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

Project #8,
Fire Service Technologies and Guidelines

June 23, 2004

J. R. Lawson, Project Leader
Building and Fire Research Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce
james.lawson@nist.gov

NIST

Contributing Personnel

NIST Personnel

- J. Randall Lawson
- Robert L. Vettori
- Schuyler Ruitberg
- Lisa Petersen

NIST Experts:

- Vincent Dunn, FDNY (retired)
- John J. Hodgens, FDNY (retired)
- Kevin S. Malley, FDNY (retired)

NIST Contractor

- Nustats, Inc.

Purpose of Project #8

To build upon work done by the New York City Fire Dept. (FDNY) and McKinsey & Company by:

1. Fully documenting what happened during the response by the fire services to the attacks on the World Trade Center (WTC), up to the time of collapse of WTC 7;

2. Identify issues that need to be addressed in changes to practices, standards and codes;

3. Identify alternative practices and/or technologies that may address these issues; and

4. Identify R&D needs that advance the safety of the fire service in responding to massive fires in tall buildings.

Technical Approach and Status

This project is divided into four tasks. The following is a brief description of the tasks:

Task 1 - Collect data to document the broad range of emergency response operations, command and control functions, communications, and equipment used at the WTC incident. *Data collection and review is largely completed*.

Task 2 - Interpret the factual analysis to determine the effect on responder successes. *Data are being analyzed and coded for analysis.*

Task 3 – Identify alternative emergency response practices and technologies that may advance the safety and effectiveness of first responders. *A findings based task that is in progress.*

Task 4 – Report preparation and the identification of R&D needs in support of the fire service. *Data analysis is in progress, the final report outline has been drafted, and report development is under way.*

NIST

Interim Report on Emergency Communications

Principal Objectives:

1. To develop a better understanding of the role that emergency communications played during the attack on the WTC, and

2. To quantify information related to communications effectiveness:

    - document radio communications readability
    - quantify radio communications traffic volume

Communications Sources

- The Port Authority of New York and New Jersey (PANYNJ) submitted radio and telephone communications recordings to NIST related to the emergency response.
- The New York City Police Department (NYPD) provided radio communications recordings for the Special Operations Units frequencies and Division 1 frequency that were used in operations at the WTC.
- New York City provided NIST with the opportunity to listen to recordings of telephone calls made to 9-1-1 Emergency Operators and FDNY Fire Dispatchers.
- PANYNJ also supplied a recording from the FDNY high-rise channel 7/Port Authority Police Dept. (PAPD) channel 30 repeater located at the WTC site.
- First person accounts of experiences with radio and telephone communications.

Note: The FDNY Field Communications truck was not in service and recordings of FDNY radio communications at the site were not made.

First Person [face-to-face] Interviews Conducted

- New York City

  FDNY Interviews - 68

  Command Officers, Company Officers, Firefighters, Rescue Squad personnel, EMS, Communications, Fire Marshals, etc.

  NYPD Interviews - 24

  Command Officers, Special Operations Division Officers, Communications Personnel, and Aviation Unit Officers

- PANYNJ Interviews - 13

  PAPD Command Officers, Police Officers, Building Safety Staff, Communications & Vertical Transportation Personnel

- Other

  Security, Fire Safety, and Communications Personnel - 3

First Person Accounts of Telephone Communications

- Before the attack at the WTC 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 WTC 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 WTC.

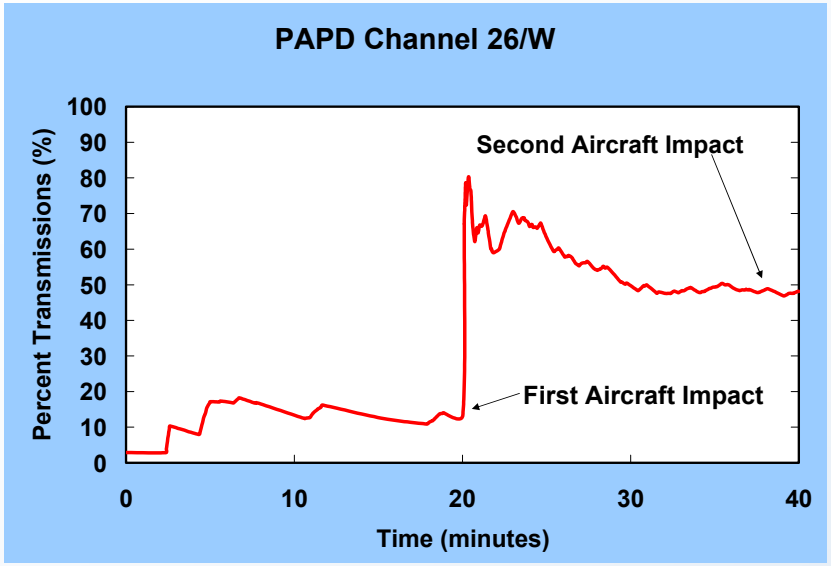
Radio Communications Analysis

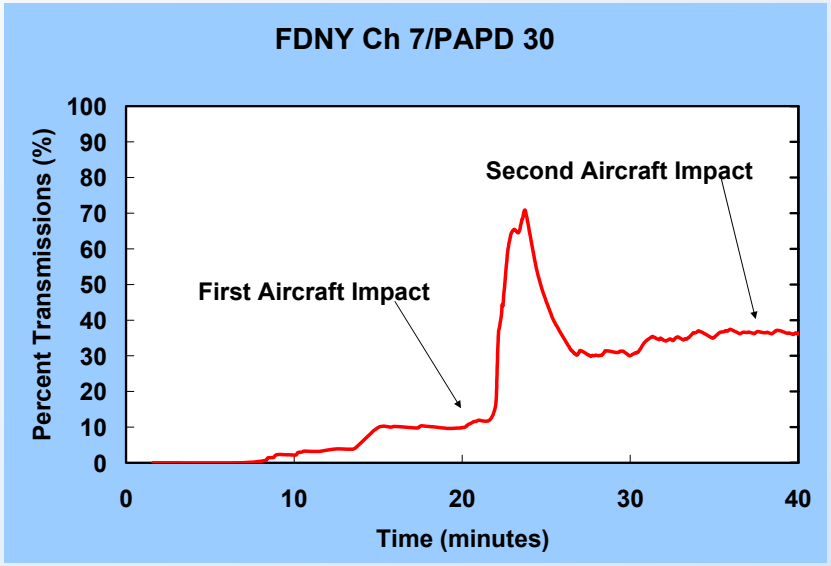
Dept.	Average time per transmission before 1st aircraft impact and maximum time (s)	Average time per transmission after 1st aircraft impact and maximum time (s)
PAPD	3.8 (max. 21.8)	3.3 (max. 19.7)
FDNY	3.8 (max. 50.9)	3.1 (max. 19.5)
NYPD (Div. 1)	1.9 (max. 5.9)	3.4 (max. 12.6)
NYPD (Special Ops. Div.)	No data	5.7 (max. 31.5)

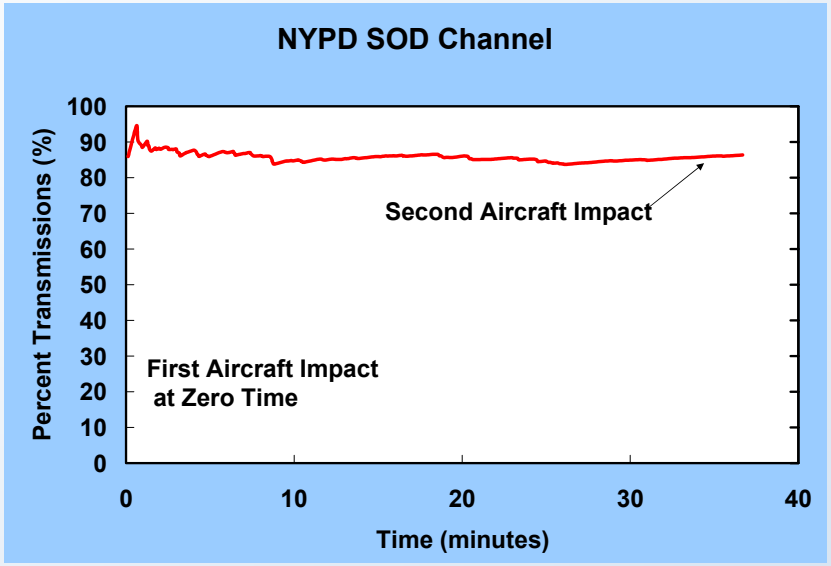
Note: Minimum transmission times were typically less than one second and were often related to keying of a microphone.

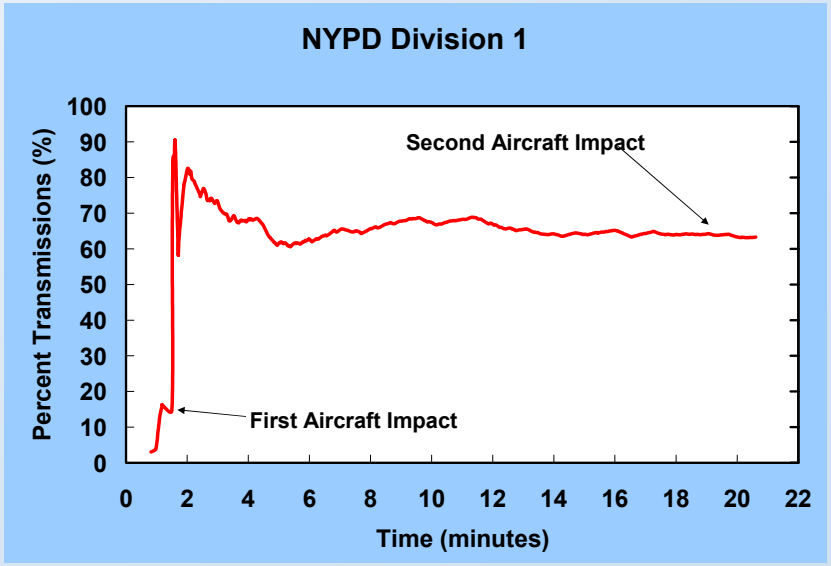
NIST

Radio Traffic Volume - T% = 100(Transmission Time/Total Time)









NIST

Quality of Radio Communications

Some factors that contributed to poor communications quality:

- background noise, either at the transmission point, or receiving point, or both;
- operating health of transmitting and receiving radios and antenna systems;
- doubling or crossing of radio signals, caused by multiple transmissions at the same time on the same radio frequency; and
- radio transmissions may be affected by attenuating materials or electromagnetic interference.

Radio Communications Readability Analysis

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

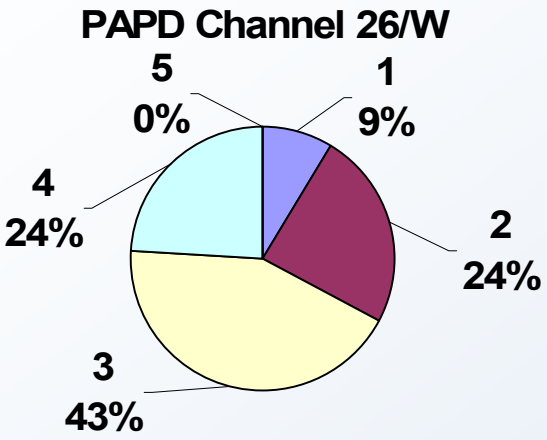
Readability Scale:

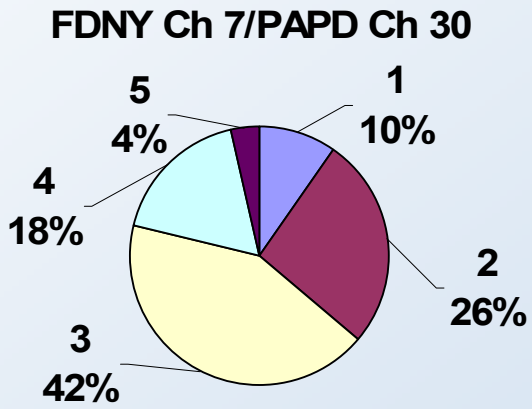
1 – Unreadable
2 – Barely readable, occasional words distinguishable
3 – Readable with considerable difficulty
4 – Readable with practically no difficulty
5 – Perfectly readable

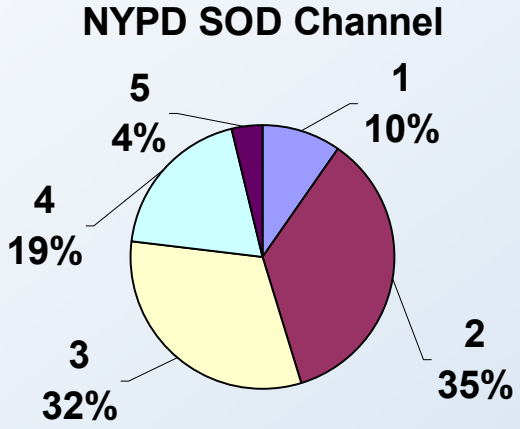
Note: This is a subjective scale related to a trained human's ability to hear and understand communications transmissions.

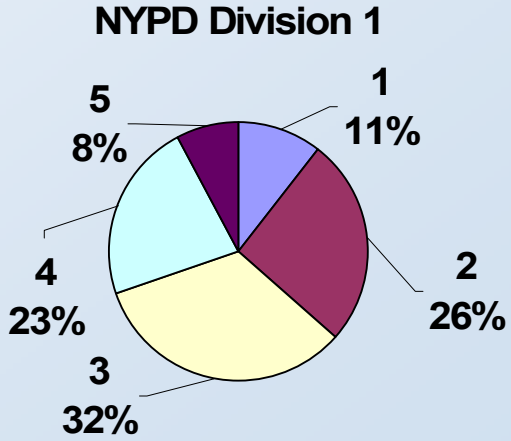
Ref: ARRL (American Radio Relay League) Handbook for Radio Communications

Radio Communications Readability









Summary of Readability Results

	Readability Scale				
Dept.	**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%

NIST

Preliminary Chronology of Emergency Communications

Five Chronologies:

1. Dispatch and arrival of emergency responders

A chronology of communications providing the times that emergency responders were dispatched and the times that they arrived at the incident.

2. Evacuation

A record of the evacuation of WTC 1, WTC 2, and the WTC site.

3. Emergency response operations

A record of emergency response operations by FDNY, NYPD, and PAPD.

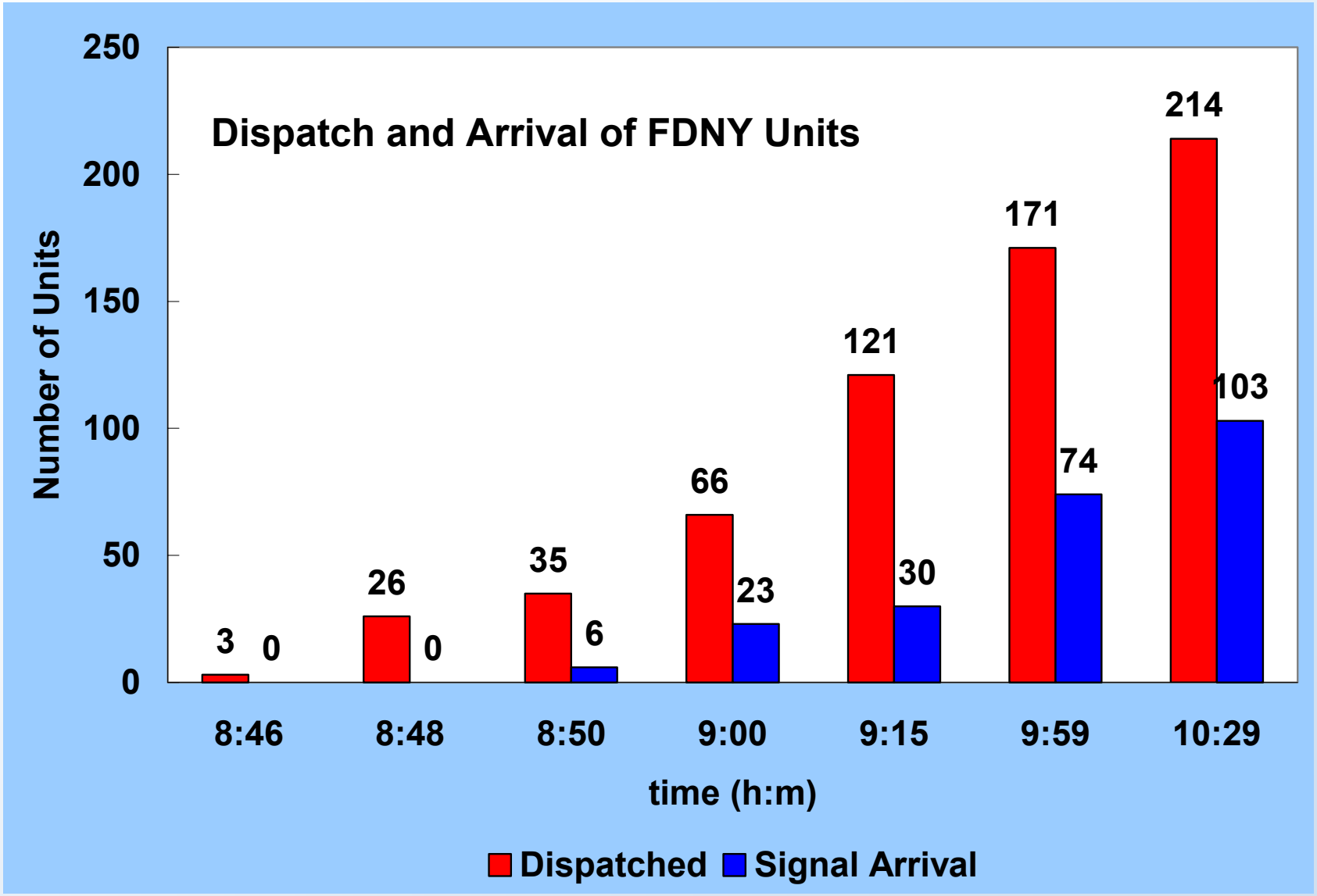
4. Emergency response communications

A record of communications, about communications operations and quality.

5. Condition of the WTC towers

A record of communications concerning the changing conditions in the towers.

Noteworthy Communications



NIST

Noteworthy Communications

Evacuation:

- PAPD Police Desk Channel Z: A senior level PAPD police officer calls twice over a two minute period immediately following the first aircraft impact for the evacuation of WTC 1. The message is acknowledged. Currently, no evidence has been found to suggest that the information was distributed to personnel responsible for evacuating the building.
- 8:59 a.m., PAPD Police Desk Channel Y: A senior level PAPD officer calls twice for the evacuation of WTC 1 and WTC 2 and then the entire WTC complex. The message is acknowledged. At 9:02 a.m. the police desk operator broadcasts the message to evacuate all tenants in the WTC complex. No evidence has be found to suggest that the information was further distributed to personnel responsible for evacuating the WTC complex.
- Communications data shows that the evacuation process was not always orderly. There were reports of people running from the PATH trains, and there was a report from WTC 5 that “I have people going crazy.”

Noteworthy Communications

Evacuation:

- At 9:12 a.m. radio communications to the PAPD police desk provided information on building functions that influenced the evacuation process. Information was received from the Fire Command Desk in the lobby of WTC 2 that the Warden phones in the building were not working. The response from the Fire Command Desk was that Wardens were to leave the phones.

- Communications from the PAPD police desk documented cases where physically impaired and elderly people were not able to walk down the stairs and that they needed assistance to get out of WTC 1. Some of these individuals were on the 51st floor at 9:30 a.m. The outcome of their evacuation attempt is unknown.

Noteworthy Communications

Emergency Response Operations:

- A radio communication at 8:50 a.m. from FDNY Ladder 10 to the PAPD police desk, using a PAPD radio, shows a level of cooperation between FDNY and Port Authority personnel.
- NYPD aviation units arrived at the WTC by 8:52 a.m. They checked to see if roof rescue was possible and reported back that they are unable to land as a result of heavy smoke conditions.
  - First person interviews with aviation unit personnel also indicates that heat from the building's fires was causing the helicopter engine temperature to increase.
  - An aviation unit called again at 9:38 a.m. for permission to land on the roof of WTC 1. A first person interview indicated that the aviation units were desperate to assist the people trapped and jumping from the upper floors. There was no indication that landing conditions had improved.
  - Five minutes after the request to land, a senior NYPD officer ordered that no one was to rappel onto the buildings.

Noteworthy Communications

Emergency Response Operations:

- At 9:18 a.m. a FDNY Chief Officer using the high-rise repeater, channel 7, reports that one elevator in WTC 2 is working up to the 40th floor. This communication led to the use of the elevator for taking emergency responders and equipment up into the tower. This elevator became stuck in the shaft and was also being scheduled for the removal of injured at the time of the building collapse.
- A radio communication on the FDNY high-rise repeater, channel 7, at 9:22 a.m. from the FDNY WTC 2 Operations Post located in the building's lobby to a Chief FDNY Officer located on the 43rd floor of the same building states that a NYPD Emergency Service Unit (ESU) is there to assist. The FDNY Chief Officer gives directions for sending the ESU team to his location. This communication provides an indication that FDNY and NYPD were working together at this level of the operation.
- At 9:45 a.m. a radio communication to the PAPD police desk states that an officer on 22nd floor, can't release locks on doors, and that there is a loss of electrical power. Interviews and other radio messages indicate significant damage to this floor in WTC 1.

Noteworthy Communications

Emergency Response Communications:

- All of the three primary responding departments FDNY, PAPD, and NYPD experienced radio communications difficulties during the incident.

- Both PAPD and NYPD had handie-talkies with open or stuck microphones that produced radio interference. In addition, reports came in from the field indicating that radios were not working well.

- There were many cases where FDNY, PAPD, and NYPD personnel made radio calls, and they never received an answer. This may be attributed to the failure of the radio system or the inability of the person called to answer. There were cases where the person called would answer and would not be heard by the party that originated the call.

Noteworthy Communications

Emergency Response Communications:

- 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.

  8:49 a.m. - PAPD police desk tells police officers to stay off the air
  8:51 a.m. - NYPD dispatcher advises officers that they are crossing
  8:53 a.m. - NYPD dispatcher advises that messages are being cut off
  9:00 a.m. - NYPD dispatcher advises that messages are crossing & unreadable
  9:14 a.m. - PAPD police desk incomplete message from crossing or doubling
  9:22 a.m. - NYPD dispatcher advises that messages are unreadable
  9:28 a.m. - PAPD police desk incomplete message from crossing or doubling
  9:54 a.m. - NYPD dispatcher requests that personnel “keep the air clear.”
  10:05 a.m. - NYPD dispatcher advises that all units should talk one-by-one
  10:10 a.m. - NYPD dispatcher advises that 3 units are talking at the same time.

- At 9:31 a.m. a PAPD officer questions if the red bags with radios for FDNY have been brought to the scene. The answer is no. These radios provide communications between PAPD and FDNY.

Noteworthy Communications

Condition of the WTC Towers:

- At 8:47 a.m. and 8:51 a.m. the PAPD police desk receives information indicating that there is a fire on the 22nd floor and there was an explosion on the B1 level of WTC 1. These communications provided emergency responders with information concerning the initial range of building damage and threat to the occupants.

- At 9:36 a.m. a NYC 911 operator receives a telephone message that there was a floor collapse in the 90's of WTC 2. The reporting person indicated that he was now on the 105th floor. At 9:41 a.m. and 9:51 a.m. a NYPD police dispatcher advises units that the 106th floor is crumbling. The 9:41 a.m. message appears to be a miscommunication based on the 9:36 a.m. message.

- At 9:47 a.m. a FDNY firefighter on the 74th floor of WTC 2 reports over high-rise channel 7 that there is no smoke or fire on the floors he climbed, but the stairway walls were breached on 68, 73, and 74th floors.

Noteworthy Communications

Condition of the WTC Towers:

- The following communications from the NYPD aviation units provide critical information concerning the impending collapse of the WTC towers. These communications describe the degrading building conditions, and they relate to the safety of individuals inside and around the buildings.

9:49 a.m. - NYPD aviation unit reports “large pieces” falling from WTC 2
9:58 a.m. - NYPD aviation unit advises WTC 2 is collapsing
10:06 a.m. - NYPD police officer advises that it will not be much longer before WTC 1 comes down.
10:20 a.m. - NYPD aviation unit reports that WTC 1 might be leaning
10:21 a.m. - NYPD aviation unit reports southwest corner of WTC 1 is buckling
10:27 a.m. - NYPD aviation unit reports WTC 1 roof will come down shortly
10:28 a.m. - NYPD police officer reports that WTC 1 is collapsing

Findings

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 the 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.

4. Preliminary analysis of the FDNY City-wide, high-rise, channel 7 (PAPD channel 30) recording indicated that the WTC site repeater was operating.

Findings Continued

5. Communications records and interviews indicate that smoke and heat conditions on the top of the two WTC buildings prevented the NYPD helicopters from conducting safe roof evacuation operations.

6. NYPD aviation unit personnel reported critical information about the impending collapse of the WTC towers several minutes prior to their collapse. No evidence has been found to suggest that the information was further communicated to all emergency responders at the scene.

Questions?