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June 2004 Progress Report on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster

Volume 6

Contains Appendices N, O, P, and Q

NIST National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

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U.S. Department of Commerce
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Technology Administration
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National Institute of Standards and Technology
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LIST OF ACRONYMS AND ABBREVIATIONS

AAPOR	American Association of Public Opinion Research
ABC	American Broadcasting Company
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALE	Arbitrary-Lagrangian-Evlerian
AMCBO	Association of Major City/County Building Officials
ANSI	American National Standards Institute
ANSYS	finite element model
ARA	Applied Research Associates, Inc.
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTM	ASTM International
AWS	American Welding Society
BOCA	Building Officials and Code Administrators
BOCA/BBC	BOCA Basic Building Code
BPAT	Building Performance Assessment Team
BPS	Building Performance Study
BSI	British Standards Institution
C/F	cancer free
CATI	computer-assisted telephone interviews
CBR	chemical, biological, and radiological
CBS	Columbia Broadcasting System
CERF	Civil Engineering Research Foundation
CFD	computational fluid dynamics
CIB	International Council for Research and Innovation in Building and Construction
CII	Construction Industry Institute
CNN	Cable News Network

CPP	Cermak Peterka Peterson, Inc.
CPU	central processing unit
CRT	cathode-ray tube
CTB&UH	Council on Tall Buildings and Urban Habitat
CTE	coefficients of thermal expansion
DC/F	BlazeShield DC/F fire protective insulation
DL	dead load
DTAP	dissemination and technical assistance program
EMS	Emergency Medical Service
EMT	Emergency Medical Team
ER&S	Emory Roth & Sons
FBI	Federal Bureau of Investigation
FCA	Flux cored arc
FDNY	New York City Fire Department
FDS	Fire Dynamics Simulator
FE	finite element
FEA	finite element analysis
FEM	finite element model
FEMA	Federal Emergency Management Agency
FMRC	Factory Mutual Research Corp.
FSI	Fire-Structure Interface
FVM	Finite Volume Method
GFI	Government Furnished Information
GG	glass over glass
GHz	gigahertz
GMS, LLP	Gilsanz Murray Steficek, LLP
HAZ	heat affected zone
HNSE	Hugo Nue Schnutzer East
HRR	heat release rate
HVAC	heating, ventilating, and air conditioning
IAQ	indoor air quality
IBC	International Building Code

ICBO	International Conference of Building Officials
ICC	International Code Council
IMTI	Integrated Manufacturing Technology
JFK	John F. Kennedy International Airport
JIS	Japan Industrial Standard
LERA	Leslie E. Robertson Associates
LES	Large Eddy Simulation
LL	live load
LSTC	Livermore Software Technology Corporation
MBC	BOCA National Building Code
MCC	Municipal Code of Chicago
MPI	Message Passing Interface
NBC	National Broadcasting Company
NBFU	National Board of Fire Underwriters
NCSBCS	National Conference of States on Building Codes & Standards, Inc.
NCST	National Construction Safety Team
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIBS	National Institute of Building Sciences
NIST	National Institute of Standards and Technology
NYC	New York City
NYCBC	New York City Building Code
NYCDOB	New York City Department of Buildings
NYPD	New York City Police Department
NYSBC	New York State Building Construction Code
P.L.	Public Law
PANYNJ	Port Authority of New York and New Jersey
PAPD	Port Authority Police Department
PC&F	Pacific Car and Foundry
PDM	Pittsburg-Des Moines
PONYA	Port of New York Authority
R&D	research and development

RWDI	Rowan Williams Davis and Irwin, Inc.
SBCCI	Southern Standard Building Code
SDL	superimposed dead load
SDO	standards development organization
SEAoNY	Structural Engineers Association of New York
SFPE	Society of Fire Protection Engineering
SFRM	spray-on fire resistant material or sprayed fire resistive materials
SHCR	Skilling, Helle, Christiansen, & Robertson
SI	metric
SLB	short legs back-to-back
SMA	Shielded Metal Arc
SOD	Special Operations Division
SOM	Skidmore, Ownings & Merrill
SPH	Smoothed Particle Hydrodynamics
SQL	Structured Query Language
SWMB	Skilling, Ward, Magnussen, and Barkshire
TL	Truss Lower Chord
TM	Truss Middle Chord
TU	Truss Upper Chord
UBC	Uniform Building Code
UL	Underwriters' Laboratories, Inc.
USC	United States Code
USM	United States Mineral Products Co.
VCBT	Virtual Cybernetic Building Testbed
WABC	WABC-TV New York
WCBS	WCBS-TV New York
WF	wide flange (a type of structural steel shape now usually called a W-shape). ASTM A 6 defines them as "doubly-symmetric, wide-flange shapes with inside flange surfaces that are substantially parallel."
WNBC	NBC4 New York
WNYW	FOX5 New York
WPIX	WPIX-TV New York
WTC	World Trade Center

WTC 1	World Trade Center Tower 1
WTC 2	World Trade Center Tower 2
WTC 7	World Trade Center Building 7

Abbreviations

×	by
±	plus or minus
°C	degrees Celsius
°F	degrees Fahrenheit
µm	micrometer
2D	two dimensional
3D	three dimensional
cm	centimeter
ft	foot
ft^2	square foot
F_y	yield strength (AISC usage)
g	acceleration (gravity)
g	gram
gal	gallon
h	hour
in.	inch
kg	kilogram
kip	a stress unit equal to 1,000 pounds
kJ	kilojoule
kN	kilonewton
kPa	kilopascal
klb	1,000 pounds
ksi	1,000 pounds per square inch
kW	kilowatt
kW/m^2	kilowatts per square meter
L	liter
lb	pound
m	meter
m^2	square meter
mm	millimeter
m/s	meters per second

min	minute
MJ	megajoule
MPa	megapascal
mph	miles per hour
ms	microsecond
Msi	millions pounds per square inch
MW	megawatt
N	newton
Pa	pascal
pcf	pounds per cubic foot
plf	pounds per linear foot
psf	pounds per square foot
psi	pounds per square inch
s	second

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METRIC CONVERSION TABLE

To convert from	to	Multiply by
AREA AND SECOND MOMENT OF AREA		
square foot (ft^2)	square meter (m^2)	9.290 304 E-02
square inch (in^2)	square meter (m^2)	6.4516 E-04
square inch (in^2)	square centimeter (cm^2)	6.4516 E+00
square yard (yd^2)	square meter (m^2)	8.361 274 E-01
ENERGY (includes WORK)		
kilowatt hour (kW * h)	joule (J)	3.6 E+06
quad (1015 BtuIT)	joule (J)	1.055 056 E+18
therm (U.S.)	joule (J)	1.054 804 E+08
ton of TNT (energy equivalent)	joule (J)	4.184 E+09
watt hour (W * h)	joule (J)	3.6 E+03
watt second (W * s)	joule (J)	1.0 E+00
FORCE		
dyne (dyn)	newton (N)	1.0 E-05
kilogram-force (kgf)	newton (N)	9.806 65 E+00
kilopond (kilogram-force) (kp)	newton (N)	9.806 65 E+00
kip (1 kip=1000 lbf)	newton (N)	4.448 222 E+03
kip (1 kip=1000 lbf)	kilonewton (kN)	4.448 222 E+00
pound-force (lbf)	newton (N)	4.448 222 E+00
FORCE DIVIDED BY LENGTH		
pound-force per foot (lbf/ft)	newton per meter (N/m)	1.459 390 E+01
pound-force per inch (lbf/in)	newton per meter (N/m)	1.751 268 E+02
HEAT FLOW RATE		
calorieth per minute (calth/min)	watt (W)	6.973 333 E-02
calorieth per second (calth/s)	watt (W)	4.184 E+00
kilocalorieth per minute (kcalth/min)	watt (W)	6.973 333 E+01
kilocalorieth per second (kcalth/s)	watt (W)	4.184 E+03

To convert from	to	Multiply by
LENGTH		
foot (ft)	meter (m)	3.048 E-01
inch (in)	meter (m)	2.54 E-02
inch (in)	centimeter (cm)	2.54 E+00
micron (m)	meter (m)	1.0 E-06
yard (yd)	meter (m)	9.144 E-01
MASS and MOMENT OF INERTIA		
kilogram-force second squared per meter (kgf * s^2/m)	kilogram (kg)	9.806 65 E+00
pound foot squared (lb * ft^2)	kilogram meter squared (kg * m^2)	4.214 011 E-02
pound inch squared (lb * in^2)	kilogram meter squared (kg * m^2)	2.926 397 E-04
ton, metric (t)	kilogram (kg)	1.0 E+03
ton, short (2000 lb)	kilogram (kg)	9.071 847 E+02
MASS DIVIDED BY AREA		
pound per square foot (lb/ft^2)	kilogram per square meter (kg/m^2)	4.882 428 E+00
pound per square inch (*not* pound force) (lb/in^2)	kilogram per square meter (kg/m^2)	7.030 696 E+02
MASS DIVIDED BY LENGTH		
pound per foot (lb/ft)	kilogram per meter (kg/m)	1.488 164 E+00
pound per inch (lb/in)	kilogram per meter (kg/m)	1.785 797 E+01
pound per yard (lb/yd)	kilogram per meter (kg/m)	4.960 546 E-01
PRESSURE or STRESS (FORCE DIVIDED BY AREA)		
kilogram-force per square centimeter (kgf/cm^2)	pascal (Pa)	9.806 65 E+04
kilogram-force per square meter (kgf/m^2)	pascal (Pa)	9.806 65 E+00
kilogram-force per square millimeter (kgf/mm^2)	pascal (Pa)	9.806 65 E+06
kip per square inch (ksi) (kip/in^2)	pascal (Pa)	6.894 757 E+06
kip per square inch (ksi) (kip/in^2)	kilopascal (kPa)	6.894 757 E+03
pound-force per square foot (lbf/ft^2)	pascal (Pa)	4.788 026 E+01
pound-force per square inch (psi) (lbf/in^2)	pascal (Pa)	6.894 757 E+03
pound-force per square inch (psi) (lbf/in^2)	kilopascal (kPa)	6.894 757 E+00
psi (pound-force per square inch) (lbf/in^2)	pascal (Pa)	6.894 757 E+03
psi (pound-force per square inch) (lbf/in^2)	kilopascal (kPa)	6.894 757 E+00

To convert from	to	Multiply by
TEMPERATURE		
degree Celsius (°C)	kelvin (K)	T/K = t/ °C + 273.15
degree centigrade	degree Celsius (°C)	t/ °C ≈ t /deg. cent.
degree Fahrenheit (°F)	degree Celsius (°C)	t/ °C = (t/ °F 2 32)/1.8
degree Fahrenheit (°F)	kelvin (K)	T/K = (t/ °F + 459.67)/1.8
kelvin (K)	degree Celsius (°C)	t /°C = T/ K 2 273.15
TEMPERATURE INTERVAL		
degree Celsius (°C)	kelvin (K)	1.0 E+00
degree centigrade	degree Celsius (°C)	1.0 E+00
degree Fahrenheit (°F)	degree Celsius (°C)	5.555 556 E-01
degree Fahrenheit (°F)	kelvin (K)	5.555 556 E-01
degree Rankine (°R)	kelvin (K)	5.555 556 E-01
VELOCITY (includes SPEED)		
foot per second (ft/s)	meter per second (m/s)	3.048 E-01
inch per second (in/s)	meter per second (m/s)	2.54 E-02
kilometer per hour (km/h)	meter per second (m/s)	2.777 778 E-01
mile per hour (mi/h)	kilometer per hour (km/h)	1.609 344 E+00
mile per minute (mi/min)	meter per second (m/s)	2.682 24 E+01
VOLUME (includes CAPACITY)		
cubic foot (ft^3)	cubic meter (m^3)	2.831 685 E-02
cubic inch (in^3)	cubic meter (m^3)	1.638 706 E-05
cubic yard (yd^3)	cubic meter (m^3)	7.645 549 E-01
gallon (U.S.) (gal)	cubic meter (m^3)	3.785 412 E-03
gallon (U.S.) (gal)	liter (L)	3.785 412 E+00
liter (L)	cubic meter (m^3)	1.0 E-03
ounce (U.S. fluid) (fl oz)	cubic meter (m^3)	2.957 353 E-05
ounce (U.S. fluid) (fl oz)	milliliter (mL)	2.957 353 E+01

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Appendix N
INTERIM REPORT ON ANALYSIS OF FIRST-PERSON ACCOUNTS FROM SURVIVORS OF THE WTC EVACUATION ON SEPTEMBER 11, 2001

N.1 INTRODUCTION

In the days following the September 11, 2001, attacks on the World Trade Center (WTC), the National Fire Protection Association (NFPA) in collaboration with the National Research Council of Canada decided to collect survivors' stories to document the event and to use this background material to develop future studies on occupant behavior during the evacuation of the World Trade Center. First-person accounts were collected from newspapers, radio and television programs, e-mail exchanges, and a variety of websites. Additional accounts were received at a later date from the National Institute of Standards and Technology (NIST). This large quantity of material was coded and analyzed to obtain a better understanding of the personal evacuation experiences of different survivors located on the different floors of the two towers. This report documents that analysis. The analysis was solely based on written accounts and does not include first-person interviews conducted as part of the NIST investigation. Rather, it provided background for the development of the telephone and face-to-face interviews conducted for the NIST investigation.

At 8:46 a.m. on Tuesday, September 11, 2001, American Airlines Flight 11, a hijacked Boeing 767, hit WTC 1 of the WTC. This impact caused extensive damage on five floors, from 93 to 99 of the 110-story high tower, trapping those above. Sixteen and a half minutes later, at 9:03 a.m., a second hijacked Boeing 767, United Airlines Flight 175, struck WTC 2 of the WTC, damaging nine floors, from 77 to 85.

Despite the massive localized damage caused by the impact, each structure remained standing. However, as each aircraft impacted the building, jet fuel on board ignited. Part of this fuel immediately burned off in large fireballs that erupted at the impact floors. Remaining fuel flowed across the floors and down elevator and utility shafts, igniting intense fires throughout upper portions of the buildings.

At 9:59 a.m., WTC 2, the second building to be hit, collapsed after burning intensely for 56 minutes. WTC 1 withstood its injury longer than the South tower, collapsing to the ground at 10:28 a.m. after burning for 102 minutes (FEMA BPAT 2002). It is estimated that approximately 2,800 people were killed and 800 others injured by the attacks and eventual collapse of the towers on September 11, 2001, including building occupants and first responders (Cauchon 2001).

Although the events of September 11, 2001, involved the WTC, the Pentagon and the hijacked airliners, the evacuation of the two towers is the focus of this research. The attacks precipitated the evacuation of the entire WTC complex. The evacuation of WTC 1 and WTC 2 was largely initiated by the occupants themselves.

The WTC was a complex of seven buildings, including the two 110-story office towers. Approximately 50,000 people worked in each tower (100,000 total), with an estimated 70,000 visitors to the complex during the course of a normal business day (Yamasaki 2002). However, the occupancy of the towers on

the morning of September 11, 2001, was not at its maximum capacity. According to USA TODAY, 5,000 to 7,000 people were in each tower at 8:46 a.m. that morning, the time of first impact (Cauchon 2001). It has been suggested that the towers were not at their maximum capacity for several reasons. That morning marked New York City's mayoral primary, and it is assumed that many people stopped to cast their ballots before heading in to work. The New York Stock Exchange does not open until 9:30 a.m., therefore many people from trading firms had not come into work yet. Tuesday, September 11, 2001, was the first day of school in several primary school districts, and many parents accompany their children to school on this day. Visitor hours had not started yet, as the viewing platform in the South Tower did not open to the public until 9:30 a.m. Perhaps the biggest factor of all was the early hour—many simply had not arrived at work by 8:46 a.m. In addition, dozens of investment firms in the WTC had closed their offices or cut employment sharply. Some offices were leased but empty or under renovation (Cauchon 2001).

By certain measures, the evacuation of the WTC on September 11, 2001, could be termed a success (Cauchon 2001). Under the impacted floors, nearly every occupant who could physically get out did get out. According to USA TODAY, in each tower, 99 percent of the civilian occupants below the crash sites survived. Their analysis shows that two-thirds of WTC 2 occupants started their evacuation of the upper floors during the 16.5 minutes between the attacks, and survived. Among the occupants under the impacted floors in WTC 1, 72 people died, whereas under the impacted floors in WTC 2, 4 people died. It should be noted that some fraction of the deaths below the impacted floors in WTC 1 occurred in the elevators, which were carrying people at the time of impact.

N.2 BACKGROUND LITERATURE

Understanding the basic concepts of human behavior in fire is necessary to envision occupants' likely response during an emergency. Human behavior in fire is a scientific field that identifies facts, concepts and relationships established through systematic observation and experimentation. What is known about human behavior in fire is that the three dimensions of the emergency, namely the occupant, building and fire characteristics, interact to explain or predict occupant response to fires (Proulx 2001).

During a fire, the nature of the information obtained, the limited time to react and the assessment of danger will create a feeling of stress. This stress is not an abnormal reaction; on the contrary, stress is regarded as a necessary state to motivate reaction and action. During the course of the event, the intensity of stress experienced will vary as a function of the information newly-perceived and the assessment of the decision taken (Proulx 1993). Key factors which increase stress include: the perception of threat to oneself or others, the suddenness of the threat and the available time to respond or prepare, the amount of sensory input needed to be processed, and the degree of physical effort (aerobic and anaerobic output) that is engaged during the incident. If the individual is physically wounded or injured, the effect will be even greater (Grossman 2002). Taking all of these factors into account, it can be said that most evacuees of the WTC were experiencing extremely high levels of stress.

Most people assume that individuals cease to act in a predictable, orderly fashion in the face of disaster, and that norms which govern our behavior collapse into Durkheim's anomie, a state of normlessness (Fisher 1998). This mindset, known as *disaster mythology*, has been greatly nourished by the mass media and movie industry to capitalize on strong emotional images (Proulx 2002). Today, it is largely known that in the face of the extreme stress of a disaster, there is an absence of widespread, irrational, antisocial

and dysfunctional behavior that has often been described as 'panic' (Quarantelli 1998). Thus, the false but common belief that people will panic in disaster situations is a myth (Sime 1980, and Keating, 1982). In human behavior fire research, it is found that panic behavior is extremely rare (Proulx 2002). Decision making during an emergency is, however, different from day to day decision making for three main reasons (Janis and Mann 1977). First, there is much more at stake in emergency decisions—often the survival of the person and of the people he or she values the most is at risk. Second, the amount of time available to make a decision before crucial options are lost is limited. Third, the information on which to base a decision is ambiguous, incomplete and unusual. Further it is usually impossible to look for more appropriate information due to the lack of both time and the means to get information (Proulx 1993).

Turning to the literature of the evacuation of the WTC following the 1993 terrorist bombing, it was concluded that there was a lack of panic flight during the evacuation, even though the occupants had to descend the crowded and smoky stairwells in total darkness. No official evacuation orders were issued by recognized emergency and building officials after the explosion, and no official information was provided about safe or proposed exit routes (Isner and Klem 1993). However, it was found that there was an overall mood of orderly evacuation during the 1993 evacuation (Wenger et al. 1994; Fahy and Proulx 1995). This lack of panic during the 1993 evacuation may be explained by the fact that although the explosion created immediate danger, it was not perceived by participants as particularly severe. Secondly, people were not alone; they were with coworkers, friends and associates. This web of social integration among participants works against the adoption of norms that would support individual, competitive flight behavior to favor the emergence of cooperative, altruistic, helping and orderly behavior (Wenger et al. 1994).

In contrast to the panic scenario of a competitive scramble towards an exit, Dr. Jonathan Sime argues that the most common behavior during a fire is movement towards familiar persons and places (Sime 1985). This is known as the *affiliation* model which suggests that detached groups will attempt to reunite before evacuating, and evacuation movement is most likely to be through a familiar way in and out of the building (Sime 1985). The grouping of people during an emergency is sometimes known as the *milling process*: the communication process that takes place among participants in a crisis setting as they attempt to define the situation, propose and adopt new appropriate norms for behavior and seek coordinated, collective action (Wenger et al. 1994). High levels of social interaction were reported during the 1993 evacuation as the tenants engaged in milling behavior regarding the definition of the situation, the attempt to give meaning to the crisis (i.e. to determine "What is happening?"), the appropriate response to it or proposed cues for action, and the attempt to give direction to the behavior of the participants by offering new, emergent norms (i.e., "What should we do? What is appropriate?") (Wenger et al. 1994).

Identification of the information available to occupants in defining the situation is essential in attempting to understand the decision-making process during an emergency. The social context of the occupants and the opportunity to observe and interact with others are also fundamental considerations when attempting to understand occupant response and the overall outcome of evacuations.

N.3 STUDY OBJECTIVES

This exploratory research project was conducted in order to gain an overall understanding of the circumstances surrounding the evacuation of the WTC towers on September 11, 2001. More specifically, this research project endeavors to gain insight into the variability of human behavior and response time

displayed during the evacuation, with the findings to be used as a guide for future research. This study can also provide insight for the NIST investigation into the WTC event. Human behavior data gathered from this project will help to create a better understanding of the individual experiences of occupants in specific locations by documenting, to the extent possible, the information available to occupants, such as conditions on their floor and along their evacuation route, perceived behavior of others, and escape conditions and timing.

N.4 METHODOLOGY

In the moments following the attack of the WTC towers on September 11, 2001, journalists started interviewing survivors to obtain the story of their evacuation. These first-person accounts were presented on television or radio and published in newspapers, magazines, or websites and later reported in books and special media programs. During the three months following the events, over 280 first-person accounts were collected. These accounts included media reports (newspapers, magazines, television and radio), as well as material from books, training videos, personal websites and emails. The information provided in some of these accounts was so detailed that it provided sufficient material for a study. Additional accounts were gathered over the next year for a total of 745 first-person accounts from 465 individuals, as some survivors provided multiple accounts through different sources. The 435 accounts retained for analysis are from evacuees of WTC 1 and WTC 2 only. Although numerous accounts were found from occupants of the surrounding WTC complex, only those civilians who had evacuated the actual towers were considered. For those survivors for whom numerous accounts were found, the information across the accounts was collapsed into one highly detailed account, containing the combined information from all of the given accounts. For instance, 16 survivors provided five to 12 different accounts to the media. These survivors had dramatic accounts and, therefore, were of particular media interest. The study involved no first-person interviews.

It is recognized that the use of first-person accounts published in the media as main sources of information for a study has many limitations. The questions asked by reporters are unknown and can be different for each journalist and with each interview. It is also noted that the date an account was published does not necessarily represent the date that the specific interview took place; the account could have been held at some point and then published at a later date. It is suspected that the most dramatic experiences are reported and that some information may be emphasized or left unreported for the purpose of the article. As stated by Dr. H.W. Fischer, the mass media has greatly reduced the level of flamboyant exaggeration in what they report as typical behavioral and organizational response to disasters over the last 50 years; however, since a larger portion of the news is now devoted to reporting disasters, a less than accurate image is still commonly portrayed both in the print and broadcast media (Fischer 1998). It also must be stressed that the findings in this study are representative only of the individual experiences captured in first-person accounts and cannot be generalized to the population of the two towers.

Recall of details of an event depends on many factors, including the intensity of the event, time since the event, and influence from other information sources. Recollection of extreme events such as the WTC attacks may be far better than ordinary daily events. Conversely, traumatic situations may result in memory impairment or "critical incident amnesia." Finally, with the intense media attention that the events of September 11, 2001, received, it is highly likely that this coverage influenced survivors' recollection of events. This phenomenon, referred to as "contamination," occurs when information outside of the actual experience is integrated into the reconstruction of memory

(Grossman 2002). Since different occupants of the WTC had a range of experiences on and after September 11, it is unclear to what extent memory issues impacted the reports included in this study.

Despite the drawbacks of using media sources for the basis of research, however, some of the accounts contained such a high level of detail, particularly the ones written by survivors themselves, they provided justification for the analysis of this information. It should also be stressed that these media accounts are the only documented descriptions of the WTC evacuation and immediate reactions of the survivors, as no research has been conducted or published 2 years after the events, regarding human behavior surrounding the events of September 11, 2001. Since documenting human behavior is time sensitive and considerable time has passed since the event, it may be said that these initial media accounts may hold significant detailed and accurate information that may only be available in these accounts.

N.4.1 Content Analysis

The most appropriate social research method for analyzing media communications is content analysis. To extract the important content from the accounts, a "questionnaire" was developed to "interview" each account. This procedure was used by Johnson (1987) to analyze police file statements related to the "Who Concert Stampede;"[1] it is also explained in some detail in Gamso's book "The Strategy of Social Protest" (1975). The approach relies on a series of identical questions used to "interview" each document. Once the information is gathered in a qualitative or descriptive database, codes are developed to reduce the variety of answers to each question to a manageable number. To ensure reliability of the coding, at least two researchers independently review each account and compare their coding. Any disagreement is discussed and resolved.

Questions to "interview" each account were designed to obtain manifest and latent information from the 745 first-person accounts. A majority of the questions, 30 of them, rely on manifest information or elements specifically reported in the account, such as the person's location at certain key moments. They are listed in Table N–1. The remaining three questions called for latent information, such as words describing emotions. They are listed in Table N–2. Data was retrieved from the accounts and entered into a qualitative database. Nominal and ordinal categories were conceptualized, which can be found in the coding scheme presented in Attachment 1. It is important to note that not all questions were answered for each account gathered, as a number of the accounts were incomplete. The fact that an individual's account is silent on some point does not mean that this factor was not important or relevant in that individual's evacuation. It simply means that it was not included in the published account or that it was never mentioned by the individual. For those questions not addressed in the account, the category was awarded the code "9" or "99," accounting for the lack of information regarding that specific question. This lack of information for some items is the equivalent in a questionnaire survey to a respondent who did not answer some of the questions. The information gathered in the qualitative database was coded and transformed into a quantitative matrix from which descriptive statistics were calculated.

[1] On December 3, 1979, 11 people were crushed to death as fans rushed the entrance of a stadium in Cincinnati, Ohio, to see a sold-out concert.

Table N–1. Questions on manifest information.

What is the date of published account?	Heard fire alarm?
Gender?	Location at WTC 2 impact?
Age?	Location at WTC 2 collapse?
In which building was the person at the time of first cue?	Location at WTC 1 collapse?
On what floor was the person at the time of first cue?	Location when met firefighters?
What was the first cue of event?	At what time person exited the building?
How long did the person take to start evacuation?	Who helped person during evacuation?
Did the person delay start time?	Was the person disabled?
What mode of egress was used?	Was the person injured?
What was the condition on floor?	Location when person placed phone call?
What was the condition on the stairs?	Who was the phone call recipient?
Were obstructions encountered during evacuation?	Was there social influence on decision making?
Heard announcement?	Use other (non-phone) communication technology?
Location when WTC 2 announcement heard?	Was person at the WTC during 1993 bombing?
Action after hearing WTC 2 announcement?	Did the person rest during evacuation?

Table N–2. Questions on latent information.

What was the person's knowledge of the situation in the initial moment?
How serious did the person judge the situation to be?
What was the person's perception of others?

N.4.2 Variables Considered

Conceptualization and operationalization involve precisely defining how the variables were measured and ensuring the attributes within those variables are mutually exclusive and exhaustive. There were 33 questions providing data ranging from demograhics and physical location, to response time and social interaction during the evacuation. Coded data included the evacuees' gender, age and which building and floor they were located in, as well as the date the account was published. The floors of the towers were categorized as lower (basement to floor 42), mid (floor 43 to floor 76), and upper (floor 77 to floor 110) based on the common areas referred to as "skylobbies" on the 44th and 78th floors, which separated the towers into three strata. The skylobbies on floors 44 and 78 served the occupants of floors 43 and 77, respectively. Mode of egress was recorded as stairs, elevators or a combination of both.

The first cue of the event was categorized according to whether the cues were "audio," such as hearing an explosion, crash or rumbling; "visual," such as seeing the plane approach the towers, or seeing fire, smoke or debris. Another category of first cue was "building movement" and was represented by feeling the building shake, sway or tremble, whereas moving office furniture, falling ceilings, jolting in the elevator and flickering lights were attributes of the variable category "contents movement." The remaining three categories were "warned by others" (either verbally or through their behavior), "physically impacted" (e.g., burned, fell from chair, thrown against a wall), and "smelled smoke or fumes

or felt heat." These cues were coded as check-off items so that multiple initial cues could be captured. Whether or not evacuees heard a building alarm during their evacuation was recorded in a separate field, if mentioned.

Time to start evacuation was recorded as immediately, shortly after impact (where the occupant took less than 5 minutes to retreive belongings before evacuating), delayed (representing those who took more than 5 minutes to start evacuating, taking time to search floors or gather company documents, etc.), stayed or stuck.

Conditions of floors immediately after the building was hit were recorded in two ways. One field summarized the conditions as follows: "devastated," meaning combinations of conditions such as scattered debris, fire, darkness and fallen ceilings and walls were reported; "abnormal," in that there was some smoke, heat or the smell of jet fuel; and "normal," represented by accounts describing usual conditions on their floors. A series of check-off columns then recorded whether a person's account reported the presence of specific conditions: door jammed, debris (e.g., from wall, floor or ceiling collapses), smoke, dust, no power or darkness, smell of fumes, water, fire, crowds or injured people, entrapment, or normal conditions. If the individual was not on an office floor when the building was struck, that was recorded in an additional check-off column. This allowed the recording of multiple conditions for each individual.

Similar check-off columns were used to record observations of conditions in stairwells during evacuation: normal, door locked or jammed, crowded and/or hot, no power, water, cracked wall, debris, smoky or smell of fumes.

If and where the evacuees heard the announcement stating that WTC 2 was secure were also noted, as were their actions after hearing the announcment (i.e., continued evacuating, continued but saw others return to offices, or returned to or remained in office). The survivors' location at the time of impact, collapse of the towers and meeting of firefighters were also coded, as well as who helped them during the evacuation. Those who provided help were categorized as firefighters, Port Authority employees, external officials such as NYPD, FBI, and coworkers. Individuals' disabilities were coded as "visually impaired," "hearing impaired," "physically challenged" (e.g., obese, pregnant, or with asthma or heart conditions), "wheelchair users," or 'injured." People who mentioned that they had aided a disabled or injured person during the evacuation were also noted in this variable category, as were those who reported seeing injured or disabled people during their evacuation.

Whether or not a person was present at the WTC during the 1993 bombing was recorded, as was whether or not each person delayed his or her evacuation on September 11, 2001. Where the evacuee placed a phone call and the recipient of it were coded, along with whether or not they rested and where they rested. A series of check-off columns recorded if a person experienced obstructions, such as door jams, debris, smoke, no power, smell of fuel, water, fire, crowds, injured and disabled people or became trapped during the evacuation. Multiple entries were possible for each individual.

Other variables included the survivors' knowledge of the situation, recorded as "high" for those who knew a plane had struck the towers or that there had been a terrorist attack; "moderate" for those who thought there was a fire, bombing or judged the situation as a serious emergency; and "low" for those who were not aware of the reasons behind the evacuation. The evacuees' indication of the level of seriousness was recorded as "very serious," "somewhat serious" and "not serious" based on the perceived

tone of the account. The variable "perception of others" included the categories of "calm," in that evacuees felt others to be orderly and composed; "upset," which represented those who judged others as nervous, anxious or visibly bothered. For survivors who described others as hysterical or pushing and shoving, this field recorded their perception of others as "momentarily panicked." When accounts reported that those around them lent assistance to others, this field was coded as "helpful."

Social influence on decision making was categorized according to who influenced the evacuee: authority figures, such as bosses or managers; groups of coworkers; or both authority figures and groups of coworkers. If a person indicated that he or she took on a leadership role, that was also captured. Use of new communication technology including utilizing text messaging over pagers or wireless e-mail devices, TV or radio to gain information was noted. (See Attachment 1 for further variable category definitions.)

The time that people reached the outside was recorded. It must be stressed that most accounts did not report specific times at which people took different actions. However, several occupants mentioned their location at key moments such as where they were when WTC 2 was hit or when WTC 1 or WTC 2 collapsed. For example, one survivor of WTC 1 reports, "When we got to the twentieth (floor) I remember hearing a rumble. One of the fellows looked at me and we knew it didn't sound good. It must have been WTC 2 coming down" (Fink and Mathias 2002). Thus, it was deduced that this survivor was on the 20th floor of WTC 1 at 9:59 a.m., when WTC 2 collapsed. Similarly, for many people, the time they reached the outside could be estimated from their description of events (e.g., WTC 2 being struck, WTC 2 collapsing) as they reached the outside.

N.4.3 Procedure

Various media avenues were utilized in gathering first-person accounts including television, radio, newspapers, magazines, websites, books and special media programs. Personal websites and e-mails written by survivors themselves were also used and are of particular interest, as they have not been altered by media editors in any way, but appear in their full, original format. During the three months following the events, over 280 first-person accounts were collected. Eventually, a total of 745 accounts were gathered from 465 individuals, as numerous survivors gave multiple stories to different journalists.

The accounts, which were gathered over a period of 18 months, were published up to 14 months after September 11, 2001. The distribution of published accounts over time is shown in Fig. N–1. Among the dated accounts studied, 51 percent were published in the first two weeks after September 11, 2001, with another influx of accounts surfacing around the one-year anniversary, 10 months to 12 months after the disaster.

Content analysis was performed on the 745 accounts using 33 questions for which the data was entered into a qualitative spreadsheet. Duplicate accounts were merged, resulting in a final study size of 435 individuals who were present either in WTC 1 or WTC 2. The data was then coded and transferred into a matrix for analysis.

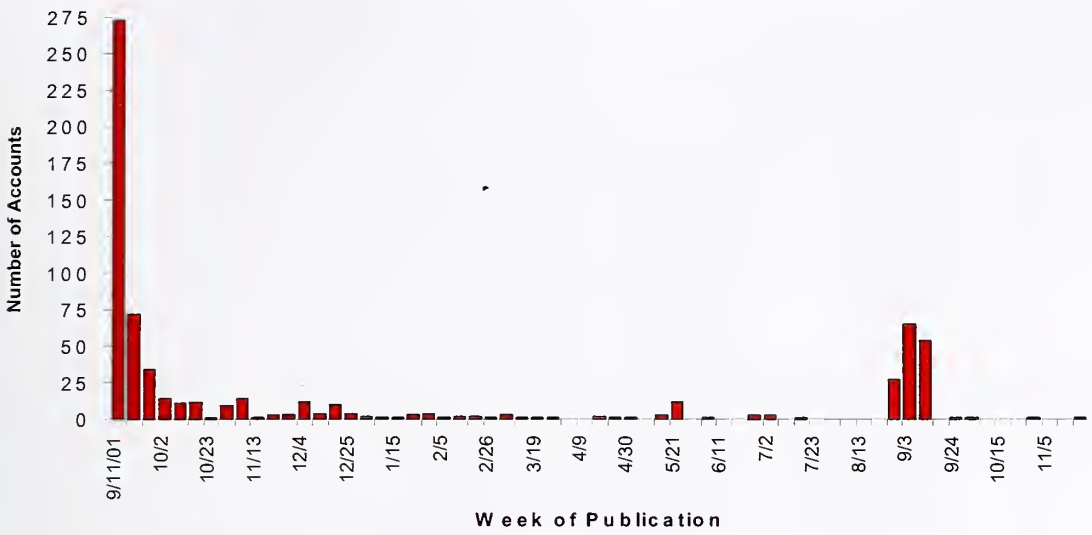

Figure N–1. Distribution of publication dates of accounts.

N.5 STUDY RESULTS

The raw data for each account was entered into an Excel spreadsheet and then coded. The coded data was transferred into SPSS 11.0 for statistical analysis. The statistical analysis conducted was essentially descriptive statistics to organize and summarize the information. Inferential statistical tests were not conducted since the data obtained is not a representative sample of the population. Results presented in this report should not be generalized to all occupants of the two towers on September 11, 2001. Although they are reported using terms such as "the occupants" and "the survivors," the results refer only to the accounts analyzed.

N.5.1 Profile: Gender and Age

The study contained accounts from 435 survivors, ranging in age from 20 to 89 years old (mean = 39.5, standard deviation = 11.8). Included were accounts from 118 women (27 percent) and 314 men (72 percent); three accounts did not mention their gender (1 percent). It is speculated that the substantially higher number of men involved in these accounts occurred because there were more men working in the two towers than women or that men may be more likely to talk to the media than women. The breakdown by gender and age is shown in Fig. N–2.

N.5.2 Location at the Beginning of the Event

There were 251 individuals who were located in WTC 1, comprising 58 percent, with the remaining 42 percent or 184 people from WTC 2. In WTC 1, 90 people (36 percent) were from upper floors (77 to 110), 79 people (31 percent) were from mid levels (43 to 76) and 58 people (23 percent) were from the lower floors of WTC 1. Another 22 people (9 percent) were in elevators and two people did not specify a location. In WTC 2, 94 people (51 percent) were from upper floors, 57 people (31 percent) were from mid floors, 28 people (15 percent) were from the lower levels of WTC 2 and five people did not specify a location. Although the distribution of accounts in the two buildings was not identical,

reports were obtained from the three strata in both buildings. It is likely that the higher fraction of individuals in WTC 1 and in higher floors reflects the more dramatic stories of those closest to the airplane impact locations in WTC 1 and WTC 2.

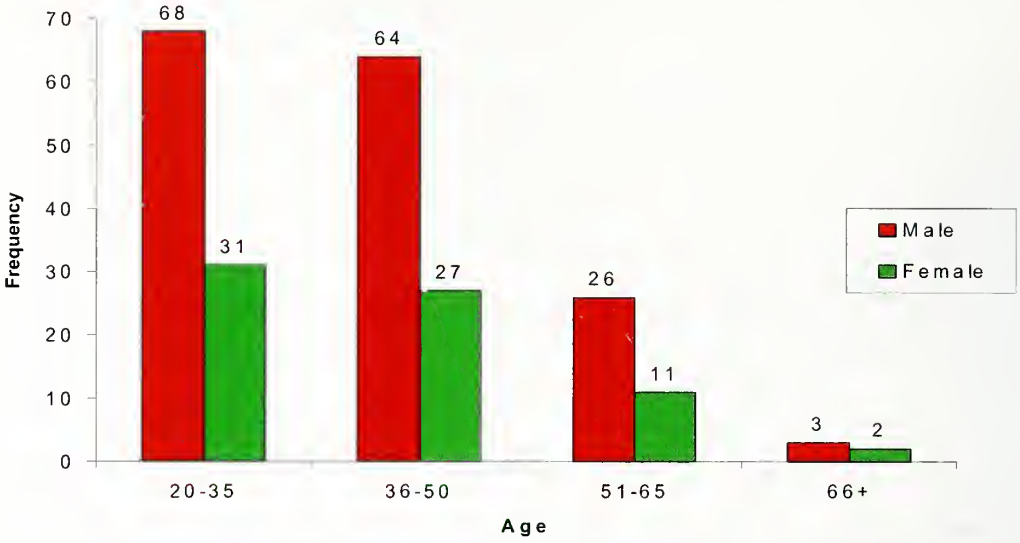

Figure N–2. Gender and age distribution.

N.5.3 Means of Egress Used

On September 11, 2001, almost all individuals from WTC 1 (198 people or 98 percent) reported using the stairs to evacuate while three used both stairs and elevator and one used the elevator only. The person who used the elevator for evacuation reported that he was in an elevator when the building was struck, and the elevator stopped on one of the floors. He was able to use the elevator to move people from that floor to the lobby. Two of the three who used both stairs and elevators were initially trapped in an elevator behind a 50th floor restroom. After freeing themselves, they were directed by firefighters to an elevator to the 44th floor, from which point they walked down. The third person who used both stairs and elevators rode with a person he was assisting from the 52nd floor to the 44th floor. Unable to find a working elevator on the 44th floor, he walked down the rest of the way. In WTC 2, 114 (72 percent of the total for that building) used the stairs while 18 people (11 percent) used elevators and 26 (16 percent) used a combination of elevators and stairs. These results are shown in Table N–3. Of the 44 people who used the elevator to evacuate WTC 2, 37 were from floors served by the 78th sky lobby and 7 were from floors between the 44th and 78th sky lobbies. From these accounts, it seems that the higher up people were in WTC 2, the more likely they were to use the elevator as a means of egress.

Table N–3. Means of egress used within the towers.

	WTC 1, N=202	WTC 2, N=158
Stairs	198 people (98.0 %)	114 people (72 %)
Elevator	1 person (0.5 %)	18 people (11 %)
Stairs and elevator	3 people (1.5 %)	26 people (16 %)

N.5.4 First Cue Reported

The first cues of the event that were mentioned in the accounts were found to differ depending on which tower the person was located. For WTC 1, the first building hit, the most common first cue of the event reported by 146 people (69 percent of people in that tower) was "building movement," such as feeling the building sway and tremble—many thought the building was going to tip over. WTC 2 occupants most commonly reported first becoming aware of the event from visual cues (96 people) such as fire, debris and smoke, most likely coming from WTC 1. Several people reported more than one first cue, so they may appear more than once in Table N–4 and percentages total more than 100 percent.

Table N–4. First cues of event within the towers.

First Cues	WTC 1, N=212	WTC 2, N=145
Audio cues: heard explosion, crash, rumble	107 (50 %)	69 (48 %)
Visual cues: saw fire, incoming plane, debris, smoke	87 (41 %)	96 (66 %)
Building movement: felt building sway, tremble, jolt	146 (69 %)	30 (21 %)
Contents movement: furniture movement, ceiling falling	66 (31 %)	11 (8 %)
Warning from others	14 (7 %)	34 (23 %)
Impact	29 (14 %)	1 (1 %)
Smelled fumes or felt heat	12 (6 %)	16 (11 %)

Interestingly, only 25 people made any mention of building alarms in their evacuation accounts. Of those, eight in WTC 1 and one in WTC 2 reported hearing alarms but did not specify where. Two in WTC 1 and one in WTC 2 heard alarms while on their floors and one person in each tower heard alarms while in the stairs. Eight people in WTC 1 stated that they did not hear alarms. Three people in WTC 2 said they never heard alarms, but two of them were outside the building when it was hit.

N.5.5 Time to Start Evacuation

After perceiving these first cues, 101 people from WTC 1 (47 percent) immediately started evacuating, while 84 people (52 percent) immediately started their evacuation of WTC 2. As can be seen in Fig. N–3, similar numbers of people from both towers started evacuating shortly after the first cue of the event (28 in WTC 1 versus 27 in WTC 2). Another 46 people in WTC 1 and 40 people in WTC 2 delayed their evacuation. Some 23 people in WTC 1 (11 percent) reported they initially stayed, while 10 people from WTC 2 (6 percent) also said they initially remained on their floors. Of the 16 people who reported being stuck and therefore temporarily unable to start their evacuation, all but one were from WTC 1.

Among occupants who initially decided to stay, it is noteworthy to mention a group in WTC 1. Two survivors reported that a group of about 16 employees gathered in a conference room on Floor 64 of WTC 1. The group stayed in the room discussing the situation for approximately 1 hour before deciding to evacuate the building.

Most of those who were not stuck but who took more than 5 minutes to begin evacuation delayed because they took the time to complete activities such as searching the floor, securing documents, making calls, or giving instructions, or because they felt it was the right thing to do. Twenty-one of 63 people in WTC 1 (33 percent) and 13 of 45 people in WTC 2 (29 percent) delayed starting their evacuation because

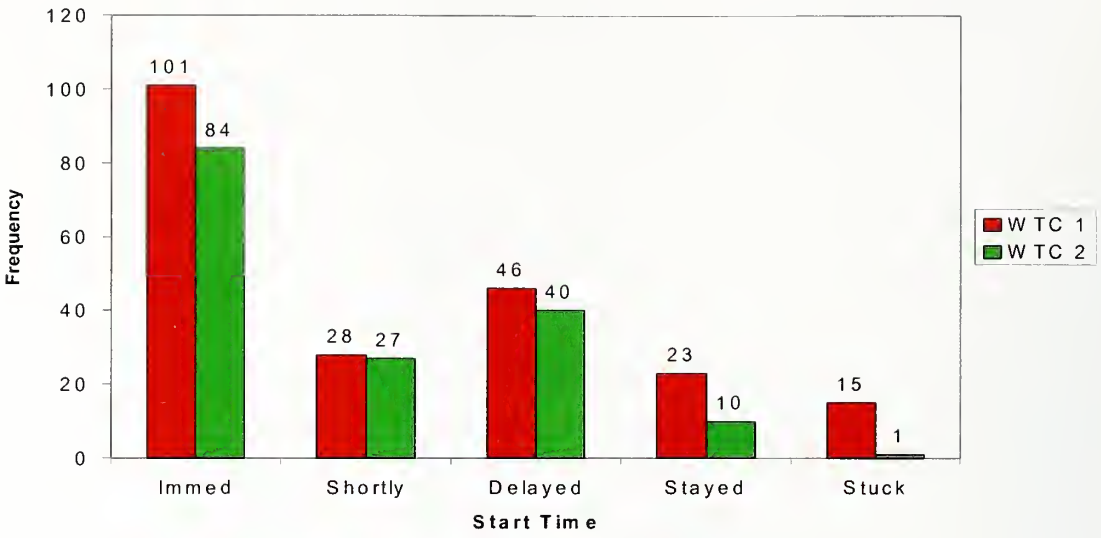

Figure N–3. Distribution of time to start evacuation.

they were completing activities such as those described above. Of those in WTC 1 who did not begin their evacuation within 5 minutes, 12 people simply decided to stay (19 percent), compared to 20 people in WTC 2 (44 percent). In WTC 1, 17 of those who did not begin their evacuation within 5 minutes (27 percent) were helping others or required assistance themselves, compared to only four people (9 percent) in WTC 2.

N.5.6 Conditions on Floors and in Stairwells

It was possible to code multiple reported conditions on floors and in stairwells for each individual. Six people in WTC 1 and seven people in WTC 2 indicated that conditions on their floor were normal after their building was struck. For the 191 evacuees who commented on adverse conditions on their floors after the plane hit their tower, similar results emerged between the towers, in terms of the large proportions reporting smoke or debris and collapse damage on their floor. Specifically, the most frequently reported adverse conditions in WTC 1 were smoke (55 percent or 74 people), debris or collapse of wall, ceiling or floor (72 people or 54 percent), fire (41 people or 31 percent), darkness or loss of power (20 people or 15 percent) and smell of fuel (13 people or 10 percent). In WTC 2, the most frequently reported adverse conditions were debris or collapse of wall, ceiling or floor (38 people or 67 percent), smoke (25 people or 44 percent), darkness or loss of power (18 people or 32 percent), dust (10 people or 18 percent), smell of fuel (7 people or 12 percent) and injured people (7 people or 12 percent). Seven people in WTC 1 who mentioned jammed doors were in the upper strata of the building. Two people in WTC 2 who reported jammed doors had moved to middle floors of their building after the first impact. The complete details on conditions are presented in Table N–5.

A large number of evacuees (106 people) mentioned that the stairwells were crowded and hot during their evacuation (71 people in WTC 1 and 35 in WTC 2). A total of 27 indicated that conditions in the stairwells were otherwise normal. For the 155 evacuees who commented on adverse conditions in the stairwells during their evacuation (other than crowdedness), the majority in both towers reported smoke and the smell of fuel in the stairs (79 people or 72 percent in WTC 1 and 29 people or 63 percent in

WTC 2). For other types of conditions in stairwells, responses between the two towers were quite different, as shown in Table N–6.

Table N–5. Adverse conditions on floor at impact.

	WTC 1, N=134	WTC 2, N=57
Debris (collapse)	72 (54 %)	38 (67 %)
Smoke	74 (55 %)	25 (44 %)
Fire	41 (31 %)	20 (35 %)
No power, dark	20 (15 %)	18 (32 %)
Smell of fumes	13 (10 %)	7 (12 %)
Dust	9 (7 %)	10 (18 %)
Water	7 (5 %)	3 (5 %)
Door jammed	7 (5 %)	2 (4 %)
Crowds, people injured	2 (1 %)	7 (12 %)
Trapped	5 (4 %)	2 (4 %)

Table N–6. Adverse conditions reported in the stairs during evacuation.

	WTC 1, N=109	WTC 2, N=46
Smoke, smell of fuel	79 (72 %)	29 (63 %)
Water	49 (45 %)	4 (9 %)
Dark, no power	14 (13 %)	9 (20 %)
Debris (damage or belongings)	9 (8 %)	14 (30 %)
Cracked walls	5 (5 %)	14 (30 %)
Doors locked, jammed	12 (11 %)	2 (4 %)

N.5.7 Obstructions during Evacuation

Tables N–5 and N–6 display details on the adverse conditions that resulted at the time of impact. These were things that were observed but that might not have presented an obstacle. (For example, a person might have reported seeing smoke or debris, without being impeded by that debris.) Obstructions are things that limited or otherwise affected a person's ability to evacuate. Many of the same items were cited as both adverse conditions and obstructions. More than one obstruction during evacuation could be recorded for each person. A total of 153 people in WTC 1 and 59 people in WTC 2 indicated encountering obstructions during their evacuation. Almost half of the evacuees in each tower reported encountering crowds and injured people in the stairways, and indicated that they interfered to some degree in their evacuation (46 percent in each tower). The next most frequently reported obstructions were smoke and debris. The details are shown in Fig. N–4.

Of the 22 evacuees who reported encountering jammed or locked doors, 20 were in WTC 1, and all but three were located on upper floors. One of the WTC 2 evacuees reported that an elevator door was jammed by debris, and the other reported a locked door on reaching the bottom of the stairs. Of the 25 evacuees who reported being trapped, nine were in elevators, eight were trapped by debris or smoke when

their building was hit, five were trapped in the collapse of WTC 2, and three were trapped when WTC 1 collapsed.

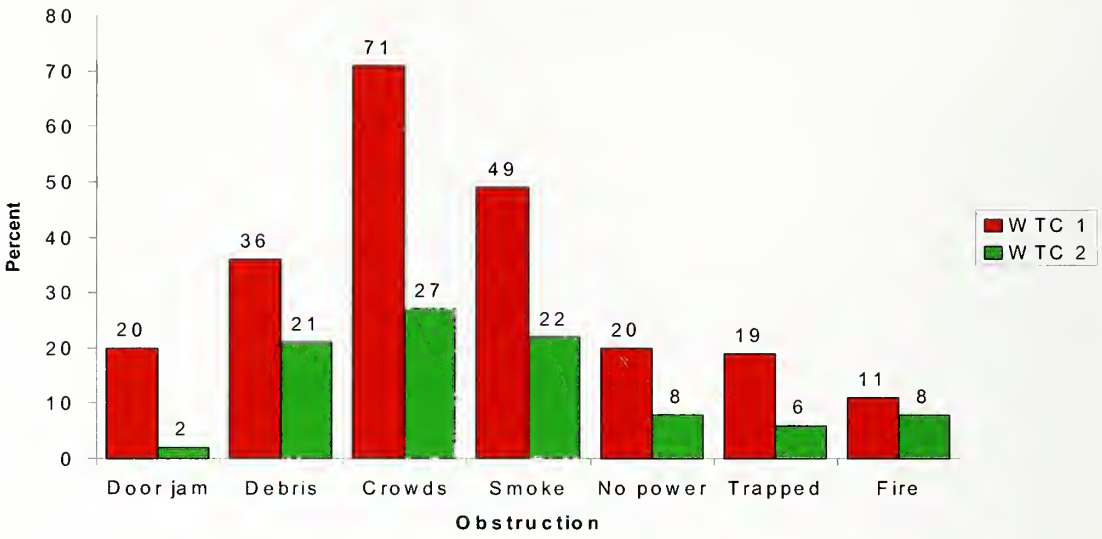

Figure N–4. Obstructions encountered during evacuation in both towers.

N.5.8 Announcement

It is estimated that the WTC 2 announcement came over the public address system at approximately 9 a.m. The majority of survivors said they heard it just minutes before WTC 2 was struck, which occurred at 9:03 a.m. As one survivor from the 103rd floor of WTC 2 describes it, "When we reached the 70th floor we heard the announcement. The building was secure; no one needed to evacuate. We had descended down 3 more floors to the 67th when the second plane hit our tower" (csmonitor.com 2001). Of the 184 WTC 2 occupants, 96 people (52 percent) mentioned hearing this announcement in their accounts. The majority of them, 69 survivors, decided to disregard the instructions of the message and continue their evacuation; however, 16 people (17 percent) said they remained in their offices or decided to return back up to their offices after hearing the message. Those returning did not have time to travel very far before the second plane hit; at that point they all resumed their evacuation.

N.5.9 Location When WTC 2 Was Hit

Of the 273 survivors who mentioned their location at the time WTC 2 was hit, 36 people reported being somewhere inside the stairwells of WTC 1, while 14 people reported being on various floors of WTC 1. Fifty-six did not give a specific location, and 15 had already reached the outside. Of the survivors from WTC 2, 65 people reported they were in the stairs and 52 occupants reported they were on various floors within WTC 2. Four did not give a specific location, and 31 had already left the building. Of the people who were on the floors within WTC 2, 19 were on the upper floors (77th and above) at impact and survived. One of these occupants, who survived the plane impact on the 78th floor of WTC 2, describes the stairwell: "a tornado of hot air and smoke and ceiling tiles and bits of drywall came flying up the stairwell. In front of me, the drywall split from the bottom up" (csmonitor.com 2001).

N.5.10 Location When WTC 2 Collapsed

WTC 2 was the first of the towers to collapse at 9:59 a.m. Of the 296 survivors who mentioned their location at the time of WTC 2's collapse, 230 people (78 percent) were outside of the buildings, on the streets and surrounding areas. Some 47 people (16 percent) were still inside WTC 1 on lower levels from the basement to the 42nd floor, and three people (1 percent) were on mid levels (43 to 76) in WTC 1 when WTC 2 fell. Thirteen did not give exact locations, and one was in an elevator. Three individuals were on the lower levels of WTC 2 (concourse) when it collapsed, and they survived.

N.5.11 Location When WTC 1 Collapsed

WTC 1, the second tower to collapse, fell at 10:28 a.m. As approximately 1 hour and 42 minutes had passed since the initial WTC 1 impact, almost everyone who reported their location at the time WTC 1 collapsed was outside (263 people or 98 percent). Four people were on the lower levels of WTC 1, and two were in the concourse when it collapsed, and they survived.

N.5.12 Location When They Saw Firefighters

For the evacuees who mentioned seeing firefighters during their evacuation, the location where they met them was recorded to gain an understanding of the dispersion of emergency workers throughout the towers. For the 169 people who reported meeting firefighters, 143 people saw them in WTC 1, with only 26 people in WTC 2 mentioning their presence. In terms of floor location within WTC 1, it was found that a majority of the people (76 people) saw firefighters in WTC 1 on the lower levels (basement to 43rd); 74 of them saw firefighters in the stairwells, and two on a floor. Another 21 people saw firefighters on the mid floors (43rd to 76th)—17 of them were in the stairs while the other four people were on floors. Another three people saw firefighters on the upper floors (77th to 110th) in office areas. All three were trapped on the 83rd floor. One survivor stated: "We saw two flashlights belonging to two New York City firemen. They told us to leave all of our possessions and to quickly follow them." (Manning 2001). At the mezzanine, lobby or concourse level, 11 people reported seeing firefighters. The remaining 31 occupants who saw firefighters inside WTC 1 did not give a location.

Among the 26 people who mentioned seeing firefighters in WTC 2, eight saw them on the lower floors (basement to 42nd), and two saw firefighters in the mid floors of the building (43rd to 76th). Seven people saw firefighters at the mezzanine, lobby or concourse levels, while six people in WTC 2 mentioned seeing firefighters but did not indicate their locations. Three people indicated that they met firefighters outside WTC 2.

N.5.13 Time of Exit

For evacuees from both towers who indicated at what time they exited, it was found that as more time passed, a progressively greater number of people exited the building, as shown in Table N–7. Of the 183 WTC 2 occupants who indicated what time it was when they left the building, 77 exited between 9:31 and 9:58 a.m. WTC 2 collapsed at 9:59 a.m. Of the 211 WTC 1 occupants who indicated the time they left their building, 70 exited between 9:59 and 10:27 a.m. WTC 1 fell at 10:28 a.m. The six people who exited the towers after 10:28 a.m. were rescued from the rubble by firefighters up to several hours after the collapse.

Table N–7. Time out of towers.

	WTC 1 (impact - 8:46 a.m.) (collapse - 10:28 a.m.) N=211	WTC 2 (impact - 9:03 a.m.) (collapse - 9:59 a.m.) N=183
8:48 – 9:02 a.m. (before WTC 2 impact)	19	37
9:03 – 9:30 a.m.	45	68
9:31 – 9:58 a.m. (before WTC 2 collapse)	72	77
9:59 – 10:27 a.m. (after WTC 2 collapse)	70	0
10:28 a.m. (after WTC 1 collapse)	5	1

N.5.14 Help Received and Help Given

Among the 435 accounts, 203 survivors described receiving help from others during their evacuation, with some mentioning more than one source of help. Some 84 people (41 percent) were helped by Port Authority personnel. Firefighters provided direct help to 65 people (32 percent). Another 65 people (32 percent) were helped by other first responders such as NYPD or other rescuers. Help from coworkers was received by 34 people (17 percent).

Overall, 166 people mentioned being comforted and reassured by passing firefighters. Several occupants of the two towers helped others during the evacuation. Among the first-person accounts, 20 people said they helped people with disabilities and 14 said they helped people who were injured during the event.

N.5.15 Occupants with Disabilities or Injuries

Among the 27 persons reporting a disability in their account, two were visually impaired, three were hearing impaired, three used wheelchairs and 19 others were physically challenged such as suffering from a heart condition, asthma, obesity, etc. Twenty-two people mentioned seeing people with disabilities.

Another 47 people who provided first-person accounts were injured that morning. Some accounts from people who suffered injuries reported exiting the buildings later in the evacuation process. However, in numerous accounts occupants mention moving aside in the stairwells to let badly injured and burned people pass, thus it is assumed that those with extreme injuries who were mobile exited the building faster than the majority of others. For instance, one survivor from floor 88 of WTC 1 who suffered burns to over 77 percent of her body reported that crowds parted in the stairwell to let her through (Kugler 2002). These victims were all accompanied by coworkers or emergency workers. Twenty-five people mentioned seeing injured people coming down in the stairwells.

Twenty-three individuals with disabilities and 43 with injuries mentioned a time to start. Of these 66 people, 50 percent (13 people with disabilities and 20 injured) started evacuating immediately, 5 percent (two disabled and one injured) left shortly after, 29 percent (7 disabled and 12 injured) delayed evacuating, 14 percent (one wheelchair user and eight injured) initially decided to stay, and 3 percent (two injured people) were initially stuck.

N.5.16 Phone Calls

An overwhelming 87 percent of those who placed phone calls (151 people) were trying to contact their families and friends to let them know their whereabouts and gather information from them. Only 12 people (7 percent) tried contacting authorities, such as building security or calling 911, and 20 people (12 percent) placed calls to their boss or colleagues. Eleven people (6 percent) did not say who they called.

The majority of people who placed phone calls that morning did so once they were outside (93 people or 54 percent); however, many did not get through. Forty-four people (25 percent) mentioned that they placed calls from their offices before evacuating, 13 people (8 percent) called from other floors and 10 people (6 percent) attempted to make phone calls while in the stairwells.

N.5.17 Knowledge of Situation

In judging the evacuees' knowledge of the situation, categories were created. A "high level" of knowledge indicated knowing that planes had hit the towers or that there had been an explosion within the towers. Those who speculated about a bombing saw fire and debris or had reason to believe an emergency was occurring were said to have a "moderate level" of knowledge. Survivors who were not aware of the reasons behind the evacuation were classified as having a "low level" of knowledge. Level of knowledge was coded for 330 people. As shown in Fig. N–5, survivors with "high levels" of knowledge totaled 69; 214 people were judged to have a "moderate level" of knowledge and 47 survivors had a "low level" of knowledge regarding the events of that morning.

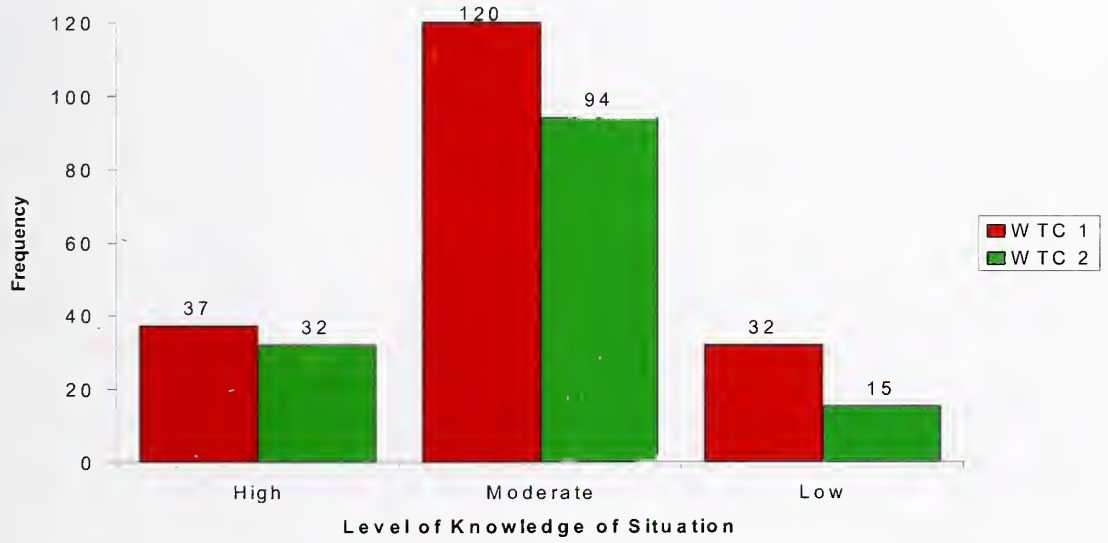

Figure N–5. Knowledge of situation in the towers.

N.5.18 Influence of Others

One hundred and ninety-one survivors reported that their decisions during the evacuation were influenced by others. It appeared that 28 people were influenced by authority figures, such as their boss or manager,

and complied with their instructions. Another 97 survivors seemed to be influenced by groups of people and coworkers. One person appeared to have been influenced by both authority figure(s) and the group. Many individuals indicated that they took on leadership roles that morning. Sixty-six people reported they directed people to the stairs, searched for others, gave orders or somehow took part in organizing the evacuation.

Males were more likely to perceive themselves as taking on leadership roles that morning than females (see Table N–8). Thirty-eight women (59 percent of the females for whom influence could be inferred) were influenced by groups of coworkers, whereas only 58 men (46 percent) were apparently influenced by the group. Concerning leadership roles, 52 men (41 percent) reported adopting this behavior, compared to the 14 women who mentioned taking a leadership role (22 percent of the women).

Table N–8. Gender and influence of others.

	Males, N=127	Females, N=64
Authority figures (boss, manager)	17 (13 %)	11 (17 %)
Groups/coworkers	58 (46 %)	38 (59 %)
Both authority and groups	0 (0 %)	1 (2 %)
Took a leadership role	52 (41 %)	14 (22 %)

N.5.19 Perception of Others

How survivors perceived others during the evacuation was recorded for 268 people—others could have been perceived as "calm," "momentarily panicked," "upset," or "helpful." Multiple responses could be coded for each person. The results show that the majority (154 people or 57 percent) described people around them as calm and orderly. Some 84 people (31 percent) judged others as "upset," which included crying, shouting, nervous or anxious, but rational. There were 78 people (29 percent) who described others as "momentarily panicked," in that they were pushing, shoving or generally displaying behavior associated with chaos, while 59 people (22 percent) found others to be "helpful." More details are presented in Fig. N–6.

It was found that of 155 people in WTC 1, 93 survivors judged others to be "calm," compared to 61 of 113 people in WTC 2. Only 33 people in WTC 1 described others as "momentarily panicked," compared to 45 people in WTC 2. For the people in WTC 2, the perception of "panic" occurred before WTC 2 was hit for at least three occupants, while another 29 survivors described others around them as "panicky" after WTC 2 was hit. For two others, the "panicky" behavior was reported at the point in time when each tower collapsed. It was not clear from the other 11 accounts from WTC 2 when the people around them were "panicky."

This variance in perception of others between the towers is illustrated by contrasting the following two accounts. One survivor from the 65th floor of WTC 1 said that those in the stairwells "maintained their calm really well" and went on to say that, a couple of people started crying a little, but we said, 'We're going to get out of here, we just have to take it one step at a time.' It wasn't quiet, people were talking–in fact someone was laughing, it was pretty normal (Anderson 2001). It is proposed that the occupants of

WTC 2 observed others "momentarily panicking" mainly once their tower had been hit. One survivor from the 70th floor of WTC 2 said she and her coworkers walked down to the 59th floor and took an elevator to the 44th floor, when at that point, another plane hit their tower and then there was a mad scramble down the stairs with people pushing, shoving and yelling (Black 2001).

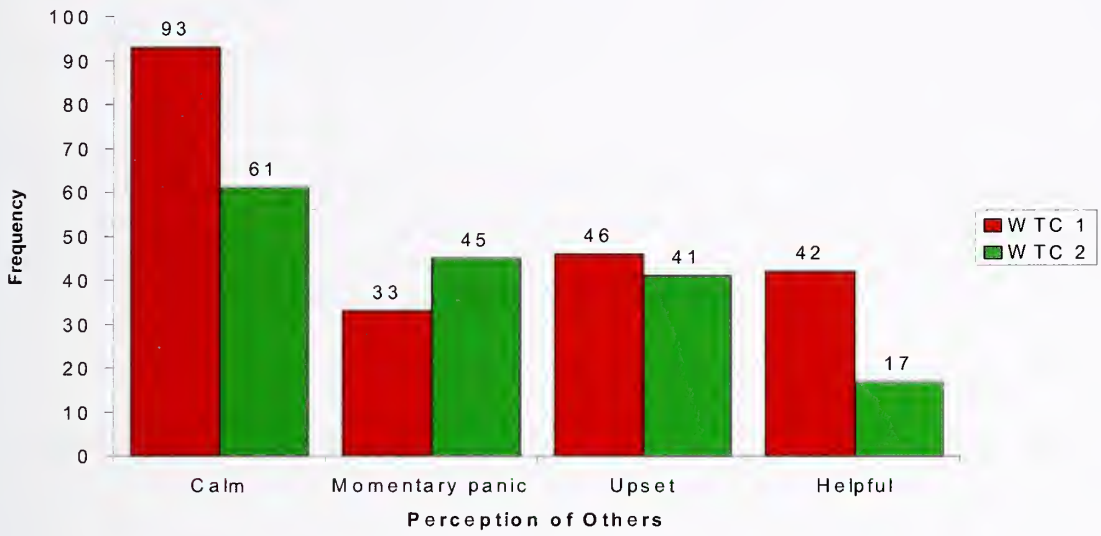

Figure N–6. Distribution of perception of others between the towers.

Perception of others and gender are compared in Fig. N–7.

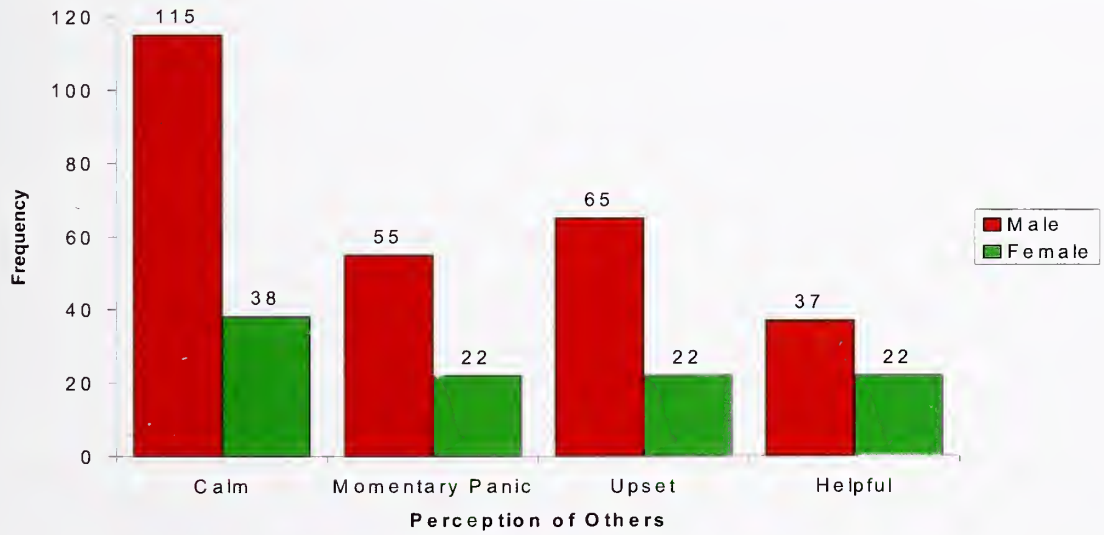

Figure N–7. Distribution of gender and perception of others.

The distribution of perception of others by age group is shown in Table N–9. It is interesting to note that some of the most dramatic language ("chaos," "total chaos," "mayhem") was used by the youngest males.

Table N–9. Distribution of age and perception of others.

	21-35 yrs old (N=74)	36-50 yrs old (N=58)	51-65 yrs old (N=21)
Calm	39 (53 %)	31 (53 %)	9 (43 %)
Panicked	25 (34 %)	14 (24 %)	6 (29 %)
Upset	31 (42 %)	22 (38 %)	4 (19 %)
Helpful	16 (22 %)	17 (29 %)	8 (38 %)

N.5.20 Technology to Gain Information

In addition to the people mentioned earlier who made cell phone calls from the stairwells, 10 people used technology such as wireless e-mail devices and text pagers as a means of gathering information about the situation. Thirteen listened to the radio or watched television, among them three evacuees who stopped to watch TV on the mid floors (43 to 76) of WTC 1 and saw live media coverage of the events.

N.5.21 Impact of the 1993 Evacuation

Only nine percent, 41 people, reported being present during the 1993 bombing and evacuation of the WTC. Of them, three people explained that their experience in 1993 helped them decide to start their evacuation immediately on September 11, 2001. Five people who were present in 1993 mentioned being better prepared this time with evacuation kits. These emergency escape kits were described as being equipped with flashlights, masks, glow sticks, whistles and water (Murphy and Levy 2001). Another 18 people specifically mentioned that 1993 was on their mind during their evacuation, although they were not present during the events of 1993.

Four survivors reported seeing photolumineseent stripes on the stairs, railings and stairwell doors—an improvement the Port Authority made following the 1993 bombing. As one survivor stated, "All you had to do was follow those yellow-green stripes. They were wonderful." The stripes were especially valuable when the emergency stairs stopped and people had to travel horizontally through mechanical equipment spaces that had many doors (Masetti 2001).

A paraplegic survivor from WTC 1 who was also present for the 1993 evacuation of the WTC commented on the successful use of an evacuation chair on September 11, 2001. The evacuation chairs were part of the improvements made to the WTC evacuation process after the 1993 bombing, and this survivor credits the chair with saving his life. In 1993, he was bounced down the stairs in his electric wheelchair from floor 69 to floor 43, where he was then transferred to a stretcher and carried down the rest of the way. It took him 6 hours to evacuate from floor 69 in 1993. On September 11, 2001, using the evacuation chair enabled him to escape floor 69 of WTC 1 and get to street level in 1 hour and 30 minutes. He went on to say, "If it weren't for the evacuation chair and the 10 people that brought me down, I would not have made it, that's for sure. That evacuation chair made the difference" (Fink and Mathias 2002).

N.6 SUMMARY RESULTS

Although it is recognized that content analysis of first-person accounts has limitations, and the results cannot be generalized to all occupants of the towers, this methodology was found to be particularly useful

in this case. With the large number of accounts that were gathered from a variety of sources (print media, television, radio, internet, emails, etc.), the similar themes and experiences within these texts became more than merely anecdotal stories. Considering that a great majority of the accounts became public within three weeks following the events and that recollection of human behavior is delicately time sensitive, it was important to analyze this information. This methodology could prove useful in future projects dealing with first-person accounts, although events of the magnitude of September 11, 2001, which produced such a large number of first-person accounts, are extremely rare.

For the accounts gathered from media sources, it is recognized that they may represent the most dramatic stories of the evacuation. At the same time, those survivors who have dramatic stories of escape may be more inclined to share them compared to other survivors who may judge their evacuation as less eventful. However, the accounts analyzed were from survivors located in several areas in each tower, providing a distribution of floors from the upper, middle and lower strata of the two towers. In total, 745 accounts were analyzed, representing 435 survivors from WTC 1 and WTC 2.

An interesting and important observation involves the emergence of new first-person accounts from survivors who had not previously shared their stories, around the first anniversary of the event. In trying to explain this phenomenon, it is speculated that survivors who had not previously shared their stories were now prepared to do so after having time to cope and deal with their experience. Many of the evacuees mentioned that telling their stories proved to be a therapeutic exercise. Media sources may have also held accounts gathered from an earlier date or searched for new, untold stories and published them as part of the anniversary coverage.

An important observation stemming from the accounts analysis encompasses the issue of evacuation strategies. It was found that 44 people, about 24 percent of WTC 2 occupants in this study, used the elevators at some point during their evacuation. It has long been accepted among fire safety experts that people know they should not use elevators as a means of egress during an emergency, but those in WTC 2 who chose to use the elevators may have thought it was the quickest or safest route of escape and may have believed that because they were not in immediate danger, they were justified in their decision to use the elevators to evacuate. The same theme is echoed when examining the reactions of the 96 WTC 2 occupants who heard the public address announcement, which told them their building was secure and to return to their offices. Only 16 people took heed of this message and stopped their evacuation, making their way back to, or remaining in, their offices. Through all accounts studied (with the possible exception of one) there was no doubt that people understood the message, as there were no audibility or intelligibility issues; the content of the message was clear. However, the majority of 69 occupants made their decision based on the information that they had at that point in time and decided to disregard the order and continue evacuating. As one survivor stated, "I was thinking that there is a real difference of opinion here about what my eyes are seeing and what the announcement was saying" (Murphy and Levy 2001). The decision to carry on with the evacuation may also reflect the concept of commitment: as these occupants had already made the decision to leave, they pursued this task.

It is also interesting to note that the official procedure for emergencies in the WTC was to meet in the lobby area on each floor and wait for instruction. Nevertheless, the majority of occupants of both towers decided to evacuate on their own after WTC 1 was hit, without waiting for an official building announcement. Thus, this is further evidence that people will make decisions based on what they judge the proper action to take despite official procedures.

Those who had experienced the 1993 terrorist bombing of the WTC left promptly. Although their past experience could have suggested that the evacuation was going to be long and difficult and that people who stayed behind would be evacuated by rescuers later on, very few used this rationale. Instead, most occupants with experience from 1993 felt an urgency to leave immediately.

The results show that 18 people who were identified as having "high levels" of knowledge delayed evacuating. Those who delayed their evacuation reported that they rushed to gather their belongings or went to backup important company files, for they suspected they would not be returning to the building for an extended period of time. These are rational actions; therefore, it is concluded that those with "high levels" of knowledge who delayed evacuating had to have been in areas where the perceived threat to personal safety was not high.

The overall impression of the emotional atmosphere during the evacuation, after reading all 745 accounts, was that of calm and order. Although some reported crying and being anxious or nervous, the majority viewed themselves and others as composed. A stark contrast in perceived behavior was found to exist between the two towers, with the majority of WTC 1 occupants reporting others as "calm" (93 of 155 people), where as a large proportion of WTC 2 occupants perceived others to be "panicked" (45 of 113 people). The perception of "panic" occurred before WTC 2 was hit for at least three occupants, while another 29 survivors perceived others as "panicked" after WTC 2 was hit. After their building had been struck, WTC 2 occupants may have realized they were under attack, which could possibly explain the heightened level of anxiety in the tower. (It is important to note, however, that the colloquial use of the word panic more often describes a state of mind—high anxiety, for example—rather than the irrational actions that more correctly define "panic.")

Emergency crews disrupted evacuation in the stairwells while going against traffic, but many evacuees who mentioned seeing firefighters felt reassured and safe due to their presence. It is assumed that this counter flow did not prevent occupants from evacuating, as the last people to exit reported being alone in the stairs while they were descending rapidly seconds before the collapse. Evacuees used technology such as cell phones, wireless e-mail devices, and text messaging over pagers during their descent as a means of gathering information about the situation unfolding around them.

N.7 FUTURE WORK

Future research is needed to fully understand the evacuation behavior of the occupants who were in the two towers of the WTC on September 11, 2001. A variety of approaches should be used to gather this information such as interviews and questionnaires. Unfortunately, the extended amount of time that has elapsed since the events is an important factor to mitigate, since occupants' recollection may be incomplete and contaminated by what has been seen, read, or heard since September 11, 2001.

Technology clearly played a role in providing occupants with information about the event during their evacuation. This phenomenon raises important issues regarding the information age and how new technologies can be taken advantage of to aid in emergency situations. If technology can help to disseminate timely information to the public in times of crises, strategies should be developed to enable authorities to fully utilize such technology.

This major event, which was repeatedly broadcast on television around the world, may also influence fire safety in high-rise buildings in general. It is essential to study how the perception of risk in high-rise buildings has changed since September 11, 2001. Do people who live, work or visit high-rise structures feel more at risk of a potential fire or fear that the building might collapse if there is a fire? If the occupants feel more at risk, what is their likely behavior and response in future emergencies? Studies should be conducted to explore the impact of high-rise risk perception on intended behavior in future emergencies. Are occupants prepared to follow procedures and instructions? Would they comply with a protect-in-place approach or to move to a refuge floor? If all occupants want to evacuate to the ground floor or exit during an emergency, requirements for stair design and building height might need to be revisited. Drills should be conducted to observe unannounced emergency evacuations in high-rise buildings, varying evacuation strategies and information provided to occupants to assess actual response. Longitudinal studies should also be conducted to assess the impact of September 11 over time on high-rise building occupants.

N.8 ACKNOWLEDGMENTS

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Attachment 1
WTC First-Person Accounts Code Book

1. BLDG - 'Building Location at the Time of Awareness / Perception of First Cue'

1 = Tower 1, North Tower

2 = Tower 2, South Tower

3 = Plaza/Outside

4 = Concourse

5 = Mall

6 = PATH Train

7 = Bldg 7 or Bldg 3

99 = n/a

2. FLR - 'Floor Location at Perception of First Cue'

SPLIT COLUMN EXACT FLOOR AND CATEGORY

1 = T1 Lower (basement-42) in stairs

2 = T1 Lower (basement-42) on a floor

3 = T1 Mid (43-76) in stairs

4 = T1 Mid (43-76) on a floor

5 = T1 Upper (77-110) in stairs

6 = T1 Upper (77-110) on a floor

7 = T1 in stairs, level not specified

8 = T1 location not specified

9 = T1 mezzanine, lobby, concourse

10 = T2 Lower (basement-42) in stairs

11 = T2 Lower (basement-42) on a floor

12 = T2 Mid (43-76) in stairs

13 = T2 Mid (43-76) on a floor

14 = T2 Upper (77-110) in stairs

15 = T2 Upper (77-110) on a floor

16 = T2 in stairs, level not specified

17 = T2 location not specified

18 = T2 mezzanine, lobby, concourse

19 = Outside

22 - T1 elevator - lower floors

23 - T1 elevator - mid floors

24 - T1 elevator - upper floors

25 - T1 elevator, level not specified

99 = n/a

3. SEX - 'Sex of Evacuee'

1 = male

2 = female

99 = n/a

4. AGE_CODE - 'Age of Evacuee'

SPLIT COLUMN EXACT AGE AND CATEGORY

1 = 21-35

2 = 36-50

3 = 51-65

4 = 66 +

99 = n/a

5. DATE - 'Date of Record'

SPLIT COLUMN EXACT DATE MENTIONED

1 = Week of (09/11/2001-09/15/2001)

2 = 2 weeks after (09/16/2001-09/30/2001)

3 = 1-3 months after (10/01/2001-12/31/2001)

4 = 4-6 months after (1/01/2002-3/31/2002)

5 = 7-9 months after (4/01/2002-6/30/2002)

6 = 10-12 months after (7/01/2002-9/30/2002)

99 = n/a

6. EGRESS - 'Evacuation Method'

1 = Stairs

2 = Changed stairwells

3 = Elevator

4 = Combo of stairs and elevator

99 = n/a

7. FSTCUE - 'First Cue of Event'

COLUMN CHECKED OFF FOR EACH INITIAL CUE MENTIONED

1 = Audio (boom, crash, explosion, thunder, blast, roar, rumbling)

2 = Visual (smoke, fire, bodies, plane approaching, panicked people, debris falling)

3 = Building Movement (impact, sway, shake, earthquake, rocking, jolt)

4 = Content Movement (chairs moving, ceiling falling, bounce in elevator, debris in halls/offices, lights flickering, change in air pressure, burned by fire)

5 = Warn by others (directly told or behavior of others)

6 = Physically impacted (burned, fell or thrown out of chair)

7 = Smelled fumes or Felt heat

99 = n/a

8. ALRM – Heard Alarm

1 = Yes, heard alarm

2 = Heard alarm on floor

3 = Heard alarm in stairs

4 = 'I did not hear an alarm'

99 = n/a

9. STTIME - 'Time to Start Evacuation'

1 = Immediately (ran, right away, rapidly): 1 minute

2 = Shortly after (short delay, picked up belongings, warn others): up to 5 minutes after

3 = Delayed (gathered belongings, look out window, make phone calls, watch TV, kept working, checked security, planned with coworkers, shut equip off, Post T2 Impact)

4 = Stayed (to help: headcount, direct people, assisted coworkers, waited to be rescued/given instructions; went up)

5 = Stuck (behind debris, walls, in elevator)

99 = n/a

10. CNDFL - 'Condition on Floor When Building was Hit'

1 = Devastated (combo of debris, fire, walls collapsed, ceiling/lights down, darkness, water/sprinklers, smoke, jet fuel, glass, bodies)

2 = Abnormal (some smoke, heat, smell fuel, power out, dusty, debris past windows, some reason for alarm/evacuation)

3 = Normal (usual working conditions)

99 = n/a (incl. not on floor when building was hit)

11. CNDFL – 'Condition on Floor'

COLUNM CHECKED OFF FOR EACH CONDITION MENTIONED.

1 = Normal

2 = Door Jammed

3 = Debris – Wall, ceiling collapsed

4 = Smoke

5 = Dust

6 = No power – dark

7 = Smell

8 = Water

9 = Fire

10 = Crowd, injuries

11 = Trapped

12 = Not on a floor

99 = n/a

12. STRS - 'Condition in Stairwell During Evacuation'

COLUMN CHECKED OFF FOR EACH CONDITION MENTIONED.

1 = Normal

2 = Door locked, jammed

3 = Crowd, hot

4 = No power

5 = Water

6 = Cracked wall

7 = Debris

8 = Smoky, smelly

99 = n/a

13. ANCHRD - 'Heard Announcement'

1 = T1 Yes

2 = T1 No (mentioned specifically not hearing message)

3 = T2 Yes

4 = T2 No (mentioned specifically not hearing message)

99 = n/a

14. ANCACT - 'Action After Hearing T2 Announcement'

1 = Continued evacuating

2 = Continued evacuating saw some returned

3 = Returned to office/Stay on location

99 = n/a

15. ANCFLR - 'Location when T2 Announcement Heard'

10 = T2 Lower (basement-42) in stairs

11 = T2 Lower (basement-42) on a floor

12 = T2 Mid (43-76) in stairs

13 = T2 Mid (43-76) on a floor

14 = T2 Upper (77-110) in stairs

15 = T2 Upper (77-110) on a floor

16 = T2 in Stairs not specified

17 = T2 Location not specified

18 = T2 mezzanine, lobby, concourse

19 = Outside

20 = T2 in Elevator

99 = n/a

16. LT2IMP - 'Location at T2 Impact'

1 = T1 Lower (basement-42) in stairs

2 = T1 Lower (basement-42) on a floor

3 = T1 Mid (43-76) in stairs

4 = T1 Mid (43-76) on a floor

5 = T1 Upper (77-110) in stairs

6 = T1 Upper (77-110) on a floor

7 = T1 in stairs, level not specified

8 = T1 location not specified (incl. Inside elevator)

9 = T1 mezzanine, lobby, concourse

10 = T2 Lower (basement-42) in stairs

11 = T2 Lower (basement-42) on a floor

12 = T2 Mid (43-76) in stairs

13 = T2 Mid (43-76) on a floor

14 = T2 Upper (77-110) in stairs

15 = T2 Upper (77-110) on a floor

16 = T2 in stairs, level not specified

17 = T2 location not specified (incl. Inside elevator)

18 = T2 mezzanine, lobby, concourse

19 = Outside

99 = n/a

17. LT2COL - 'Location at T2 Collapse'

1 = T1 Lower (basement-42) in stairs

2 = T1 Lower (basement-42) on a floor

3 = T1 Mid (43-76) in stairs

4 = T1 Mid (43-76) on a floor

5 = T1 Upper (77-110) in stairs

6 = T1 Upper (77-110) on a floor

7 = T1 in Stairs not specified

8 = T1 in Elevator

9 = T1 mezzanine, lobby, concourse

10 = T2 mezzanine, lobby, concourse

11 = T2 Lower (basement-42) in stairs

12 = Outside

13 = Other WTC building

14 = Subway

99 = n/a

18. LT1COL - 'Location at T1 Collapse'

1 = Lower T1 (basement-43) stairs

2 = T1 mezzanine, lobby, concourse

3 = Outside

99 = n/a

19. LFFS - 'Location When Met Firefighters'.

1 = T1 Lower (basement-42) in stairs

2 = T1 Lower (basement-42) on a floor

3 = T1 Mid (43-76) in stairs

4 = T1 Mid (43-76) on a floor

5 = T1 Upper (77-110) in stairs

6 = T1 Upper (77-110) on a floor

7 = T1 in stairs, level not specified

8 = T1 location not specified

9 = T1 mezzanine, lobby, concourse

10 = T2 Lower (basement-42) in stairs

11 = T2 Lower (basement-42) on a floor

12 = T2 Mid (43-76) in stairs

13 = T2 Mid (43-76) on a floor

14 = T2 Upper (77-110) in stairs

15 = T2 Upper (77-110) on a floor

16 = T2 in stairs, level not specified

17 = T2 location not specified

18 = T2 mezzanine, lobby, concourse

19 = Outside

99 = n/a

20. HELP - 'Who Helped Evacuee during Evacuation'

COLUMN CHECKED OFF FOR EACH HELPER MENTIONED

1 = Firefighter

2 = Port Authority (building staff/security)

3 = External Official (police, FBI, EMT, rescue workers)

4 = Coworkers

5 = Passed Firefighters in Stairs

99 = n/a

21. DSBLD - 'Evacuee Disability and Injury'

1 = Visual impairment

2 = Hearing impairment

3 = Physically challenged (obese, asthma, heart condition)

4 = Wheelchair user

5 = Injured during event (burned, sprained ankle, broken bones, emotional trauma)

6 = Helped disabled (during the evacuation)

7 = Saw disabled (during the evacuation)

8 = Helped injured

9 = Saw injured

99 = n/a

22. B1993 - '1993 WTC Bombing Presence'

1 = Yes

2 = Yes, prepared since (evacuation packs)

3 = Yes, reason evacuated early

4 = Yes, reason stayed

5 = No

6 = 1993 bombing in the back of their mind but were probably not there at the time

99 = n/a

23. DELAY - 'Reason for Delay in Evacuation'

1 = Decide to stay

2 = Activity to complete before leaving (search floor, secure document, made calls, instruct others)

3 = Went Up/Return

4 = Stuck or trapped

5 = Help others, disabled or injured/Being helped

6 = Told to stay

99 = n/a

24. LPHONE - 'Location when Evacuee Made Phone Call'

1 = Office

2 = Other floor

3 = Stairs

4 = Outside

5 = Multiple locations

99 = n/a

25. WPHONE - 'Recipient of Evacuee Phone Call'

COLUMN CHECKED OFF FOR EACH GROUP MENTIONED

1 = Family and friends (spouse, parents, home)

2 = Colleague or boss

3 = Authorities (building security, 9-1-1)

99 = n/a

26. REST - 'Rest during Evacuation'

1 = T1 Lower (basement-42) in stairs

2 = T1 Lower (basement-42) on a floor

3 = T1 Mid (43-76) in stairs

4 = T1 Mid (43-76) on a floor

5 = T1 Upper (77-110) in stairs

6 = T1 Upper (77-110) on a floor

7 = T1 in stairs, level not specified

8 = T1 location not specified

9 = T1 mezzanine, lobby, concourse

10 = T2 Lower (basement-42) in stairs

11 = T2 Lower (basement-42) on a floor

12 = T2 Mid (43-76) in stairs

13 = T2 Mid (43-76) on a floor

14 = T2 Upper (77-110) in stairs

15 = T2 Upper (77-110) on a floor

16 = T2 in stairs, level not specified

17 = T2 location not specified

18 = T2 mezzanine, lobby, concourse

19 = Outside

99 = n/a

27. OBSTCN - 'Obstructions Encountered During Evacuation'

COLUMN CHECKED OFF FOR EACH OBSTRUCTION MENTIONED

1 = Door Jam (locked or jammed)

2 = Debris (wall falling, floor collapse, material damaged)

3 = Smoke

4 = No power

5 = Smell (of fuel)

6 = Water

7 = Fire

8 = Crowd, disabled, injured

9 = Trapped by building rubble

99 = n/a

28. TMOUT - 'Time Evacuee Exited Building'

1 = T1: 8:48-9:02

2 = T1: 9:03-9:30

3 = T1: 9:31-9:58

4 = T1: 9:59-10:27

5 = T1/T2: 10:28+

6 = T2: 8:48-9:02

7 = T2: 9:03-9:30

8 = T2: 9:31-9:58

99 = n/a

29. KNWSIT - 'Evacuee's Knowledge of the Situation in the Initial Moment'

1 = High (terrorism/plane attack/ T2 collapsed/saw plane approaching/hitting building)

2 = Moderate (fire/bomb/earth quake/serious emergency/speculated plane/rumors)

3 = Low (reason for evacuation unknown or limited)

99 = n/a

30. SRSNSS - 'Level of Seriousness to Themselves in the Initial Moment'

1 = Very serious (fear, scared, want to get out ASAP)

2 = Somewhat serious (worried, did not know what was happening)

3 = Not serious (not concerned)

99 = n/a

31. SOINFL - 'Social Influence on Evacuee's Decisions'

1 = Authority figure (boss, supervisor, manager)

2 = Coworkers/Group influence

3 = Survivor took leadership role

4 = Boss and group influence

99 = n/a

32. TCINFL - 'Technological Influence on Knowledge during Evacuation'

1 = Cell phone

2 = Blackberry, Text pager (deaf)

3 = TV, radio

4 = Walkie Talkie

99 = n/a

33. PERCEP - 'Perception of Others During Evacuation'

COLUMN CHECKED OFF FOR EACH PERCEPTION MENTIONED

1 = Calm/Orderly (civil, supportive, chatty, composed)

2 = Momentarily Panicked (running, pushing, shoving)

3 = Upset (crying, shouting, fearful, anxious)

4 = Helpful (assisting others)

99 = n/a

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Appendix O
INTERIM REPORT ON TELEPHONE INTERVIEWS

O.1 SCOPE AND OBJECTIVE

Interviews with survivors of the World Trade Center (WTC) attacks were conducted using three methods: telephone interviews, face-to-face interviews, and focus groups. This appendix will review four aspects of the telephone interviews: methodology, sample disposition, telephone questionnaire, and preliminary results of the telephone interviews for the pre-September 11, 2001, data. Significant additional analysis will be completed over the next several months to develop as clear an understanding as possible of the evacuation of WTC 1 and WTC 2 on September 11, 2001. These findings will be enhanced and compared with findings from many other sources, including face-to-face interviews, focus groups, published accounts (see Appendix N of this report for a discussion of published accounts analysis), 9-1-1 records, and other materials.

The multimethod approach was selected for several reasons. First, multiple methods increase confidence in the conclusions and findings when more than one method arrives at the same conclusions. Second, the multiple objectives of the investigation mandated complementary approaches to accomplish all the goals. In other words, it is difficult to establish a scientific foundation for general findings while also broadly investigating and establishing new facts and discovering unique events using only one method. Finally, concerns associated with the time latency since September 11, 2001, suggest the use of different approaches and techniques in order to increase memory recall and accuracy.

The telephone interview questions and protocols met all Federal requirements regarding the Common Rule for the Protection of Human Subjects, including Institutional Review Board (IRB) and National Institute of Standards and Technology (NIST) approvals. Further, the telephone interview questions met the requirements of the Paperwork Reduction Act, subject to Office of Management and Budget (OMB) approval number 0693-0044.

O.2 METHODOLOGY

The survey objectives of the telephone interviews called for collecting 800 computer assisted telephone interviews (CATI) of persons occupying either of the two WTC towers (WTC 1 and WTC 2) at the time of the terrorist attacks on September 11, 2001. The sample size of 800 and allocation of n=400 to each tower were determined to simultaneously maximize the statistical precision within each tower. Primary statistical analyses are in the form of tabulations and linear statistics (e.g., reporting of percentages and average/means). Estimates of percentages from tower-specific survey data (at n=400) exhibit sampling errors no greater than 2.5 percentage points, and 95 percent confidence intervals of percentages are no

greater than +/- 5 percentage points. This level of precision is more than adequate for examining characteristics of occupants and egress attributes.[1]

Attempts were made to equally divide the respondents among WTC 1 and WTC 2 occupants (i.e., n=400 occupant interviews from each tower). Within each of the WTC buildings, independent proportionate stratified samples of survivors were drawn. In other words, each occupant of a particular tower had an equal probability of being selected.

O.2.1 Sampling Frame

The sampling frame (i.e., the list from which the sample was drawn) consisted of the names of occupants from badge lists of WTC 1 and WTC 2. All occupants of the WTC were required to provide personal data in support of issuing badges to clear through the security station at the entrance of each tower. The badge lists were provided to NIST by the Port Authority of New York and New Jersey. The lists provide name, floor of occupancy, employer, and social security number, the only available means of uniquely identifying individuals.

O.2.2 Tracking and Screening the Sample

The badge lists contained September 11, 2001, occupants, occupants who were absent on the day of the attacks, decedents, former occupants, and nonperson listings (false names used in sample testing). This means that a screening effort was needed to identify "eligible" badge list members—namely, those who were inside WTC 1 or WTC 2 during the attacks. Moreover, the absence of telephone numbers for the badge holders on the list necessitated a tracking/locating effort. The primary tracking mechanism was to search public databases using commercially available batch matching and Web-based search utilities. This necessitated a large sample to generate the 800 completed interviews.

O.2.3 Design Parameters

The number of occupant selections drawn into the sample was contingent on four key design parameters:

- The percentage of individuals from badge listings for whom a working telephone number could be found (initial estimate: 80 percent tracking success)
- The percentage of badge listings that corresponded to a surviving WTC 1 or WTC 2 occupant on September 11, 2001 (initial estimate: 14 percent)
- The cooperation rate for screening the occupants (initial estimate: 65 percent)

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[1] Multivariate modeling such as correlation analyses, multiple linear regressions, and path analyses, are also a prominent part of the survey analyses. Like the tabulations, these analyses are being conducted independently by tower. A sample size of n=400 per tower provides more than ample statistical power for the F tests used to determine the significance of the regression models (i.e., testing the null hypothesis that the ratio of explained variance to error/residual variance is equal to zero). For instance, in a multiple regression analysis featuring 20 independent variables, the sample size of 400, and 0.05 level of significance (Type I error), the power of the F test to detect an r^2 statistic (i.e., proportion of explained variance) of 0.06 is just over 81 percent. See also Chapter 9 of Cohen, J., 1988, Statistical Power Analysis for the Behavioral Science, Lawrence Erlbaum Associates, Inc., Hillsdale, N.J. Multivariate modeling results will be presented at a later date.

- The interview response rate among September 11, 2001 survivors (initial estimate: 50 percent)

O.2.4 Expected Dispositions

In planning the CATI survey, a number of design parameters needed to be quantified in order to determine the number of persons to draw from the badge list. The expected disposition of the sample was developed using the parameters defined in the aforementioned paragraph. A total sample of 22,735 persons from the badge list was needed to generate the desired 800 completed interviews. The expected disposition by tracking efforts, screening, and interviewing are discussed later.

O.2.5 Reserve Sample

A reserve sample of about 14 percent (or about n=3,265) was added in the event additional sample size was needed due to unanticipated circumstances (e.g., the eligibility rate is lower than anticipated). This brought the total sample size to 26,000. The reserve was held "in reserve" while the main sample was worked. Working the main sample allowed preliminary estimates of all design parameters to be monitored so that an informed decision could be made on the necessity of releasing none, some, or all of the reserve.

O.2.6 Disproportionate Allocation

The badge list contained different counts of persons from each tower, yet our sample design called for equal samples to be drawn from the collections of badge holders in WTC 1 and WTC 2. Thus, a disproportionate design (across tower strata) was employed. But within a tower, independent proportionate samples were drawn using stratification by floor (within tower), employer (within floor) and last name (within employer). This served to increase the statistical precision of the tower-specific samples.

Thus, equal-sized samples of 13,000 selections were drawn from each of WTC 1 and WTC 2 badge lists. Each tower-specific sample was partitioned into 20 random replicates (comprising 5 percent of the total), and the reserve sample was determined by the last several random replicates for each tower. It is important to note that all badge holders from WTC 1 floors 92 and above were omitted from sampling because there were no survivors from those floors.

O.2.7 Final Sample Disposition Analysis

A total sample of 26,000 was drawn, comprising 13,000 names for each tower. Table O–1 summarizes the final disposition of the CATI sample and the total (locating) sample. The table is comprised of two sets of rows. The top set pertains to the CATI sample and represents those sample persons for whom an initial telephone number was identified prior to commencing the CATI survey operations. The bottom set of rows with the heading "Total Sample Disposition" represents the results of our locating/tracking effort used to identify usable telephone numbers associated with the sample subjects. (Recall that only name, SSN and employer were available; no other contact information was readily available).

Table O–1. Disposition of the CATI sample and the total sample by tower.

CATI Disposition	WTC 1[a]	WTC 2[a]	Total	% Distn
Interview	427	376	803	4.0 %
Partial interview	47	37	84	0.4 %
9/11 decedent	20	40	60	0.3 %
Other decedent	49	39	88	0.4 %
Not eligible	3,712	3,752	7,464	37.5 %
Language barrier	135	129	264	1.3 %
Eligible refused to interview	138	139	277	1.4 %
Other refusal	224	181	405	2.0 %
Respondent not interviewed	247	168	415	2.1 %
Can't contact/locate respondent	4,987	5,076	10,063	50.5 %
CATI total	9,986	9,937	19,923	100.0 %
Total sample disposition:	WTC 1	WTC 2	Total	% Distn
Found initial telephone number	9,986	9,937	19,923	76.6 %
Unable to find a telephone number	3,014	3,063	6,077	23.4 %
Sample total	13,000	13,000	26,000	100.0 %

a. Table data are unweighted. Tower location as indicated in the badge list and may differ from reported tower location.

The bottom set of rows shows that telephone numbers were identified for just over three quarters (76.6 percent) of the sampled subjects. Moreover, this rate was fairly uniform across towers. The 19,923 individuals with an initial telephone number were then loaded into the CATI sample management system for calling. Ultimately, all reserve samples were used in the telephone survey. In the initial design parameters, it was assumed that 82 percent of the subjects would be locatable. While 76.7 percent is close, many of the numbers were obsolete (e.g., disconnect, wrong number) and necessitated additional tracking during CATI operations. Ultimately, by the end of data collection, only half the sample (49.5 percent) represented confirmed contacts with subjects.

The top set of rows in Table O–1 presents the final disposition of the sample by tower as well as for the overall sample. Several statistics in the percentage distribution (rightmost) column are notable. First, we were unable to contact subjects for half the sample (50.5 percent), due either to failures to answer the phone, answering machines, unusable numbers (e.g., wrong number, disconnected, business), etc. Most of these telephone numbers represent "unlocatable" subjects—subjects for whom the initial telephone number was incorrect. It bears reiterating that substantial additional research during CATI operations was conducted using powerful subscription-based Web-based search engines. Unfortunately, little information was available for these individuals.

A second result of interest is the prevalence of ineligible subjects—those not in the building on the morning of September 11, 2001. An assessment of eligibility rates appears later in this appendix. A third result is the existence of decedents—some from the September 11 attack and others from causes not necessarily related to September 11, 2001 (e.g., cause unknown, natural causes). Most of the September 11, 2001, decedents were encountered due to a difference in the full (formal) name of the subject and the name that appeared on the badge list (e.g., the badge list sometimes contained maiden names, middle

names, nicknames, misspelled first or last names, out-of-sequence names, titles, and so on). This impeded the ability to remove known decedents prior to calling.

The outcome of CATI operations on the final outcome rates is presented by tower in Table O–2. The table shows screening rates, interview rates, and rates of eligible occupants (among those who responded to the screening questions). The first row shows that screening response rates were relatively uniform across towers at about 46 percent. A screening response rate of 65 percent had been planned. Similarly, interview response rates (among screened eligible subjects) were relatively stable across towers at about 49 percent. This is consistent with the planned interview response rate of 50 percent.

Table O–2. Summary disposition rates by tower.

Disposition Rate	WTC 1	WTC 2	Total
Screen	46.5 %	45.8 %	46.1 %
Interview	48.6 %	49.5 %	49.0 %
Eligibility	18.9 %	16.7 %	17.8 %
Overall	22.6 %	22.7 %	22.6 %

Note: Definitions for "Rates" consistent with American Association of Public Opinion Research (AAPOR) Standards, which may be found at http://www.aapor.org/pdfs/standarddefs2004.pdf.

The eligibility rates were higher than expected – about 18 percent overall compared to the 14 percent expected. The eligibility rate among WTC 1 subjects was slightly higher than those of WTC 2. However, the overall response rates are essentially uniform across towers, at 22.6 percent.

O.3 TELEPHONE INTERVIEW SCHEDULE

The telephone interview was conducted by a trained interviewer using a computer program which provides questions and answer categories for the interviewer. Prior to calling, subjects received a letter that outlined the scope and purpose of the investigation, the purpose of the interview, and the telephone call that came several days later. A full informed consent statement appeared in the letter, as well. A copy of the letter can be found in Attachment 1 of this appendix.

When interviewers reached the subjects by telephone, the respondents were provided a description of the survey, the confidentiality of responses, the length of the interview, and the voluntary nature of participation. They were then asked if they wished to participate, thereby obtaining oral informed consent. The full text of the informed consent statement appears after the advance letter as Attachment 2.

The telephone interview instrument, Attachment 3 at the end of this appendix, includes the questions, variable names, response options, and skip patterns directly from the computer program used by the interviewers. Variable names are used as shorthand for subsequent data analysis. Questions had a variety of response option categories: multiple choice, interval, Likert scale, or open-ended. Open-ended responses were minimized where possible due to the analysis burden and the fact that face–to–face interviews are also being conducted. Skip patterns reduce burden on the respondent by skipping questions that would not apply to a particular respondent. For example, a respondent would not be further questioned about fire drills if they did not receive fire drill training. Subsequent discussion of the questions indicates whether a respondent was read a list of choices or was expected to give a free response.

The interview was designed with five primary groups of questions, covering emergency training and preparedness, three stages of evacuation experience, and background information about the respondent.

O.3.1 Preparedness and Training

The first group of questions served to measure the extent to which an occupant had any special level of knowledge about the building, other than what would be obtained by performing their job. The most prevalent special knowledge would be formal evacuation training, or fire drills. If a respondent indicated that they participated in evacuation training during the 12 months prior to September 11, 2001, further questions were asked about the content of the training. The occupant's understanding of the emergency procedures, or the way it was 'supposed to go,' was also measured. Next, a Likert Scale[2] measured the usefulness of the evacuation training in the context of their egress experience on September 11, ranging from very helpful to very unhelpful. Finally, the respondent was asked whether he or she knew that there was a floor warden for their floor.

O.3.2 Initial Experience on September 11, 2001

The second group of questions covered the first moments of September 11, 2001, as experienced by the respondent, also known as the initial awareness period. How a person first became aware that something was not normal, whether in their building or the neighboring building, may have influenced subsequent decisions. Examples of awareness channels may include sensory perception, such as feeling, hearing, or seeing the building shake, seeing or smelling fire or smoke, or may include a conversation with a person inside or outside the WTC complex. Next, the respondent was asked to provide context to the initial moment of awareness. Context was first created by identifying what activity the respondent was performing. Activities may include, but are not limited to, working, conversing with coworker(s), eating, or participating in a meeting. The respondent was then asked to recall the number of other people they were with at the first moment of awareness. People in groups often defer to group decisions rather than making their own evacuation decisions. Next, a list of observations was read aloud and the respondent is asked to indicate whether they noticed the event during the period of initial awareness. These events included smoke, fire, fireballs, collapsed walls, jet fuel, severely or fatally injured people, sprinklers going on, fire alarm sounding, power outage or flickering lights, fallen ceiling tiles, and extreme heat. The event proximity was probed for every affirmative response to determine whether the observed event was in the immediate area or outside the building. If no affirmative responses were indicated, the respondent was asked whether they observed any disaster related events not previously mentioned. Finally, the extent of any injuries to the respondent or those in the immediate area was ascertained, as well as whether the respondent felt that their life or the lives of other people were in danger.

[2] A Likert Scale measures the degree to which the respondent agrees or disagrees with a statement. In this case, the scale measured helpfulness, including very helpful, helpful, unhelpful, and very unhelpful. A neutral response was not included.

O.3.3 Interim Experience on September 11, 2001

The format of the interim experience group of questions mirrored the format of the initial awareness questions. The interim time period was defined as the time after initial awareness, but before the person entered a stairwell or elevator to leave the building. This time period may range from moments to tens of minutes. The objective of the interim period questions was to determine what motivated/forced people to either immediately evacuate or delay their evacuation by some period of time.

Information about the nature of the event often forms the basis for decision-making during the interim period. Many people may have found the environmental cues from the initial awareness period sufficient to initiate an immediate evacuation. Others may have required additional information in order to feel comfortable leaving the workplace. Occupants could have obtained information in two ways: passively and actively. Passive information is information received without seeking it out. In other words, the information was received regardless of whether the person felt it was needed. Active information is information which the respondent actively seeks and considers important with respect to their decision to evacuate. The respondent was first asked whether they received any additional information about the event during the interim period. If so, the source (who), the nature (what), and the channel (how) of the information was probed. Next, additional information sought out by the respondent was probed, including the source, nature, channel, and whether the process was successful in gathering additional information.

The perception of risk to the respondent's life, as well as the lives of others was asked in the same way as during the initial period, in order to determine whether the sense of risk was increasing or decreasing over time. The interviewer probed about the activities of other people in the proximity of the respondent, which may influence the respondent's subsequent choices. Whether people began evacuating prior to the respondent was specifically asked. Next, the respondent was asked about the activities they undertook during the interim period, as well as activities that they wanted to do but could not. These activities included work-related actions, such as saving files or shutting machines down; personal actions, such as gathering belongings or calling people; or emergency-related actions, such as fighting fires/smoke, and searching for or helping others. If a respondent was unable to accomplish an action, the action and the reason for being prevented from accomplishing the action was gathered.

As with the initial period, any observations of building damage or distress were collected. If the respondent received help in any way before initiating evacuation, the nature and source of the assistance was determined. The respondent was asked what the primary cue was which initiated their evacuation on September 11 and how many minutes passed before they started evacuating. Finally, the respondent was asked whether anything prevented them from evacuating sooner than they reported.

O.3.4 Evacuation Experience on September 11, 2001

The next group of respondents completed the questions about the September 11, 2001, evacuation experience and focused on time spent in the stairwell and/or elevator(s). The respondent was first asked whether they began their evacuation alone or with other people. Which stairwell (or elevator) the respondent entered was collected as either the stair identification letter (A, B, or C) or the geographic location, if known. Knowing where the stairwell emptied out at the bottom may also narrow down which stairwell was used, which was collected near the end of this group of questions, [Stairs A/C (44 in. wide)

emptied out to the upper, Mezzanine level, while Stair B (54 in. wide) went to the lower, Concourse level]. Next, the respondent's rationale for using a particular stairwell was probed. The respondent was then asked whether they left the stairwell or turned back for any reason during the evacuation and, if so, why?

Some events and features of the stairwells aided the progress of the evacuation, while other features constrained the progress of the evacuation. The following features or events were identified to the respondents, who were asked to indicate whether it acted as an aid to their egress: instructions or assistance from their floor warden, a police office, or fire fighter, support/encouragement from others, exit signage, and photoluminscent paint. The following items were identified to determine whether they served to constrain the evacuation: crowded stairwells, counterflow (people moving up the stairs, against the flow of occupants), disabled or injured people being taken down the stairwell, locked doors, poor lighting, confusing or missing signage, and lack of clear instructions.

As with the initial and interim time periods, environmental cues related to fire smoke, jet fuel, and other disaster-related observations were probed, as well as whether the observation was in the immediate area or outside the tower. The final question about the respondent's own evacuation estimated the elapsed time from entering the stairwell until they left the building. A concluding evacuation question determined whether they knew why someone on their floor did not survive the WTC attack, if applicable.

O.3.5 Respondent Background

The final group of questions explored the background of the respondent relevant to evacuation. The first question identified any preexisting disabilities or injuries which made evacuation more difficult. The respondent's age, gender, and primary language were collected. If the respondent was working in the building prior to 1993, they were asked whether they were present during the February 26, 1993 bombing. If so, respondents were asked questions about their evacuation experience.

The interview concluded with an open-ended opportunity for the respondent to say anything additional about their evacuation experience on September 11, 2001. Respondents who indicated that they had a disability, were near the floors of impact, observed fire, smoke, or fireballs in their immediate area, or had a role of building responsibility on September 11, 2001, were asked if they would be willing to participate in a follow-up face-to-face interview.

O.4 PRELIMINARY RESULTS

The following section is a preliminary analysis of the telephone interview data. For this interim report, only pre-September 11, 2001 questions, or occupant background, preparedness, and training data, are analyzed and presented. Data related to September 11, 2001, evacuation experiences are currently being analyzed in the context of other data, such as face-to-face interviews and 9-1-1 tapes.

O.4.1 Response Rate Analysis

The response rate analysis of the telephone interview sample indicated an inverse relationship between floor height and the rate of response in WTC 1, as shown in the last column of Table O–3. The nonresponse weight adjustment is the inverse of the overall response rate. For example, the inverse of

25.3 percent is 3.95. In general, the weight adjustment for WTC 1 indicates that representative results should reflect that a single interview with a respondent high in the building is representative of more occupants than a single interview with a person lower in the building.

Table O–3. Response rate analysis for WTC 1.

Floor Stratum	Number of Selections	Number of Interviews	Screen	Eligibility	Interview	Overall	Non-response Weight Adjustment
1 to 42	4,464	256	46.2 %	22.6 %	54.8 %	25.3 %	3.95
43 to 75	3,714	137	48.6 %	16.6 %	45.8 %	22.3 %	4.49
76 to 92	1,802	34	42.7 %	14.7 %	30.1 %	12.9 %	7.78
Floor missing	6	0	50.0 %	0.0 %	N/A	N/A	
Total	9,986	427	46.5 %	18.9 %	48.6 %	22.6 %	

While a similar analysis of telephone interview response rates for WTC 2 (shown below in Table O–4) does not indicate a significant need to weight the results, it is a conservative assumption to be consistent with WTC 1 analysis and the results will be weighted.

Table O–4. Response rate analysis for WTC 2.

Floor Stratum	Number of Selections	Number of Interviews	Screen	Eligibility	Interview	Overall	Non-response Weight Adjustment
1 to 42	4,339	143	44.8 %	14.8 %	49.7 %	22.3 %	4.49
43 to 75	3,187	134	45.0 %	17.7 %	52.8 %	23.8 %	4.21
76 to 110	2,203	94	48.3 %	19.5 %	45.2 %	21.8 %	4.58
Floor missing	208	5	50.5 %	9.5 %	50.0 %	25.2 %	3.96
Total	9,937	376	45.8 %	16.7 %	49.5 %	22.7 %	

All subsequent telephone interview data analysis will thus reflect weighting of the results in order to more accurately generalize the results. By convention, when a sample number is indicated (n =), the sample number will be the actual number of responses. Where percentages are indicated, however, the percentages were weighted to allow for generalization, unless otherwise indicated.

O.4.2 Initial Building Populations

The total building population is the sum of survivors and decedents. At the time of this report, the City of New York has officially determined 2,749 people to be killed at the WTC on September 11, 2001; no official breakdown of where people were killed presently exists. While an analysis of this issue by Dennis Cauchon,[3] a reporter for *USA Today*, in the months immediately following September 11, 2001, was remarkably complete, differences between his projections and the official numbers from the City of New York and other official sources exist. These differences are shown in Table O–5. For example, the number of first responders depends upon the definition of first responder. The City of New York published an occupational analysis of WTC decedents based upon a Census of Fatal Occupational Injuries

[3] Cauchon, Dennis. '*For many on September 11, survival was no accident.*' USA Today, December 20, 2001.

(U.S. Department of Labor, Bureau of Labor Statistics, in cooperation with the New York City Department of Health and Mental Hygiene and State and Federal agencies). Four hundred and thirty-three decedent's occupations were listed as firefighting, police, or security. This number exceeds by 30 the number of FDNY, NYPD, and PAPD reported killed. This may be attributable to private security forces present inside the towers on September 11, 2001, and/or first responders not employed by New York City or the Port Authority. NIST is attempting to resolve these differences in order to fully understand the initial building population.

Table O–5. Reports of WTC decedents.

Decedent	Official Numbers		USA Today[a]
WTC 1 occupants			1,434
At or above impact			1,360
Below impact			72
WTC 2 occupants			599
At or above impact			595
Below impact			4
First responders (total)	433 [b,c]		479
FDNY	403[d]	343[e]	
NYPD		23[f]	
PAPD		37[g]	
UA 175 and AA 11	157[d]		157
Uncertain location in towers			147
Bystanders			10
Total number of decedents	**2,749[b,h]**		**2,826**

a. Cauchon, Dennis. 'For many on Sept.11, survival was no accident.' USA Today, December 20, 2001.
b. Summary of Vital Statistics 2002: The City of New York. Bureau of Vital Statistics, New York City Department of Health and Mental Hygiene. December 2003.
c. Table WTC 8: Occupation of Decedents. All decedents classified as 'protective service' occupations, which includes firefighting, police, and guards.
d. World Trade Center Building Performance Study. FEMA 403. May 2002.
e. Increasing FDNY's Preparedness (McKinsey Report). Available at: http://www.ci.nyc.ny.us/html/fdny/html/mck_report/index.shtml
f. Available at http://www.ci.nyc.ny.us/html/nypd/html/memorial_01.html
g. Available at: http://www.panynj.gov/AboutthePortAuthority /PortAuthorityPolice/InMemorium/
h. Does not include 10 airplane hijackers for whom the City has not issued death certificates.

Using the known eligibility rates allows for a projection of the survivors of WTC 1 and WTC 2 present in the building at 8:46 a.m. on September 11, 2001. The analysis indicates that WTC 1 had approximately 7,470 ± 750 surviving occupants, while WTC 2 had approximately 7,940 ± 920 occupants. Thus, the total population of survivors from both towers was 15,410 ± 1,180. Table O–6 summarizes the projection of population of WTC 1 and 2 on September 11, 2001. Pending resolution of decedent locations, the total

building population at the time of the first airplane impact was 17,440 ± 1,180, calculated using the building decedent locations reported by Cauchon.

Table O–6. Occupancy estimates on September 11, 2001, by tower.

	WTC 1	WTC 2	Total
Number in sampling frame	39,454[a]	47,608	87,062
Survivor occupancy rate	18.9 %	16.7 %	17.7 %
Estimated total population of survivors	7,470	7,940	15,410
Statistical Precision Calculations			
Sample n	427	376	803
Standard error (p)~	1.90 %	1.92 %	1.36 %
Standard error (total)	750	920	1,180
Confidence limits at 5 %	±1,470	±1,790	±2,320
Number of Occupant/Decedents			
Decedents	1,434[b]	599[b]	2,033 - 2,192[c]
Total Building Population			
	8,900	8,540	17,440

a. Includes only occupants below floor 92.
b. Calculated from Cauchon as 1,434 + 599.
c. Calculated as 2,749 – 403 first responders – 157 airplane passengers.

O.4.3 Occupant Characteristics

The results of the background analysis of the average WTC occupant are identical to the precision presented whether the data was weighted or unweighted. Occupants of the WTC towers were twice as likely to be male as female (65 percent male [n=284]) for WTC 1 and 69 percent [n=250] for WTC 2). As shown in Table O–7 and Table O–8 below, the average age of the occupants was mid-forties, with a range of people from their early twenties to mid-seventies. The vast majority of respondents (92 percent (n=739)) spoke English as their primary language, although no attempt was made to account for the fact that some telephone contacts ended with a language barrier and no interviews were conducted in any language other than English.

Table O–7. Age for WTC 1 respondents.[a]

N	Valid	439
	Refuse	1
Mean		45
Median		46
Minimum		22
Maximum		73

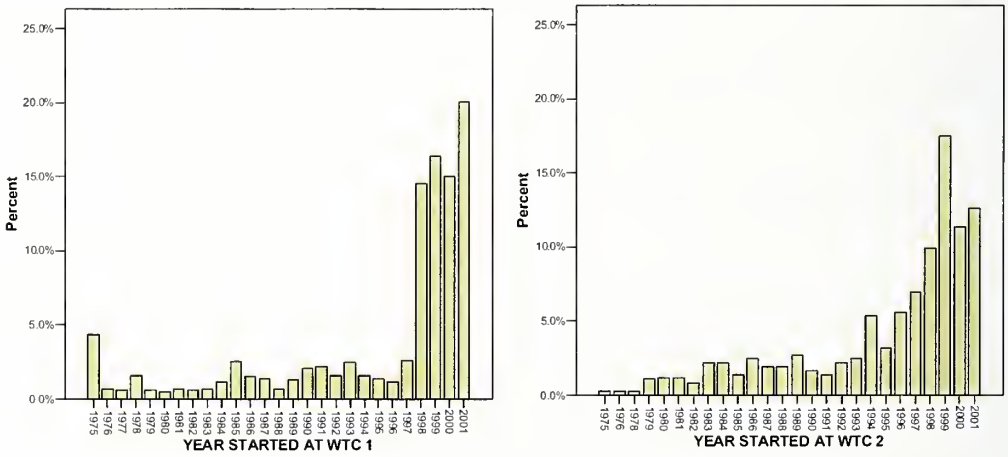
a. Mean and Median values are weighted. N, Min, and Max are unweighted.

Table O–8. Age for WTC 2 respondents.[a]

N	Valid	361
	Refuse	2
Mean		45
Median		44
Minimum		21
Maximum		74

a. Mean and Median values are weighted. N, Min, and Max are unweighted.

Tenant and employee turnover at the WTC was not uncommon. Figure O–1 shows the reported start dates for respondents in WTC 1 and WTC 2. In WTC 1, 4 percent (n=18) of the occupants had worked in the building since 1975. Further, 25 percent (n=110) had been working in the building prior to the 1993 bombing, although only 15 percent (n=64) of the WTC 1 respondents were present on February 26, 1993. For WTC 1, 67 percent (n=287) of the occupants had started working in the building in the last four years (1998–2001). The mean residence time in WTC 1 was over 5.6 years, while the median was 2 years.



Percentages are weighted.

Figure O–1. Employment start date at WTC.

Occupant tenure in WTC 2 demonstrated a similar trend. While only one respondent had worked in the building since 1975, 25 percent (n=91) of the respondents had been working in the building prior to the 1993 bombing (with 16 percent (n=59) present on the day of the bombing). Another 51 percent (n=185) started working in the building in the previous 4 years (1998–2001). The mean residence time in WTC 2 (n=360) was 5.9 years, while the median was 3 years.

Overall, 7 percent (n=56) had a formal responsibility or special knowledge about the building. These respondents were fire safety staff, floor wardens, searchers, building maintenance, or security staff. Approximately 13 percent (n=105) of the respondents were employed by the Port Authority, which may not imply a special knowledge of the building as some Port Authority employees had job duties related to functions outside the WTC.

Some 6 percent (n=52) reported having a limitation which impacted their ability to evacuate. These limitations included obesity, heart condition, needing assistance to walk, pregnancy, asthma, elderly, chronic condition, recent surgery or injury, and other.

O.4.4 Previous Experience

Whether an occupant had a previous evacuation experience may have affected the decisions an individual made during the September 11, 2001, evacuation. Further analysis will develop this hypothesis. Of the WTC 1 occupants present on September 11, 2001, 16 percent (n=64) were also present during the 1993 Bombing. In WTC 1, 60 percent (n=38) of evacuees in 1993 reported that they evacuated immediately, 30 percent (n=20) reported that they waited to evacuate, and 9 percent (n=6) did not recall. Most (95 percent [n=53]) who were able to recall their 1993 evacuation decision felt that they made the right decision, while 5 percent (n=3) did not believe they made the right decision.

Similarly, 16 percent (n=59) of WTC 2 evacuees on September 11, 2001, also evacuated in 1993. In WTC 2, however, only 75 percent (n=42) felt that they made the right decision in 1993, possibly due to the fact that many more waited to evacuate in 1993 in WTC 2 (69 percent (n=39)) than did so in WTC 1. Only 31 percent (n=17) who reported their decision evacuated immediately from WTC 2 in 1993, keeping in mind that the bomb had a more significant impact upon WTC 1 in 1993.

O.4.5 Preparedness and Training

Long a cornerstone of public policy on the emergency preparedness of office workers around the country, the Port Authority required tenants to conduct regular fire drills and appoint employee floor wardens and searchers. Overall, 66 percent (n=529) of WTC 1 and WTC 2 occupants reported participation in at least one fire drill in the 12 months immediately prior to September 11, 2001. Another 17 percent (n=139) reported that they did not participate in any fire drills in the 12 months prior to September 11, 2001, and 17 percent (n=135) did not know. Fire drill participation rates were similar between the two towers, as shown in Table O–9.

Table O–9. WTC fire drills in 12 months prior to September, 11, 2001.

Number of Drills	WTC 1[a]	WTC 2[a]
None	18 % (n=78)	17 % (n=61)
1	13 % (n=57)	8 % (n=29)
2	21 % (n=90)	24 % (n=88)
3	11 % (n=47)	15 % (n=53)
4	10 % (n=44)	9 % (n=32)
5 – 11	7 % (n=31)	9 % (n=32)
12 or more	3 % (n=13)	4 % (n=13)
Don't know	18 % (n=80)	15 % (n=55)

a. Percentages are weighted, n values unweighted.

One of the goals of fire drill training is to make occupants aware of the location of the emergency exits. Of respondents who reported participation in a fire drill, 93 percent (n=490) were instructed about the

location of the nearest stairwell. However, of the respondents who reported being shown a stairwell, 82 percent (n=432) did not enter or use the stairwell. Some 17 percent (n=92) reported that they did use the stairs during a drill, while approximately 1 percent (n=5) reported not knowing. Overall, more than half (51 percent (n=415)) of the occupants had never used a stairwell in WTC 1 or WTC 2 prior to September 11, while 48 percent (n=386) had used a stairwell. Two persons reported not knowing whether they had used the stairs previously.

Another goal of the fire drills was to introduce the floor warden system and evacuation procedures. Most occupants (82 percent (n=528)) with fire drill training were aware that there was a floor warden for their floor. Approximately 70 percent (n=557) of all occupants reported that they were aware of the evacuation procedures. When asked what those evacuation procedures comprised, however, answers varied significantly, including: wait in hallway for further instructions; do not use elevators, use stairs; meet at a designated site outside the building for a head count; or proceed down (varied number of) flights of stairs and wait. Further analysis of the understanding and implementation of the emergency procedures is under way.

O.5 SUMMARY

Eight hundred and three occupants of WTC 1 and WTC 2 were interviewed by telephone. Sample disposition analysis indicated differential nonresponse, particularly for WTC 1. In other words, the closer the occupant was to the impact area in WTC 1, the more likely it was that they would choose not to complete the telephone interview. Telephone interview percentages were then weighted to adjust for this effect.

On the morning of September 11, 2001, 17,440 people (± 1,180) were present at WTC 1 and WTC 2. This does not include first responders. The initial population of both towers was similar: 8,900 (± 750) in WTC 1 and 8,540 (± 920) in WTC 2.

The average age of an occupant of the WTC towers was mid-forties. Two-thirds of WTC 1 occupants had started working in the building during the previous 4 years (1998–2001), while half of WTC 2 occupants had begun working there during the same time period. Overall, 7 percent of occupants reported having special knowledge about the building, and 6 percent reported a preexisting limitation to their mobility.

Of those present on September 11, 2001, 16 percent were also present during the 1993 bombing. Two-thirds of occupants reported having participated in a fire drill in the 12 months immediately prior to September 11, while 17 percent reported that they received no training during that same period. Ninety-three percent of those participating in fire drills were instructed about the location of the nearest stairwell. Slightly over half of the occupants, however, had never used a stairwell at the WTC prior to September 11.

Significant additional analysis is presently under way. It is particularly important that results of questions related to the events, observations, and activities within the towers on September 11, 2001, be analyzed within the context of the findings coming from face-to-face interviews, focus groups, and other data collection activities.

Attachment 1
CATI Advance Letter to Occupants

Dear [Name]:

You are being asked to voluntarily participate in the federal investigation of the collapse of World Trade Center structures on September 11, 2001. The National Institute of Standards and Technology (NIST) is investigating the cause of the collapse of the World Trade Center towers on September 11 in order to improve the way that building professionals, emergency responders, and regulatory authorities prepare for and respond to future emergency events.

Because you were an occupant of the WTC buildings, you have been identified as a person who can provide NIST with information critical to its investigation. Your cooperation with the investigation involves participating in a 20 minute telephone interview with a representative of our survey research contractor, Datasource. The purpose of the interview is to gather information about where you were in the WTC buildings at the time of the September 11 events, what you observed and experienced, and how you evacuated the building.

You may also be asked to participate in a voluntary face-to-face interview. Participating in the telephone survey does not obligate you to participate in the face-to-face interview.

NIST and its contractors NuStats and Datasource will keep the identity of all participating individuals as confidential as possible. To the extent permitted by law, no one other than NIST, authorized Federal officials, NIST contractors NuStats and Datasource, and Essex Institutional Review Board will have access to your identity. Access to identifying information will only be provided to staff members on an as-needed basis. Data will be reported in summary form.

NIST is a non-regulatory agency within the U.S. Department of Commerce and is conducting this investigation under the authority of the National Construction Safety Team Act (P.L. 107-231). The investigation involves strict fact-finding. No part of the NIST Investigation report can be used in any suit or action for damages. For more information, see http://wtc.nist.gov.

A representative of Datasource will phone you in the next week or two. Please be aware that he / she will want to conduct the interview at your convenience. If you agree to do the survey, you may choose not to answer any question. If you wish, you can choose to withdraw your responses at any time during the interview or at the end of the interview.

If you have any questions or comments regarding your participation in the NIST investigation, please feel free to contact Dr. Johanna Zmud, NuStats project director, at 800-447-8287, ext. 2225 or Jason Averill, NIST project director, at 301-975-2585. If you have any questions about your rights as a participant or if you have any concerns, you may contact the Essex Institutional Review Board, Inc. (IRB), 121 Main Street, Lebanon, NJ; Phone: 908-236-7735. The IRB is a committee that has reviewed this research investigational plan to help ensure that your rights and welfare are protected and that the investigation is carried out in an ethical manner.

Sincerely,

NIST OFFICIAL

NIST

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Attachment 2
ORAL CONSENT STATEMENT

THE TELEPHONE INTERVIEWER USES THE FOLLOWING SEQUENCE OF STATEMENTS AND QUESTIONS TO EFFECT ORAL CONSENT PRIOR TO BEGINNING THE INTERVIEW:

SUBJECT NAME: _____

Hi, may I please speak with <SUBJECT NAME>?

YES, CONTINUE	1	
NO	2	SET CALLBACK

Hi, my name is _____ and I am calling on behalf of the National Institute of Standards and Technology (NIST). NIST is conducting the federal investigation of the World Trade Center disaster. *Information about the investigation is available at the website "wtc.nist.gov" or we can provide you a toll-free number to call.*

We are interviewing people about their experiences on September 11. We sent you a letter about the study informing you of our call. Did you receive the letter?

YES	1	→ *ASK IF THERE ARE ANY QUESTIONS*
NO	2	→ *ASK IF THERE ARE ANY QUESTIONS*

SCREENER:

First, I need to ask you a few questions because we want to speak to people who had certain types of experiences that may be especially helpful to NIST. For this study, we are conducting interviews with people who were in WTC 1 or WTC 2 during the September 11, 2001 attacks.

(SCREEN) At the time of the attack, were you in WTC 1 or WTC 2 at the World Trade Center?

YES	01	
NO	02	[THANK AND TERMINATE]
RF	99	[THANK AND TERMINATE]

(SCREEN) Which tower were you in?

WTC1	01	
WTC2	02	
OTHER, specify	97	[THANK AND TERMINATE]
RF	99	[THANK AND TERMINATE]

(SCREEN) What floor were you on?

<Enter floor number>

BASEMENT	990
CONCOURSE/LOBBY	991
PLAZA	992
OTHER, SPECIFY	997
DK	998
RF	999

PROGRAMMER NOTE: NEED CODED FLOOR NUMBER CATEGORIES FOR SAMPLE TRACKING:

LOWER FLOORS (T1: BASEMENT – 42)	01
LOWER FLOORS (T2: BASEMENT – 42)	02
MIDDLE FLOORS (T1: 43 – 76)	03
MIDDLE FLOORS (T2: 43 – 76)	04
UPPER FLOORS (T1: 77 – 91)	05
UPPER FLOORS (T2: 77 – 110)	06

We would like you to participate in our study. Before we start, I'd like to read a statement to you about this study to help you decide if you wish to participate:

In this study, we want to ask about when and how you left the tower you were in during the attack on 9/11. The information you provide will help engineers and emergency planners to improve the safety and evacuation procedures for high rise buildings. The interview length is about 20 minutes and your participation is voluntary. Because this interview involves recalling a traumatic event, you may experience emotional discomfort. You are free to skip over any question you do not wish to answer. You may take a short break or stop the questions at any time. We can also provide you counseling referrals if you like. *Your identity will* be kept as confidential as *possible. To* the extent permitted by *law, no* one other than NIST, authorized Federal officials, NIST contractors *NuStats and Datasource, and Essex Institutional Review Board* will have access to your identity. *There are no direct benefits to participants. If you have any questions or comments regarding your participation in the NIST investigation, you may contact Dr. Johanna Zmud, NuStats project director, at 800-447-8287, extension 2225. If you have any questions or concerns about your rights as a participant, you may contact the Essex Institutional Review Board at 908-236-7735.*

3a. Are you willing to participate?

YES, NOW	1	
YES, LATER	2	[SET CALLBACK APPOINTMENT]
NO	99	THANK AND TERMINATE

Attachment 3
TELEPHONE INTERVIEW INSTRUMENT

I would like to start by getting some background information. What year did you first start working at the World Trade Center? RANGE: 1975 – 2001

$E 1975 2001

DK	9998	
RF	9999	

«YRWRK»

On September 11, 2001, were you in any of the following positions with the World Trade Center?

PORT AUTHORITY STAFF	1	
FIRE SAFETY STAFF	2	
FLOOR WARDEN OR SEARCHER	3	
MAINTENANCE OR SECURITY STAFF	4	
NONE OF THESE	0	X
DK	8	
RF	9	

«ROLES_01»
«ROLES_02»
«ROLES_03»
«ROLES_04»

During the year from September 11, 2000 to September 11, 2001, how many fire drills did you take part in at the World Trade Center?

$E 0 99

NONE	00	=> SWLOC
DK	98	=> SWLOC
RF	99	=> SWLOC

«FIRED»

During these drills, were you ever instructed about the location of the emergency stairwell nearest to your office?

YES	1	
NO	2	=> SWLOC
DK	8	=> SWLOC
RF		=> SWLOC

«DEXIT»

How many emergency stairwells were you shown?

ONE	1
TWO	2

THREE		=> LVFSW
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«HMEXT»
«O_HMEXT»

Before September 11, had you learned in other ways about the locations of the three emergency stairwells?

YES	1
NO	2
DK	8
RF	9

«SWLOC»

SKIP IF NO FIRE DRILLS

=> USESW

Else => +1

if FIRED=00,98-99

«SOUT1»

During any of the fire drills, did you leave your floor using one of the stairwells?

YES	1	
NO	2	=> USESW
DK	8	=> USESW
RF	9	=> USESW

«LVFSW»

Which stairwells did you use?

STAIRWELL A	1	
STAIRWELL B	2	
STAIRWELL C	3	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«WHSW1_01»
«WHSW1_02»
«WHSW1_03»
«WHSW1_04»
«O_WHSW1»

Which side of the building was the stairwell located on?
=> +1

if NOT WHSW1=8

NORTH	1	
SOUTH	2	
EAST	3	
WEST 4	4	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«WHSL1»
«O_WHSL1»

Had you ever used any of the emergency stairwells prior to September 11?

=> DHELP
if LVFSW=1

YES	1	
NO	2	=> DHELP
DK	8	=> DHELP
RF	9	=> DHELP

«USESW»

SKIP FOR NO DRILLS AND NO USE OF STAIRWELLS

=> AEVOF
Else => +1

if FIRED=00,98,99 AND USESW>1

«SOUT2»

Which stairwell did you use?

STAIRWELL A	1	
STAIRWELL B	2	
STAIRWELL C	3	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«WHSW2_01»
«WHSW2_02»
«WHSW2_03»
«WHSW2_04»
«O_WHSW2»

SKIP IF NO FIRE DRILLS

=> AEVOF
Else => +1

if FIRED=00,98-99

«SOUT3»

When you were evacuating on September 11, how helpful was your experience during these drills?

=> +1
if FIRED=00

VERY HELPFUL	1	
SOMEWHAT HELPFUL	2	
SOMEWHAT UNHELPFUL	3	
VERY UNHELPFUL	4	
DK	8	
RF	9	

«DHELP»

Prior to September 11, were you aware of the evacuation procedures for your floor?

YES	1	
NO	2	=> FLWAR
DK	8	=> FLWAR
RF	9	=> FLWAR

«AEVOF»

Prior to September 11, what was the evacuation procedure you were told to follow?

LEAVE BUILDING IMMEDIATELY	1	
GO TO ELEVATOR LOBBY	2	
GO TO FLOORS UP OR DOWN	3	
GO TO ROOF	4	
STAY WHERE YOU ARE	5	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«EVACP»
«O_EVACP»

Did you know that there was a Floor Warden for your floor?

=> +1
if ROLES=1-4

YES	1
NO	2
DK	8

RF 9

«FLWAR»

The next questions ask about 3 different time periods. The first series of questions asks about when you first became aware that something had happened at the World Trade Center. This is a period of just a few seconds. The next series of questions asks about the time from when you first became aware that something had happened, to the time you first entered a stairwell or elevator to exit the building. The third series of questions asks about what happened during your evacuation, meaning the time from when you first entered a stairwell or elevator until you exited the tower. At the end of the interview, I will ask you if there is anything else about your experience on September 11 that you would like to contribute.

CONTINUE 1 D

«IFAWA»

Now thinking back to the morning of September 11, how did you first become aware that something had happened at the World Trade Center?

$E 1 9

HEARD SOMETHING (BOOM, CRASH, EXPLOSION, BLAST, ROAR, RUMBLING, ALARM)	01	
SAW SMOKE OR FLAMES	02	
SAW DEAD BODIES	03	
SAW A PLANE	04	
SAW DEBRIS	05	
FELT SOMETHING (BUILDING MOVING, IMPACT, SHAKING, SWAYING, ROCKING, JOLT, EARTHQUAKE)	06	
FELL DOWN/FELL OFF CHAIR	07	
WARNED BY SOMEONE AROUND ME	08	
CONTACTED VIA PHONE	09	
CONTACTED VIA EMAIL	10	
PUBLIC ADDRESS SYSTEM	11	
NEWS MEDIA (TELEVISION, RADIO)	12	
OFFICE FURNITURE OR FIXTURES FALLING	13	
FURNITURE OR OTHER ITEMS FALLING OVER/DOWN	14	
OTHER, SPECIFY	97	O
DK	98	
RF	99	

«FAWAR»
«O_FAWAR»

What were you doing when you first became aware that something had happened to the World Trade Center? PROBE: Anything else?

$E 1 9

WORKING INDEPENDENTLY	01
IN MEETING	02

ON PHONE	03	
CHECKING/WRITING EMAIL	04	
WAITING FOR ELEVATOR	05	
RIDING IN ELEVATOR	06	
CHATTING WITH COWORKERS	07	
EATING/HAVING COFFEE	08	
ENTERING BUILDING	09	
OTHER, SPECIFY	97	O
DK	98	X
RF	99	X

«ACTV1_01»
«ACTV1_02»
«ACTV1_03»
«ACTV1_04»
«ACTV1_05»
«ACTV1_06»
«ACTV1_07»
«ACTV1_08»
«ACTV1_09»
«ACTV1_10»
«O_ACTV1»

At the moment when you first became aware that something had happened at the World Trade Center, did you notice any of the following? FOLLOW UP: Was that in your immediate area or outside the Tower?

	Did Not Notice	Noticed in Immediate Area	Noticed Outside the Tower
Smoke	☐	☐	☐
Fire or Flames	☐	☐	☐
Fireballs	☐	☐	☐
Collapsed walls	☐	☐	☐
Jet Fuel	☐	☐	☐
Severely or fatally injured people	☐	☐	☐
Sprinklers going on	☐	☐	☐
A fire alarm sounding	☐	☐	☐
Power outage or flickering lights	☐	☐	☐
Fallen ceiling tiles	☐	☐	☐
Extreme heat	☐	☐	☐

«NOT01_01»
«NOT01_02»
TIME PERIOD: 1
Were there any disaster related events going on around you at this time?
=> WHTW2
if OR[NOT01-NOT11]=2-3

YES	1	
NO	2	=> WHTW2
DK	8	=> WHTW2
RF	9	=> WHTW2

«OEVEN»

TIME PERIOD: 1
What was going on?

ENTER RESPONSE	1	O
DK	8	
RF	9	

«GOING»
«O_GOING»
TIME PERIOD: 1

Were you still in<WHTOW>at this time? IF YES, SELECT APPROPRIATE CHOICE IF NO, ASK WHICH TOWER THEY WERE IN

WTC 1	1
WTC 2	2
DK	8
RF	9

«WHTW2»

TIME PERIOD: 1

And were you still on the<WHFLO>floor at this time? RANGE: 1st - 110th FLOOR IF YES, SELECT/ENTER FLOOR IF NO, ASK WHICH FLOOR THEY WERE ON AND SELECT/ENTER IT

SE 1 110

BASEMENT	990	
CONCOURSE/LOBBY	991	
PLAZA	992	
IN ELEVATOR	993	
OTHER, SPECIFY	997	O
DK	998	
RF	999	

«WHFL2»
«O_WHFL2»

TIME PERIOD: 1

At the moment when you first became aware that something had happened to the World Trade Center, approximately how many people were with you? RANGE: 0 - 999 PEOPLE WE WANT THE NUMBER OF PEOPLE THAT WERE IN THE SAME LOCATION AS THE RESPONDENT. (IN THEIR LINE OF SIGHT)

SE 0 999

NONE	00	=> YOUIN
DK	98	=> YOUIN
RF	99	=> YOUIN

«PEOP1»

TIME PERIOD: 1
Were any of these people injured at that time as a result of the event?

YES	1	
NO	2	
DK	8	
RF	9	

«PEOIN»

TIME PERIOD: 1

Were you injured at that time, as a result of the event?

YES	1	
NO	2	=> ORISK
DK	8	=> ORISK
RF	9	=> ORISK

«YOUIN»

TIME PERIOD: 1

Would you say your injury was a …

AN INJURY THAT DID NOT IMPACT YOUR ABILITY TO EVACUATE,	1	
AN INJURY THAT DID IMPACT YOUR ABILITY TO EVACUATE BUT WAS NOT LIFE THREATENING, OR	2	
A LIFE THREATENING INJURY	3	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«NATIN»
«O_NATIN»

TIME PERIOD: 1

Still thinking about the moment when you first became aware that something had happened at the World Trade Center, did you believe that other people were in danger of being killed?

YES	1
NO	2
DK	8
RF	9

«ORISK»

TIME PERIOD: 1

Did you believe you were in danger of being killed?

YES	1

NO	2	
DK	8	
RF	9	

«YRISK»

TIME PERIOD: 2

Now please think about the time period between when you first became aware that something had happened and when you first entered a stairwell or elevator to leave the tower. During this entire time period, were you given any additional information about what was going on? AFTER BECOMING AWARE OF THE EVENT, BUT BEFORE EVACUATION.

YES	1	
NO	2	=> SEEKI
DK	8	=> SEEKI
RF	9	=> SEEKI

«GETIN»

TIME PERIOD: 2

Who gave you this information? PROBE: Anyone else?

MANAGER/SUPERVISOR	1	
COWORKER INSIDE BUILDING	2	
FAMILY/FRIEND OUTSIDE BUILDING	3	
POLICE/FIREFIGHTER	4	
FLOOR WARDEN	5	
MEDIA PERSON (TV/RADIO)	6	
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«WHINF_01»
«WHINF_02»
«WHINF_03»
«WHINF_04»
«WHINF_05»
«WHINF_06»
«WHINF_07»
«O_WHINF»

TIME PERIOD: 2

What information did you get? PROBE: Any other information?

INFORMATION ABOUT WHAT HAD HAPPENED	1	
INSTRUCTIONS TO LEAVE	2	
INSTRUCTIONS TO STAY	3	
OTHER, SPECIFY	7	O
DK	8	X

RF	9	X

«WHATI_01»
«WHATI_02»
«WHATI_03»
«WHATI_04»
«O_WHATI»

TIME PERIOD: 2

How did you get this information? PROBE: Any other way?

FACE TO FACE	1	
TELEPHONE	2	
EMAIL/BLACKBERRY	3	
PA ANNOUNCMENT	4	
TV/RADIO	5	
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«HOWGT_01»
«HOWGT_02»
«HOWGT_03»
«HOWGT_04»
«HOWGT_05»
«HOWGT_06»
«O_HOWGT»

TIME PERIOD: 2

And during this same time period, did you try to get additional information about what was going on? AFTER BECOMING AWARE OF THE EVENT, BUT BEFORE EVACUATION

YES	1	
NO	2	=> ORIS2
TRIED, BUT WAS UNABLE TO GET INFORMATION	3	=> ORIS2
DK	8	=> ORIS2
RF	9	=> ORIS2

«SEEKI»

TIME PERIOD: 2

Who did you go to for this information? PROBE: Anyone else?

MANAGER/SUPERVISOR	1
COWORKER INSIDE BUILDING	2
FAMILY/FRIEND OUTSIDE BUILDING	3
POLICE/FIREFIGHTER	4
FLOOR WARDEN	5
MEDIA PERSON (TV/RADIO)	6

OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«GOINF_01»
«GOINF_02»
«GOINF_03»
«GOINF_04»
«GOINF_05»
«GOINF_06»
«GOINF_07»
«O_GOINF»

TIME PERIOD: 2

What type of information did you try to find? PROBE: Anything else?

INFORMATION ABOUT WHAT HAD HAPPENED	1	
INSTRUCTIONS TO LEAVE	2	
INSTRUCTIONS TO STAY	3	
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«WHAI2_01»
«WHAI2_02»
«WHAI2_03»
«WHAI2_04»
«O_WHAI2»

TIME PERIOD: 2

How did you get this information? PROBE: Any other way?

FACE TO FACE	1	
TELEPHONE	2	
EMAIL/BLACKBERRY	3	
PA ANNOUNCMENT	4	
TV/RADIO	5	
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«HOWG2_01»
«HOWG2_02»
«HOWG2_03»
«HOWG2_04»
«HOWG2_05»
«HOWG2_06»
«O_HOWG2»

TIME PERIOD: 2

And during the time between when you first became aware that something had happened at the World Trade Center and when you first entered the stairwell or elevator to leave the tower, did you believe that other people were in danger of being killed? AFTER BECOMING AWARE OF THE EVENT, BUT BEFORE EVACUATION

=> YRIS2
if ORISK=1

YES	1
NO	2
DK	8
RF	9

«ORIS2»

TIME PERIOD: 2

During that time period, did you believe you were in danger of being killed?

=> PEODO
if YRISK=1

YES	1
NO	2
DK	8
RF	9

«YRIS2»

TIME PERIOD: 2

During this time period, what were the people around you doing? PROBE: Were they doing anything else? AFTER BECOMING AWARE OF THE EVENT, BUT BEFORE EVACUATION
$E 0 10

NOONE AROUND/WAS ALONE	00	X
TALKING TO OTHERS	01	
GATHERING PERSONAL/WORK ITEMS	02	
SEARCHING FOR OTHERS	03	
CALLING OTHERS	04	
FIGHTING FIRE/SMOKE	05	
LOCKING UP	06	
WORKING	07	
EVACUATING THE TOWER	08	
CRYING, RUNNING AROUND, IN SHOCK	09	
HELPING OTHERS	10	
OTHER, SPECIFY	97	O
DK	98	X
RF	99	X

«PEODO_01»

«PEODO_02»
«PEODO_03»
«PEODO_04»
«PEODO_05»
«PEODO_06»
«PEODO_07»
«PEODO_08»
«PEODO_09»
«PEODO_10»
«O_PEODO»

TIME PERIOD: 2

Did the people around you start evacuating before you did?

=> DOBEF
if PEODO=08

YES	1
NO	2
DK	8
RF	9

«EVACB»

TIME PERIOD: 2

Did you do any of the following before starting your evacuation?
$E 1 9

TALK TO ANOTHER PERSON FACE TO FACE	01	
GATHER PERSONAL ITEMS	02	
TELEPHONE OTHER PEOPLE	03	
CONTINUE WORKING	04	
SAVE OR TRANSFER COMPUTER FILES	05	
SEARCH FOR OTHERS	06	
FIGHT FIRE OR SMOKE	07	
MOVE TO ANOTHER FLOOR	08	
HELP OTHERS	09	
LOGGING OFF/SHUTTING DOWN COMPUTER	10	
NONE OF THESE	11	X

«DOBEF_01»
«DOBEF_02»
«DOBEF_03»
«DOBEF_04»
«DOBEF_05»
«DOBEF_06»
«DOBEF_07»
«DOBEF_08»

TIME PERIOD: 2

Did you do anything else during this time?

ENTER RESPONSE	1	O
NO OTHER ACTIVITIES	0	
DK	8	
RF	9	

«OACTI» «O_OACTI»

TIME PERIOD: 2

Before you began your evacuation, was there anything you wanted to do, but couldn't?

YES	1	
NO	2	=> SEE01
DK	8	=> SEE01
RF	9	=> SEE01

«WANTD»

TIME PERIOD: 2

What was that? PROBE: Anything else?

$E 1 7

GATHER WORK ITEMS	01	
GATHER PERSONAL BELONGINGS	02	
CALL FRIEND/FAMILY MEMBER	03	
FIND FRIEND/COWORKER	04	
HELP FRIEND/COWORKER	05	
LOCK UP	06	
EVACUATE IMMEDIATELY	07	
OTHER, SPECIFY	97	O
DK	98	X
RF	99	X

«WANAC_01»
«WANAC_02»
«WANAC_03»
«WANAC_04»
«WANAC_05»
«WANAC_06»
«WANAC_07»
«WANAC_08»
«O_WANAC»

TIME PERIOD: 2

Why couldn't you do that/those things?

$E 1 9

AFRAID	01	
LOCKED DOORS	02	
PHONE LINES DEAD	03	
INJURED	04	
EXIT BLOCKED	05	
TOO CROWDED	06	
TOLD TO STAY IN BUILDING	07	
TOLD TO LEAVE	08	
FATIGUE	09	
DISABLED	10	
SMOKE	11	
DAMAGE TO FLOOR	12	
WAS HELPING OTHERS	13	
OTHER, SPECIFY	97	O
DK	98	
RF	99	

«WHYNO_01»
«WHYNO_02»
«WHYNO_03»
«WHYNO_04»
«WHYNO_05»
«WHYNO_06»
«WHYNO_07»
«WHYNO_08»
«WHYNO_09»
«WHYNO_10»
«WHYNO_11»
«WHYNO_12»
«WHYNO_13»
«WHYNO_14»
«O_WHYNO»

Still thinking about the time between when you first became aware that something had happened at the World Trade Center and when you entered the stairwell or elevator to leave the tower, did you notice any of the following? FOLLOW UP: Was that in your immediate area or outside the Tower?			
	Did Not Notice	Noticed in Immediate Area	Noticed Outside the Tower
Smoke	☐	☐	☐
Fire or Flames	☐	☐	☐
Fireballs	☐	☐	☐
Collapsed walls	☐	☐	☐
Jet Fuel	☐	☐	☐
Severely or fatally injured people	☐	☐	☐
Sprinklers going on	☐	☐	☐
A fire alarm sounding	☐	☐	☐
Power outage or flickering lights	☐	☐	☐
Fallen ceiling tiles	☐	☐	☐
Extreme heat	☐	☐	☐

«SEE01_01»
«SEE01_02»

TIME PERIOD: 2

Were there any disaster related events going on around you at this time?

=> EVACF
if OR[SEE01-SEE11]=2-3

YES	1	
NO	2	=> HELPY
DK	8	=> HELPY
RF	9	=> HELPY

«ODISE»

TIME PERIOD: 2

What was going on?

ENTER RESPONSE	1	O
DK	8	
RF	9	

«GOIN2»
«O_GOIN2»

TIME PERIOD: 2

Were you still on the<WHFL2>floor at this time? RANGE: 1st - 110th FLOOR IF YES, SELECT/ENTER FLOOR IF NO, ASK WHICH FLOOR THEY WERE ON AND SELECT/ENTER IT

$E 1 110
=> +1
if (AND[SEE01-SEE11]=1) AND PEODO>0 AND PEODO<98

BASEMENT	990
CONCOURSE/LOBBY	991
PLAZA	992
ELEVATOR	993
OTHER, SPECIFY	997
DK	998
RF	999

«EVACF»
«O_EVACF»

TIME PERIOD: 2

Did anyone help you in any way before you started your evacuation?

YES	1	
NO	2	=> DECID
DK	8	=> DECID
RF	9	=> DECID

«HELPY»

TIME PERIOD: 2

Who helped you? PROBE: Anyone else? WE WANT THEIR ROLE NOT THE NAME OF THE PERSON

POLICE OFFICER/FIREFIGHTER	1	
COWORKER	2	
STRANGER	3	
FLOOR WARDEN	4	
MANAGER/SUPERVISOR	5	
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«WHOHE_01»
«WHOHE_02»
«WHOHE_03»
«WHOHE_04»
«WHOHE_05»
«WHOHE_06»
«O_WHOHE»

TIME PERIOD: 2

What did they help you with? PROBE: Anything else?
$E 1 7

LOCATING OTHERS	01	
HELPING OTHERS	02	
FINDING EXITS	03	
TREATING YOUR INJURIES	04	
PROVIDED INFORMATION/INSTRUCTIONS	05	
GATHER BELONGINGS	06	
CALM DOWN/EMOTIONAL ASSISTANCE	07	
OTHER, SPECIFY	97	O
DK	98	X
RF	99	X

«WHATD_01»
«WHATD_02»
«WHATD_03»
«WHATD_04»
«WHATD_05»
«WHATD_06»

«WHATD_07»
«WHATD_08»
«O_WHATD»

TIME PERIOD: 2

What was the one thing that made you decide to evacuate?

WAS TOLD TO EVACUATE	1	
FRIENDS CO-WORKERS EVACUATED	2	
AFRAID/FELT IN DANGER	3	
FIRE ALARM WAS GOING OFF	4	
SAW SMOKE	5	
SAW FIRE	6	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«DECID»
«O_DECID»

How many minutes had passed before you started to evacuate? IF NEEDED: How much time passed between when you first became aware that something had happened to the World Trade Center and when you entered the stairwell or elevator to leave the tower. THIS IS NOT TIME TO EVACUATE. PLEASE CLARIFY WITH RESPONDENT IF TIME APPEARS TOO LONG. RESPONDENT WAS IN<WHTW2> RANGE FOR WTC 1: 1 - 103 MINUTES RANGE FOR WTC 2: 1 - 75 MINUTES
$E 1 103

DK	998
RF	999

«TIMEP»

SKIP FOR TOWERS

=> EVAC2
Else => +1
if WHTW2=2

«SKIP1»

Did you begin your evacuation… WE ARE INTERESTED IN WHAT THEY KNOW NOW. THEY MAY NOT HAVE KNOWN WHEN THEY WERE EVACUATING, BUT NOW THEY CAN TELL US WHEN IT WAS.

BEFORE THE PLANE HIT WTC 2	1
AFTER THE PLANE HIT WTC 2, BUT BEFORE THE WTC 2 COLLAPSE	2
AFTER THE WTC 2 COLLAPSE	3
DK	8
RF	9

«EVAC1»

SELECT1
$S NS=2 CO=1 IN=EVAC1<=1 ;CO=2 IN=EVAC1<=2 ;

BEFORE THE PLANE HIT WTC 2	1
AFTER THE PLANE HIT WTC 2, BUT BEFORE THE WTC 2 COLLAPSE	2
AFTER THE WTC 2 COLLAPSE	3
DK	8
RF	9

«SEL1»

SELECT2

BEFORE THE PLANE HIT WTC 2	1
AFTER THE PLANE HIT WTC 2, BUT BEFORE THE WTC 2 COLLAPSE	2
AFTER THE WTC 2 COLLAPSE	3
DK	8
RF	9

«SEL2»

Did you begin your evacuation…
=> EVCSO
if EVAC1>0

BEFORE THE PLANE HIT WTC 2	1
AFTER THE PLANE HIT WTC 2	2
DK	8
RF	9

«EVAC2»
SELECT4
$S CO=1 IN=EVAC2<=1 ;

BEFORE THE PLANE HIT WTC 2	1
AFTER THE PLANE HIT WTC 2	2
DK	8
RF	9

«SEL3»

Was there anything that kept you from evacuating sooner?

YES, RECORD RESPONSE	1	O
NO	2	
DK	8	
RF	9	

«EVCSO»
«O_EVCSO»

TIME PERIOD: 3

When you began your evacuation, were you alone or with other people? PEOPLE THAT THEY KNOW, PEOPLE THAT THEY WERE TALKING WITH

ALONE	1	
WITH OTHER PEOPLE	2	
DK	8	
RF	9	

«ALONE»

TIME PERIOD: 3

Which stairwell did you use for your evacuation?

STAIRWELL A	1	
STAIRWELL B	2	
STAIRWELL C	3	
USED ELEVATOR	4	=> FOLA1
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«STAIR_01» «STAIR_02»
«STAIR_03»
«STAIR_04»
«STAIR_05»
«O_STAIR»

TIME PERIOD: 3

Which side of the building was the stairwell located on?
=> /WHYST
if NOT STAIR=8,7

NORTH	1	
SOUTH	2	
EAST	3	
WEST	4	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«WHISI»
«O_WHISI»

TIME PERIOD: 3

Why did you choose that/those stairwell(s) for your evacuation? PROBE: Any other reason?

CLOSEST ONE	1	
FOLLOWED OTHER PEOPLE TO IT	2	
OTHER EXITS WERE BLOCKED	3	
SAME AS I USED IN PREVIOUS EMERGENCY	4	
I WAS TOLD TO USE THIS STAIRWELL	5	
OTHER, SPECIFY	7	O
DK	8	X
RF	9	X

«WHYST_01»
«WHYST_02»
«WHYST_03»
«WHYST_04»
«WHYST_05»
«WHYST_06»
«O_WHYST»

TIME PERIOD: 3

At any time during your evacuation, did you leave that/those stairwell(s)? DO NOT INCLUDE PEOPLE WHO FOLLOWED THE PASSAGE WHERE THE STAIRWELLS START AND END.

YES	1	
NO	2	=> FOLA1
DK	8	=> FOLA1
RF	9	=> FOLA1

«LEVST»

TIME PERIOD: 3
Which floor were you on when you left the stairwell? IF RESPONDENT UNSURE, SELECT 997 AND RECORD RANGE OF FLOORS EXAMPLE: 34-40

$R 1 110

UNSURE, RECORD RESPONSE	997	O

«FLLST»
«O_FLLST»

TIME PERIOD: 3

Why did you leave the stairwell? PROBE: Any other reason?
$E 1 9

I GOT LOST	01
WAS TOLD TO LEAVE STAIRWELL	02
TO HELP SOMEONE	03
TO GO BACK AND GET SOMETHING	04
TOO CROWDED	05

SMOKE IN STAIRWELL	06	
PATH OBSTRUCTED	07	
A LOCKED DOOR	08	
STAIRWELL LED TO A FLOOR	09	
OTHER, SPECIFY	97	O
DK	98	
RF	99	

«WHYLS_01»
«WHYLS_02»
«WHYLS_03»
«WHYLS_04»
«WHYLS_05»
«WHYLS_06»
«WHYLS_07»
«WHYLS_08»
«WHYLS_09»
«WHYLS_10»
«O_WHYLS»

Screen [Template 3] -> FLOA5
=> +1
if FLWAR>1

Did any of the following help you evacuate while you were in the building?				
	Yes	No	DK	RF
Instructions or assistance from your floor warden	☐	☐	☐	☐
Instructions or assistance from Police or Firefighters	☐	☐	☐	☐
Support and encouragement from others	☐	☐	☐	☐
Exit signs	☐	☐	☐	☐
Photo luminescent paint in stairwells	☐	☐	☐	☐

«FOLA1»

Screen [Template 3] -> EVCM7

=> +1

if NOT STAIR<4

Did any of the following make your evacuation more difficult while you were in the building?				
	Yes	No	DK	RF
Crowded stairwells	☐	☐	☐	☐
Firefighters or Police moving up stairwell	☐	☐	☐	☐
Disabled or injured people being taken down stairwell	☐	☐	☐	☐
Locked doors	☐	☐	☐	☐
Poor lighting	☐	☐	☐	☐
Confusing or missing signs	☐	☐	☐	☐
Lack of clear instructions	☐	☐	☐	☐

«EVCM1»

Screen [Template 3] -> EXP11

Please tell me if you noticed any of the following at any time during your evacuation. FOLLOW UP: Was that in your immediate area or outside the Tower?			
	Did Not Notice	Noticed in Immediate Area	Noticed Outside the Tower
Smoke	☐	☐	☐
Fire or Flames	☐	☐	☐
Fireballs	☐	☐	☐
Collapsed walls	☐	☐	☐
Jet Fuel	☐	☐	☐
Severely or fatally injured people	☐	☐	☐
Sprinklers going on	☐	☐	☐
A fire alarm sounding	☐	☐	☐
Power outage or flickering lights	☐	☐	☐
Fallen ceiling tiles	☐	☐	☐
Extreme heat	☐	☐	☐

«EXP01_01»
«EXP01_02»

TIME PERIOD: 3

During your evacuation, did you turn back at any time? "TURN BACK" MEANS "GO BACK UP".

YES	1	
NO	2	=> EXITS
DK	8	=> EXITS
RF	9	=> EXITS

«TURNB»

TIME PERIOD: 3

Why did you turn back? PROBE: Any other reason?
$E 1 7

I GOT LOST	01	
I WAS TOLD TO TURN BACK	02	
TO HELP SOMEONE	03	
TO GET SOMETHING	04	
IT WAS TOO CROWDED	05	
SMOKE IN THE STAIRWELL	06	
MY PATH WAS OBSTRUCTED	07	
OTHER, SPECIFY	97	O
DK	98	X
RF	99	X

«WHYTB_01»
«WHYTB_02»
«WHYTB_03»
«WHYTB_04»
«WHYTB_05»
«WHYTB_06»
«WHYTB_07»
«WHYTB_08»
«O_WHYTB»

TIME PERIOD: 3

Did you exit the stairwell or elevator to the mezzanine or to the concourse?

MEZZANINE	1	
CONCOURSE	2	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«EXITS»
«O_EXITS»

TIME PERIOD: 3

How much time passed between the moment you first began your evacuation to when you exited the Tower? PLEASE CLARIFY WITH RESPONDENT IF TIME APPEARS TOO LONG. RESPONDENT WAS IN<WHTW2> RANGE FOR WTC 1: 1 - 103 MINUTES RANGE FOR WTC 2: 1 - 75 MINUTES
$E 1 103

DK	998
RF	999

«TIMP2»

SKIP FOR TOWERS

=> +2
Else => +1
if WHTW2=2

«SKIP2»

TIME PERIOD: 3

Did you exit the tower…

ELIMINATE ->	2	
ACCORDING TO NOT SEL1-SEL	2	
BEFORE THE PLANE HIT WTC	2	=> GETOU
AFTER THE PLANE HIT WTC 2 BUT BEFORE THE WTC 2 COLLAPSE, OR	2	=> GETOU
AFTER THE WTC 2 COLLAPSE	3	=> GETOU
DK	8	=> GETOU
RF	9	=> GETOU

«EXIT1»

TIME PERIOD: 3

Did you exit the tower…

Eliminate ->	1
According to NOT SEL	3
Before the plane hit WTC 2, or	1
After the plane hit WTC 2	2
DK	8
RF	9

«EXIT2»

Please remember that this study is intended as a fact finding mission and not a fault finding mission. It is crucial that we determine why some people were successful in their evacuation while others were not. Was there anyone on your floor that was not successful in their evacuation?

YES	1	
NO	2	=> PHYSI
DK	8	=> PHYSI
RF	9	=> PHYSI

«GETOU»

Why didn't they make it out? PROBE: Any other reason?
$E 1 8

WAS INJURED	01
WAS DISABLED	02
REFUSED TO LEAVE	03
DID NOT THINK IT WAS SERIOUS	04

STAYED BACK TO HELP SOMEONE	05	
WAS TOLD TO STAY	06	
STRUCTURAL DAMAGE	07	
SMOKE OR FIRE	08	
OTHER, SPECIFY	97	O
DK	98	X
RF	99	X

«WHYNG_01»
«WHYNG_02»
«WHYNG_03»
«WHYNG_04»
«WHYNG_05»
«WHYNG_06»
«WHYNG_07»
«WHYNG_08»
«WHYNG_09»
«O_WHYNG»

On September 11, 2001, did you have any physical problems that made it more difficult for you to leave the tower? Please do not include injuries caused by the incident or evacuation.

YES	1	
NO	2	=> AGE
DK	8	=> AGE
RF	9	=> AGE

«PHYSI»

What type of physical problem? PROBE: Anything else?
$E 1 9

BLIND/PARTIALLY BLIND	01	
DEAF	02	
IN WHEELCHAIR	03	
NEED WALKING ASSISTANCE	04	
OBESITY	05	
HEART CONDITION	06	
PREGNANT	07	
ASTHMA	08	
ELDERLY	09	
OTHER, SPECIFY	97	O
DK	98	X
RF	99X	

«LIMIT_01»
«LIMIT_02»
«LIMIT_03»
«LIMIT_04»
«LIMIT_05»
«LIMIT_06»

«LIMIT_07»
«LIMIT_08»
«LIMIT_09»
«LIMIT_10»
«O_LIMIT»

What is your age? RANGE: 1 - 98 YEARS
$E 1 99

RF	99

«AGE»

READ ONLY IF YOU CAN'T TELL. What is your gender?

MALE	1	
FEMALE	2	
RF	9	

«GEND»

What language do you speak best?

ENGLISH	1	
SPANISH	2	
OTHER, SPECIFY	7	O
DK	8	
RF	9	

«PLANG»
«O_PLANG»

Were you working in WTC 1 or WTC 2 during the 1993 bombing?
=> SAY11
if YRWRK>1993

YES	1	
NO	2	=> CONCR
DK	8	=> CONCR
RF	9	=> CONCR

«WBOMB»

During the 1993 bombing, did you evacuate immediately or wait to evacuate?

EVACUATE IMMEDIATELY	1	
WAIT TO EVACUATE	2	
DK	8	=> +2
RF	9	=> +2

«EVBOM»

At the time of the 1993 bombing, did you feel you that your decision to<EVBOM>was the right decision?

YES	1
NO	2
DK	8
RF	9

«DEC93»

After the 1993 bombing how concerned were you that terrorists would attack the World Trade Center? Were you...

EXTREMELY CONCERNED	1
VERY CONCERNED	2
MODERATELY CONCERNED	3
SLIGHTLY CONCERNED	4
NOT AT ALL CONCERNED	5
DK	8
RF	9

«CONCR»

Is there anything else you would like to say about your experience on September 11?

YES, RECORD RESPONSE	1	O
NO	2	
DK	8	
RF	9	

«SAY11»
«O_SAY11»

IMPACT FLOOR FLAG
=> *
if IF(((WHTW2=1 AND WHFL2>91 AND WHFL2<99) OR (WHTW2=2 AND WHFL2>77 AND WHFL2<111)),1,0)

IMPACT FLOOR FLAG 1

«FFLAG»

163: LFLAG
Single
min = 1 max = 1 1 = 1
2003/09/18 15:21
LOCATION FLAG
=> *
if IF((WHFL2>990 AND WHFL2<994),1,0)

LOCATION FLAG 1

«LFLAG»

EVENT FLAG
=> *
if IF(((AND[NOT02-NOT06]=2-3) OR (AND[SEE02-SEE06]=2-3) OR (AND[EXP02-EXP06]=2-3)),1,0)
EVENT FLAG 1

«EFLAG»

DISABILITY FLAG
=> *
if IF((PHYSI=1),1,0)

DISABILITY FLAG 1

«DFLAG»

ROLE FLAG
=> *
if IF((ROLES=1-4),1,0)

ROLE FLAG 1

«RFLAG»

We may be interested in learning more about your experience on September 11. Would it be okay if we follow up with you sometime in the future to get more detailed information on your evacuation experience?

=> +1
if FFLAG+LFLAG+EFLAG+DFLAG+RFLAG==0

YES 1
NO 2

«FOLUP»

PRESS ENTER TO CONTINUE

Those are all the questions we have. The valuable information you provided will help designers and engineers improve building safety, and help emergency planners improve building evacuation procedures. Thank you so much for taking the time to talk with me, and have a good day/evening. Good-bye.

END OF SURVEY 1 D => /INT99

«THANK»

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Appendix P
INTERIM REPORT ON EMERGENCY COMMUNICATIONS

P.1 INTRODUCTION

On September 11, 2001, radio and telephone communications played a significant role in the operations of emergency responders at the World Trade Center (WTC). Radio and telephone communications were a primary means of communicating information to emergency responders concerning the incident. These forms of communication were also used by emergency responders to communicate with people trapped in the WTC buildings and people attempting to evacuate from the buildings. They were used to communicate between members of the same emergency responder departments for planning and operations at the incident, and they were used to communicate between different departments or responding organizations at the incident.

Each of the governmental departments that had emergency responders at the WTC—New York City Fire Department (FDNY), New York City Police Department (NYPD), and the Port Authority Police Department (PAPD)—depended on their ability to communicate to accomplish their mission and to obtain information related to operations safety at the incident. Personnel from each of the departments used radios, cellular phones, and wired or landline telephones for communications during the incident. In addition, the emergency responders relied on the most basic form of communication, direct face-to-face communications.

As a normal practice during a typical emergency response many radio and telephone communications are recorded by the respective departments that respond to an incident. These recordings are normally made by the departments to provide an accurate record of operations during an incident. These records are often used by departments during review of incident operations. They are also used for investigative purposes and are sometimes used as evidence in legal cases. During the attack on the WTC many of the emergency responder communications were recorded and preserved. This study is based on these recordings. In addition, information gathered by personnel from the National Institute of Standards and Technology (NIST) during first-person interviews with more than 100 emergency responders has contributed to the report.

P.2 REPORT OBJECTIVES

The objective of this study is to develop a better understanding of the role that emergency communications played during the attack on the WTC, and to quantify information related to communications effectiveness. Although there have been numerous reports of radio equipment failures during the emergency response at the WTC, the only radio system examined in this study is that of the FDNY WTC site high-rise repeater that was installed by the Port Authority. This report does not address issues related to the technical capabilities of any other radio equipment. The analysis of handie-talkies and other radio equipment is in progress and will be addressed in a following report.

Many factors are associated with the ability of emergency communications to be successful. The following objectives were set in this report:

- To document radio and telephone communications operations
- To document radio communications readability or understandability
- To quantifying radio communications traffic volume
- To understand the impact of traffic volume on communications readability and the transfer of information
- To identify communications associated with dispatch and arrival of responders
- To identify communications related to evacuation and emergency response operations
- To identity communications related to building conditions at the WTC and the impact of this information on the emergency response

P.3 RADIO AND TELEPHONE COMMUNICATIONS

Both the Port Authority of New York and New Jersey (PANYNJ) and the NYPD supplied copies of audio recordings from the emergency response operations at the WTC. The PANYNJ provided digital copies of the audio communications tapes recorded by them during the incident. These recordings included communications from emergency response personnel, maintenance personnel, PAPD personnel, and a recording of the FDNY's Channel 30 radio repeater that was located at the WTC. Channel 30 was a City-wide channel designated by FDNY for use in high-rise building operations. The Port Authority had installed this radio repeater system at the WTC for use by FDNY after the 1993 bombing.

The NYPD submitted their communications to NIST in the form of audio tapes that were copies of the original tapes recorded on September 11, 2001. These tapes included radio communications from NYPD internal department operations.

FDNY communications recordings were not available from the incident location that day because the primary Field Communications truck was in the shop for repairs and a backup Field Communications van was used in its place. The backup Field Communications van did not have the capability to record the on-scene incident command or tactical communications; also, the backup van was destroyed when the towers collapsed. Therefore, the best record of radio communications available to NIST on FDNY operations came from the FDNY/PAPD Channel 30 tape and first-person accounts provided by FDNY personnel during their interviews. The Channel 30 tape provides a limited amount of information on FDNY communications and operations at the incident, but it does provide insight into FDNY operations inside WTC 2.

Each audio communications file was received from the source with the starting and ending times marked on the media jacket or the surface of the media. A list of all communications recordings acquired from the various departments is found in Attachment 1 at the end of the report.

P.3.1 Telephone Communications Recordings

Because telephone communication (both landline and cellular phone) was a contributing part of the emergency communications process during the incident, NIST received copies of telephone emergency response communications from the PANYNJ. Identification information for these recordings is also listed in Attachment 1. The City of New York provided NIST with opportunities to review their telephone recordings for 9-1-1 Emergency Operators and FDNY fire dispatchers in their New York City offices. At this time, the telephone recordings have been reviewed and documented, and the analysis work is still in progress. A detailed analysis of emergency telephone communications will be covered in a following report.

P.3.2 First-Person Accounts of Telephone Communications

As mentioned earlier, more than 100 first-person interviews were conducted with emergency responders that reported to the WTC incident. The following information was drawn from these interviews:

- Before the attack occurred on the WTC both the landline and cellular systems appeared to be working normally.
- Only moments after the first aircraft impacted WTC 1, the landline and cellular telephone systems were stressed by increased caller volume that made it difficult to get messages through. This condition continued for many hours following the attack.
- Telephone calls from the WTC to the 9-1-1 emergency operators and statements from various individuals being interviewed shows that even though WTC 1 and WTC 2 were severely damaged by the aircraft impact and fires, many of the landline telephones in the buildings continued to work up until the collapse of WTC 2.
- After the collapse of WTC 2, a number of cellular phone systems were not functional in the area of lower Manhattan.
- After the collapse of WTC 2, there were still some landline telephones working within the city block areas adjacent to the WTC site.

P.4 COMMUNICATIONS FILES PROCESSING AND PRELIMINARY EVALUATION

P.4.1 Audio Data Files and Processing

An evaluation of methods for listening to the recorded communications files was carried out. Comparisons were made between the functionality of using tape recorders versus that of using digital computer-based software for listening to the various emergency response communications files. It became apparent that the computer based listening system had advantages over the use of tape recorders. Some of the advantages of the computer based system are the ease of operation, ability to use the computer monitor for visually observing the beginning and end of communications periods, and the ability to easily and accurately reverse through a recording to a selected location so that a selected section

of a communication could be listened to multiple times. As a result, it was decided to conduct the audio communications study using the computer based audio software system. This decision had a direct impact on the type of data format and media that would be needed for conducting the audio communications study. Therefore, NIST requested that audio communications be provided in a digital format on CD-ROM disks.

The communications recordings provided by the PANYNJ were digital files that were copied onto CD-ROMs, and they were in a format that could be played by computers while using audio player computer software. The audio recordings on each of the NYPD cassettes had to be converted to a digital format, and each file was then recorded onto a CD-ROM disk. In addition, some of the recordings that were received were recorded at very low amplitude that made it difficult to hear the communications. NIST used professional-quality computer audio software to increase the low audio volume recordings to a usable audio level.

P.4.2 Audio Data Computer Software

Three different types of software were used while conducting communications analysis on the audio recordings. Each of these software packages incorporated a clock for timing the audio recording and important communications during the incident.

The first, Sound Forge 6.0, a product of Sonic Foundry, Inc., of Madison, Wisconsin, is a professional digital audio editor (Sonic 2002). It possesses tools that can assist with increasing audio quality and volume of digital audio recordings. It has a graphic output to the computer monitor that allows for rapid evaluation of large audio files. It is also capable of operating as a tool for spectrum analysis. As a spectrum analyzer, it can be used to analyze waveforms by frequency, and it helps to identify noise problems in communications data. In addition, the audio waveforms can be expanded on various scales for detailed analysis. This software was used throughout the study for analysis of the recordings that required audio adjustments to improve quality.

The other two software packages were used as general purpose audio players. They both possess the same basic capabilities and were applied in this audio analysis process based on user preference.

Windows Media Player, a digital media player software package, is a product of Microsoft, Inc. (Microsoft 2003). This media player can be downloaded from the Internet. The player allows for viewing of audio wave forms from the digital audio files that are being listened to. It allows for easily changing a computer's audio volume, and it may be used effectively for locating specific points on an audio recording. The software also allows for movement through an audio file in a reverse direction so that selections of an audio file can be listened to multiple times.

WinAmp3 is a media playback software package for Windows that can be downloaded from the Internet, and it is a product of Nullsoft, Inc. (Nullsoft 2002). This player allows for viewing of audio wave forms from the digital audio files that are being listened to. It allows for easily changing a computers audio volume and it may be used effectively for locating specific points on an audio recording. The software also allows for movement through an audio file in a reverse direction so that selections of an audio file can be listened to multiple times.

P.5 ANALYSIS OF AUDIO COMMUNICATIONS FILES

Analysis of the communications recordings was a multistep process that began with sorting and cataloging the files. The initial sort separated radio communications files from telephone communications files. The files were also cataloged as it related to emergency response operations: PANYNJ, PAPD, FDNY, and NYPD. The respective files were then checked for content and primary emergency response channel files were selected for analysis first. Primary emergency response channels were channels specifically used by PAPD, NYPD, and FDNY for conducting emergency response operations at the WTC. The secondary channels relate to maintenance channels and other emergency responder channels that were not directly associated with operations at the WTC.

Analysis was carried out using the computer based software media players described above. The professional quality digital audio software, Sound Forge 6.0, was used for listening to and enhancing audio files that were difficult to hear. The two other media player software packages, Windows Media Player and WinAmp3, were used to listen to the majority of audio recordings.

P.5.1 Communications Transcription

Two different processes were used to transcribe the emergency communications. Data for the primary emergency communications files were put into a spreadsheet format so that a detailed analysis of results could be made. The overall analysis work is continuing; however, some of the data put into the spreadsheets was used to assist in quantifying communications quality and the radio traffic volume as related to time, as will be discussed in Section P.7. The second and simplest form of communications transcription was the verbatim transcription of the communications into a word processor data file, which was used to record the secondary communications files.

The primary communications audio files were selected for complete transcription to generate information concerning the quality of communications. The files selected were the FDNY Channel 7/PAPD Channel 30 radio repeater, the PAPD police desk radio channel, and the NYPD Special Operations Division channel and Division 1. These files included the following:

- Time of the radio transmission (radio transmission time was taken from the media player clock and was adjusted for the start time supplied with the communications file.)
- Type of radio transmission (voice or tone only for primary emergency response communications channels)
- Readability signal quality (done only for the primary emergency response communications radio channels)
- Content of the communication

As the communications transcripts were being prepared, the names of individuals identified during the communications were deleted to protect the identity of individuals and to adhere to the confidentiality agreements with the various organizations that supplied the communications data files.

P.5.2 Transcription Methods

As mentioned earlier, the communications transcripts were generated using three different computer based media players. The media players were installed on computer systems that were stand alone and isolated from the internet. The process for preparing a communications transcript was the following:

- The communications data file was loaded onto the computer.
- The media player was opened and the data file was selected.
- The spreadsheet on the computer was opened and prepared for data input.
- The transcriber would queue the communications recording to the beginning and check to be sure that the media player clock time was zeroed.
- The data file starting time was put into the spreadsheet.
- The communications recording was started, and the output was written into the spreadsheet.
- To improve accuracy of the transcripts, a second transcriber checked sections of the transcript against the audio recording.

For audio passages that were difficult to understand on the first pass, multiple passes of the section were used to improve comprehension.

P.5.3 Assessment of Radio Communications Quality

The Readability, Signal Strength, and Tone system for rating the quality of radio communications is used widely throughout the field of radio communications and is described in *The ARRL Handbook for Radio Communications* (ARRL 2003). This system is broken into three distinctive groups that can be rated: Readability, Signal Strength, and Tone. The rating for tone is only used to identify the quality of radio communications for "Continuous Wave" transmissions, and it does not apply to this analysis as "Tone" does not relate to voice communications. For voice radio communications, only "Readability" and "Signal Strength" are used. Signal Strength" is usually read from a signal strength meter at the time of the actual radio communication and is not available on the audio recordings.

Thus, in this study "Readability" only was used for rating the primary emergency responder radio communications channel recordings. It is recognized that this form of analysis is subjective, and it relates to the ability of an individual to hear and understand the radio communications. In an attempt to minimize the influence of the subjective rating system, individuals with extensive experience using radio communications and project staff trained by the experienced personnel were used to conduct the analysis. In addition, communication periods from the various recorded data sets were reviewed by more than one

person where radio communications readability was difficult. The rating table for communications readability is listed below (ARRL 2003):

Readability (the term "readable" means "understandable"):
1 – Unreadable2 – Barely readable, occasional words distinguishable
3 – Readable with considerable difficulty
4 – Readable with practically no difficulty
5 – Perfectly readable

P.5.4 Training of Transcribers

Four NIST personnel were used to transcribe the emergency responder communications files. This included the Project Leader and three other staff personnel. The transcription protocol listed above was planned and tested by the two senior NIST personnel, including the project leader. When the protocol was found to be acceptable, the two other NIST personnel were trained by the senior members of the group. After the basic transcription training was completed, each of the new transcribers was given a communications file to transcribe. This communications file had previously been transcribed by the two senior personnel. After the file was transcribed by the new transcriber, their results were compared to that transcribed by the senior personnel. When it was demonstrated that the new transcriber had a full understanding of the transcription process, they were then assigned communications files to transcribe.

P.6 RADIO COMMUNICATIONS CONCEPTS

Currently, for most emergency responder radio systems the only way to produce a totally clear communication that can be received and understood is for only one communications signal to be transmitted at a time on a given radio frequency. This means that only one person can transmit a radio message at a time without creating communications interference on that radio frequency. With these systems, if two or more radio transmissions are made on the same radio frequency at the same time, signal mixing may occur and the communications may not be understandable. This difficulty with radio communications is often referred to as doubling. Under these conditions, usually the radio with the highest transmitting power will override transmissions from the lower-power radios and only the highest-power radio signal will be heard. This is often the case where an emergency response radio system uses a higher-power base station for dispatch communications or where a repeater is used to amplify a radio system's signal output. Where multiple radio communications are received by a radio repeater, signal mixing is likely to occur and the communications will not be understandable (ARRL 2003).

Over the last several years radio communications technology has undergone some significant advancements, particularly with cellular phones. These new systems can increase the effective use of the radio frequency/time factors related to radio communications (ARRL 2003), and are now beginning to be applied to emergency responder communications equipment.

P.7 COMMUNICATIONS DATA ANALYSIS

This analysis of communications addresses five major factors: (1) radio traffic volume, (2) communications duty cycle, (3) readability of communications, (4) operation of the FDNY site high-

rise repeater at the WTC, and (5) the development of a chronology of radio communications from the incident.

The first two factors, radio traffic volume and communications duty cycle, are directly related, and each has an impact on readability, the ability to understand and also deal with the information being communicated. Generally, as radio traffic rate increases, the operations duty cycle approaches overloaded conditions. With very high traffic volumes it becomes more difficult for personnel at central communications facilities and personnel in the field to respond to the volume of traffic. Human operators of communications equipment become overloaded with work because not only do the operators have to verbally communicate with personnel over the radio, but they must often transfer the information gained to other locations. The transfer of information may also be done verbally using other communications systems or it may be done by hand through keyboard inputs or by both methods. Analysis of the radio traffic for each of the departments shows periods where radio traffic rates during the surge conditions potentially resulted in situations where base station radio operators were unable to relay important information.

P.7.1 PAPD Radio Communications

All radio communications evaluated for this report experienced traffic volume surge conditions as a result of the attack. The traffic volume surge greatly exceeded the traffic volume experienced under normal operating conditions.

PAPD Channel 26/W is used to demonstrate typical radio communications and operations conditions that occurred with the PAPD before and during the incident. This radio channel is used by PAPD police officers, NYPD supervisors and FDNY Engine 10 and Ladder 10 for communications at the WTC site. Tables P–1 and P–2 compare the number of transmissions and their length of time before and after the first aircraft impacted WTC 1. The percent of radio transmissions versus time are also shown on Fig. P–1. This percent of radio transmission, as well as others discussed in this report, was calculated based on the sum of transmission time and no transmission time over a given period of time. These data show that there was a 13 percent rate of radio transmissions on the PAPD police desk channel just prior to the aircraft impact. After the first aircraft impact on WTC 1 the radio communications were occurring 87 percent of the time. This surge in communications significantly impacted the functional capability of the radio system. After approximately 10 minutes, communications dropped to a steady operating level of 48 percent capacity.

P.7.2 FDNY Radio Communications

The communications for this FDNY, City-wide, high-rise building, radio Channel 7 was recorded by PAPD on their Channel 30. The Port Authority installed this high-rise repeater at the WTC for FDNY following the 1993 bombing. This FDNY channel was used primarily by FDNY personnel during operations in WTC 2. Personnel using this channel were FDNY Chief Officers, Company Officers, Aides, and firefighters.

Table P–1. Comparison of radio transmissions before and after the first aircraft impact.

Department	Number of transmissions before first aircraft impact (20 min period)	Number of transmissions after first aircraft impact (20 min period)
PAPD	42	176
FDNY	39	134
NYPD Division 1	7[a]	225
NYPD Special Operations Division	No data	192

a. Data only available for 2 min prior to first aircraft impact

Table P–2. Comparison of average and maximum radio transmission times before and after first aircraft impact.

Department	Average time per transmission before first aircraft impact and maximum (s)	Average time per transmission after first aircraft impact and maximum (s)
PAPD	3.8 (maximum 21.8)	3.3 (maximum 19.7)
FDNY	3.8 (maximum 50.9)	3.1 (maximum 19.5)
NYPD Division 1	1.9 (maximum 5.9)	3.4 (maximum 12.6)
NYPD Special Operations Division	No data	5.7 (maximum 31.5)

Note: All minimum transmission times were typically less than 1 s and were often related to the keying of a microphone.

While looking at these data it is important to keep in mind that several FDNY personnel at the incident did not think that the WTC site, high-rise channel, radio repeater was working. This is based on radio communications tests that were conducted by two Chief Officers working inside WTC 1 when the first Command Post was being set up in that lobby. A record of this radio communications test was recorded on the PAPD Channel 30 tape. Following this radio test, a Chief Officer involved in the test chose to use different channels for command and tactical communications during the incident. However, as FDNY operations increased in WTC 2, it was determined by members of the FDNY that the high-rise channel was functioning and use of the channel developed.

Preliminary analysis by NIST indicates that the repeater was operating at the WTC; however, there also appears to be some type of malfunction with the communications equipment. This malfunction was detected by the FDNY officers during the initial communications test, but it was not identified. As a result, this radio frequency was not primarily being used by many emergency responders. Two hypotheses are currently being studied related to the malfunction: (1) damage to the repeater antenna system and (2) failure of the radio hand set located at the Fire Command Desk in the lobby of WTC 1. Two failure modes are being considered, (1) the radio handset was broken, and (2) the volume on the handset was turned down. The evaluation of the repeater and its operation is still under way, and final

conclusions have not yet been drawn concerning the repeater's performance. Additional information will be covered in the WTC Investigation final report.

Traffic load for this FDNY channel is summarized in Tables P–1 and P–2 and in Fig. P–2. Figures P–1 and P–2 shows that there was a significant peak in radio traffic that approached an 80 percent level which then dropped to a near steady high level of operations several minutes following the aircraft impact. The communications traffic level following the aircraft impact was four times greater than the level prior to impact.

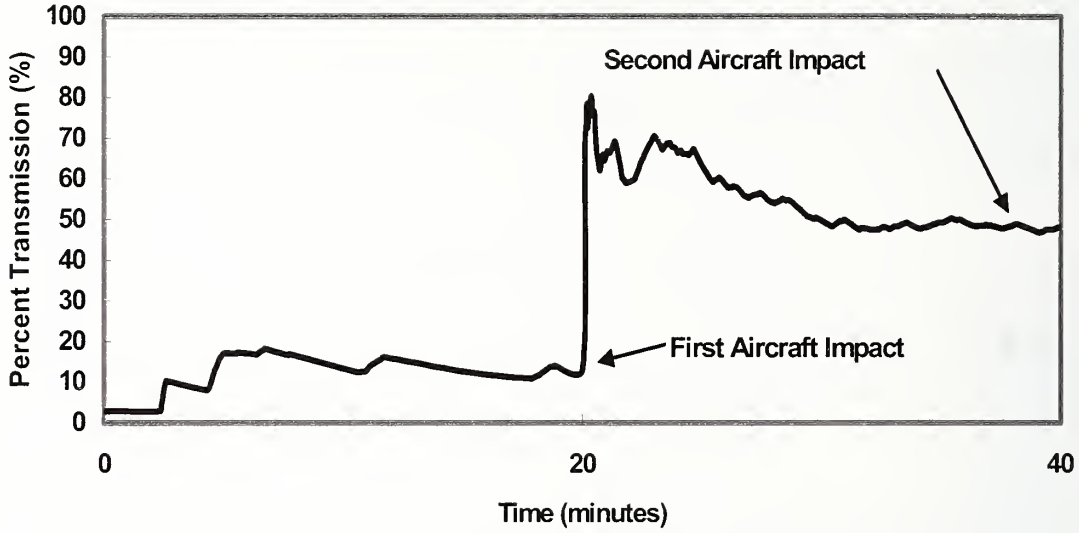


Figure P–1. PAPD police desk Channel 26/W plot of percent transmission versus time.

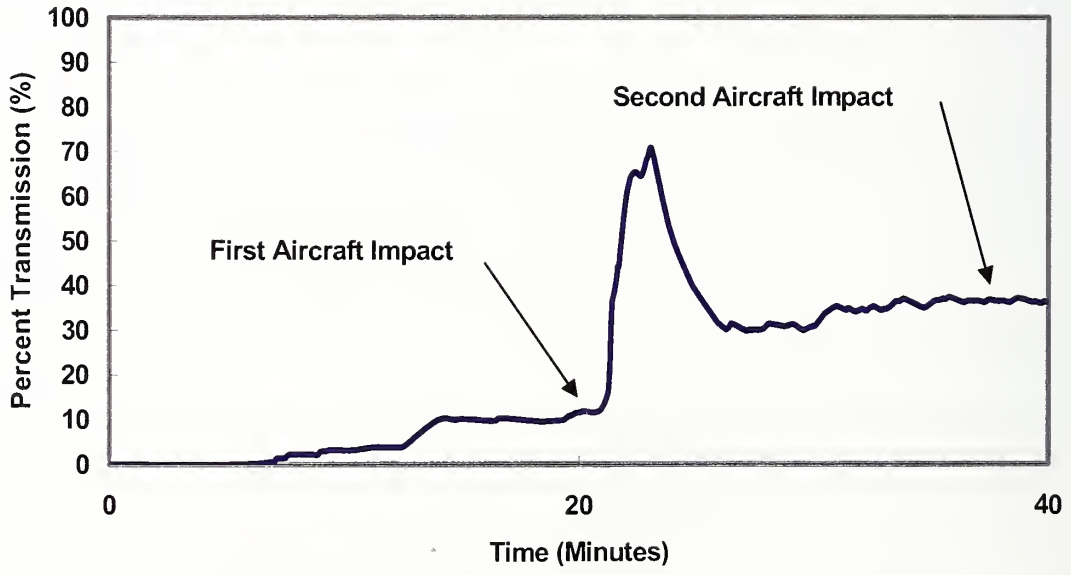


Figure P–2. FDNY City-wide high-rise Channel 7 (PAPD Channel 30) plot of percent transmission versus time.

P.7.3 NYPD Radio Communications

The third example illustrates radio communications for the NYPD Division 1 channel and the NYPD Special Operations Division channel. The Division 1 channel was used by police officers and supervisory police officers. The Special Operations Division channel was used by senior level NPYD management, supervisory police officers, Emergency Service Unit personnel, and aviation unit personnel.

The communications recordings provided by NYPD did not typically contain communications that preceded the attack. However, the Division 1 radio channel recording did start approximately 2 minutes before the first aircraft impacted WTC 1. This 2 minute period provides a limited sample of the level of radio communications prior to the attack. The volume of NYPD communications is shown in Tables P–1 and P–2. These data demonstrate that NYPD had a similar surge in radio traffic immediately following the attack. Figure P–3 shows that the level of transmissions before the attack was at approximately 15 percent. Following the attack the level of transmissions jumped to over 90 percent and then settled down to a level of 63 percent. Radio traffic on the Special Operations Division channel was even higher, as shown in Fig. P–4, peaking near the 95 percent level and staying in the 80 percent range over the remainder of the sample period.

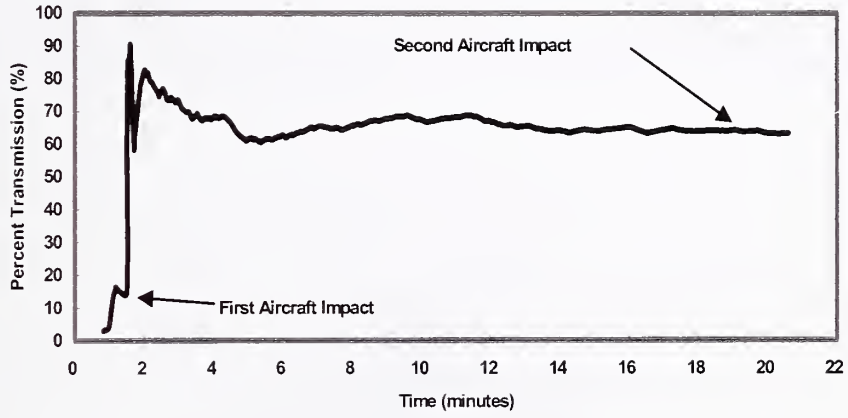


Figure P–3. NYPD Division 1 channel plot of percent transmission versus time.

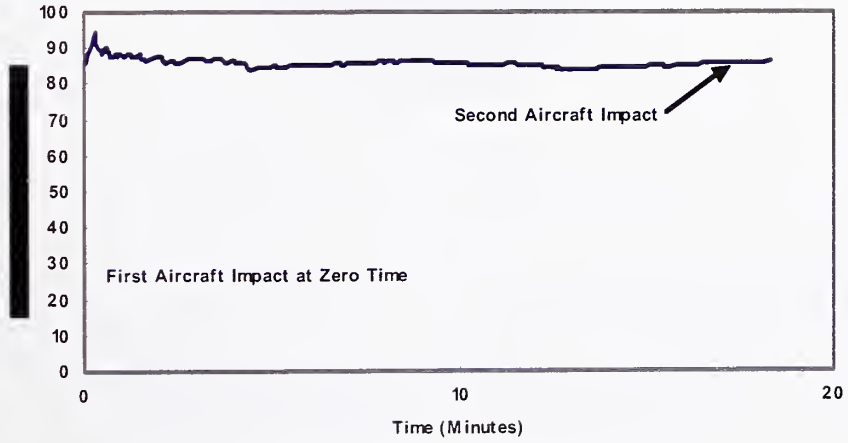
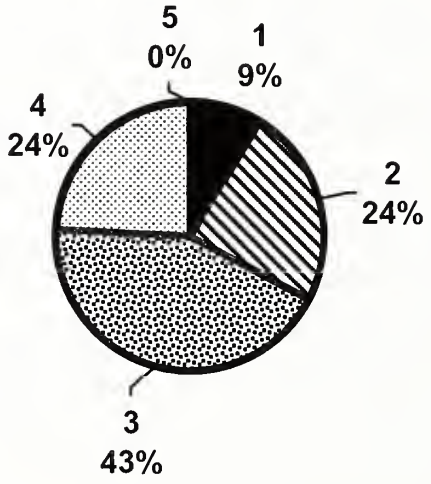


Figure P–4. NYPD Special Operations Division channel plot of percent transmission versus time.

P.7.4 Radio Communications Readability Analysis

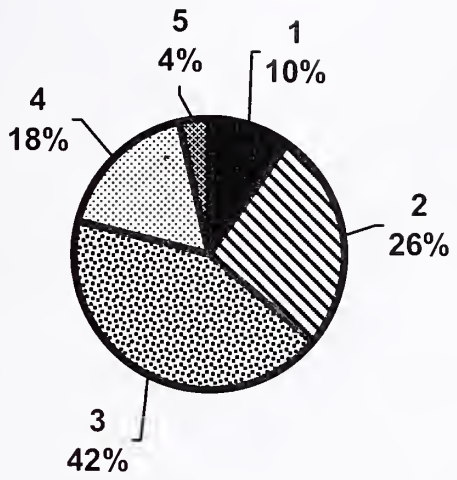
As each of the communications files was transcribed a readability value was assigned for each attempt to communicate. Results of this analysis are shown in Figs. P–5 through P–8. Analysis of these data showed that the ability to transmit a complete message was difficult during the communications surge. Data showed that approximately one-third to one-half of the radio communications for each of the three departments did not exceed a readability level of 2. These emergency communications were not complete and may have not been fully understood. The largest fraction of readability for all radio communications analyzed was recorded at a readability level of 3. This means that this fraction of communications was readable, but audio and radio transmission problems were being experienced. Some conditions that will cause poor communications quality are:

- 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 that may be affected by alternating materials or electromagnetic interference.



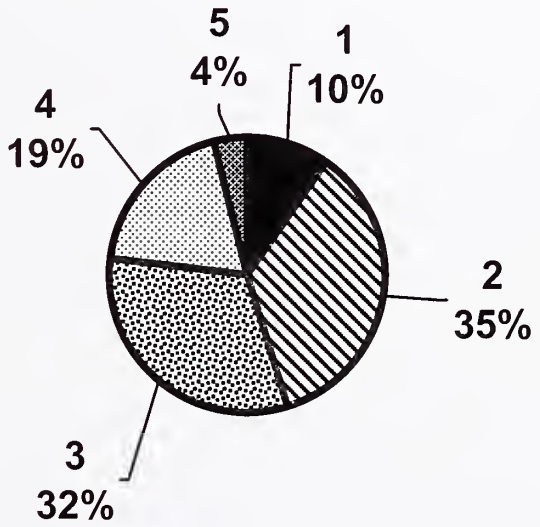
Note: Readability scale:
1 – Unreadable
2 – Barely readable, occasional words distinguishable
3 – Readable with considerable difficulty
4. – Readable with practically no difficulty
5. – Perfectly readable

Figure P–5. PAPD police desk Channel 26/W radio communications readability.



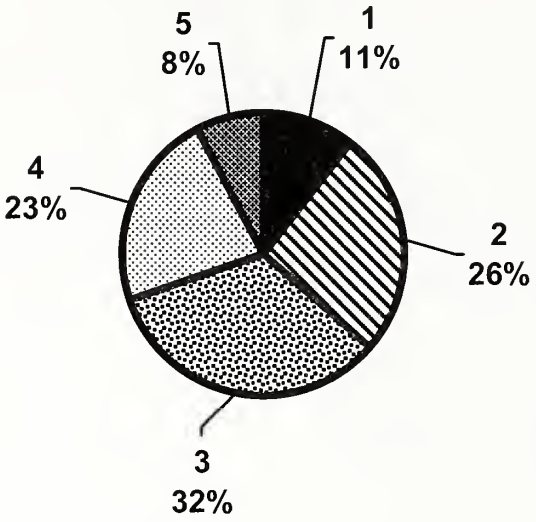
Note: Readability scale:
1 – Unreadable
2 – Barely readable, occasional words distinguishable
3 – Readable with considerable difficulty
4. – Readable with practically no difficulty
5. – Perfectly readable

Figure P–6. FDNY City-wide high-rise repeater Channel 7 at the WTC site (PAPD Channel 30), radio communications readability.



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

Figure P–7. NYPD Special Operations Division channel radio communications readability.



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

Figure P–8. NYPD Division 1 channel radio communications readability between FDNY personnel in the lobby of WTC 2 and FDNY personnel some 40 or more floors up inside the same building.

In addition, approximately 25 percent of the radio communications had readability levels 4 or above. Typically, the higher readability levels were produced by the various department base stations that operate at a higher radio transmission output power than the hand held radios. However, there is one exception: several of the radio communications on the FDNY City-wide high-rise radio channel, the PAPD recording of Channel 30. It appears that the repeater was operating at the WTC site. Several of the radio communications on this channel were assigned readability values of four and five as the FDNY began its operations in WTC 2. In addition, some of these 4 and 5 readability value radio communications were occurring between FDNY personnel in the lobby of WTC 2 and FDNY personnel some 40 or more floors up inside the same building.

P.7.5 Observations on Radio Communications

All of the radio systems analyzed appeared to work well during the period of normal operations before the attack on the WTC. It was noted that Channel W of the PAPD was experiencing some difficulty with a handie-talkie radio transmitting a carrier wave as a result of an open or keyed microphone, which disrupted communications on that channel. PAPD personnel recognized the problem and were busy trying to correct it just before the first plane struck WTC 1. The keyed microphone problem continued after the attack occurred. NYPD also had a problem with an open or keyed microphone after the incident began, occurring on the Special Operations Division channel. The problem was recognized and efforts were also made by the NYPD desk operator to get the problem cleared up. Initial attempts to correct the open microphone problem appeared to be successful.

Also, the data above for the various departments demonstrate the significant changes that occurred in radio communications traffic during the incident. It is evident that PAPD, FDNY, and NYPD all experienced similar surges in radio traffic volume following the first aircraft impact into WTC 1. It is also interesting to note that when the second aircraft struck WTC 2, 17 minutes later, there was no major surge in radio communications. This may be attributed to the fact that the initial emergency response assignments had already been made and that operations had already begun at the WTC, and an additional surge in radio communications was not needed. In addition, it is observed from the communications recordings and from first-person interviews that the emergency responders were trying to limit their use of the radios to reduce interference on their operating frequencies.

P.7.6 Preliminary Chronology of Emergency Communications

The following are lists of selected chronological communications messages that provide information concerning (1) dispatch and arrival of emergency response units, (2) evacuation, (3) emergency response operations, (4) emergency response communications, and (5) observations of building conditions.

Note: These chronologies are based on the best possible data provided to NIST for the analysis. The times are given to represent the exact event sequence. Based on the variations of recorded clock times for the data and times assigned for each recording provided by the departments, it is estimated that the error for time with these chronologies is likely to be on the order of ±2 minutes.

Dispatch and Arrival of Emergency Responders Chronology

This chronology clearly demonstrates that the emergency response to the World Trade Center was immediate. Within the first 3 minutes of the aircraft impact on WTC 1, PAPD was responding by providing information on the incident to the police desk, FDNY had dispatched 26 units to the incident, and NYPD had called of a department mobilization that included dispatching aviation units to the incident for visual assessment. In less than 10 minutes, PAPD had called a chemical mobilization; NYPD had dispatched five ESU teams and had two aviations units at the scene providing observations. In less than 30 minutes, 121 FDNY units had been dispatched to the scene and 30 units had signaled their arrival at the scene. This response combined with the activities undertaken demonstrates a high level of professionalism by the various departments.

8:46 a.m.	FDNY Chief makes report that an airplane has struck the upper floors of a WTC building and transmits a first and second alarm.
	PAPD officer reports to the police desk an explosion at the WTC.
8:48 a.m.	26 FDNY units dispatched. NYPD calls for a department mobilization.
8:49 a.m.	NYPD requests for aviation to get in the air and make a visual assessment.
8:50 a.m.	PAPD officer calls for a chemical mobilization.
8:52 a.m.	5 NYPD Emergency Service Units dispatched.
	NYPD aviation requests landing zone in the vicinity of the WTC.
	NYPD aviation unit arrives at the WTC and examines possibilities of roof rescue.
8:54 a.m.	NYPD aviation advises they have two units in the air to do aerial survey.
8:59 a.m.	FDNY Chief calls for all but one Rescue Squad to the WTC.
9 a.m.	66 FDNY units have been dispatched at this time.
9:03 a.m.	FDNY Marine unit reports that a second plane struck WTC 2.
9:15 a.m.	121 FDNY units dispatched and 30 FDNY units signal* their arrival.
9:29 a.m.	FDNY dispatcher relays that a department-wide recall has been instituted.

9:59 a.m. 171 FDNY units dispatched and 74 FDNY units signal their arrival.
10:29 a.m. 214 FDNY units dispatched and 103 FDNY units signal their arrival.
*Note: Arrival times are determined from 10–84 signals transmitted by units as they arrive at their assigned location. A 10-84 signal is sent by a firefighter from a fire department vehicle by pressing a button on the communications console.

Evacuation Chronology

The evacuation chronology exhibits a mix of responses to the incident. It provides insight into the successes and shortcomings of the evacuation from the WTC buildings and site. The first noteworthy event is that multiple orders were given by a senior PAPD police officer to evacuate the WTC buildings and the entire complex. There is no evidence that these orders were transmitted to appropriate personnel at the site to initiate the full evacuation of the complex. Data from these communications also show that the evacuation process was not always orderly and controlled. This is demonstrated by the fact that the first people jumped from WTC 1 at 8:52 a.m., only 6 minutes after the first aircraft struck WTC 1. In addition, it was reported that people were running from the PATH trains, and a report came in to the PAPD police desk from a police officer in WTC 5 stating that "I have people going crazy." However, it is a fact that most of the evacuation process from the WTC complex was orderly. This chronology also provides a view of the professionalism of the PA, PAPD, and building security personnel that held their posts in the face of life threatening conditions to assist people in the evacuation. In addition, these communications provide some basic information related to the status of people trapped in the buildings and the fact that the buildings elevators were not functioning or dangerous to use. Finally, several cases are listed where injured, elderly, or physically impaired people are not able to walk down the stairs in the building and need assistance to evacuate.

8:47 a.m. PAPD police desk receives a message to evacuate the building (WTC 1) and send people out towards WTC 5
PAPD police desk receives a message from a PAPD officer instructing employees to avoid the Concourse.
8:48 a.m. PAPD police desk receives two orders from a senior police officer calling for the evacuation of the building.
8:52 a.m. PAPD police desk receives report from police officer that people are jumping out of the windows from WTC 1.
8:53 a.m. PAPD police desk report indicates that people are running from the PATH trains.
8:55 a.m. PAPD police desk handles message calling for the evacuation of the Plaza
FDNY dispatcher relays information that people are trapped on floor 106 of WTC 1.
8:56 a.m. PATH trains are still bringing people into the WTC site.
PAPD police desk message attempts to assemble personnel at WTC 1 exits to the plaza to show people how to get out. One Port Authority person responds to the message that he cannot get over to the building exits because glass is falling all over the place.
PAPD police desk receives a radio message that they need assistance in WTC 4 because people are attempting to exit the building.
8:57 a.m. PAPD police desk: a message is sent stating, "Don't let anyone in the building evacuate to the Plaza at this time."
8:58 a.m. PAPD police desk instruction to security guards: hold your post and don't allow people into the Plaza or out onto the Courtyard.
PAPD police desk reports that people are trapped on floor 79 WTC 1.
8:59 a.m. PAPD police desk: a senior PAPD officer calls for the evacuation of WTC 1 and WTC 2.

PAPD police desk: a senior PAPD officer calls for the evacuation of the entire WTC complex, all buildings.

9 a.m. PAPD police desk: a police officer asks if building five should be evacuated and he was told to stand by.
PAPD police desk receives a report that there are people trapped inside suite 4711 of WTC 1 and can't get out.
PAPD police desk: orders were given to evacuate WTC 1, B4 level.
PAPD police desk: a Port Authority employee calls in that he is on floor 27 in the C staircase and has a man in a wheel chair and needs assistance.

9:01 a.m. PAPD police desk: a senior PAPD officer calls for the evacuation of all buildings in the WTC complex.

9:02 a.m. PAPD police desk: Port Authority person calls in reporting that he is stuck in an elevator on floor 78 of WTC 1 in car number 81A.

9:03 a.m. A second aircraft strikes WTC 2.

9:04 a.m. PAPD police desk: a call is made to evacuate everybody from the building now. Note: Building not identified.

9:05 a.m. PAPD police desk: a police officer indicates that WTC 4 is being evacuated. He is then going to WTC 5. He also reports that, "I have people going crazy."
PAPD police desk: a report comes in that Port Authority employees heard people stuck inside of some elevators and also report that they are getting them out. Note: Building and location not identified.
PAPD police desk: a call comes in to get everybody off the complex.

9:07 a.m. PAPD police desk: a report comes in that somebody is stuck in an elevator on floor 76. Note: Building not identified.

9:08 a.m. PAPD police desk report from an officer that debris is falling from WTC 2 by WTC 4 and Liberty Street, and to let the people out of WTC 4.

9:09 a.m. PAPD police desk report is received indicating that FDNY is entering elevator bank 11, 12. Note: Building not identified. Elevators 11 and 12 are shuttle elevators. Elevator 11 goes from the lobby to the 44th floor. Elevator 12 goes from the lobby to the 78th floor.

9:10 a.m. PAPD police desk receives a report that the express elevators could be in jeopardy of falling. Note: Building not identified.

9:12 a.m. PAPD police desk receives a radio report from the Command Desk in the lobby of WTC 2 that they cannot pick up the Warden phones and that they are making announcements telling people not to stay at the Warden phones. Note: This communication indicates that the Warden phones in WTC 2 were not working. Warden phones are located on each floor of the building for the use of floor wardens. They are wired for communications with the fire command desk in the building lobby.

9:14 a.m. PAPD police desk receives confirmation that no elevators are working. Note building not identified.

9:16 a.m. FDNY radio dispatcher advises a chief that there are people trapped in WTC 1 at the following locations: floor 82 east side; floor 83, room 8311; floor 103, room 103 near the corner, floor 104; and floor 106. WTC 2 at the following locations: floor 82 west side, floor 88, and floor 89.

9:17 a.m. PAPD police desk reports that four callers have made contact and need assistance on floor 106 of WTC 1.

9:20 a.m. PAPD police desk receives a message from an officer that no one is down on the B4 level of WTC 1.

9:23 a.m. FDNY radio dispatcher advises FDNY Field Communications Unit that 100 people are overcome in WTC 1 on the northwest and southwest corner of floor 103. The dispatcher also reports that Ladder 3 reports numerous injuries in the stairwell of floor 35 on up.

9:24 a.m. PAPD police desk receives a report from an officer that people from floor 64 are now coming down onto the courtyard level of WTC 1.

9:28 a.m. PAPD police desk receives a radio report of an injured person with burn injuries caused by a falling elevator. Note: Location of injured person was provided as A20. This may mean WTC 1 on floor 20 on the A stairway.

9:29 a.m. PAPD police desk reports that there is a medical emergency in the B stairway; there is a person that cannot walk down. The people are coming down from floor 51, and the person needing assistance has asthma. Note: Building not identified.

9:30 a.m. PAPD police desk receives a report that two elderly people on floor 51, B stairway, WTC 1, cannot walk down and need medical assistance.

9:37 a.m. PAPD police desk recorded the following message: "All World Trade Center units to the Command Post. All World Trade Center units escort everybody over the land bridge on West Street to the Financial Center. Do not, repeat, do not send people out into the Concourse on to south side."

9:45 a.m. PAPD police desk receives a report that officers are sending people down, evacuating on the A stairway in WTC 1.
PAPD police desk copies a request for crowd control on Broadway. Answer to the request is that the City police should be responding.

9:56 a.m. PAPD police desk receives a report that WTC 1 is not completely evacuated and that people are still coming out of each stairway.

Emergency Response Operations Chronology

This section provides a view of the emergency response operations carried out by FDNY, NYPD, and PAPD at the WTC. The chronology highlights several communications that identify cases where emergency responders are assisting injured people, call for EMS assistance, and search for functioning elevators to help evacuate injured people. Some fires in the buildings are identified and some fire fighting operations in WTC 2 are identified. Communications from PAPD provide information on the locations of many people that were trapped in the buildings and in elevators. Several communications provide insight into FDNY operations in WTC 2 and show that some fire fighters actually reached the 78th floor in WTC 2. This assent to the 78th floor was assisted by the use of an elevator that operated up until just before the building collapsed. The elevator became stuck in the elevator shaft and the firefighter operating the elevator was chopping his way out when the building collapsed. Several radio communications provide insight into the difficulty that emergency responders had trying to climb the stairs of the WTC. Cases are noted where FDNY personnel had to stop and rest. Radio communications for the FDNY channel 7 repeater also point out the difficulty that some firefighters had with the identification of the two buildings. The exchange of communications by FDNY personnel at 9:29 a.m. clearly shows this difficulty. Several communications from NYPD aviation units show how the aircrews repeatedly accessed the possibility of landing on the roof of WTC 1 and reported that conditions were not safe for landing. However, at 9:38 and 9:40 a.m. an aviation unit calls in for permission to land on the roof of WTC 1. No evidence has been found that indicates that people were seen on the tower roof or that conditions had improved when these radio requests were made. Interviews with aviation personnel indicate that many of them were highly troubled by the number of occupants trapped in the buildings and the number of people jumping from the buildings, and they were distressed that they were unable to help them. At 9:43 a.m. the order came from a senior police department official that no one from the aviation units is to rappel on the building's roofs. Communications in this section also provides information that many people were coming to the WTC to volunteer their assistance. This assistance was turned away as the emergency responders felt that they needed to get everybody away from the WTC complex.

8:46 a.m. An aircraft strikes WTC 1.

8:49 a.m. PAPD police desk a message is received that Emergency Medical Service (EMS) is needed because there is an injured security guard. The message was not complete; the location was not understandable.

8:50 a.m. FDNY establishes a command post in the lobby of WTC 1.
PAPD police desk message from an officer on the B2 level of WTC 1 that there are two workers injured on that level and that EMS is needed ASAP.
PAPD police desk receives a radio call from FDNY Ladder 10 requesting information from PAPD about which building was struck and the location of the fire, WTC 1 or WTC 2.
FDNY uses a Port Authority Radio for the communication.

8:52 a.m. NYPD aviation unit arrives at the WTC to examine possibilities for roof rescue.

8:56 a.m. PAPD police desk recording: an officer calls for an ambulance at WTC 4 for an injured person.

8:58 a.m. NYPD aviation unit advises that they are unable to land on the roof due to heavy smoke conditions.

9 a.m. PAPD police desk receives a message that there is an injured person between floors 14 and 15 of WTC 2.

9:01 a.m. PAPD police desk receives a report of a fire in a parking lot.

9:02 a.m. PAPD police desk receives a report of a gas leak. (Incomplete message, location of leak not identified.)

9:03 a.m. An aircraft strikes WTC 2.

9:03 a.m. PAPD – by this time a PAPD senior officer has called three times for the evacuation of the World Trade Center, WTC 1 and WTC 2, and then "all buildings in the complex."

9:03 a.m. PAPD police desk reports that another aircraft has stuck WTC 2.

9:05 a.m. PAPD police desk, an officer calls in and requests that every ambulance that can be spared be sent to the WTC.

9:10 a.m. FDNY dispatcher receives message that people are trapped on floor 86 of WTC 2.

9:11 a.m. FDNY reports that Engine 10 requests that all responding units stop short of the WTC buildings, either north or south of Liberty and West Street because of the large number of parked ambulances and debris falling from the buildings.

9:17 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30) indicates that they are using an elevator for operations in WTC 2.

9:18 a.m. FDNY radio communication from WTC 2 indicates they have one elevator working to floor 40, and it is staffed by a firefighter from Ladder 15.
PAPD police desk receives a report that FDNY is abandoning its command post and going across the street.

9:22 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30) states that a Battalion Chief is on floor 43 or WTC 2 in the B stairway.
FDNY Battalion Chief now located on floor 43 of WTC 2 receives a message from a FDNY member in the lobby that NYPD Emergency Service police officers (Emergency Service Unit) want to provide support for him. The Battalion Chief gives the Emergency Service Unit police officers direction to his location on floor 43 in the B stairway.

9:26 a.m. NYPD aviation unit advises that it is impossible to land on the roof at this time.

9:29 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): a Battalion Chief is communicating that he is located inside "Tower 2, the South Tower." A firefighter follows the communication attempting to correct the Chief by saying that he was actually in the "North Tower, Tower 2." This communication confused the actual location of the Battalion Chief, who later came back on the radio reporting that he was in the South Tower. Interviews with FDNY personnel conclusively show that the Battalion Chief was actually inside WTC 2, the South Tower.

9:30 a.m. PAPD police desk receives a report that EMS is setting up a triage station in the lobby of WTC 2.

9:32 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): firefighters have been able to get to floor 55 inside WTC 2.

9:38 a.m. NYPD aviation unit calls in to request a landing on the roof of the North Tower as soon as possible.

9:39 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): FDNY officer inside WTC 2 indicates that he is sending 10 to 15 injured people down to floor 40 and that the firefighter at that location should take the injured to the building's lobby in the elevator. The officer also requests that the firefighter operating the elevator bring an EMS crew back up with him.

9:40 a.m. NYPD officer advises that they need the aviation units on the roof as soon as possible.

9:41 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): Hazmat 1 reports that they are on floor 48 of WTC 2 in the B stairway.

9:42 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30) a firefighter informs the Battalion Chief that he cannot find any elevator banks that are operating above floor 40. The Chief advises the firefighter that he should climb the B stairway from his location.

PAPD police desk receives a report that people have arrived and want to volunteer to help and where should they be sent. Answer: "Right now just send everybody away from the World Trade. We are not letting anybody come close to it."

PAPD police desk receives a radio report that a triage center has been set up at WTC 4 at Victoria's Secret.

9:43 a.m. NYPD officer advises that no one is to rappel onto the top of the buildings.

Note: The term "rappel" in this case refers to the process of emergency responders using ropes suspended from a helicopter to descend onto the roof of a building.

9:44 a.m. PAPD police desk receives a communication that "They haven't evacuated the Fire Command over here in building 2 or 1."

9:45 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): a firefighter calls the Battalion Chief and reports that they had to take their coats off.

9:49 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): Battalion Chief instructs firefighter that it is imperative that he get down to the lobby command post to get some people up to floor 40. Injured people are being sent down from floor 70. The firefighter is inside an operating elevator and is reporting that it is not operating properly and expresses concerns about the elevator becoming stuck in the shaft.

9:50 a.m. PAPD police desk receives a message that FDNY needs a resuscitator on floor 19, B corridor of WTC 1.

9:54 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): a Battalion Chief calls for a ladder company in the A stairway to extinguish two fires. They are attempting to stretch building hose lines on about floor 78.

FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): a firefighter calls to the Battalion Chief that he is on floor 55 and must stop to rest.

PAPD police desk message indicates that an officer is located on floor 22, fire command center and that there is heavy traffic in the B stairway. The person indicates that they cannot release any emergency locked doors due to fire and the loss of electrical power.

Note: Communication appears to originate from WTC 1.

PAPD police desk receives a report that there are 18 passengers stuck in an elevator on floor 78 sky lobby of WTC 2 and that firefighters are working to get them out. They request EMS at the location on the double.

9:56 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): inside WTC 2, a firefighter states they are in the B stairway and that they will have to put some fire out in order to get to the A stairway.

9:57 a.m. PAPD police desk receives reports by radio on Channel X and by phone at 435-2131 from floor 78 of WTC 2 that people are coming out of the elevator banks.
At and below floor 79 of WTC 2, FDNY, NYPD, and PAPD personnel are evacuating occupants, assisting the injured, and fighting fires.
FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): a firefighter in WTC 2 reports that he is trapped in an elevator in the elevator shaft and that they are chopping their way out.

9:59 a.m. FDNY Marine unit reports the collapse of WTC 2.

10:28 a.m. FDNY Marine unit advises that the second WTC tower collapsed.

Emergency Response Communications Chronology

This chronology provides information on communications difficulties experienced by NYPD and PAPD following the attack on the WTC. Much has been published concerning the communications difficulties experienced by FDNY during the incident, and first person interviews with FDNY personnel confirms some of these difficulties. However as shown by this chronology, FDNY was not the only emergency responder department that experienced radio equipment and communications difficulties. There are reports of radios not working well and communications showing that some personnel were not being heard or responded to. Also, some of the radio transmissions demonstrate the failure to communicate as a result of radio traffic surge conditions.

The chronology provides examples of numerous cases where radio transmissions were not understood because of "crossing or doubling" of radio signals when too many people are trying to talk at one time.

8:45 a.m. PAPD police desk Channel W: requests a radio check to locate an open microphone on a handie-talkie radio.

8:49 a.m. PAPD police desk requests, as a result of the surge in radio traffic volume, that police officers stay off the air.
PAPD police desk Channel W: extended period with an open microphone, lots of background noise and people talking.

8:50 a.m. PAPD police desk receives a message that the officer did not copy the previous transmission and asks what is going on.

8:51 a.m. NYPD Special Operations Division channel: a dispatcher advises a police lieutenant that his message was crossed and to repeat it. A message came through that he can't get ahold of someone on the cell phone.

8:53 a.m. NYPD Special Operations Division channel: a dispatcher advises a police department truck that their radio message is cutting off and all that the dispatcher got was something about the upper floors.

8:54 a.m. PAPD police desk is reporting that it is having trouble reading incoming radio transmissions.
PAPD police desk receives a message that an officer is having trouble reading radio messages because of so much commotion on the floor.

8:59 a.m. NYPD Special Operations Division channel: a dispatcher advises a police truck that their radio message is breaking up, and the dispatcher asks what units he wants to respond.

9 a.m. NYPD Special Operations Division channel: dispatcher advises that various units are crossing each other and that the dispatcher cannot understand them.

9:01 a.m. PAPD police desk Channel Y: a microphone is stuck open, interfering with communications.

9:02 a.m. NYPD Special Operations Division channel: a police officer asks the dispatcher if the last transmission was heard. The police office asks twice. There is no answer.

9:03 a.m. PAPD police desk receives a report that someone has found a supervisor's radio that has been lost.

NYPD Special Operations Division channel: an officer in an NYPD car requests that units give their messages slowly.

9:05 a.m. FDNY chief officers conduct tests of the City-wide, high-rise repeater located at the WTC.

9:07 a.m. NYPD Special Operations Division channel: a police officer requests that the air be cleared for emergency vehicles and personnel unimpeded.

9:08 a.m. NYPD Special Operations Division channel: a dispatcher advises officers directing traffic that they are coming over the air. Approximately 30 s later the dispatcher advises a second time that the officers directing traffic are coming over the air and requests that they stop.

9:09 a.m. NYPD Special Operations Division channel: a Special Operations Division officer requests that the dispatcher designate two channels for this emergency, one for units on the scene and one for units that are responding.

9:11 a.m. NYPD: a backup transmitter for City-wide communications is put into service in anticipation of potential problems with the primary transmitter.

9:12 a.m. NYPD City-wide channel: a dispatcher advises that "We need to keep this frequency clear unless it is in regards to the level four mobilization."

NYPD Special Operations Division channel: dispatcher state "Only emergency transmissions are to be made on this frequency."

FDNY Chief begins using the FDNY channel 7 repeater while working inside WTC 2.

PAPD police desk receives a radio report from the Fire Command Desk in the lobby of WTC 2 that they cannot pick up the Warden phones and that they are making announcements telling people not to stay at the Warden phones. Note: This communication indicates that the Warden phones in WTC 2 were not working.

9:15 a.m. PAPD police desk Channel W: a radio microphone is stuck open.

9:19 a.m. NYPD Special Operations Division channel: a dispatcher advises a police officer that his message was being cut off and that only part of the message was copied.

9:20 a.m. NYPD Special Operations Division channel: a dispatcher advises that there is an open carrier and the units should check their radios.

9:22 a.m. NYPD Special Operations Division channel: a dispatcher advises a police truck that his radio message was unreadable.

NYPD Special Operations Division channel: the dispatcher advises a second time that there is an open carrier and that messages are not being understood.

9:23 a.m. NYPD Special Operations Division channel: the dispatcher advises that the two frequencies are the Manhattan IO (Interoperability Channel) and the City-wide. The dispatcher also advises that the various units are crossing.

9:25 a.m. PAPD police desk Channel W: a radio microphone is stuck open and interfering with communications. Radio signals are garbled and broken, and there is a high level of background noise.

9:30 a.m. PAPD police desk Channel X has a communication indicating that everybody should turn their phone off.

9:31 a.m. PAPD police desk Channel X: a Port Authority officer is questioned as to whether they have brought any red bags with radios for the fire department. The answer is no, and is it safe to go into the building.

9:32 a.m. NYPD City-wide channel: a unit advises that he cannot communicate, his radio is going in and out and the cell phone is not working.

9:36 a.m. NYPD Special Operations Division channel: a police officer reports that the telephones at his location are not working. Note: Location not identified.

9:43 a.m. NYPD Special Operations Division channel: a police officer advises that he heard over an AM radio that a plane had crashed into the Pentagon.
9:49 a.m. PAPD police desk instructs officer that he was speaking too fast and that he must slow down so that he could be understood.
9:53 a.m. NYPD Special Operations Division channel: the dispatcher advises all units to check their portable radios for an open carrier.
9:54 a.m. NYPD City-wide channel: a dispatcher requests "Keep the air clear. We have problems in the City. Keep the air clear right now."
9:55 a.m. PAPD police desk Channel Z: police officers are having trouble reading communications over the radio and indicate that they will try to call on the telephone.
9:57 a.m. PAPD police desk Channel X: a report is received that an officer is responding to WTC 1 Fire Command and that he had been trying to contact the Command Center on floor 22, but they didn't know how to operate the other set of communications equipment.
9:59 a.m. NYPD Special Operations Division channel: an Emergency Service Unit police officer calls several times for the dispatcher. The dispatcher answers each time and apparently was not heard by the calling unit.
10:03 a.m. NYPD Special Operations Division channel: a dispatcher requests that some units standby while the needs of other units are addressed.
10:05 a.m. NYPD Special Operations Division channel: the dispatcher advises that all units need to talk one by one. The dispatcher further advises that units are cutting each other off.
10:09 a.m. NYPD Special Operations Division channel: an Emergency Service Unit advises the dispatcher that he can hear the dispatcher but is not sure if the dispatcher is hearing him.
10:10 a.m. NYPD Special Operations Division channel: the dispatcher advises that there are three units trying to talk at the same time and requests, "One at a time."

Condition of the WTC Towers Chronology

Information provided by this chronology partially describes the variable conditions found in WTC 1 and WTC 2 towers. It is shown that the impact of the first aircraft into WTC 1 produced an explosive condition all the way down to the building's basement. The impact of the aircraft into what appears to be WTC 2 produced jet fuel fires in the building on the 51st floor. Other communications indicate that there was no smoke or fire on the 68th, 73rd, or 74th floors, the walls in stairway B had been breached. A telephone call to a New York City Radio 9-1-1 telephone operator at 9:36 a.m. indicates that a floor in the 90's level of WTC 2 had collapsed. Information from this call concerning the floor collapse appears to be misstated by the NYPD Division 1 radio operator in the message transmitted at 9:41 a.m. and again at 9:51 a.m. Communications from the NYPD aviations units describe a steady deterioration of the two WTC towers before they collapsed.

8:47 a.m. PAPD police desk reports that there is a fire on floor 22 of WTC 1.
PAPD police desk receives a report that there is a lot of debris on floor 22 of WTC 1.
8:49 a.m. PAPD police desk reports that there is damage and a lot of debris on floor 22 of WTC 1.
8:51 a.m. PAPD police desk receives a call that an explosion was observed in the basement of the B1 level of WTC 1. The police desk informs the officer on the B1 level that what he saw resulted from an explosion on the upper floors of the building.
8:57 a.m. PAPD police desk receives report that water pipes are broken on the B4 level of WTC 1.
9:02 a.m. PAPD police desk receives message from a person trapped in an elevator on floor 78 of WTC 1 that the area has smoke, and water and debris are coming down from above.
9:10 a.m. PAPD police desk receives a report that there is burning jet fuel on floor 51 of one of the towers. Note: Communications suggest this is WTC 2.
9:13 a.m. PAPD police desk receives a report that WTC 1 is flooding.

9:32 a.m. PAPD police desk receives a message from an officer that the WTC Concourse is flooding.
9:36 a.m. New York City 9-1-1 telephone operator receives a message from an occupant of WTC 2 that a floor had collapsed below them in the 90's level.
9:41 a.m. NYPD dispatcher advises units that floor 106 in WTC 2 is collapsing and that the message comes from someone on that floor.
9:47 a.m. FDNY radio communications on the City-wide, high-rise Channel 7 (PAPD Channel 30): a firefighter inside WTC 2 reports that he is standing in the B stairway on floor 74 and there is no smoke or fire problem. He reports that the stairway walls have been breached on floors 73 and 74. Another FDNY unit in the same stairway reports that the walls were also breached on floor 68.
9:49 a.m. NYPD aviation unit gives a radio report stating that "large pieces" are falling from WTC 2.
9:51 a.m. NYPD dispatcher advises that at WTC 2, floor 106 is crumbling per communications with victims trapped on the floor.
9:58 a.m. NYPD aviation unit advises that the south tower is coming down.
10:06 a.m. NYPD officer advises that it isn't going to take much longer before the north tower comes down and to pull emergency vehicles back from the building.
10:20 a.m. NYPD aviation unit reports that the top of the tower might be leaning.
10:21 a.m. NYPD aviation unit reports that the north tower is buckling on the southwest corner and leaning to the south.
NYPD officer advises that all personnel close to the building pull back three blocks in every direction.
10:27 a.m. NYPD aviation unit reports that the roof is going to come down very shortly.
10:28 a.m. NYPD officer reports that the tower is collapsing.

P.8 FINDINGS

The following is a list of preliminary findings based on the current status of emergency responder communications analysis:

1. After the first aircraft struck the WTC, there was a peak increase in emergency responder radio communications by approximately a factor of 5, followed by an approximate factor of 3 steady level of radio communications.

2. A surge in communications traffic volume made it more difficult to handle the flow of communications and delivery of information.

3. Analysis of the radio communications records received by NIST indicates that roughly one-third to one-half of the radio messages transmitted during these radio traffic surge conditions were not complete messages nor understandable.

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

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.

P.9 REFERENCES

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Attachment 1
COMMUNICATIONS OF THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

The National Institute of Standards and Technology received duplicates of many radio and telephone channels. The tapes listed below cover a wide range of times. All recordings cover at least from 0845 to 0958. The remainder of the communications can be placed in two categories as follows: 0705 to 0958 and 0705 to 1800.

Central Police Desk (CPD): Police Command Channel 2 to 39 – Each one of these recordings is 198 minutes long.

CPD Ch. 002 – CPD.wav – Not assigned
CPD Ch. 003 – CPD.wav – Not assigned
CPD Ch. 004 – CPD.wav – Not assigned
CPD Ch. 005 – CPD.wav – Not assigned
CPD Ch. 006 – CPD.wav – Not assigned
CPD Ch. 007 – CPD.wav – Not assigned
CPD Ch. 008 – CPD.wav – Not assigned
CPD Ch. 009 – CPD.wav – Not assigned
CPD Ch. 010 – CPD.wav – Not assigned
CPD Ch. 011 – CPD.wav – Not assigned
CPD Ch. 012 – CPD.wav – Not assigned
CPD Ch. 013 – CPD.wav – Not assigned
CPD Ch. 014 – CPD.wav – Not assigned
CPD Ch. 015 – SPEN 1 State Police Emergency Network.wma
CPD Ch. 016 – Radio SPEN 2 State Police Emergency Network.wma
CPD Ch. 017 – Radio (Ch. A) PA Area Wide.wma
CPD Ch. 018 – Radio (Ch. W) LT Police.wma
CPD Ch. 019 – CPD.wav – Not assigned
CPD Ch. 020 – CPD.wav – Not assigned
CPD Ch. 021 – Phone 9-1-1 Emergency.wma (Note: Recording was blank.)
CPD Ch. 022 – Phone 9-1-1 Emergency.wma (Note: Recording was blank.)
CPD Ch. 023 – Phone SGT's Desk - 201-216-6800.wma
CPD Ch. 024 – Phone Clerk - 201-216-6800.wma
CPD Ch. 025 – Phone TTY NY- 201-216-6800.wma
CPD Ch. 026 – Phone Clerk Extra - 201-216-6800.wma
CPD Ch. 027 – Phone TTY NJ - 201-216-6800.wma
CPD Ch. 028 – Phone Absence Control Line 1 - 201-216-6988.wma
CPD Ch. 029 – Phone Absence Control Line 2 - 201-133-6988.wma
CPD Ch. 030 – Phone 800 number SGT's Desk - 201-216-6858.wma
CPD Ch. 031 – Desk TTY number 3.wma
CPD Ch. 032 – CPD.wav – Not assigned
CPD Ch. 033 – CPD.wav – Not assigned
CPD Ch. 034 – CPD.wav – Not assigned
CPD Ch. 035 – Phone 201-963-7247 Assignment Line 800-776-8580.wma

CPD Ch. 036 – Phone 201-963-7248 Assignment Line 800-776-8580.wma
CPD Ch. 037 – Phone 201-963-7249 Assignment Line 800-776-8580.wma
CPD Ch. 038 – Phone 201-659-3028 Toll Rob 800-TOLL-ROB.wma
CPD Ch. 039 – Phone 201-216-6794 Drug Tip 800-828-PAPD.wma

PATH Police Command: Ch. 02 to 31 – Recordings vary in length from 106 minutes to 193 minutes.

PATH Ch. 02 – Phone Desk Right.wma
PATH Ch. 03
PATH Ch. 04
PATH Ch. 05
PATH Ch. 06 – SGT. desk.wma
PATH Ch. 07 – Tour Commander.wma
PATH Ch. 08 – Report Room.wma
PATH Ch. 09 – Juvenile Room.wma
PATH Ch. 10 – Reserve Room 216-6078.wma
PATH Ch. 11 – Phone Desk Left.wma
PATH Ch. 12 – Jersey City Fire Department.wma
PATH Ch. 13 – Jersey City Medical Center.wma
PATH Ch. 14 – Jersey City Police.wma
PATH Ch. 15 – NYPD.wma
PATH Ch. 16
PATH Ch. 17
PATH Ch. 18
PATH Ch. 19 – Conference Room 1.wma
PATH Ch. 20 – Conference Room 2.wma
PATH Ch. 21 – Radio (R2) Train Master.wma
PATH Ch. 22 – PD Wall (Desk Area).wma
PATH Ch. 23 – Court Office 1.wma
PATH Ch. 24 – Court Office 2.wma
PATH Ch. 25 – Court Sgt.wma
PATH Ch. 26 – Radio (R1) Train Master.wma
PATH Ch. 27 – Radio (R30) Communications.wma
PATH Ch. 28
PATH Ch. 29
PATH Ch. 30
PATH Ch. 31

WTC Police Desk 1: Ch. 002 to 039 – Each one of these recordings is 171 min.

Ch. 002 WTC.wav
Ch. 003 WTC.wav
Ch. 004 WTC.wav
Ch. 005 WTC phone 435-8456 clerk.wav
Ch. 006 WTC phone 435-8462 clerk.wav
Ch. 007 WTC phone 435-2135 TC.wav
Ch. 008 WTC phone 435-3541 desk left.wav
Ch. 009 WTC phone 435-3541 desk center.wav
Ch. 010 WTC phone 435-3541 desk right.wav
Ch. 011WTC phone 435-8460 conf. room.wav
Ch. 012WTC .wav

Ch. 013 WTC phone 435-3519 office.wav
Ch. 014 WTC direct line FDNY.wav
Ch. 015 WTC direct line NYC EMS.wav
Ch. 016 WTC phone 435-7666 floor warden.wav
Ch. 017 WTC direct line fire command WTC 1.wav
Ch. 018 WTC direct line fire command WTC 2.wav
Ch. 019 WTC.wav
Ch. 020 WTC.wav
Ch. 021 WTC phone 435-2133 police reserve rm.wav
Ch. 022 WTC phone 435-2131 SHO desk.wav
Ch. 023 WTC phone 435-2948 desk.wav
Ch. 024 WTC radio Ch. A.wav
Ch. 025 WTC radio Ch. B.wav
Ch. 026 WTC radio Ch. W.wav
Ch. 027 WTC radio Ch. X.wav
Ch. 028 WTC radio Ch. Y.wav
Ch. 029 WTC radio Ch. Z.wav
Ch. 030 WTC FDNY radio.wav
Ch. 031 WTC.wav
Ch. 032 WTC.wav
Ch. 033 WTC.wav
Ch. 034 WTC.wav
Ch. 035 WTC.wav
Ch. 036 WTC.wav
Ch. 037 WTC.wav
Ch. 038 WTC.wav
Ch. 039 WTC.wav

Newark International Airport: Police Command – Ch. 02 to 39

EWR Ch. 002
EWR Ch. 003
EWR Ch. 004
EWR Ch. 005
EWR Ch. 006
EWR Ch. 007
EWR Ch. 008 – Phone 733-7525 – Newark PD.wma
EWR Ch. 009 – Phone PL234846 – Eliz. PD.wma
EWR Ch. 010 – Phone PL92866- Newark FD.wma
EWR Ch. 011 – PL234881 – Eliz. FD.wma
EWR Ch. 012 – Phone PL230333 – AFA.wma
EWR Ch. 013
EWR Ch. 014 – Phone PL234979 – REMCS.wma
EWR Ch. 015 – FAA Tower Crash Alarm.wma
EWR Ch. 016
EWR Ch. 017
EWR Ch. 018 – PNPD PVL - OSNA660-650.wma
EWR Ch. 019 – Phone 589-6321 - PNPD.wma
EWR Ch. 020 – Phone 589-0292 - PNPD.wma
EWR Ch. 021 – Phone 961-6666 - Line 3.wma
EWR Ch. 022 – Phone 961-6666 - Line 4.wma

EWR Ch. 023 – Radio – EWR Command – 800Mhz.wma
EWR Ch. 024 – Radio – EWR ARFF – 800Mhz.wma
EWR Ch. 025 – Radio – EWR TAC 1 - 800Mhz.wma
EWR Ch. 026 – Radio – Central police desk - 800Mhz.wma
EWR Ch. 027 – Radio – EWR Detectives.wma
EWR Ch. 028 – Police desk left phone – 961-6230.wma
EWR Ch. 029 – Police desk phone center – 961-6230.wma
EWR Ch. 030 – Police CAD desk phone – 961-6230.wma
EWR Ch. 031 – Police desk right phone – 961-6230.wma
EWR Ch. 032 – Phone 961-6666 – Line 2.wma
EWR Ch. 033 – Phone 961-6666 – Line 1.wma
EWR Ch. 034
EWR Ch. 035
EWR Ch. 036 – Radio Ch. Z – Operations & Terminals.wma
EWR Ch. 037
EWR Ch. 038 – Radio – Ch. X – Facility maintenance.wma
EWR Ch. 039 – Radio – Ch. B – Maintenance.wma

NYPD WTC Communications:

NYPD Special Operations Division
Tape 1, 08:46 – 09:33
Tape 2, 09:32 – 10:18
Tape 3, 10:18 – 11:04

NYPD City-wide 1 radio, Tape 4, 08:40 – 09:27
Tape 4b, 09:27 – 10:12
Tape 5c, 10:12 – 11.59
Tape 5d, 10:59 – 11:46

NYPD Division 1, Tape 6, 08:45 – 9:30
Tape 7, 09:29 – 10:15
Tape 8, 10:14 – 11:00

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Appendix Q
NIST's Working Hypothesis for Collapse of the WTC Towers

In response to the terrorist attacks of September 11, 2001, and the resulting collapse of the World Trade Center (WTC) buildings, the National Institute of Standards and Technology (NIST) has been investigating possible collapse scenarios. Establishing the sequence of events that led to the towers collapsing is important in determining which factors allowed the buildings to hold up for as long as they did without collapsing, and which factors, if any, could have delayed or prevented the collapse of the WTC towers. Understanding these factors will provide valuable information on which to base recommendations for improvements to buildings practices, standards, and codes that may be warranted.

Background

NIST has estimated that 17,400 occupants (± 1,200) were present in the WTC towers on the morning of September 11, 2001, about equally divided between the two buildings (8,900 in WTC 1 and 8,540 in WTC 2). 2,159 building occupants and an additional 433 first responders, including security guards, were reported to have lost their lives that day. This does not include aircraft passengers and crew or bystanders.

Approximately 87percent of the WTC tower occupants were able to evacuate successfully. More than 99 percent of occupants below the crash impact areas had sufficient time prior to collapse of the buildings to safely evacuate. WTC 1 stood for one hour and 43 min after impact; WTC 2 collapsed 56 min after it was struck.

Preliminary estimates indicate that about 20 percent or more of those in the WTC towers who lost their lives may have been alive in the buildings just prior to their collapse. This includes nearly all of the first responders and 76 building occupants below the floors of impact. There were 72 fatalities reported in WTC 1 and 4 fatalities reported in WTC 2, not including first responders, below the floors of impact.

Buildings are not designed to withstand the impact of fuel-laden commercial airliners. However, Port Authority documents indicate that the impact of a Boeing 707 flying at 600 mph and possibly crashing into the 80th floor had been analyzed during the design of the WTC towers in February/March 1964. While NIST has not found evidence of the analysis, the documents state that such a collision would result in localized damage only, and that it would not cause collapse or substantial damage to the WTC towers. The effect of fires due to jet fuel dispersion and ignition of building contents was not considered in the 1964 analysis. Loss of life in the immediate area of aircraft impact was anticipated, but loss of life from fire and smoke was not considered.

Q.1 OBJECTIVES

The objectives of the NIST analysis are:

- Establish how and why the WTC towers collapsed after the aircraft impact, i.e., the 'triggering event'
- Determine the most probable collapse sequence
- Identify the factors that have the strongest influence on the most probable sequence

Q.2 APPROACH

To identify the most probable of the technically possible collapse sequences, NIST is adopting an approach that combines mathematical modeling, well-established statistical and probability based analysis methods, laboratory experiments, and analysis of photographic and video evidence. The approach accounts for variations in models, input parameters, analyses, and observed events. It allows for

evaluation and comparison of possible collapse hypotheses based on different damage states, fire paths, and structural responses to determine the following:

1. The most probable sequence of events from the moment of aircraft impact until the initiation of global building collapse;

2. How and why WTC 1 stood nearly twice as long as WTC 2 before collapsing (103 min versus 56 min), though they were hit by virtually identical aircraft;

3. What factors, if any, could have delayed or prevented the collapse of the WTC towers.

Q.3 FACTORS TO EVALUATE THE WORKING HYPOTHESIS

In further evaluating the working hypothesis for the collapse of the WTC towers, NIST is considering the following factors:

- The relative contributions of aircraft impact damage and subsequent fires
- How safe each building was immediately after aircraft impact but before fire weakened the structures, i.e., to what extent the capacity of the buildings to carry design loads[1] was reduced
- Relative roles of the perimeter and core columns[2] and the composite floor system,[3] including connections
- The role played by fireproofing, especially the extent to which fireproofing may have been damaged due to aircraft impact
- Whether the undamaged towers would have remained standing in a "maximum credible fire"[4]
- The role compartmentation (i.e., areas divided by fire-rated walls) may have played, i.e., what would have happened if the floors had been separated into 7,500 or 10,000 ft^2 compartments with 1 h fire-rated partition walls or separations

Q.4 THE WORKING HYPOTHESIS

NIST has developed a working hypothesis to explain the sequence of events from aircraft impact until the initiation of global structural collapse. This hypothesis will be further refined based on the results of

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[1] The design of the WTC towers was governed by gravity and lateral wind loads.

[2] The perimeter columns were designed to carry both gravity and wind forces and acted together as a framed-tube system. The core columns were designed to carry only gravity loads and not required to provide frame action.

[3] The composite floor truss system, which included long-span open-web bar joist elements, was designed to carry floor loads to the supporting core and perimeter columns. It also acted as a diaphragm that distributed wind forces to the perimeter columns of the framed-tube system and provided lateral stability to the perimeter columns.

[4] A maximum credible fire for the WTC towers is assumed to have the following characteristics: the sprinkler system is compromised, overwhelmed, or not present; there is no active firefighting; combustible building contents averaging 10 psf (in the range of about 5 to 20 psf for conventional office buildings); floor-to-floor fire spread to next upper floor at 30 or 60 min; and ventilation from windows broken by fire and a total of 50 ft^2 of air leakage between floors.

NIST's continuing comprehensive analyses to identify specific load redistribution paths and damage scenarios that are possible for each building, from which the most probable collapse sequence will be identified. NIST welcomes comments from technical experts and the public on the working hypothesis.

NIST's working hypothesis is based on analysis of the available evidence and data, consideration of a range of hypotheses (including those postulated publicly by experts), and a newly enhanced understanding of structural and fire behavior. It is consistent with all current evidence held by NIST, including photographs and videos, eyewitness accounts, and emergency communication records. NIST's analysis allows for different sequences of events and different possible event paths for each building.

To accommodate the aircraft impact and subsequent fire damage, the structure redistributed loads from structural element to structural element via redundant load paths and maintained overall structural stability. Structural collapse began when the structure was not able to redistribute loads any further. The working hypothesis addresses the following chronological sequence of major events; specific load redistribution paths and damage scenarios are currently under analysis:

1. Aircraft impact damage to perimeter columns with redistribution of column loads to adjacent perimeter columns and to the core columns via the hat truss;

2. After breaching the building's exterior, the aircraft continued to penetrate into the buildings, damaging core columns with redistribution of column loads to other intact core and perimeter columns via the hat truss and floor systems;

3. The subsequent fires, influenced by post-impact condition of the fireproofing, further weakened columns and floor systems (including those that had been damaged by aircraft impact), triggering additional local failures that ultimately led to column instability;

4. Initiation and horizontal progression of column instability ensued when redistributing loads could not be accommodated any further. The collapses then ensued.

Role of the Hat Truss System

The purpose of the hat truss was to support gravity and wind loads on the antenna. It was not designed to resist lateral forces on the towers, and, in an undamaged state, it did not have a significant role in carrying gravity loads. Lateral loads due to wind were distributed to the framed-tube system via diaphragm action of the floor system. The hat truss was connected to each perimeter face at only four points, all at the same level (at the 108th floor just below the concrete floor slab). The 47 core columns were connected to diagonal elements, heavier transfer beams, or smaller beam elements in the hat truss. Most of the core columns extended to the roof level, but four core columns, which were only minimally connected to the hat truss, terminated at floor 110. The hat truss provided minimal redistribution of loads (less than 10 percent) from perimeter columns to core columns. Most of the load redistributed due to aircraft impact damage occurred on the external face through vierendeel action.

Aircraft Impact Damage to Perimeter Columns

Initially, the WTC towers withstood the impact virtually identical aircraft. Based on video that NIST has obtained, it is known that WTC 2, which collapsed first and in about half the time as WTC 1, vibrated for over 4 min at an oscillation rate nearly equal to that measured for the undamaged building after it was struck, indicating that the buildings were continuing to respond normally. The lightly damped (about 1.2 percent of critical damping) oscillation had a maximum amplitude of approximately 20 in. at the roof

level, where sway was about 3 ft to 4 ft under design wind conditions. Based on this information, structural damage to perimeter columns as a result of aircraft impact of the framed-tube system appears to have played a minimal role in initiating the collapse. Perimeter column bowing prior to collapse occurred on other faces (i.e., fire floors on the south face of WTC 1 and east face of WTC 2) that were not severed by the aircraft.

Aircraft Impact Damage to Core Columns

The core columns were designed to carry only gravity loads and not required to provide frame action. The aircraft trajectory at impact suggests damage to the core columns occurred as follows:

WTC 1—The aircraft was traveling about 450 mph and hit the tower near the center of the north face damaging floors 93 to 99. The aircraft fully entered the core area and severed or damaged central core columns in the north-south direction. Aircraft and building debris accumulated in the remaining core area and south-side floor areas as contents were displaced from the point of impact.

WTC 2—The aircraft was traveling about 550 mph and hit the tower near the southeast corner of the building damaging floors 77 to 85. Core columns to the south and east were severed or damaged. Aircraft and building debris accumulated in the core area and floor areas to the east and north.

Severed core columns redistributed their loads in three ways, depending on how many and which core columns were severed.

1. Isolated core columns were severed. Severed column and tributary floor loads at and above the point of impact were redistributed locally at each floor to adjacent intact core columns via core floor framing. This was limited by shear/bending capacity of floor-framing connections to adjacent columns.

2. Critical (e.g., corner) core columns and/or several other core columns were severed. The severed column and tributary floor loads, at and above impact floors, redistributed to intact core columns via the hat truss. Significant hat truss deflections may have occurred if there was adequate connection capacity since the severed core columns and the associated floors were hanging from the hat truss which was not designed to carry such loads. This was limited by the tensile capacity of bolted splices in the severed core columns, tensile/compression capacity of hat truss members, and tensile capacity of column connections to the hat truss.

3. Extent of core column failures precluded redistribution through the hat truss and/or exceeded redistribution capacity of the hat truss: severed column and associated floor loads, at and above floors of impact, redistributed to intact core and perimeter columns via the core and composite truss floor system. Floors were subjected to combined bending and diaphragm action (e.g., consider the scenario of no core columns in the floor span direction to visualize this action). The overall capacity of the floors was limited by shear capacity of floor-to-column connections (including perimeter columns) and tensile/bending capacity of composite truss floor connections to core or perimeter columns. Significant sagging of the hat truss system may have occurred if its capacity was exceeded.

Relative Roles of Fires and Aircraft Impact

Fires played a major role in collapse initiation. The tower structures withstood the initial aircraft impacts and remained stable. While aircraft impact damage did not, by itself, initiate building collapse, it had the following harmful effects that then contributed greatly to the subsequent fires:

- Compromised the sprinkler and water supply systems,
- Dispersed jet fuel and ignited building contents over large areas,
- Created large accumulations of combustible matter containing aircraft and building contents,
- Increased air supply into the buildings (through broken windows and holes in the sides of the buildings, and between floors due to damaged floors, vertical shafts, and columns) permitted significantly higher energy release rates than would normally be seen in ventilation limited building fires, allowing the fires to spread rapidly within and between floors, and
- Damaged ceilings enabling "unabated" heat transport over the floor-to-ceiling partition walls and to the floor trusses, spandrels, and tops of columns.

The jet fuel, which ignited the fires, was mostly consumed within the first few minutes after impact. The fires that burned for almost the entire time that the buildings remained standing were due mainly to burning building contents and, to a lesser extent, aircraft contents, not jet fuel.

Thermal Effects on Columns and Floors

Some floors in WTC 2 experienced partial collapse due to aircraft impact. For example, partially collapsed floor slabs were visible on the east and north faces. This included failures at the edges with perimeter columns causing floor edge sagging. There is no visible evidence of hanging floors in WTC 1.

Role of Fireproofing

The post-impact condition of the fireproofing played a key role in the structural response to fires. The post-impact condition of the fireproofing depends on the condition of the fireproofing prior to aircraft impact and the extent to which fireproofing was damaged due to aircraft impact. The fire-affected floors in WTC 1 had, in general, upgraded or thicker fireproofing (1.5 in. specified) while, in general, those in WTC 2 did not have upgraded fireproofing (0.5 in. specified].

- Fires may have had the following thermal effects: core columns and core floors may have been further weakened, with reduced ability to carry and/or redistribute load, causing such loads to be redistributed to other core and perimeter columns consistent with the residual reserve capacities of these columns and the transfer mechanisms (i.e., hat truss and floor system).
- The floor system may have been further weakened, either along the span of the floor system or localized at connections with columns. The weakening floor system may have pulled the perimeter columns inward (observed on the south face of WTC 1 and the east face of WTC 2 minutes prior to building collapse) and then initiated connection failures at perimeter or core columns.

- Perimeter columns may have been further weakened, with reduced ability to carry loads. Thermal effects could also cause inward bowing of perimeter columns due to differential temperatures between the inner and outer faces of the columns. The loads that could no longer be carried by the weakened columns would have been redistributed to adjacent perimeter columns.

Column Instability and Collapse Initiation

The perimeter columns were designed as part of a framed-tube system to carry both gravity and wind forces. Instability of perimeter columns resulted from a combination of (1) redistributed loads from the core columns via the floor system and possibly the hat truss, (2) inward bowing due to thermally weakened and sagging floors, (3) increased unsupported length due to failed floors, and (4) thermal effects directly on the perimeter columns.

The instability of a few perimeter columns spread instability across the entire face and around the corners just before or during collapse initiation. The initiation or spread of perimeter column instability also may have been facilitated by the hoop stress demand on the framed-tube system exceeding the capacity of the spandrels (horizontal steel plates) that tied the perimeter columns together (e.g., at the northeast corner of WTC 2).

The initiation of global collapse for both towers was first observed by the tilting of the sections above the impact regions of both WTC towers. The top section of WTC 1 rotated to the south (observed via antenna tilting in a video recording) and the top of WTC 2 rotated to the east and south and twisted in a counterclockwise motion. The primary direction of tilt of each tower was around the weaker axis of the core (north-south for WTC 1 and east-west for WTC 2). The rigid body rotation associated with the tilting and the propagation of column instability are synchronous processes that initiated global collapse. The rigid body rotation may have caused forces such as shear and torsion to spread the column instability laterally.

Q.5 ISSUES STILL BEING INVESTIGATED

Over the next few months, NIST will continue to investigate the following technical issues and modify its working hypothesis as needed. Findings on these issues will be included in the final report.

- Aircraft impact damage to structural components, fireproofing, and hat truss connections.
- Distribution of aircraft/building contents.
- Thermal effects on core columns and core floors, especially extent of fires and growth history.
- Thermal effects on welded perimeter columns, especially temperature gradients on columns.
- Extent of load redistribution to intact core columns and their reserve capacity to accommodate thermal loads.

- Capacity of hat truss connections to perimeter columns, especially to meet the demands of aircraft impact and any torsional effects.
- Capacity of hat truss to accommodate the load redistribution from severed columns.
- Capacity of bolted splices in the severed core columns to carry loads to the hat truss.
- Relative magnitude of the load redistribution provided by the local core floor, hat truss, and the core-truss floor system for each tower.
- Axial/shear/bending capacity of floor connections to core and perimeter columns.
- Effect of localized fires on floor truss connections.
- Mechanisms to propagate instability laterally in the perimeter columns (e.g., shear and torsion forces induced by a rigid body movement)
- Capacity of spandrels, including splices, to carry shear transfer in the framed-tube system, especially at the corners.
- Role of bolted splices on instability of perimeter columns.
- Outward bowing of perimeter columns due to thermal expansion of floors.
- Effect of uneven floor thermal expansion on perimeter column instability due to potential biaxial bending.
- Comparison and reconciliation of working hypothesis with observed facts (photographs and videos, eyewitness accounts, emergency communication records).
- Examination of other possible or probable hypotheses.

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