Federal Building and Fire Safety Investigation
of the World Trade Center Disaster

Reconstruction of the Thermal and Tenability Environment

June 22, 2004

Richard G. Gann, Ph.D.
Senior Research Scientist
Building and Fire Research Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce
rggann@nist.gov

NIST

Project Objective

Reconstruct, with assessed uncertainty limits, the time-evolving temperature, thermal radiation, and smoke fields in World Trade Center buildings 1, 2, and 7 for use in evaluating the behavior and fate of occupants and responders and the structural performance of the buildings

Project Approach

- Due to lack of physical evidence, we rely almost exclusively on:
  - Fire insight
  - Computer simulations
  - Experiments
  - Photographic evidence
  - Eyewitness accounts
- Since this type of reconstruction has never been done before, we have re-defined the state-of-the-art in fire and thermostructural modeling
- Integrated with other Projects, esp. 2 and 6

Tasks

1. Visual collection and time line development [Pitts]
2. Characterization of combustibles [Gann]
3. Characterization of partitions [Averill]
4. Characterization of structural insulation [Yang]
5. Fire model development [McGrattan]
6. Experiments for model development [Mulholland]
7. Fire reconstruction [McGrattan]
8. Reconstruction validation [Hamins]

Total: 32 people

Status

- Gathering of visual evidence - completed
- Building information – generally complete; specifics on a few floors would be useful:
  - Verification of absence of high combustible loading
  - Verification of location and nature of interior walls
- Building combustibles - completed
- Aircraft contents - completed
- Insulation property data – completed

Status

- Reports in process:
  - Shake table tests of ceiling systems: complete draft
  - Fire tests: heat transfer to steel members: complete draft
  - Fire tests: single workstations: complete draft
  - Fire tests: multiple workstations: draft mostly written
  - Visuals collection and analysis: draft mostly written (analysis and interpretation still ongoing)
- Current technical activity:
  - Execution of Fire Dynamics Simulator (FDS) runs of model fires in all 3 buildings (*cf*. McGrattan presentation)
  - Execution of Fire-Structure Interface (FSI) runs for bare and coated assemblies in all 3 buildings (*cf*. Prasad, Gross presentations)
  - Further analysis of visuals (*cf*. Pitts presentation)

Interim Findings

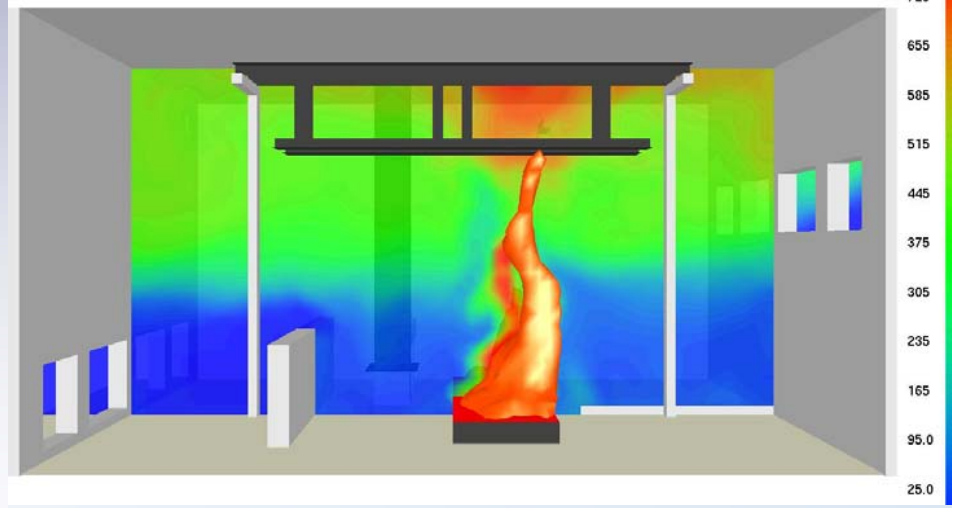
- Loading of building combustibles was on the light side of typical
- Mass of aircraft solid combustibles was significant relative to the mass of the building combustibles in the impact zone
- Ceiling tiles were likely to have been dislodged throughout the impact floors
- View of fires through many windows was hindered by interior walls, as well as by steep viewing angles and smoke clouds
- Some fire damage of exterior columns and floors occurred well after the aircraft impact
- FDS and FSI can be used with confidence to recreate the thermal effect of a given WTC fire event

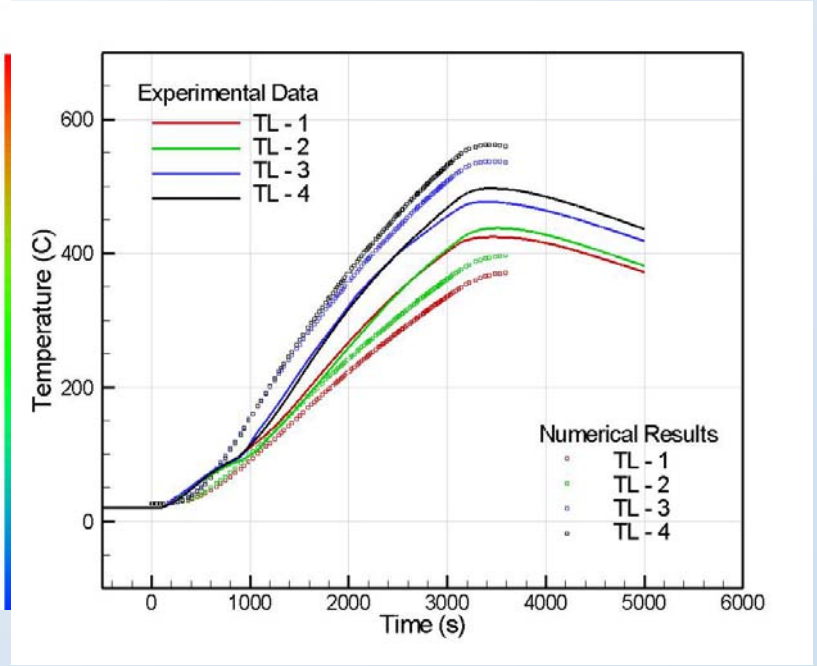
Summary of Fire Experiments

- Three sets of large-scale tests, generating data for:
  - Accuracy assessment of heat transfer to and transport within structural components, testing of FSI
  - Upgrading the combustion module within the FDS
  - Verifying the accuracy of FDS fire growth predictions

Heat Transport and Transfer Experiments

- Gas burner tests in a large enclosure
- Various steel shapes; bare, two thicknesses of insulation
- Measured temperatures, heat fluxes

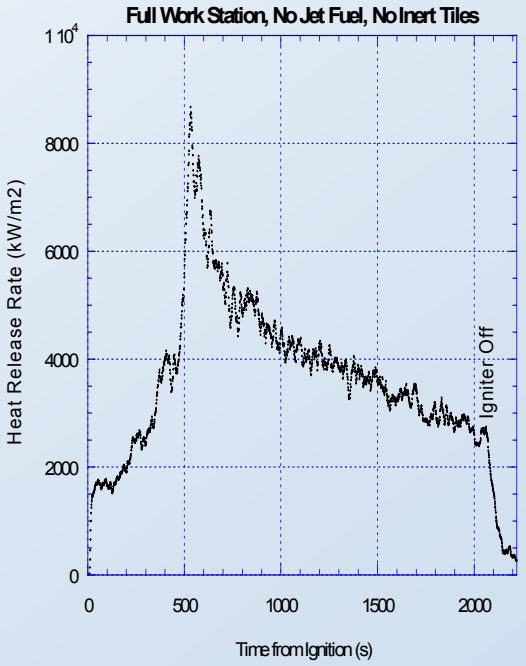




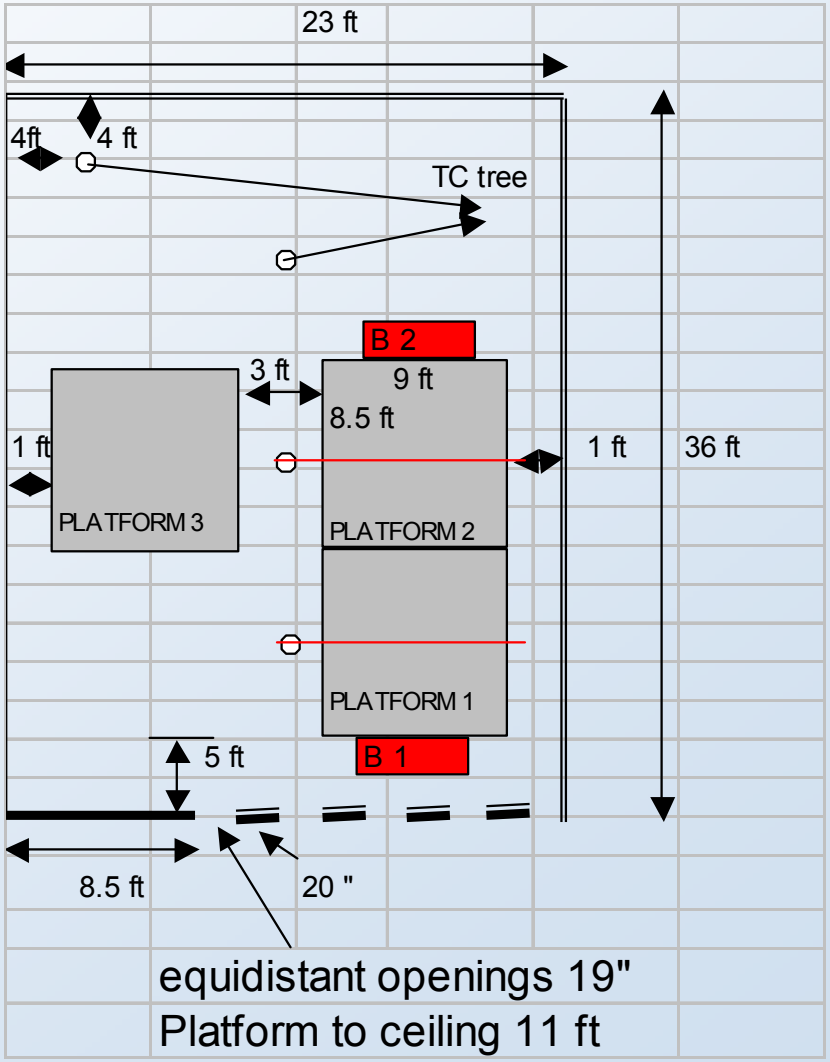
NIST

Single Workstation Fire Experiments

- Conducted under a hood with a confined ceiling
- Variables: presence of jet fuel, 30 % coverage by inert material
- Measured heat release rate (HRR), sample mass, [CO]
- Materials data from Cone Calorimeter

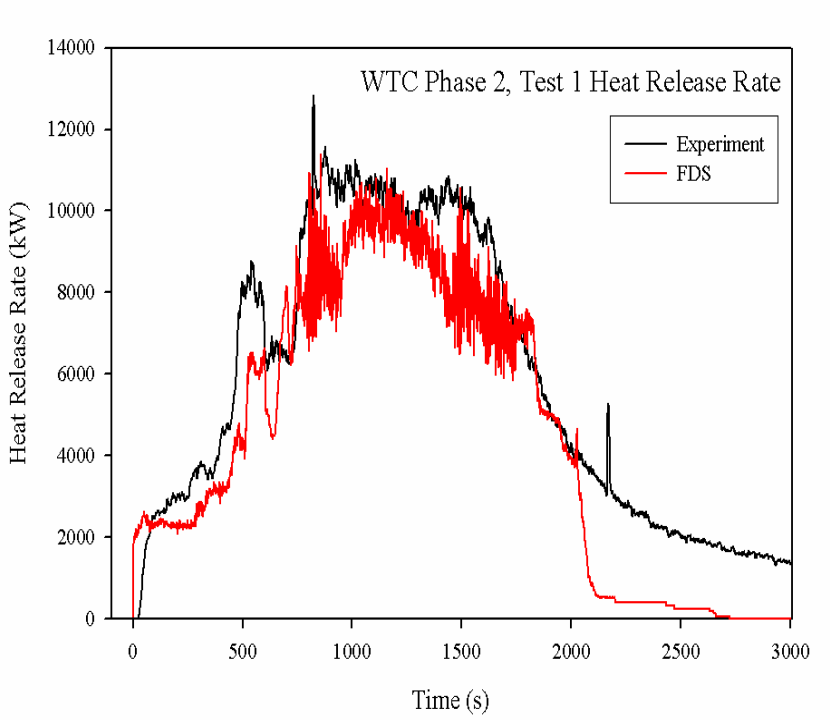


Multiple Workstation Experiments



Multiple Workstation Experiments

- Variables:
  - Presence of jet fuel
  - *ca.* 70 % coverage by inert material
  - Ventilation
  - Condition of workstation
- Measured HRR, mass of each workstation, [CO], temperatures, heat flux; video
- FDS predictions completed before experiments



Federal Building and Fire Safety Investigation
of the World Trade Center Disaster

Reconstruction of the Thermal and Tenability Environment

Thank you

Richard G. Gann, Ph.D.
Senior Research Scientist
rggann@nist.gov

NIST