National Institute of Standards and Technology
U. S. Fire Administration
Federal Emgergency Management Agency

FIRE.GOV

Better fire fighting through research

Winter Issue -- 2002

Computer Models Recreate WTC Fires

Dr. Ronald Rehm and other scientists in the Fire Research Division at the National Institute of Standards and Technology (NIST) are using computer models to help recreate and analyze fire conditions that may have existed in the World Trade Center (WTC) towers before collapse. This work is expected to yield an estimate of the total heat release rates produced by the fires in the towers. In addition, the research is anticipated to provide estimates of local temperatures and heat fluxes to which structural elements remaining after the plane collisions were subjected. Such information will be very important for the structural analyses of the collapses being undertaken now, since elevated temperatures within these elements can lead to significant reduction in the strength of the materials used in these elements.

Photographs and video footage are some of the most important evidence or "data" remaining for reconstruction of the events leading to the collapse of the towers. New data sources are determined almost daily, and this additional information, about both the exterior damage and the fire conditions, is used to guide and refine the modeling efforts.

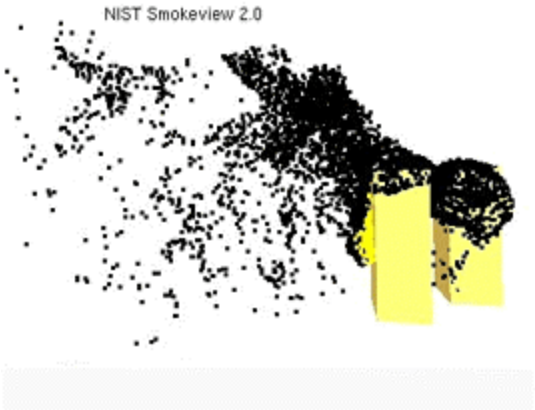
A major challenge facing researchers is to assign a time-from-ignition to each image. These "time stamps" allow the information from the picture to determine the progression of the fire within each tower for comparison later with the model predictions. Such comparisons then put significant constraints on the modeling and, thereby, improve understanding of the interior damage and fuel distributions within each building.

Until now, models of the interior damage and of the fuel distributions have been entirely arbitrary.

There has been one successful example resulting from the comparison of video images and the predictions of a mathematical model of the WTC fires. The video images of the smoke plume down wind of the towers has been compared with the model predictions of this plume, and a very reasonable estimate of the total heat release rate (HRR) due to the tower fires has been made.

If you know of information that may be helpful to the team in unraveling the fire spread and the times of fire events in the buildings please contact Ron Rehm at 301-975-2704 or e-mail ronald.rehm@nist.gov.

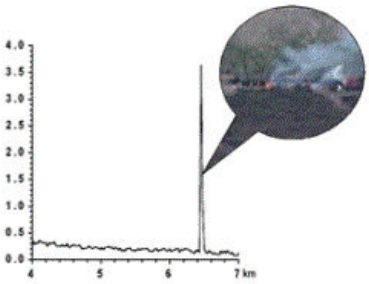
Matching computer model predictions of the smoke plume trajectory with images from a home video recording provided information on the size of the combined building fires.



SMOKEVIEW generated movie of the predicted smoke plume trajectory from fires in the WTC towers.

Forest Fire Detection by Lidar Measurements

Schematics of line-of-sight fire detection system.



Lidar signal with a fire signature.

Every year Mediterranean Europe is severely hit by forest fires. The resulting economic and environmental damage is enormous. The problem of forest fires has cultural, social and economic aspects that cannot be easily addressed. To limit the burned area, it is important that once a fire has started, the firefighting services intervene rapidly, as after a certain point fires become increasingly difficult to control and this requires very early detection.

Currently, detection of forest fires is carried out by observers or by means of passive sensing systems such as near-infrared cameras. However their range of detection depends excessively on environmental and weather conditions and since they are line-of-sight systems, their detecting capability is drastically reduced in mountainous areas. The aim of the work that has been carried out at Instituto Superior Técnico is to assess alternative active sensing methods for fire detection based on lidar. These systems emit electromagnetic radiation and capture the radiation that is backscattered by the smoke plume.

Appropriate mathematical processing of the signal enables the dimensions, distance, and velocity of the target to be determined. The advantages of active (as opposed to passive) sensing methods are greater sensing distances, constant sensitivity around the clock, relative independence of atmospheric conditions, and accurate determination of the distance to the fire. Lidar has been used extensively for studying the atmosphere and wind regimes, for military applications and in remote sensing, but currently available lidar equipment is unsuitable in terms of cost, size, and ease of use for the application under consideration. The on-going project aims to apply for the first time a simple, biaxial monostatic lidar to the sensing and study of forest fires.

In field tests carried out within the framework of a joint international project (GESTOSA, see http://www2.ruf.uni-freiburg.de/fireglobe/iffn/country/pt/pt_5.htm) the researchers have successfully detected experimental campfires produced by burning dry grass and olive logs at a rate of just 0.02 kg/s up to distances of 6.5 km. For burning rates of 2 and 10 kg/s, theoretical calculations allowed to estimated ranges of 17 and 23 km, respectively, provided that the weather conditions are good. The smoke plumes manifest themselves in raw lidar signals as narrow peaks. Automatic fire recognition with acceptable low level of false alarms was solved using neural networks. A new instrument provided with scanning ability and based on an eye-safe laser is presently under development.

For additional information, contact Prof. Rui Vilar, Departamento de Engenharia de Materiais, Instituto Superior Técnico, Av. Rovisco Pais 1, Lisbon 1049-001, Portugal, telephone: +351 21 841 8121, email: rui.vilar@ist.utl.pt

Australian Prison Mattress Tests

Note the data being collected as soon as the mattress is ignited. At 2.25 seconds a thermal image is overlaid so that the burning mattress flames can be viewed.

After a number of prison fires, (in particular, a prison fire which claimed the lives of five inmates in 1987.) the **Metropolitan Fire and Emergency Services Board, Melbourne, Victoria, Australia**, was asked to conduct fire tests on prison mattresses. The focus of the study was on the flammability of mattresses that could be or were in use in the Victorian prisons.

The goal of the fire tests was to identify the best mattresses to be used in a correctional facility. However, before work could begin, a study was made of the standards for testing mattresses and bedding. Standards from Australia, Britain, New Zealand, and the United States of America analyze the material properties used in mattresses and their resistance to various ignition sources, heat production, flammability and smoke development. Not all tests used a pass or fail grading system to rate mattresses. It was learned that no single standard assessed the fire hazard of the mattresses under actual fire conditions. To gather fire performance data for prison mattresses, test mattresses were ignited in a replica of a prison cell.

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Australian Prison Mattress Tests, cont.

Testing involved igniting a variety of mattresses and measurements of air temperature, carbon monoxide levels, oxygen depletion to determine when untenable conditions were produced. Suitability for use in correctional facilities was assessed in relation to the fire risk. A comprehensive report, **Fire Safety Considerations of Correctional Facilities,"** is available on their web site: URL: http://www.mfbb.org.au .

The report documents and explains the fire tests and includes the recommendations that were made to the Prison Fire Safety Advisory Group.

A companion video of all the tests, **FIAU Prison Mattress Test Burns,** has been prepared to aid readers of the technical report in understanding the results of the study.

Please request a copy, either in VHS or PAL format, from fstockton@mfbb.vic.gov.au . Provide your complete name, mailing address and format needed in the e-mail.

Inquiries may be addressed to Inspector Frank Stockton, Manager, Fire Investigation & Analysis Unit (fstockton@mfbb.vic.gov.au) or Mr. Luke Hopper, Project Manager, Community Safety (lhooper@mfbb.vic.gov.au) .

Tiny Vibrations May Provide Warning of Collapse

In the future, devices attached to buildings may "listen" for signs of structural collapse. Professor Ziyad Duron at Harvey Mudd College is studying the minute vibrations in burning structures for ways to provide reliable advanced warning of collapse. This research funded by NIST as part of a joint USFA-NIST research effort to look for indicators of building collapse is in its second year. House burns conducted by the Bureau of Alcohol, Tobacco and Firearms (ATF) and the **Kinston, NC Department of Fire and Rescue** provided an opportunity to test sensors and develop analysis methods. Professor Duron and his students attached micro-accelerometers to the brick facing on a single family detached house.

The sensitive instruments are capable of measuring the vibrations of the exterior wall caused by the pulsating flames from furniture fires within the structure. For this test, the roof was loaded with a water-filled tank to force a sharply defined collapse. Vibrations of the house taken during the test indicated that warning signs of collapse could be detected about three minutes before the tank fell through the partially burned roof. This result is encouraging, but will it work in larger, heavier and complex buildings? No one knows. The researchers would like a chance to find out in other field-testing opportunities. For further information contact: Professor Ziyad Duron, Harvey Mudd College, (1) + 909-607-3883 or e-mail ziyad_duron@hmc.edu.

Fire test in Kinston, NC. the square foil covered box on the house wall below the tank contains instruments that sense the structures minute vibrations.

Arc Fault Circuit Interrupters -- New Technology in Fire Safety

Problems in home electrical wiring, like arcing and sparking, cause more than 40,000 home fires annually. These fires claim more than 350 lives and injure 1,400 victims each year [1] Electrical fires may be caused by a phenomenon called "arcing". Typical household fuses and circuit breakers may not respond to early arcing and sparking conditions in home wiring. By the time a fuse or circuit breaker opens a circuit to alter these conditions, a fire already may have begun. In the 1990s **arc fault circuit interrupters** (AFCIs) were introduced.

The AFCI is a new electrical safety device for homes and it is expected to provide better protection from unsafe home wiring. AFCI involves a technology that detects arcing-faults in electrical circuits that could cause fires. By recognizing characteristics unique to arcing and functioning to de-energize or open the circuit when an arc-fault is detected, AFCIs further reduce the risk of fire beyond the scope of conventional fuses and circuit breakers. Once the circuit is open, the arcing stops and an electrical fire is prevented.

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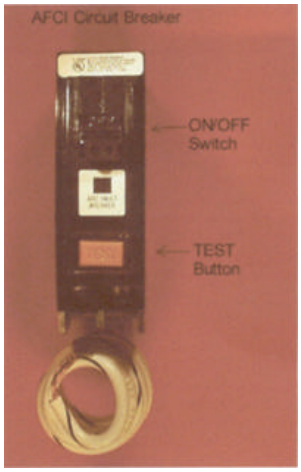
Arc Fault Circuit Interrupters -- New Technology in Fire Safety, cont.

The National Fire Protection Association's ***2002 National Electrical Code*** **(NEC)**, Section 210.12, requires that all branch circuits supplying 125 volt, single phase, 15- and 20-ampere outlets installed in dwelling unit bedrooms be protected by an ACFI. Although not required, AFCIs may be used in other circuits or rooms throughout the dwelling unit if desired. Mr. Walter Smittle, West Virginia State Fire Marshal (retired), says that the National Association of State Fire Marshals (NFASFM) has studied the effectiveness of AFCIs and has publicly endorsed the technology. Benefits from using AFCIs could be significant by reducing property losses and safeguarding lives from electrical fires.

Two web sites that have information about AFCIs are the Consumer Product Safety Commission's (CPSC) site at http://www.cpsc.gov/cpscpub/pubs/afci.html and the Underwriters Laboratories' site, http://www.ul.com/regulators/afci/.

For additional information you may contact Mr. David Dini at Underwriters' Laboratories; telephone (1) + 847-664-2982 or send e-mail to David.A.Dini@us.ul.com . and Mr. Walter Smittle, West Virginia State Fire Marshal (retired), telephone: (1) + 304-372-2326 or send e-mail to wsmittle3@wirefire.com .

[1] Ault, Singh, and Smith, ***1996 Residential Fire Loss Estimates***, October 1998, U.S. Consumer Product Safety Commission, Directorate for Epidemiology and Health Sciences.



Arc Fault Circuit Interupter

NIST Researcher Recognized for His Work with the Fire Service

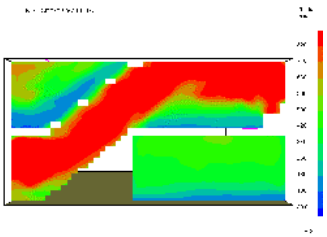
Mr. Daniel Madrzykowski was awarded the U.S. Department of Commerce's Bronze Medal in recognition of his exemplary leadership in conducting fire experiments, and his outstanding effort to transfer fire dynamic modeling technology to the fire service and arson investigators. Through Dan's tireless effort, NIST has become the principal source of large-scale data used by fire investigators, fire modelers, and national consensus standard and code organizations. Data has been collected at hundreds of full-scale fires over the past 5 years. Teaming with local fire departments, the US Fire Administration, the Bureau of Alcohol, Tobacco, and Firearms (ATF), International Association of Arson Investigators (IAAI), and the National Institutes of Occupational Safety and Health (NIOSH), data have been generated from many buildings ranging from single houses to multi-story apartment buildings.

Mr. Madrzykowski's computer simulation/re-creation of the townhouse fire that occurred at 3146 Cherry Road, Washington DC on May 30, 1999, killing two-firefighters is particularly noteworthy. A simulation of the fire events in the townhouse was constructed using **NIST's Fire Dynamics Simulator model.** Dan utilized NIST's Smokeview software to display the model simulation for the fire department investigating committee.

Results are available on CD, NISTIR 6510, which includes still and animated images from the simulations. As the information is important to help other firefighters avoid similar tragedies, every fire fighter should take the time to learn the lessons from this investigation. Since its release in April 2000, over 8000 fire departments have requested and received copies of the CD.

To obtain a copy of the report, you may download it from the web site http://fire.nist.gov, or you may request the CD-ROM by e-mailing Dan at daniel.madrzykowski@nist.gov.

Dan Madrzykowski (left) works with the ***Regional FD, Casa Grande, AZ*** *gathering data from burning house.*



Simulation of the unexpected flare-up of basement fire shows hot gases racing up the staircase in the DC townhouse.

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