

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

**Investigation of Active Fire Protective Systems  
Project 4**

June 23, 2004

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## Disclaimer

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# OUTLINE

- **Objective and Scope**
- **Engineering Teams**
- **Update -- WTC 1, 2, and 7 Fire History**
- **Progress:**
  - Sprinkler and Standpipe Systems**
  - Fire Alarm Systems**
  - Smoke Management Systems**

## **Objective**

NIST is investigating the design, capabilities, and performance of the installed active fire-protection systems in WTC 1, 2, and 7 and their role in fire control, emergency response, and fate of occupants and responders.

## **Scope**

Three systems are being investigated: the fire sprinkler system, including the fire standpipes and pre-connected hoses; the fire alarm system; and the smoke management system.

# Engineering Teams

- Fire History  
Erica Kuligowski, NIST
- Sprinklers, Standpipes and Pre-connected Hoses  
Hughes Associates, Inc., Baltimore, MD, under contract from NIST, Edward Budnick (PI)
- Fire Alarms  
Stephen Hill, ATF  
Rolf Jensen and Associates, Inc., Fairfax, VA, under contract from NIST, Raymond Grill (PI)
- Smoke Management  
Stuart Dols, NIST  
Hughes Associates, Inc., Baltimore, MD, under contract from NIST, Michael Ferreira (PI)

# Fire History WTC 1, 2, and 7

- In addition to the well known 1975 fire and 1993 bombing, 16 fires involving multiple sprinklers or multiple standpipes occurring from 1977 to 1999 were identified from New York City Fire Department (FDNY) records in NIST's last WTC Investigation report.
- NIST's working definition of a significant fire has been revised to include those involving at least one standpipe connected hose with or without sprinklers.
  - Within that expanded definition, 31 additional fires occurring in WTC 1 and 2 from 1973 to 1999 were identified. Of those, 27 involved only the use of standpipe hoses.
- **A full reporting of the fire history findings are contained in Appendix G of the progress report. Included in the appendix are copies of the FDNY fire reports dealing with the 47 fires selected.**

# Fire History WTC 1, 2, and 7

Two of the 27 fires involving the activation of only standpipe hoses required evacuations:

- On April 19, 1980 at 2:06 p.m.
  - FDNY received reports of an activated smoke detector in the return air duct on the 106th floor of WTC 1.
  - FDNY also received reports of heavy smoke on the 106th floor, light smoke on the 109th floor, and heavy odor of smoke in stairways A and B.
  - The FDNY report notes that while only one standpipe was used, approximately **300 people** were evacuated from the area.
  - The fire cause was labeled as abandoned or discarded material and involved plastic material.
  - There were no reported injuries or casualties.
- On April 17, 1981 at 9:18 a.m.
  - FDNY was informed of a fire on the 7th floor and a smoke condition on floors 7 through 11 of WTC 1.
  - The fire department hooked up one standpipe and extinguished the fire located in an air conditioning unit in the “MER” room on the 7th floor.
  - The cause of this fire was labeled as a mechanical failure.
  - The fire report notes that Port Authority personnel reported an evacuation of approximately **1500 people** from floors 9 through 23.
  - There were no reported injuries or casualties.

# Sprinkler and Standpipe Systems

*Preliminary findings for the undamaged and fully operational sprinkler and standpipe systems.*

- Water supply capacity and redundancy met or exceeded state of the art best practices.
- Water supplies to the automatic sprinklers and standpipe systems exceeded minimum requirements for high-rise office occupancy protection in accordance with NFPA 13.
- Generally, sprinkler risers provided single points of supply at each floor level, which creates the potential for single point failures.
- In specific cases, the lack of interconnections for adjacent standpipe zones resulted in the potential for single point failures of the standpipe systems.

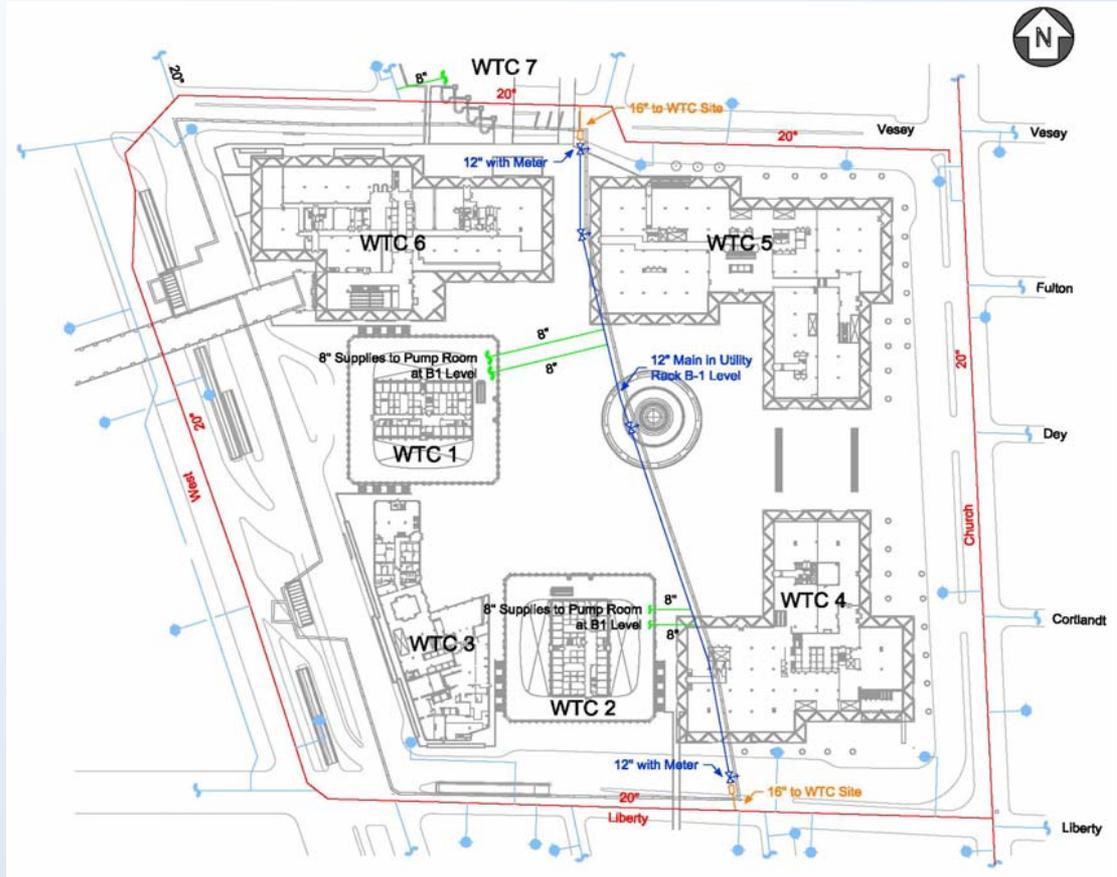
# Water Source at The WTC Complex: NYC Water Distribution System

## Finding (1):

Water supply capacity and redundancy met or exceeded best practices.

### Legend

- Red – 20" Plaza Loop
- Orange – 16" Connection to Distribution System
- Blue – 12" Cross-Connection Main for Plaza
- Green – 8" Feed Mains for Standpipe and Sprinkler Systems
- Cyan – Continuation of Distribution System



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# Sprinkler and Standpipe Systems Risers

**Finding (2):** Water supplies to the automatic sprinklers and standpipe systems exceeded minimum requirements for high-rise office occupancy protection in accordance with NFPA 13.

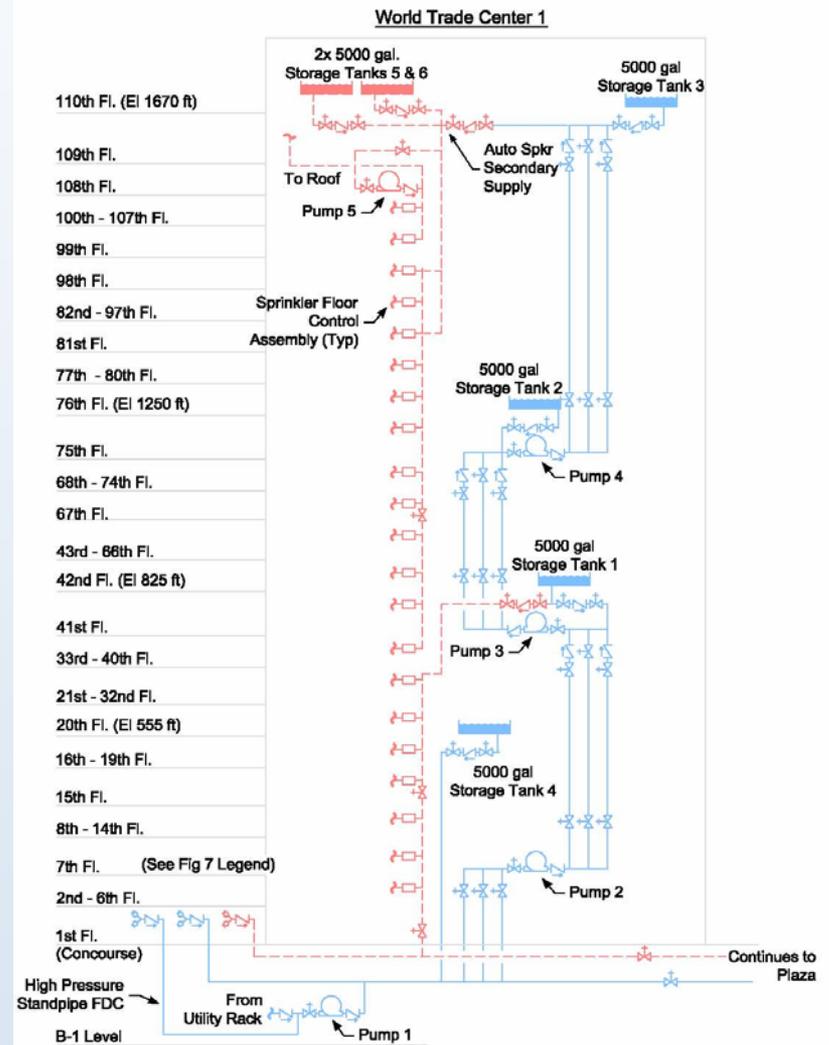
**Finding (3):** Generally, sprinkler risers provided single points of supply at each floor level, which causes the potential for single point failures.

**Finding (4):** In specific cases, the lack of interconnections for adjacent standpipe zones resulted in the potential for single point failures of the standpipe systems.

## Legend

Blue – Standpipe system

Red – Sprinkler system



Original drawing used with permission of Silverstein Properties.

## Fire Alarm Systems WTC 1 & 2

WTC 1 & 2 fire alarm systems consisted of multiple panels distributed within each tower.

The distributed panels shared intelligence, information, control, and communication through system signal communication paths.

# Fire Alarm Systems

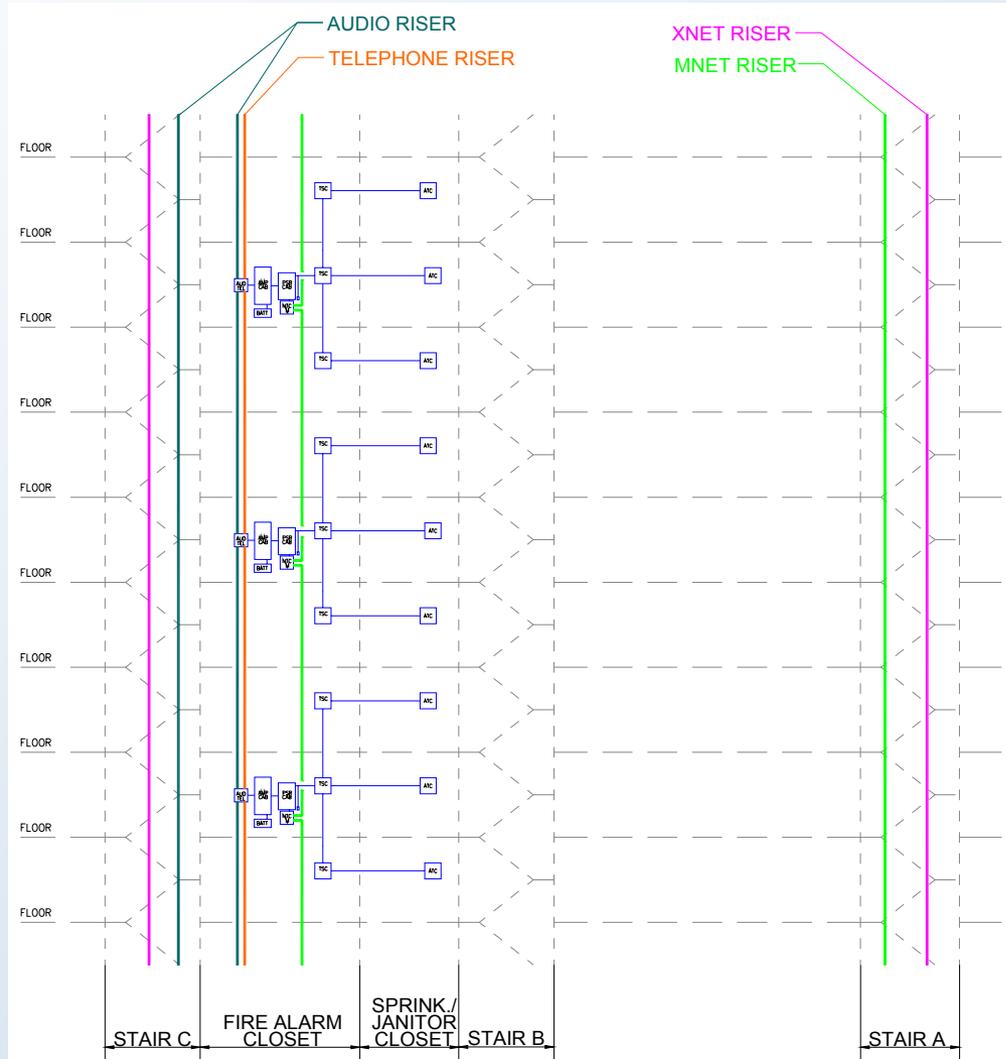
Each tower had 4 separate signal communication paths connecting the distributed fire alarm panels between multiple floors.

XNET – “global”  
(24 floors, typical)

MNET – “local” (3 floors)

Audio Tones & Voice  
Announcement Appliances

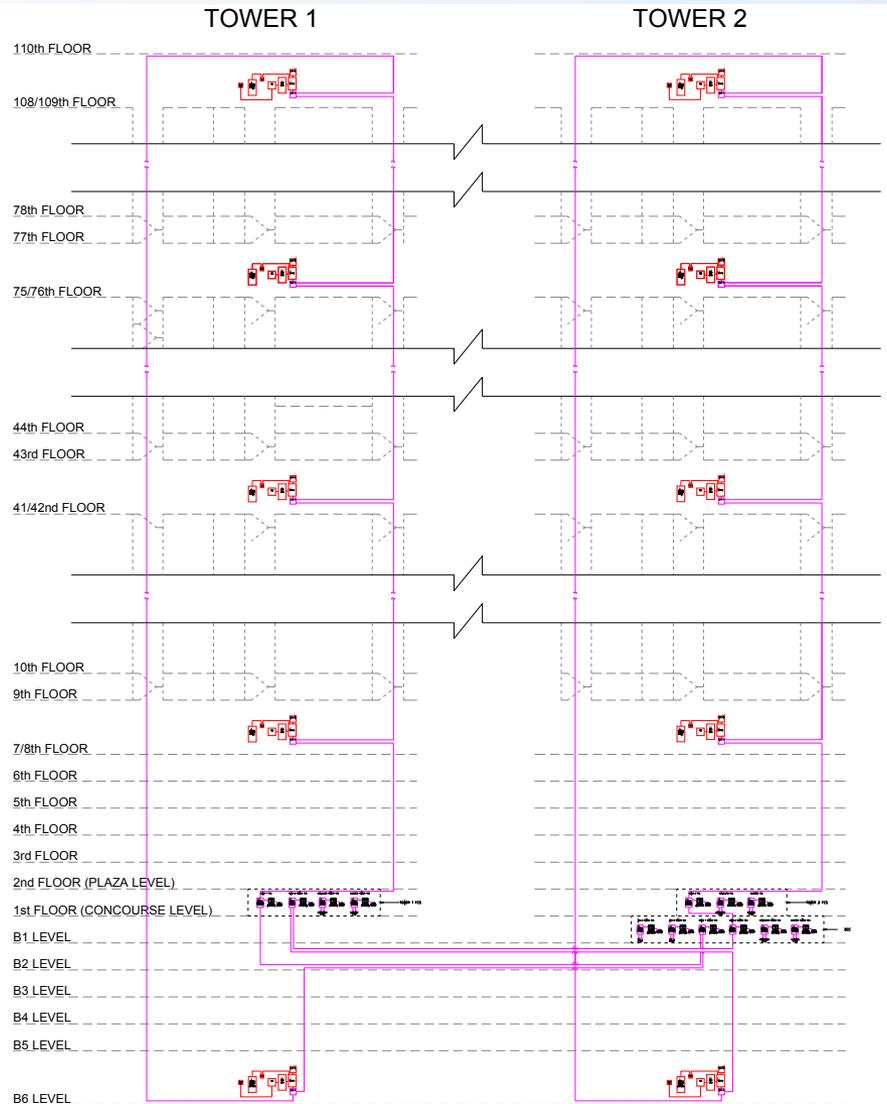
Firefighter & Warden  
Telephone



# XNET “global”

Provided a communication path between the 4 master fire alarm panels and the head-end fire alarm station (manual monitoring and control) distributed within each tower. The path shared monitoring and control information between the fire alarm panels. This system signal communication path went from the lowest level to the highest level of each tower.

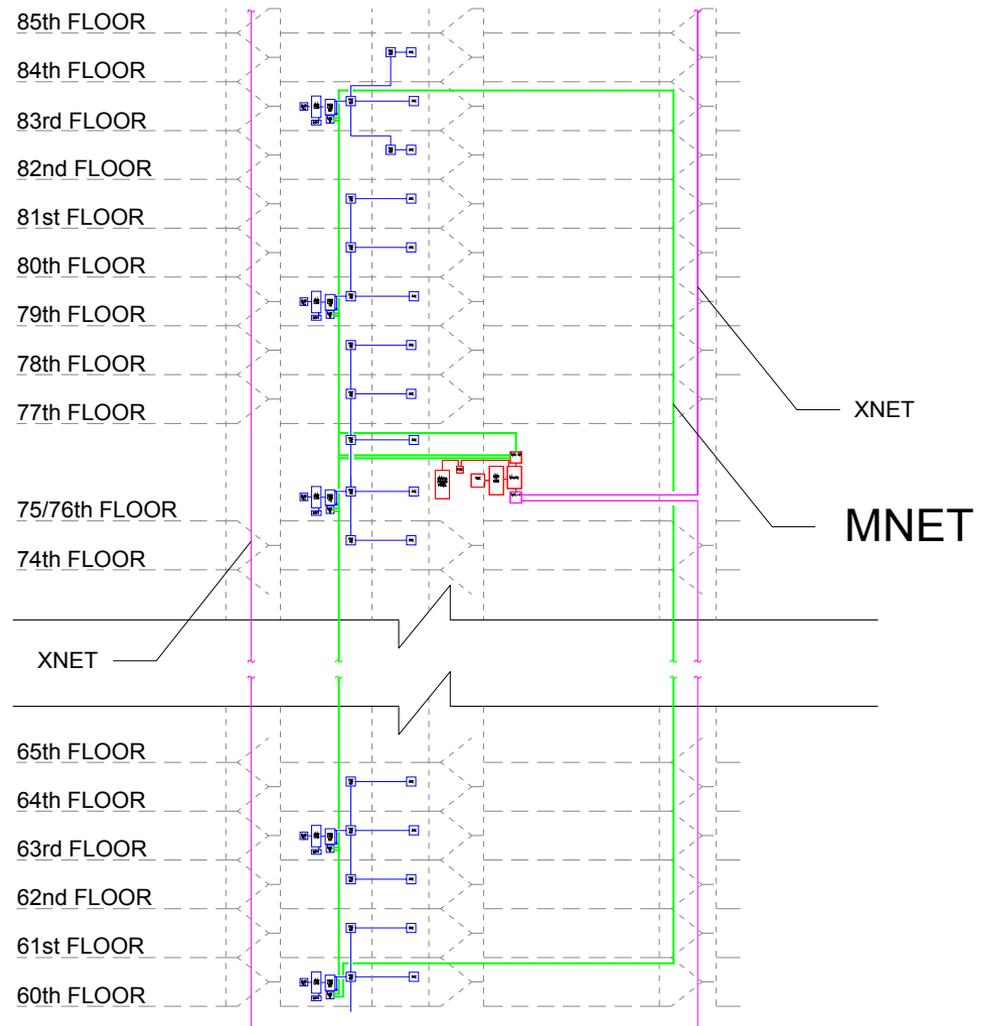
## XNET Riser



# MNET “local”

Provided a communication path for the monitoring and control information between the master fire alarm panels and the distributed slave panels located (typically) every 3 floors. This system signal communication path connected (typically) 24 floors.

## MNET Riser



## **AUDIO/VOICE**

Provided a communication path for the occupant notification signal and voice messages. This system signal communication path went from the lowest level to the highest level of each tower.

## **FIREFIGHTER AND WARDEN TELEPHONE**

Provided a communication path for the firefighter and warden telephone system. This system signal communication path went from the lowest level to the highest level of each tower.

# Findings

- The XNET and MNET signal transmission path had redundant risers and had the capability to provide communication **below** the impact area where the risers where **shorted, opened or grounded**.
- The Audio/Voice signal transmission path had redundant risers and **DID NOT** have the capability to continue to provide communication to any panel where the risers where **shorted**.
- The Firefighter and Warden Telephone signal transmission path was a single riser and **DID NOT** have the capability to continue to provide communication to any panel above the point where a cable was open, or to **ANY** connection where the risers were **shorted**.
- Interviews of firefighters indicated that the firefighter “standpipe” telephone systems were not used on September 11.

# Smoke Management Systems

Evaluated Smoke Management System Capabilities using CONTAM Model

Examine photographic evidence, radio traffic, and survivor/emergency responder testimony to determine factors that may have impacted smoke management system performance

Special attention given to study of rapid vertical smoke spread in WTC 1

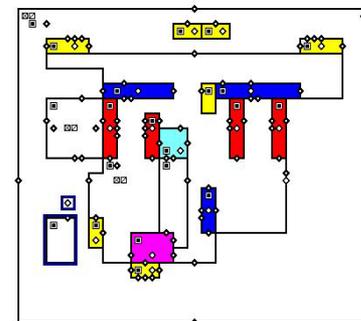
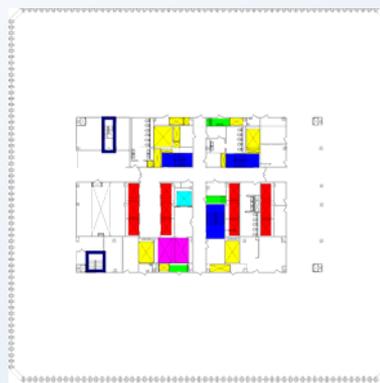


Photo By:  
Det. Greg Semendiger  
NYC Aviation Unit

*North Face – WTC 1*  
Smoke Exits NW Interior  
Ventilation Zone Supply Inlet



# Findings

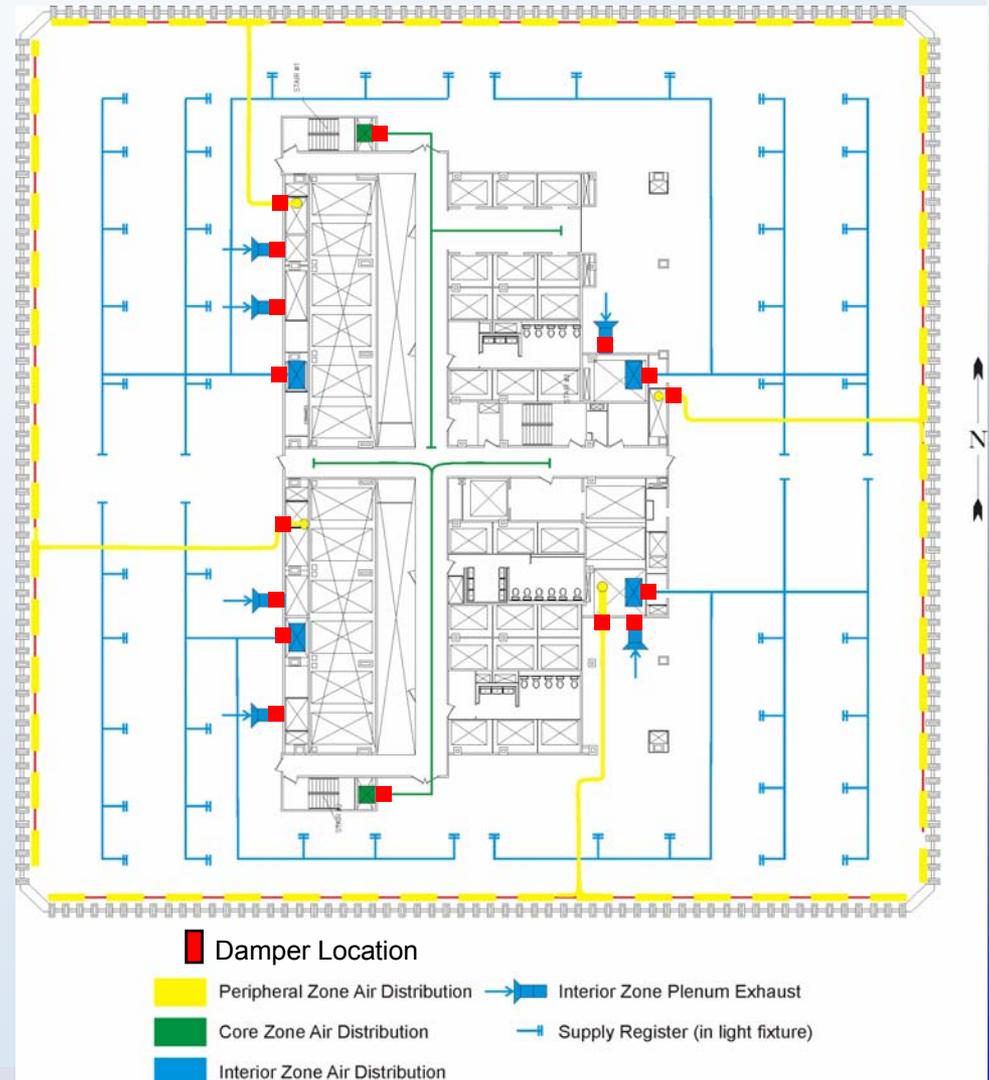
- The smoke management systems in WTC 1 and WTC 2, which provided the capability for a manual smoke purge within an individual HVAC zone on a quadrant-by-quadrant basis, were not initiated on September 11, 2001.
- Had the smoke purge sequence been initiated in WTC 1 or 2, it is unlikely the system would have functioned as designed, due to loss of electrical power and/or damage to the HVAC shafts and other structural elements in the impact zone.
- Provision of active smoke management systems and/or combination fire/smoke dampers was not required by the 1969 NYCBC or retroactive provisions in the various local laws enacted after WTC 1 and 2 were constructed for existing high-rise buildings equipped with automatic sprinklers throughout.

# Findings (cont.)

- None of the potential smoke management system configurations evaluated in this investigation would have provided sufficient pressure differentials to contain smoke for the postulated aircraft impact damage scenarios, even if these systems were capable of operation after the building sustained damage from the aircraft impact.
- During the events occurring on September 11, 2001, stair pressurization would have been ineffective in improving conditions for occupants trying to exit the buildings.

# Findings (cont.)

- Installation of combination fire/smoke dampers in HVAC ductwork, which was not required in WTC 1 or 2, would have acted to slow the development of hazardous conditions on the uppermost floors of the building.



# Status of Project 4 Deliverables

WTC 1, 2, and 7 Fire History	Completed
Draft contractor reports to NIST on design, capabilities, and performance of active fire protection systems:	
Smoke Management	July 2004
Sprinkler, Standpipe, and Pre-connected Hoses	July 2004
Fire Alarm	July 2004
NIST findings and recommendations	August 2004

# **Investigation of Active Fire Protective Systems Project 4**

Thank you.

Comments and Questions