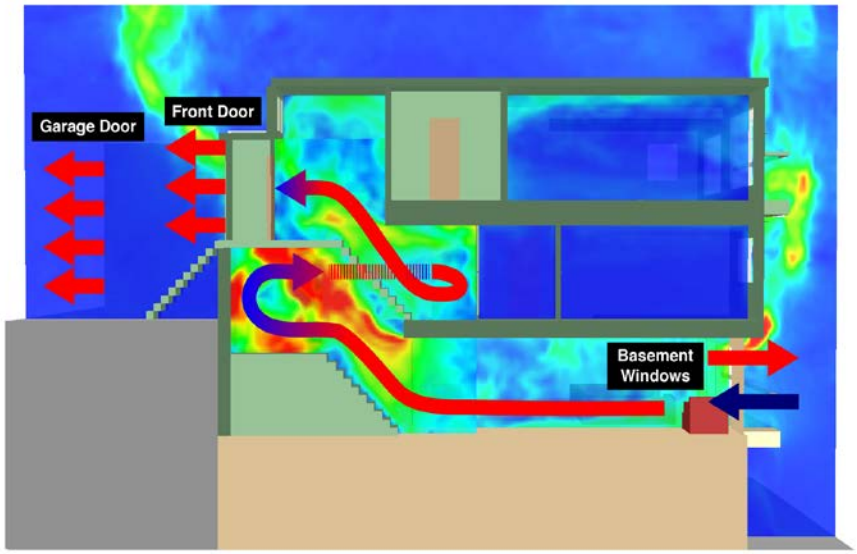


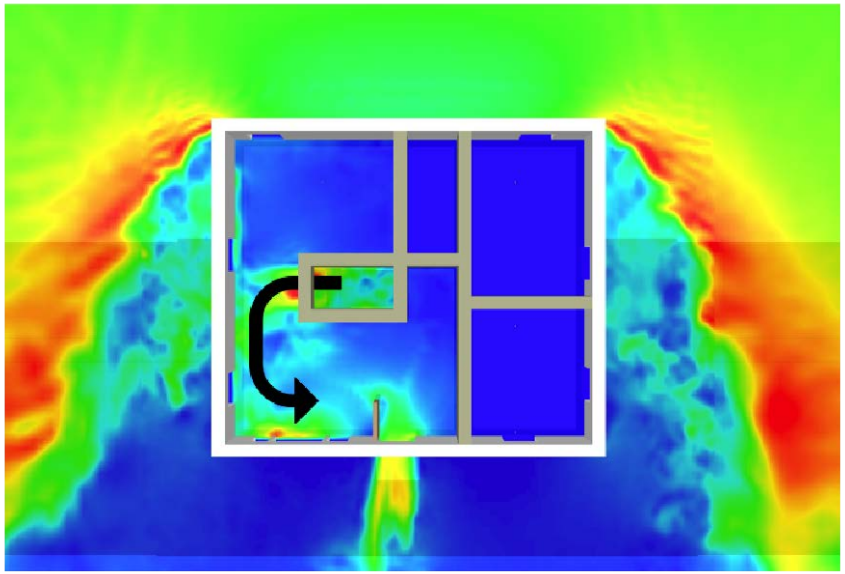
Fire was under-ventilated until basement windows failed – then rapid fire growth

Interior HRR below prescribed indicated burning through basement vent to exterior.

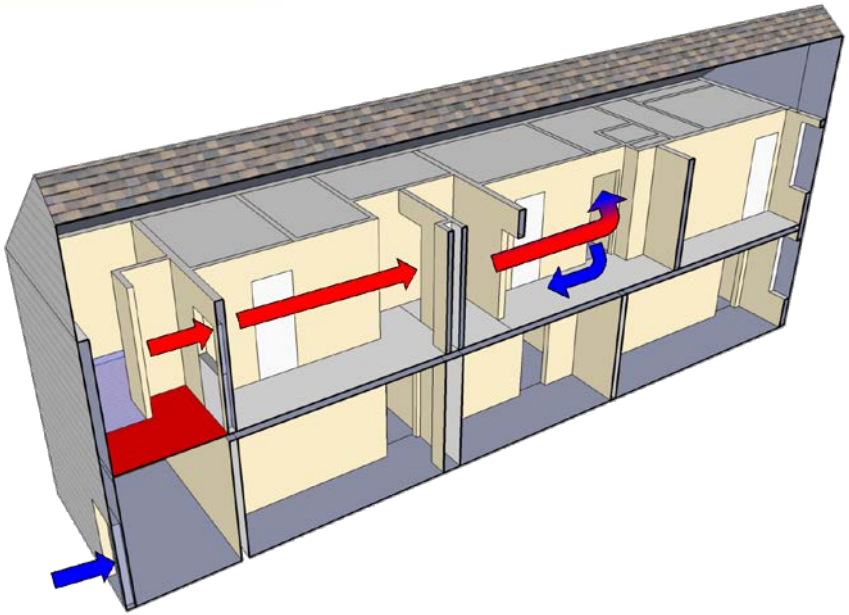


Structure Flow Path

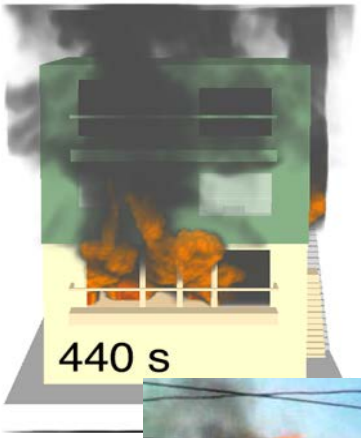




Clockwise from top:
San Francisco, CA
PG County, MD
Chicago, IL

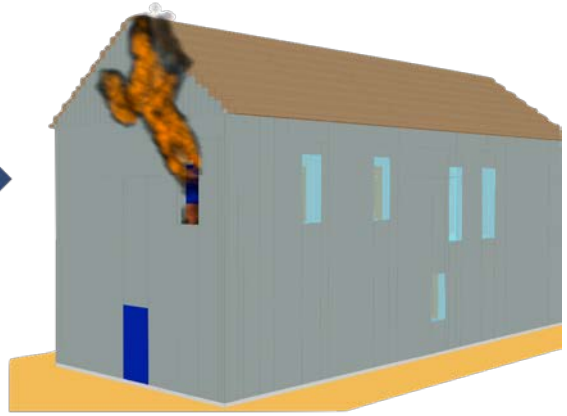


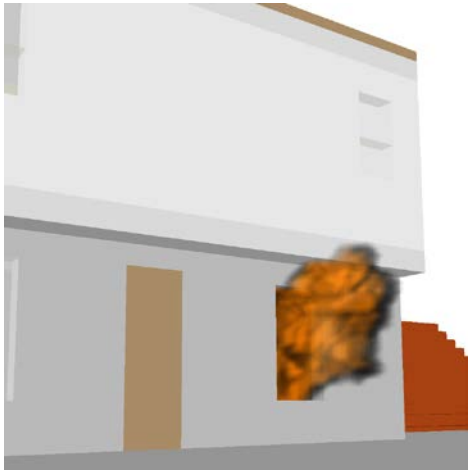
Matching Model to Incident



San Francisco, CA

Chicago, IL





PG County, MD

Summary - Flow Path Related LoDDs

- A change/development of a flow path can lead to rapid, high hazard changes to the fireground - leaving firefighters little time to react

- Increased understanding of fire dynamics, boundary conditions, tactics can provide firefighters the best chance for success

Wind Driven Firebrands

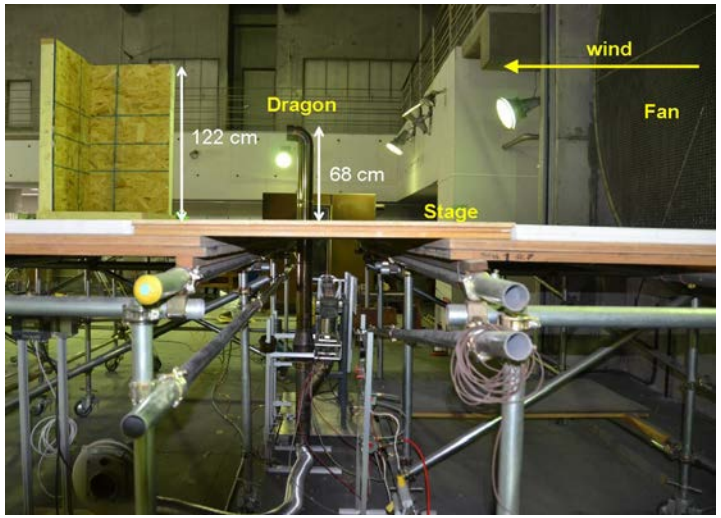
- Firebrands major cause of ignition
- Identify vulnerabilities of structures at full-scale
- Develop test methods at reduced-scale

Southern California Fire

Chile Fire

Wind Tunnels

BRI – 12 x 15 ft; < 25 mph



NRIFD – 3 x 3 ft; 15 mph

IBHS – 50 x 150 ft; 130 mph

Wind-Driven Fire – Wall Ignition at BRI

Glowing firebrands producesmoldering ignition (SI) in mulch beds

SI transitions to flaming ignition of mulch bed

Increasing distance from lower edge of siding to mulch reduces wall ignition

102 mm

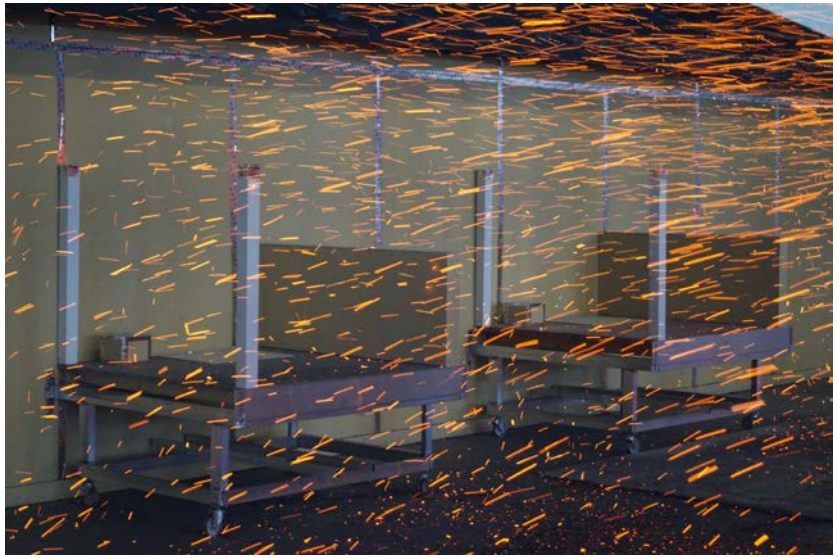
203 mm

Wind-Driven Fire – Wall Ignition at NRIFD

Glowing firebrands ignite mulch beds

Small-scale tests developed to replicate exposure of full-scale structure components

Wind-Driven Fire – Deck Ignition at IBHS



Full-scale tests with deck sections attached to residential structure

Decking material-
Pine, cedar, redwood, & composite wood/plastic

Wind Angle – 0, 45, 90 degrees

Wind Velocity – 25 & 40 mph

Fire Chiefs White House Summit on Climate Change Impacts at the WUI

- Summit / Roundtable discussion
  - November 9, 2015
- 30 fire chiefs, Federal agencies (Chief Mitchell)
- Report out: Wildland Fire Science and Technology Task Force
  - Subcommittee on Disaster Reduction http://www.sdr.gov/
    - Grand challenges for disaster reduction
    - Implementation plan for wildland fire, earthquake,hurricane.....

- Waldo Canyon Post-Fire Analysis
- Roundtable Discussion on Actions to Enhance Community Resilience at the WUI

2015 National Fire Service Research Needs Symposium

- Review and update fire service research agenda
- 7th Firefighter Life Safety Initiative
  - Creation and maintenance of a research agenda
- Fourth agenda
  - 1999 NIST – San Antonio, TX
  - 2005 NFFF - Emmitsburg, MD
  - 2011 NFFF - Emmitsburg, MD
  - 2015 NFFF - Arlington, VA – November 16-19, 2015
- Breakout Groups (2011)
  - Community Risk Reduction
  - Wildland Firefighting
  - Data Collection
  - Technology & Fire Service Science
  - Firefighter Health and Wellness
  - Emergency Service Delivery
  - Tools and Equipment

Single Vision for First Responders

- First Responder of the Future Working Group
  - Technology Development Council for First Responders

- Established in 2013
- 20-25 year outlook
- Developed by and for law enforcement, fire, EMS
- Captures future capabilities, requirements and needs for first responders
- Future threats-

  population growth, demographics, laws, communication

Single Vision for First Responders

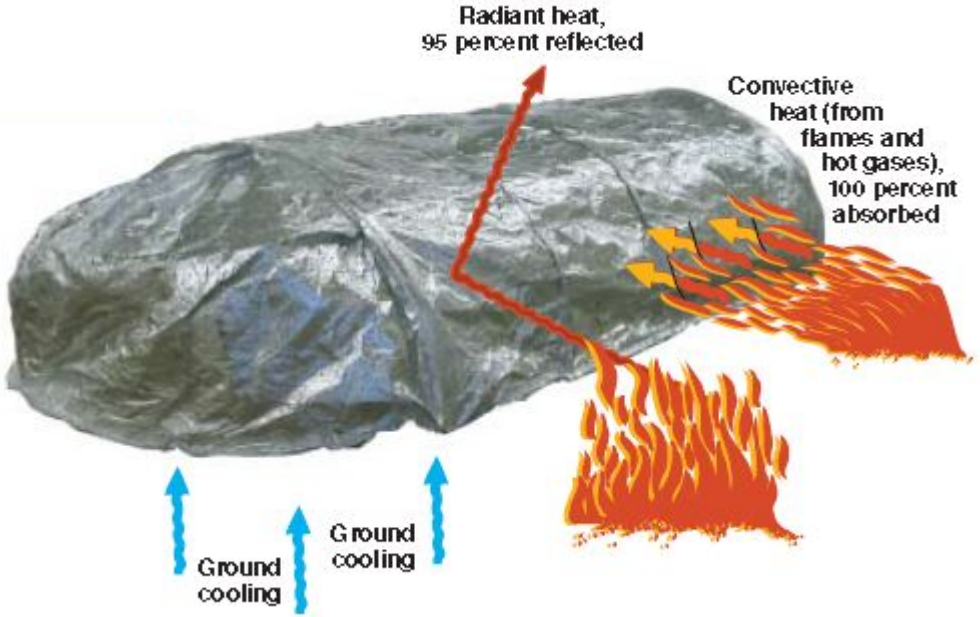
- Current participation
  - IAB NIJ NIST
    NFPA NIOSH DHS S&T FRG
  - -Expand to include others
    Dod USFA USFS
    CDC CIBP

- Purpose
  - Influence the direction of research and development dollars
  - Increase coordination of ongoing and future R&D Priorities
  - Dedicated resources and capabilities to manage and continually advance
  - Create a Vision and Develop a roadmap where First Responders are intimately involved

Next Gen Wildland Fire Fighter Shelter

- Loss of 19 fire fighters – Yarnell Hill fire
- Advanced Fire Blocking Materials for Wildland Fire Shelters Project
- NCSU – Roger Barker
  - NFPA, DHS, & USFS

- Fire conditions
- New materials



Next Gen Wildland Fire Fighter Shelter

- Fire conditions
  - Fire line velocity - 0.4- 1m/s (Yarnell 4.5-5.5 m/s)
  - Radiant exposure 40 kw/m2
  - Flame contact 80 kw/m2
  - Wind velocity – not part of test

- New materials
  - Aerogels
  - Silica cloth (developed by Russian space program)
  - Intumescents
  - Active air gap
  - Shape memory
  - Phase change materials

Questions?

Flow Path Related LODDs - craig.weinschenk@nist.gov

Wind-Driven Fire Studies - samuel.manzello@nist.gov
erik.Johnsson@nist.gov

Other agendas- nelson.bryner@nist.gov
301-975-6868