

NIST Response to the World Trade Center Disaster

World Trade Center Investigation Status and First-Person Data Collection

September 17, 2003

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Goals

- To investigate the building construction, the materials used, and the technical conditions that contributed to the outcome of the World Trade Center disaster
- To serve as the basis for national benefits:
 - Improvements in the way buildings are designed, constructed, maintained, and used
 - Improved tools, guidance for industry and safety officials
 - Revisions to codes, standards, and practices
 - Improved public safety

Objectives

- Determine:
 - why and how the WTC Towers collapsed following the initial impact of the aircraft, and
 - why and how the 47-story WTC 7 collapsed
- Determine why the injuries and fatalities were so low or high depending on location, including technical aspects of fire protection, **occupant behavior, evacuation, and emergency response**
- Determine what **procedures and practices** were used in the design, construction, operation, and maintenance of the WTC buildings
- Identify, as specifically as possible, national building and fire codes, standards, and practices that warrant revision

NIST WTC Investigation Projects

**BPAT
Recommendations**

**Government,
Industry,
Professional,
Academic Inputs**

Public Inputs

Public Inputs

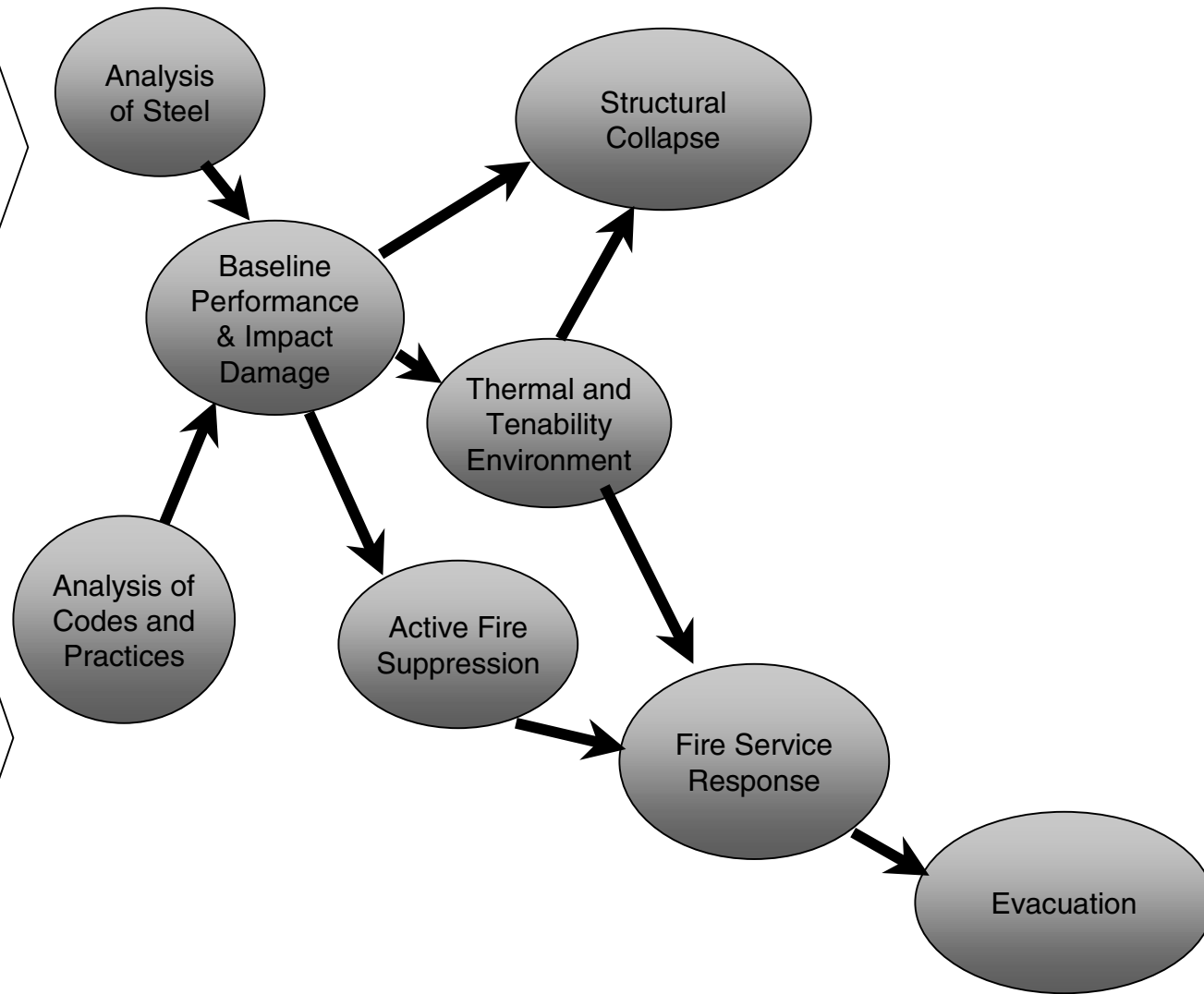
Documents

Video/ Photographic
Records

Oral History Data

Emergency Response
Records

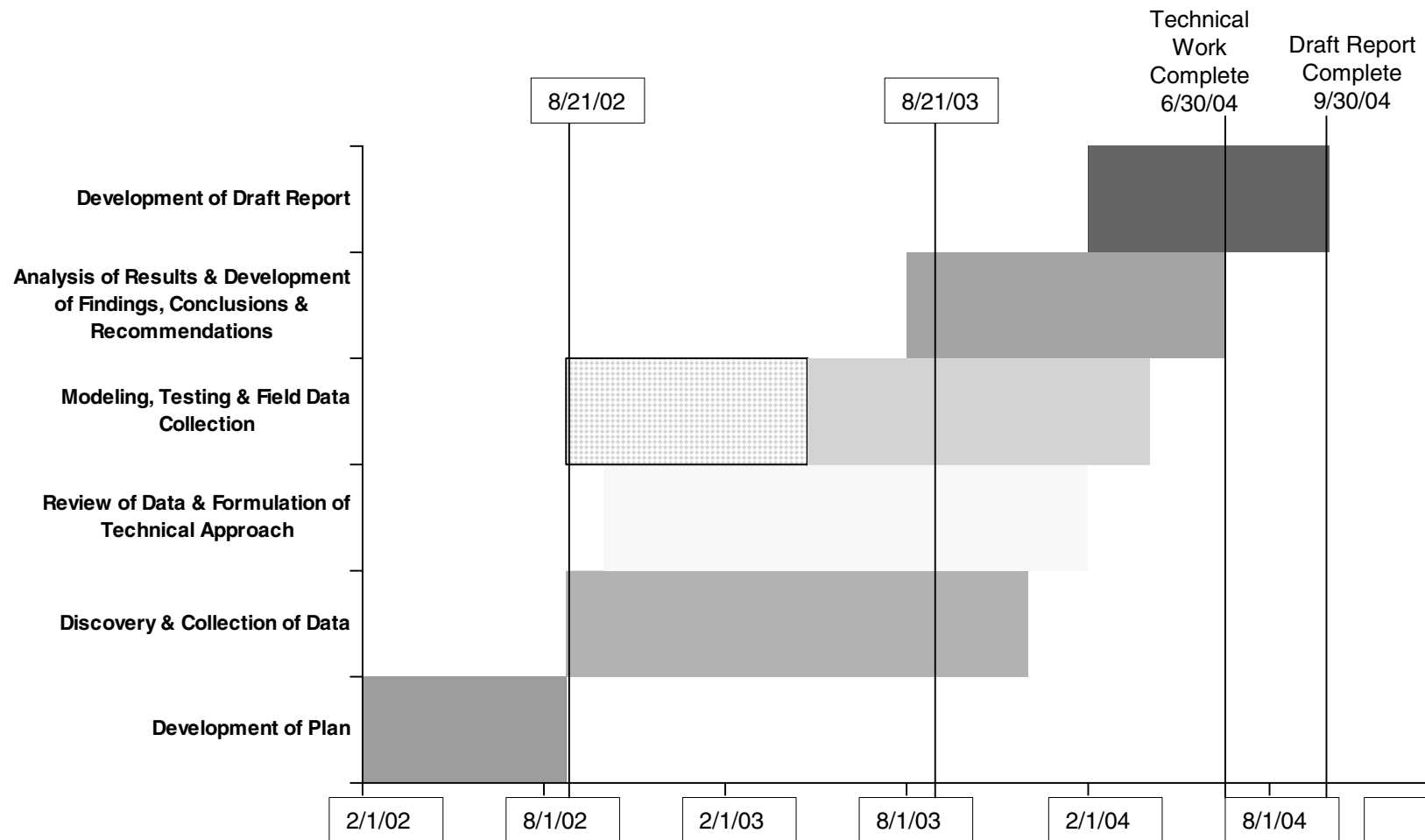
Recovered Structural
Steel



WTC Investigation Status

- Halfway into 24-month investigation; good progress on all projects
- \$16 million investigation; \$5.5 million planned for contracts; \$5.4 million awarded or in review/negotiation process for 15 of 16 contracts
- Drawing on top-notch talent from NIST, outside experts, and contractors
- Large amounts of data and information received; working hard to access missing crucial information; **summary status available at <http://wtc.nist.gov>**
- Two progress reports issued (December 2002 and May 2003); next progress report scheduled for December 2003
- Extensive briefings at two meetings of the National Construction Safety Team Advisory Committee (April 2003 and August 2003)

WTC Investigation Schedule



Selection of External Experts and Contractors

- **Process nearing completion**

- Solicitations issued: 16 (1 replaced w/consultant)
- Awards made: 6 contracts
9 experts (3 solicitations)
- Under review 2 contracts (anticipate by 10/15/03)
- Under negotiation: 3 contracts (anticipate by 9/22/03)
- Open solicitations: 1 contracts (anticipate by 10/15/03)

- Four others hired as expert consultants

- V. Junker; K. Malley, V. Dunn, J. Hodgins

- **Excellent group of contractors and experts to augment NIST in-house capabilities**

World Trade Center Investigation Contract Solicitations

WTC No.	Project	Title	Status	Recipient
1	7	Outside Experts for Occupant Behavior and Evacuation	Awarded 9/30/02 and 10/16/02	D. Mileti, G. Proulx, N. Groner
2	5, 6, 7	Fire Safety Engineering Expertise	Awarded 12/23/02	H. Nelson
3	5	Media, Visual and Database Expert with Experience in Obtaining Visual Materials for the World Trade Center	Hired expert consultant	V. Junker
4	3	Document and Evaluate the Steel Recovered from the WTC Towers	Awarded 6/9/03	WJE Associates
5	7	WTC Investigation Survey Administration and Report Delivery: Questionnaires, Interviews and Focus Group Synopsis	Awarded 6/9/03	NuStats, DataSource, GeoStats, MBC Res Ctr
6	2	Development of Structural Databases and Baseline Models for the WTC Towers	Awarded 2/23/03	LERA
7	1	Analysis of Building and Fire Codes and Practices	Awarded 7/25/03	RJA, SKG, RG
8	7	World Trade Center Investigation First Person Accounts of Egress	Awarded 4/15/03	NFPA
9	6	Fire Endurance Testing of the WTC Floor System	Awarded 7/10/03 Modified 8/22/03	Underwriters Laboratories
10	2, 5, 6	Outside Experts for Baseline Structural Performance, Impact Analysis, Structural Response to Fire, Collapse Initiation and Probabilistic Assessment of the WTC Investigation	Awarded 6/16/03, 6/23-25/03, 7/3/03	SOM, D. Parks, UC Boulder, Teng Assoc, D. Veneziano/J. Van Dyck
11	2	Analysis of Aircraft Impacts into the WTC Towers	Anticipate 9/22/03	TBD
12	4	Analysis of Sprinklers, Standpipe, Pre-Connected Hoses in WTC 1, 2, 7	Anticipate 9/22/03	TBD
13	6	Development of WTC 7 Structural Models and Collapse Hypotheses	Anticipate 9/22/03	TBD
14	6	Structural Response of WTC Towers to Fire With/Without Impact Damage	Anticipate 10/15/03	TBD
15	4	Analysis of Active Fire Alarm Systems, WTC 1, 2, and 7	Anticipate 10/15/03	TBD
16	4	Analysis of Smoke Management Systems, WTC 1, 2, and 7	Open; closes 9/26/03	TBD

Update on Data Collection Efforts

- **Significant progress achieved since May 2003**
 - Reports of critical UL tests performed for the supplier of fireproofing materials
 - Tapes of NYPD internal communications concerning WTC terrorist attacks
 - Design of WTC internal radio system and FDNY radio repeater from PANYNJ
 - WTC list of occupants issued security badges by PANYNJ
 - Photos (5616 versus 3100); video clips (4674 versus 3400)
 - **NIST continues to seek photos and videos from the south face of WTC 7**
- NIST requests for materials that are currently pending with, or not yet located and/or provided by organizations
 - Original contract specifications for WTC towers
 - Construction logs and maintenance logs for WTC 1, 2, and 7
 - 9-1-1 tapes and logs, transcripts of about 500 first responder interviews (privilege claim NYC)
 - Supporting documents for McKinsey & Company's FDNY and NYPD studies
 - Complete set of NYPD records identified in request lists submitted by NIST (in progress)
 - Contents of aircraft (cabin furnishings, cargo, etc.) that contributed to fires (in progress)
 - Descriptions of partitions and furnishings in most of the tenant spaces of WTC 2 & 7
- **It is vital that this information be made available to NIST**

Update on Fireproofing and Fire Rating of WTC Floor System

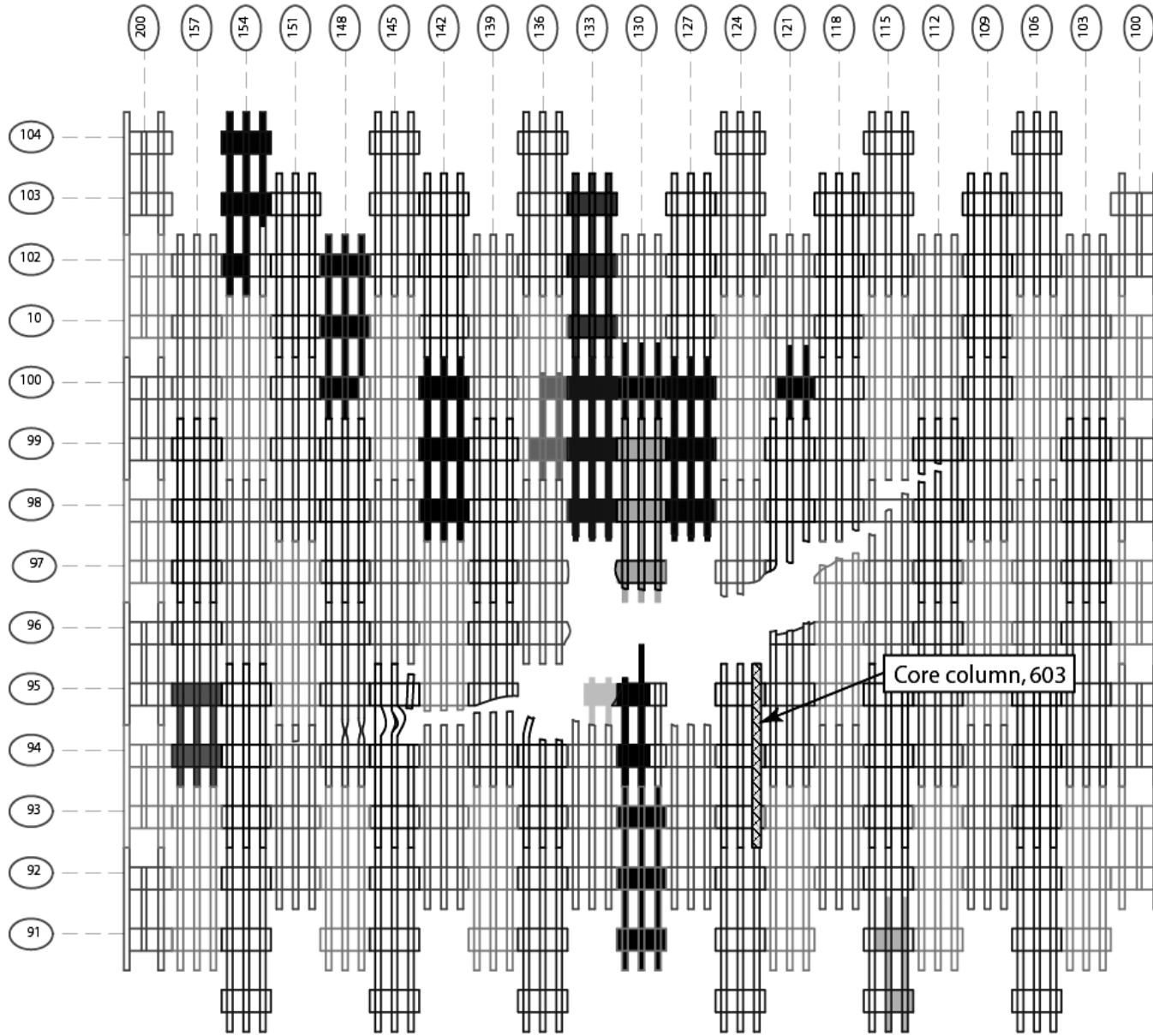
- May 2003 progress report: NIST has not been able to determine the technical basis for the selection of fireproofing material for the WTC floor system, and the determination of the thickness of fireproofing to achieve the specified 2-hour rating
- **Contract to Underwriters Laboratories to determine the fire endurance rating of typical WTC floor systems under both as-built and specified conditions**
- Tested composite floor assembly to include: concrete slab, 2-pairs of main trusses, 2-bridging trusses, fireproofing applied on steel with primer paint
- Three tests will be performed:
 - 17 ft span, restrained: **current U.S. practice**, typical furnace size
 - 35 ft span, restrained: twice typical size; **full-scale 35-ft assembly**
 - 35 ft span, unrestrained: bound effect of **thermal restraint**
- Additional rods and double angle structural members to be placed within furnace to evaluate effect of different **fireproofing thicknesses**
- **Additional testing and analysis underway to estimate condition of fireproofing prior to 9/11 and after airplane impact**

Update on Analysis of Structural Steel

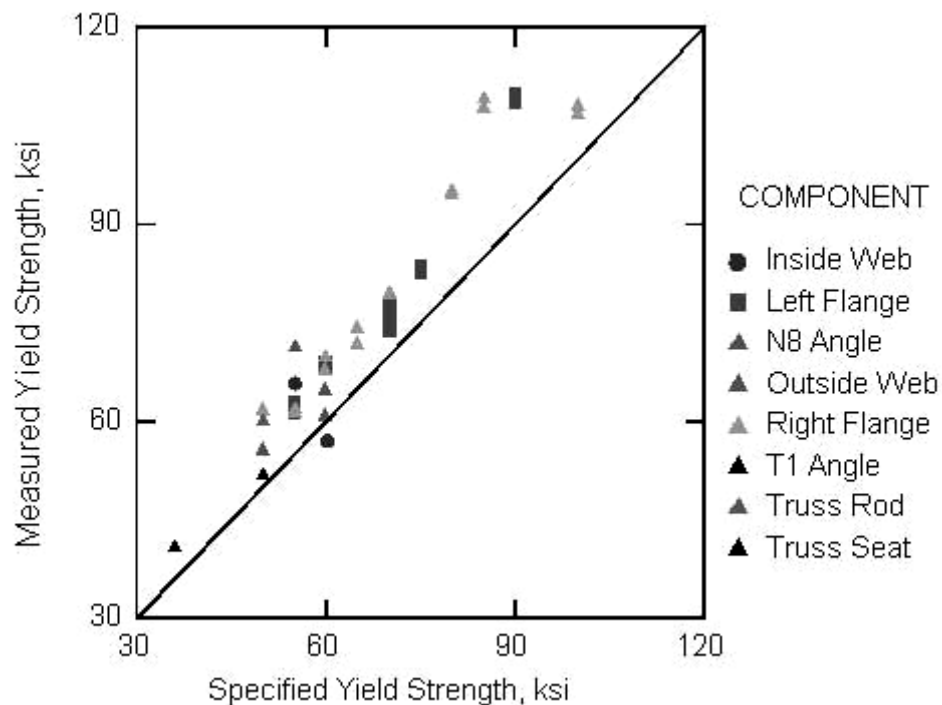
- **NIST has 236 pieces of WTC steel in its possession; NIST believes the collection of steel from the WTC towers is adequate for purposes of its investigation:**
 - vast majority are of significant size (exterior column-spandrel panels, box beams, wide flange sections, floor trusses, channels); smaller pieces such as bolts
 - roughly 1/4 to 1/2 percent of 200,000 tons of steel used in WTC towers; **regions of impact and fire damage emphasized in selection of steel pieces**
 - **NIST has all 14 specified steel grades for exterior panels; 2 specified grades that represent 99 percent of core columns; and both specified grades for floor bar joists**
 - Specified steel grades vary in strength from 36,000 psi to 100,000 psi.
- **127 room temperature tensile tests conducted so far** (per ASTM A370 and ASTM E8) on specimens taken from 36 distinct steel pieces and representing nearly all grades of steel; additional room temperature testing underway
- Room temperature properties used in conventional structural design; to be used to analyze baseline structural performance of WTC towers under wind and gravity loads

Sections Identified as of May 5, 2003

As determined by the NIST Metallurgy Division



Update on Analysis of Structural Steel



- **Preliminary results show that the measured room temperature steel strength met the specifications; in many instances exceeding the specifications by 10,000 to 15,000 psi**
- Additional steel testing underway:
 - High strain rate loading tests for use in aircraft impact damage analysis
 - Elevated temperature tests for use in analysis of thermal and structural response under fires
- Ongoing work to evaluate the design of the steel building components and system and their performance under impact and fire conditions up until the time of collapse initiation

WTC Fire Model Input Study



Two Views of WTC-1 Work Station



Motivation for workstation burns

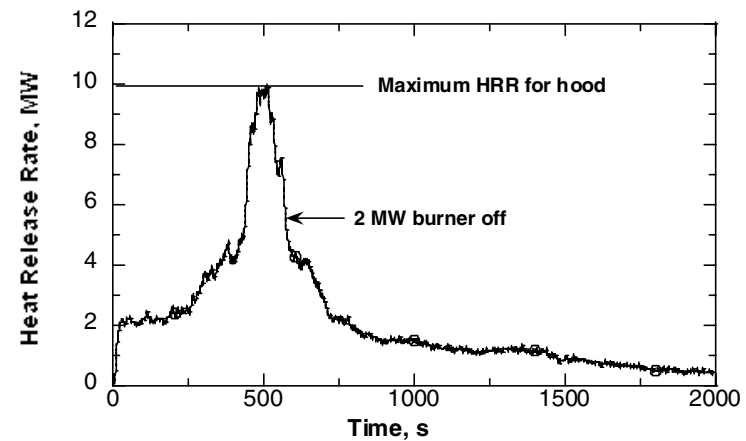
- Computer workstations major fuel source
- Combustibles – at least 200 kg per 2.4 m × 2.4 m unit
- 778 workstations on 5 floors most affected (94 –98)
- Input for Fire Dynamics Model

Test design

- 4 tests of workstation/loading similar to WTC-1
- 2 tests with jet fuel added, 2 with inert tile added
- 2 MW line burner source to represent fire spread between cubicles
- 2.7 m ceiling with 0.6 m lip to simulate radiant feedback
- 1 test with same workstation as found in WTC-1



Full Involvement of Fire near Peak Heat Release Rate



First-Person Data on Occupant Behavior, Evacuation, and Emergency Response

- NIST's study of WTC evacuation and emergency response requires a systematic collection of first-person data from:
 - Survivors (occupants, first responders, others with safety responsibilities)
 - Families of victims who were in touch with victims after aircraft impact
 - Individuals with operational and command authority
- **It is possible to learn from the tragic WTC events, and to improve public safety through the collection and analysis of first-person accounts**
- **This is an ambitious undertaking and will need active participation of survivors, current and retired first responders, and families in its face-to-face, telephone, and focus group interviews**

Scope of Occupant Behavior, Evacuation, and Emergency Response Study

- **Occupant behavior and evacuation technologies and practices for tall buildings**
 - Decision-making and situation awareness
 - Time-constrained evacuation strategies (e.g., defend-in-place)
 - Role of floors wardens and fire safety directors
 - Issues concerning people with disabilities
 - Human factors issues and design of egress system
- **Firefighting technologies and practices for tall buildings**
 - Means for emergency access, time to reach affected floors
 - Firefighting versus evacuation
 - Physical condition of firefighter under high-rise work conditions
- **Command, control, and communication systems for emergency response**
 - Location of incident command post; mobilization, staging, and deployment; logistics; equipment; training; pre-event planning
 - Content and timing, among occupants and authorities, within and outside buildings, intra and inter group communications
- **Observations of fire/smoke conditions, structural damage, water flow, aircraft fuel**

Multiple Data Sources

- Existing published first-person accounts of WTC evacuation; over 500 interviews collected and analyzed
- Communication tapes from Port Authority of NY & NJ and NYPD; 1000 plus hours of taped recordings
- Filings with the Occupational Safety and Health Administration by survivors and families of victims; over 50 written statements
- Documents from Port Authority, FDNY, NYPD, and others on design of egress and emergency communication systems; WTC evacuation history; WTC evacuation planning and drills; emergency response preparedness and operational data
- Photographic and video data on occupant behavior, evacuation, and emergency response
- **First-person data collection from survivors, current and retired first responders, and families of victims**

Comprehensive Study Methodology

- One of the largest studies of occupant behavior, evacuation, and emergency response ever conducted
- First-person data collection methodology developed in cooperation with social scientists and experts in evacuation and emergency response:
 - geared toward enhancing recall of directly experienced events;
 - combines face-to-face, telephone, and focus group interviews;
 - results validated through triangulation with multiple data sources
- Review, compare, and analyze documentary, photographic, electronic, and first-person data to:
 - develop detailed timeline of events, visual representation of disaster site
 - assess occupant behavior, evacuation, and emergency response
 - derive findings, conclusions, and recommendations
- **The personal privacy and confidentiality of individual respondents will be protected to the maximum extent permitted by law**

Preparing for Future Extreme Events

- Buildings are not normally designed for fire protection and evacuation under extreme conditions
- **Critical lack of information on which to base evacuation and emergency response practice, standards, and codes**
- Unique opportunity to systematically collect and analyze first-person accounts that is essential to:
 - document and identify areas for improvement from the events of 9/11
 - better protect occupants and first responders in future events
 - implement better evacuation and emergency response procedures
- **This vital public safety study needs the active participation of survivors, current and retired first responders, and families of victims in via face-to-face, telephone, and focus group interviews**

Coordination of Field Data Collection

- Cooperating organizations representing potential participant groups:
 - Port Authority of New York and New Jersey
 - New York City^{*}
 - Fire Department of New York
 - New York Police Department
 - Skyscraper Safety Campaign
- Coordination with concurrent studies:
 - Centers for Disease Control and Prevention (CDC)
 - Columbia University

*** NIST and NYC are engaged in negotiations regarding these interviews**

Bottom Line

**Make all buildings safer
for occupants and first responders**

Contact Information

- **Survivors, families, and retired first responders may volunteer to participate in the face-to-face interviews by contacting:**

877-221-7828 (toll free)

- **Alternatively, families of victims may volunteer to participate in the face-to-face interviews via the following web site:**

<https://wtc.nist.gov/family>

- **Anonymous tip line: 888-804-7581 (toll free)**

- Mail address: NIST World Trade Center Investigation Team
100 Bureau Drive, Stop 8610
Gaithersburg, MD 20899-8610

- E-mail: wtc@nist.gov
- Facsimile: 301-975-6122
- WTC web site: <http://wtc.nist.gov>