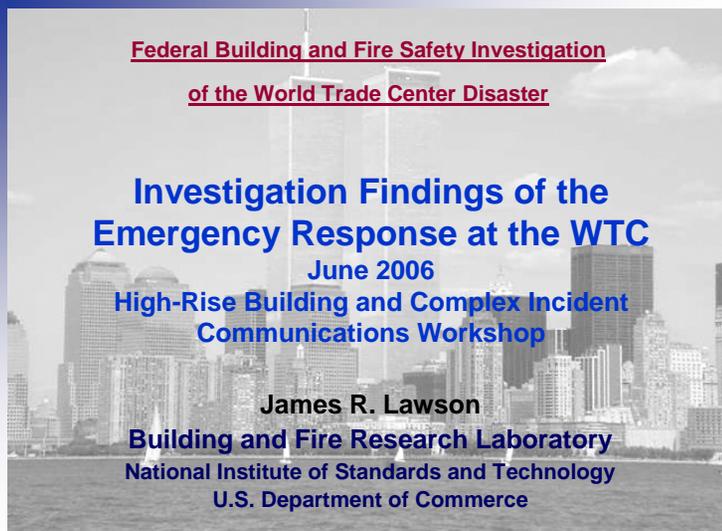


## Appendix 4 - Presentations

### Presentation by James R. Lawson – National Institute of Standards and Technology



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### Radio Communications

- All three of the responding departments, FDNY, NYPD & PAPD experienced difficulties with radio communications.
- Each of the departments was aware of the shortfalls associated with their radio communications systems as it related to operations in high-rise buildings.
- Two basic issues with radio communications:
  1. Normal function of the radio equipment in high-rise environments. (Radio signal attenuation in steel and steel reinforced concrete buildings)
  2. The volume of radio traffic.

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### Emergency Responder Radio Systems

**Simplex Communications** - direct point-to-point, HT-to-HT, or HT-to-Base Station (HT = Handie-talkie)

**Duplex Communications** - transmissions are channeled through a radio repeater.

PAPD Operations - Duplex through their dedicated WTC police department repeater.

FDNY Operations - Simplex for command channel and tactical operations  
- Duplex through their dedicated WTC FDNY high-rise repeater.  
- Cross-band through the Battalion Car repeater.

NYPD Operations - Simplex between ESU teams members and the ESU Mobilization Point.  
- Duplex through the NYPD SOD and Div 1 repeaters.

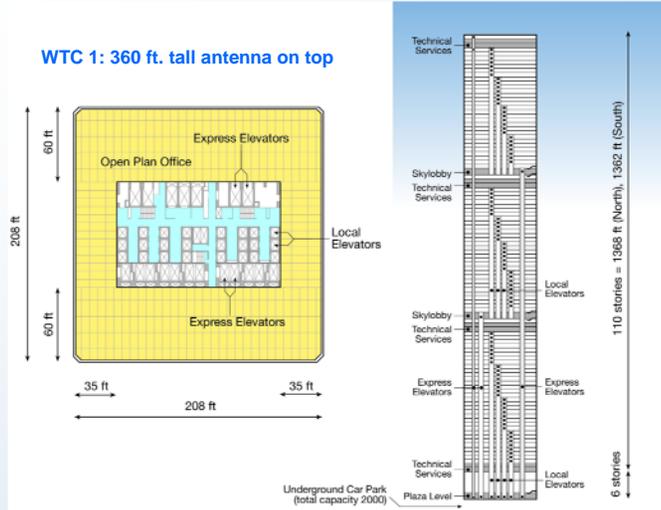
NIST



**Locations of FDNY and NYPD Command Posts**

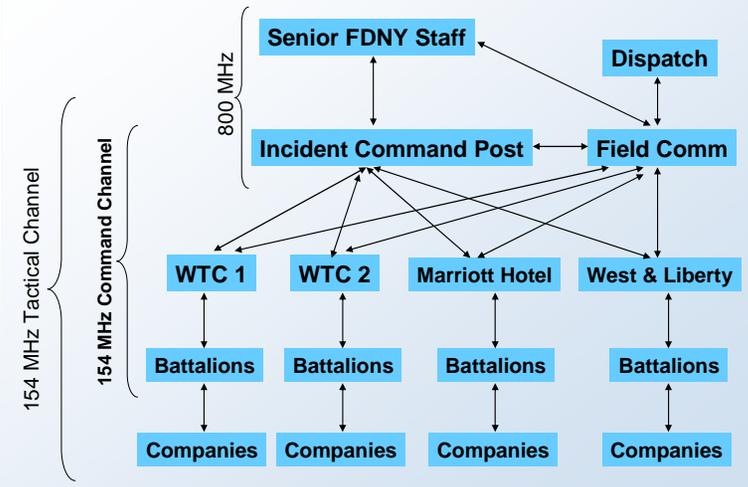
NIST

## World Trade Center Buildings



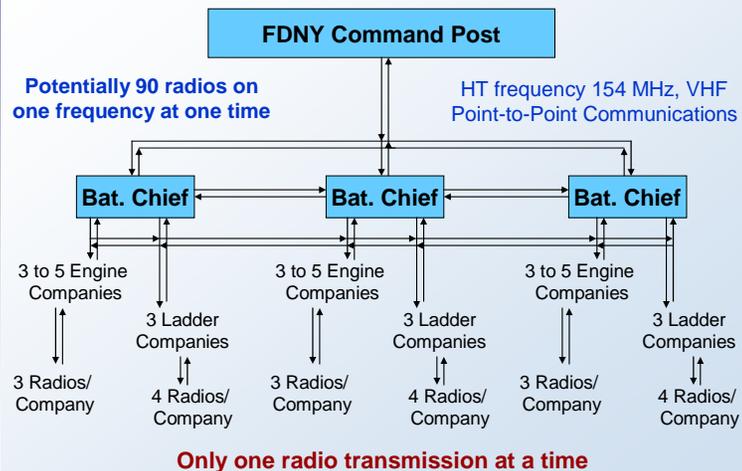
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## FDNY Radio Communications System



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## Example: Handie-Talkie Radio System Structure



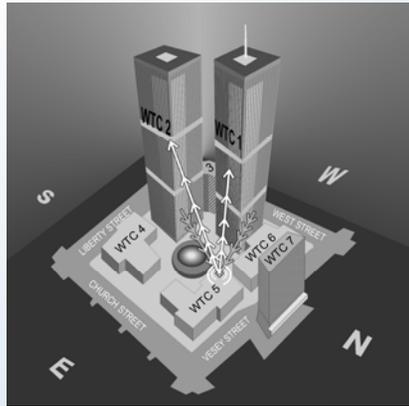
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Video image of EMS responder attempting to improve communications from inside the lobby of WTC 1 by lifting his radio above head level.



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## Graphic Showing the FDNY High-Rise Repeater Antenna Location Relative to the WTC Towers



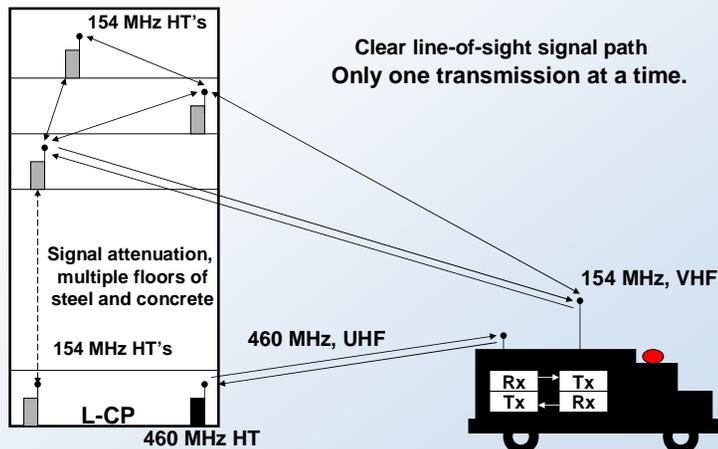
NIST

## Video Image of FDNY WTC 1 Lobby Command Post Showing a Repeater Phone



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## Example: Battalion Car Cross-band Repeater



Drawing by NIST base on document by Battalion Chief Orio J. Palmer and original drawing by FF Bill Kristoff, FDNY, WNYF, Repeater Systems, 3<sup>rd</sup> 1998.

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## Radio Communications, continued

- Even though the Battalion Car Cross-band Repeater was turned on at approximately 9:07 a.m. and was to be delivered to the WTC 2 lobby command post, there is no record that FDNY used the cross-band repeater at the WTC site. All known personnel that may have used the repeater died with the collapse of WTC 2.
- FDNY radio protocol specified that **only one Battalion Car cross-band repeater was to be used at any incident**. This was to prevent multiple repeaters at one site from interfering with each other.
- There is no evidence that the WTC 1 lobby Command Post used either the FDNY/ WTC high-rise channel 7 repeater or the cross-band repeater to communicate with other personnel up inside the tower.

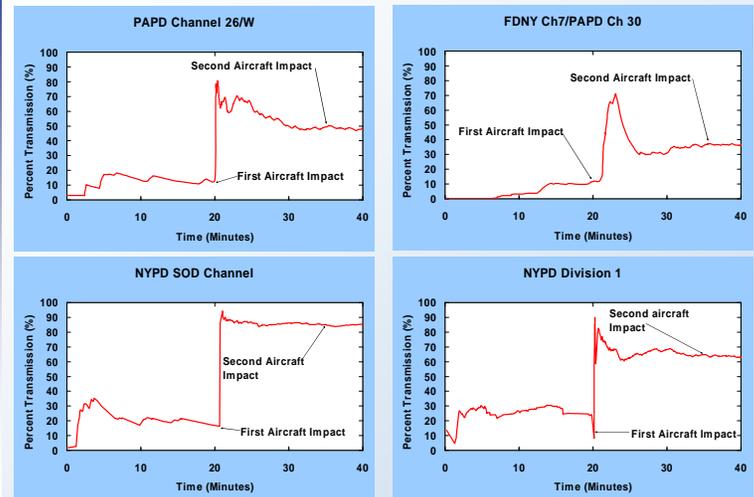
NIST

## Radio Communications, continued

1. After the first aircraft struck WTC 1, there was an approximate **factor of 5 peak increase in traffic level** over the normal level of emergency responder radio communications, followed by an approximate **factor of 3 steady increase in level of subsequent traffic**.
2. A surge in communications traffic volume made it more difficult to handle the flow of communications and delivery of information.
3. Analysis of radio communications records indicates that **roughly 1/3 to 1/2 of the radio messages during surge conditions were not complete nor understandable**.

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## Radio Traffic Volume – $T\% = 100(\text{Transmission Time}/\text{Total Time})$



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## Radio Communications, continued

The following examples of radio communications relate to:

- 1) the surge in radio traffic
- 2) the inability of the radio systems to handle more than one message at a time, and
- 3) undesirable radio operations practices
- 4) radios not working well & open microphones

Between when the first aircraft hit and approximately 10:00 AM, emergency responder communications included the following types of messages:

- asking officers to stay off the air
- comments that messages were being cut-off, there was crossing or doubling, and messages were unreadable
- comments that multiple units were talking at the same time and requests that units talk one-by-one

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## Radio Communications Readability Analysis

**Readability**, is a communications term used to define the ability of a person to hear and understand a radio transmission.

### Readability Scale:

- 1 – Unreadable
- 2 – Barely readable, occasional words distinguishable
- 3 – Readable with considerable difficulty
- 4 – Readable with practically no difficulty
- 5 – Perfectly readable

**Note:** This is a subjective scale related to a trained human's ability to hear and understand communications transmissions.

Ref: The ARRL Handbook for Radio Communications

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## Readability Summary Before Attack

Dept.	Readability Scale				
	1	2	3	4	5
PAPD Ch 26/W Police Desk	8%	17%	19%	56%	0%
FDNY H-R Ch 7 (PAPD Ch 30) Repeater	n/a	-	-	-	-
NYPD Div. 1	2%	9%	8%	21%	60%
NYPD SOD	0%	0%	14%	23%	63%

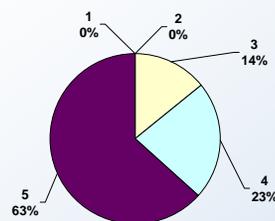
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## Readability Summary During Operations

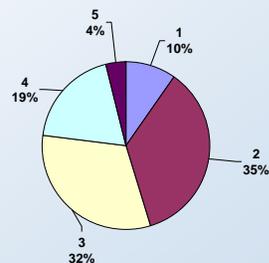
Department	Readability Scale				
	1	2	3	4	5
PAPD Ch 26/W Police Desk	9%	24%	43%	24%	0%
FDNY H-R Ch 7 (PAPD Ch 30) Repeater	10%	26%	42%	18%	4%
NYPD Div. 1	11%	26%	32%	23%	8%
NYPD SOD	10%	35%	32%	19%	4%

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## Radio Communications Readability Analysis NYPD Special Operations Division (SOD)



Before Attack



After Attack

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## Radio Communications, continued

- NYPD had relatively good radio communications on their point-to-point communications in the WTC towers because there were only six ESU teams working on the frequency, and
- NYPD's mobilization point that was communicating with ESU personnel inside the towers was set up more than a city block away from the towers allowing for more direct or line-of-sight communications with the towers.
- FDNY was attempting to operate communications systems from inside the WTC towers where building components attenuated radio communications signals.

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## Inter-Agency Cooperation

- A significant amount of evidence (first person interviews, reports, and photographic data) shows that the different agencies were working together during the WTC disaster.
- Data also indicates that inter-agency operations were hampered by the loss of the OEM command center that was located inside WTC 7.
  - OEM functions became dispersed
  - The OEM communications center was lost
  - The computer systems and other equipment used to provide support for emergency response operations was lost
  - Unified operations structure for the emergency response was diminished
- First person interview data and photographic data shows OEM personnel working with different emergency responder departments and located at the various department command posts.
- First responder interviews suggest that inter-department competition had minimal affect on operations at the WTC complex on the morning of September 11<sup>th</sup>. First person interview data also suggests that some of the problems experienced were due to personnel not understanding operating practices of the other agencies.

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## FDNY Incident Command Post Outside of World Financial Center 2 on West Street



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## Command and Control

- FDNY command and control was seriously affected by the lack of good communications.
- FDNY's system for maintaining records of unit assignments at each command post was not capable of managing the numbers of units and personnel being assigned to the incident.
- FDNY, NYPD, and PAPD: there was no means to back-up the unit assignment records generated at the command posts.

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## FDNY Command Board Located in the Lobby of WTC 1



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## First Person Accounts of Telephone Communications

- Before the attack at the World Trade Center both landline and cellular telephone systems were working.
- Moments after the first aircraft impacted WTC 1 the telephone systems were stressed by increased caller volume.
- Although there was impact damage and fires were burning in the two World Trade Center towers, some landline telephones were working in the buildings.
- After the collapse of WTC 2, a number of cellular phone systems were not functioning in lower Manhattan.
- After the collapse of WTC 2, there were still some landline telephones working within the city block areas adjacent to the World Trade Center.

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## Issues

### Emergency Response - Communications

- Lack of rigorous pre-emergency inspection and testing of radio communications systems within high-rise buildings to identify performance gaps and inadequacies.
- Missed opportunities to better communicate information among the occupants, 911 operator dispatch, fire department dispatch, police department dispatch, emergency management service dispatch, and site security. (Inadequate situational awareness)
- Performance requirements for emergency communication systems in buildings.
  - Design, testing, certification standards
  - Maintenance and inspection requirements

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## Emergency Responder Operations

### Situational Awareness:

- Emergency responders working outside of the WTC buildings that could view building conditions and communicate over radios had adequate situational awareness.
- Situational awareness for personnel that observed the building damage and fires from outside the buildings before entering experienced difficulty maintaining their awareness after entering the buildings.
- Emergency responders working inside of the WTC buildings, who could not see what was happening outside and had poor radio communications, had poor situational awareness.
- Emergency responders working inside of the WTC buildings who could not see what was happening outside and had good radio communications had better situational awareness over those with poor radio communications.

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## Issues

### Emergency Response - Communications continued

- Lack of communications network architecture (interoperability) and operational protocols for intra- and inter-agency communication at all levels of organizational hierarchy. This includes:
  - Overall network architecture that covers local networking at incident sites, dispatching, and wide-area urban and rural networks
  - Scalability in terms of the number of first responders using the system and in providing radio coverage in large buildings with challenging radio frequency propagation environments
  - Interoperability with existing legacy emergency communications systems
  - Localization techniques to identify first responders within indoor building environments
  - Conventional two-way systems versus wireless network systems

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