4 Career Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

Revised on April 5, 2017 to update the Executive Summary and the Cause of Death and December 3, 2021 to update Appendix Four

Executive Summary

On May 31, 2013, a 35 year-old career captain, a 41 year-old career engineer operator, a 29 year-old career fire fighter, and a 24 year-old career fire fighter were killed when the roof of a restaurant collapsed on them during fire-fighting operations. The captain was assigned to Engine 51 (E51). The engineer/operator was assigned to Ladder 51, but was detailed to E51 and assigned to the left jumpseat (E51B). The two fire fighters were assigned to Engine 68 (E68). Upon arrival, the captain of E51 (E51A) radioed his size-up stating they had a working fire in the restaurant with heavy smoke showing plus a temperature reading from his thermal imager. E51 made an offensive attack from Side Alpha with a 2½ inch pre-connect hoseline in the restaurant. District Chief 68 (D68) arrived on scene and established "Command". He ordered E51 out of the building because the engine operator of E51 (E51D) advised that E51 was down to a quarter tank of water. Engine 68 had arrived on scene and had laid two 4-inch supply lines from E51 to a hydrant east of the fire building on the feeder road. Once E51 had an established water supply, E51's crew re-entered the building. Engine 68 (E68) was ordered to back-up E51 on the 2½ inch hoseline. Engine 82 (E82) (4th due engine company) was pulling a 1¾ inch hoseline to the front doorway that E51 had entered, when the collapse occurred. The roof collapsed 12 minutes after E51 had arrived on-scene and 15 minutes and 29 seconds after the initial dispatch. The fire fighter from E51 (E51C) was at the front doorway and was pushed out of the building by the collapse. The captain from E82 called a "Mayday" and Rapid Intervention Team (RIT) operations were initiated by Engine 60. During the RIT operations, a secondary wall collapse occurred injuring several members of the rescue group. Due to the tremendous efforts of the Rescue Group, a successful RIT operation was

An aerial view of the structure with the restaurant located on the front left, (Side Alpha/Bravo), motel entrance in the middle (Side Alpha), and a sports bar on the right (Side Alpha/Delta).
(Photo courtesy of the fire department)

conducted. The captain of E68 was located and removed from the structure by the Rescue Group and transported to a local hospital. The engineer operator from E51 (E51B) was removed from the structure by the Rescue Group and later died at a local hospital. A search continued for the captain of E51 and the two fire fighters from E68. Approximately 2 hours after the collapse, the body of the captain from E51 was located on top of the restaurant roof debris. The two fire fighters from E68 (E68B and E68C) were discovered underneath the restaurant roof debris. The officer and two fire fighters were pronounced dead at the scene. ***Note:*** *The captain of Engine 68 (E68A) died on March 7, 2017 from complications of the severe injuries suffered in the restaurant fire on May 31, 2013.*

Contributing Factors

- *Fire burning unreported for 3 hours*
- *Delayed notification of the fire department*
- *Building construction*
- *Wind impacted fire*
- *Scene size-up*
- *Personnel accountability*
- *Fireground communications*
- *Lack of fire sprinkler system*

Key Recommendations

- *Based upon fire department procedures, the strategy and tactics for an occupancy should be defined by the organization for fire-fighting operations. The Incident Commander should ensure that the strategy and tactics match the conditions encountered during initial operations and throughout the incident*
- *Fire departments should review and update standard operating procedures on wind-driven fires which are incorporated into fireground tactics*
- *Fire departments should integrate current fire behavior research findings developed by the National Institute of Standards and Technology (NIST) and Underwriter's Laboratories (U.L.) into operational procedures by developing standard operating procedures, conducting live fire training, and revising fireground tactics*

4 Career Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

Revised on April 5, 2017 to update the Executive Summary and the Cause of Death

Introduction

On May 31, 2013, a 35 year-old career captain, a 41 year-old career engineer operator, a 29 year-old career fire fighter, and a 24 year-old career fire fighter died when the roof of a restaurant collapsed during fire-fighting operations. The captain and engineer operator were assigned to Engine 51 (E51). The two fire fighters were assigned to Engine 68 (E68). On June 3, 2013, the United States Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On June 10 - 17, 2013, an investigator, two general engineers, and occupational safety and health specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) traveled to Texas to investigate this incident.

The NIOSH investigators met with the Fire Chief, Executive Assistant Chief, and the executive staff of the fire department; the Fire Marshal and his staff; the SCBA Maintenance and Repair staff; the International Association of Fire Fighters local union; the department's training academy staff; physicians with the county medical examiner's office; representatives from the city's Building Officials Office; investigators from the Texas State Fire Marshal's Office; investigators from the Bureau of Alcohol, Tobacco, Firearms, and Explosives; and the city's 911 communication and dispatch center. The investigators reviewed the fire department's standard operating procedures, training records from the department and the State of Texas, dispatch and tactical channel printouts, plus audio radio transmissions. The NIOSH investigators visited and photographed the fire scene. During the investigation, witness statements were reviewed and interviews were conducted with the fire fighters, fire officers, District Chiefs and the Deputy Chief that served as the Incident Commander during this incident. The NIOSH investigators inspected and photographed the personal protective clothing (turnout gear) and SCBA of the fire fighters, which was under control of the department's Arson Bureau.

On June 29 – July 2, 2013, a NIOSH investigator and a NIOSH occupational safety and health specialist returned to Texas to complete the interviews with fire fighters and fire officers involved in this incident.

Fire Department

The career fire department involved in this incident serves a city with a population of 2,151,475 which is the fourth largest city and the third largest fire department in the United States. The fire department is rated by the Insurance Services Office (ISO) as a Class I fire department and is an Internationally Accredited department through the Commission on Fire Accreditation International (CFAI).

The urban population is 4,944,332 residents and the metropolitan population is 6,177,035 residents. The city has a total area of 656.3 square miles which is comprised of 634.0 square miles of land and 22.3 square miles of water. The fire department provides aircraft rescue fire-fighting (ARFF) for two large commercial airports. The fire department provides automatic aid with one career fire department and one volunteer fire department which are located in entities within the municipality. The fire department is part of a regional mutual aid pact which covers transportation emergencies in the greater metropolitan area.

The fire department employs 3,907 personnel, of which 3,789 are uniformed members. The daily minimum staffing for the Emergency Response Division is 832 personnel. The Emergency Response Division operates on 24/72 work schedule which equates to a 46.7 work-week including a 24-hour debit day which is worked approximately once every 36 days.

The Emergency Response Division is divided into two divisions – north and south. A deputy chief staffs each division on each shift. The South Division (Shift Commander 37) has 13 districts or battalions (District 21, 28, 59, 68, 78, 83, 20, 26, 46, 70, 71, 11 (Rescue), and 22 (Haz Mat). The North Division (Shift Commander 15) has 11 districts or battalions (4, 5, 6, 8, 19, 30 (Safety), 34, 45, 64, 102, and ARFF). District 54, provides aircraft rescue fire-fighting (ARFF) and emergency medical services at two of the city's airports, which are located in the north and south areas of the city. District 54 and is under the direction of the Aircraft Rescue Coordinator who oversees four stations - 54, 92 and 99 at the airport located in the north section of the city and Station 81 at the airport located in the south section of the city. District 22 is the department's hazardous materials unit staffed at Fire Station 22. District 11 is the department's rescue district which has rescue companies: Rescue 10, Heavy Rescue 11, and Rescue 42. District 30 is staffed with the department's Shift Safety Officers. They are located at Stations 24, 30, and 57.

The fire department operates a fire administration office, a fire marshal's office, fire training academy, arson division, logistics center, fire apparatus maintenance shop, and fire operations division.

The Emergency Response Division directs all fire suppression, special operations and emergency medical services. These units are housed in 92 fire stations and staff the following resources: 87 engine companies; 37 ladder or truck companies (including 5 tower ladders); 56 basic life support (BLS) ambulances which are staffed with one EMT/B fire fighter and one EMT/B engineer operator per unit; 34 medic units (advanced life support) (ALS) with one fire fighter paramedic and one engineer operator paramedic; and 11 squads (non-transport ALS units) staffed with one fire fighter paramedic and one engineer operator paramedic. Additional units on duty include three rescue companies including one heavy rescue and 3 safety officers.

The fire department utilizes the following designations for riding assignments on fire apparatus: Officer is "A"; right jumpseat is "B"; left jumpseat is "C"; and the engineer operator is "D".

The minimum staffing for each engine company, ladder company, and rescue company is an officer (senior captain or captain), engineer operator, and two fire fighters. Each district is staffed with a district chief and an incident command technician.

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The rescue companies (Rescue 10, Heavy Rescue 11, and Rescue 42) provide technical rescue services such as structural collapse, high and low angle rescue, trench rescue, and confined space rescue. The hazardous materials team consists of 10 members (two captains, three engineer operators, and five fire fighters) per shift operating response vehicles – HM22 Unit 1, HM22 Unit 2, and Foam Engine 22. The hazardous materials team is under the direction of a district chief (District 22) and assisted by a senior captain.

In calendar year 2013 (January 1 – December 31) the fire department responded to 299,107 incidents (257,107 - EMS and 42,064 – Fire). The average response time for EMS incidents was 5.8 minutes and the average response time for a fire incident was 5.6 minutes.

The Prevention Bureau is managed by an Assistant Chief and consists of 127 fire inspectors (1 Assistant Fire Marshal, 7 Chief Inspectors, 16 Senior Inspectors, and 103 inspectors) and 7 civilian positions. The members of the Fire Marshal's Office are certified to NFPA 1031, *Standard for Professional Qualifications for Fire Inspector and Plan Examiner* [1] through the local community college. Each inspector must receive 20 hours of continuing education units (CEU) annually.

The Prevention Bureau consists of the following divisions and teams:

- Schools Division including Home Day Care facilities (Inspections)
- High-Rise Team (Inspections)
- Plans Review Division
  - Fire Alarm System;
  - Sprinkler Systems through the Building Officials Office
- Liaison to the city's Building Officials Office
  - New construction
  - Sprinkler Systems; Electrical; Plumbing; Building Construction
- Special Operations Team
  - Providing fire and EMS for festivals and special events
- Weekend and Night Inspections
  - 24-hour coverage
  - Occupancy Load
  - Complaints

The Public Education Division of the Prevention Bureau conducts life safety training in:

- Schools
- High-Rise occupancies

The Fire and Arson Investigation Bureau is a law enforcement agency under the Prevention Division. The Arson Bureau responds in the event of incendiary fires, multiple alarm fires, fire deaths, bombings, and criminal or terrorist activity associated with fires. In many cases, investigators work with federal, state, and local agencies, such as the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), Federal Bureau of Investigation (FBI), and the city's police department. Other operations within the Fire and Arson Bureau are crime lab, polygraphs, forensics, and the region's

Arson Task Force.

Other Divisions within the department include:
- Planning/Administration, which includes: Office of Emergency Communication (Fire), Human Resources, Information Technology Liaison, and Planning.
- Finance, which includes: Finance, Budget, Procurement, Fixed Assets, Internal Audit, Grant Accounting, Warehouse Operations and the Selection, Care, and Maintenance of SCBA.

The rank structure in the fire department is fire fighter, engineer operator, captain, senior captain, district chief, deputy chief, assistant chief, executive assistant chief, and fire chief.

Training and Experience

The fire department involved in this incident requires potential candidates for employment as a fire fighter to have a high school diploma or GED and 60 hours of college credit, or two years of military service with an honorable discharge.

Once selected as a candidate, the fire fighter trainee begins a 15-month probation period with the fire department. As a fire fighter trainee, the initial step is to attend the 9-month Recruit Training Program at the department's fire academy. The training consists of Texas Commission of Fire Protection Basic Fire Suppression Curriculum. The Texas basic curriculum includes 468 hours of training. The curriculum covers all of the National Fire Protection Association's (NFPA) qualifications for: NFPA 1001, *Standard on Fire Fighter Professional Qualifications*, Fire Fighter I, Fire Fighter II, Hazardous Materials-Awareness, and Hazardous Materials-Operations.[2] The trainee meets the requirements of NIMS 100 – *Introduction to ICS*; NIMS 200 – *Basic ICS*; IS 700A – *The National Incident Management System, An Introduction*; and IS 800B - *The National Response Framework, An Introduction*. In addition to the fire fighter training, the fire fighter trainees receive *Emergency Medical Technician Basic* (EMT/B) certification.

Upon completion of recruit school, the fire fighter trainee becomes a probationary fire fighter and is assigned within the Emergency Response Division as follows:
- Phase 1: 2 months with an engine company
- Phase 2: 2 months with a truck company
- Phase 3: 2 months with EMS

Upon completion of probation, the probationary fire fighter is promoted to the rank of fire fighter.

The department requires that all Emergency Response Division fire fighters receive two hours of continuing education unit (CEU) training, one hour of risk management training, and 24 hours of in-service training per month. The fire department utilizes District Training Officers to assist with this in-service training as well as assuring that probationary fire fighters are obtaining the proper training during their six-month period in the Emergency Response Division. The Texas State Fire Commission requires 20 hours of CEUs per year and the Insurance Services Office requires 8 hours of CEUs plus 8 multi-company drills per year.

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The department conducts live fire training twice a year at the department's fire academy. The live fire training is compliant with NFPA 1403, *Standard on Live Fire Training*.[3] Each live fire training evolution utilizes four engine companies, two ladder companies, one medic unit, and one district chief. The department provides a certification program for all emergency operators (EO), which is a tested position. The fire academy provides the training for the 56-hour certification program, which complies with NFPA 1002, *Standard for Apparatus Driver/Operator Professional Qualifications*.[4] The department pays for the state certification process through the Texas State Fire Commission.

The fire department provides an officer development program for members which is part of the department's career path plus the opportunity to acquire a college degree. This process uses curriculum from the National Fire Academy; local community colleges; various colleges and universities; and continuing education programs.

The captain of E51 (E51A) was hired by the department on April 24, 2003. He successfully completed recruit school at the department's Recruit Training Program and was certified as a fire fighter and EMT/B as of November 9, 2002. He was promoted to engineer operator on April 27, 2007 and promoted to captain on May 8, 2011. Other training courses and certifications included: radio communications, incident management system, apparatus familiarization, crew resource management, pump operations, infection control, ropes and knots, master streams, water supply, area familiarization, diversity awareness, overhaul, building construction, stokes basket operations, patient assessment, water rescue, AED protocol, hydraulics, PPE inspection and care, forcible entry, NIMS 100 – Introduction to ICS, NIMS 200 - *Basic ICS*, NIMS 700 – *An Introduction to NIMS*, 800 and 800A – *The National Response Framework, An Introduction*, review of departmental Orders and Bulletins, fire fighter safety, aerial operations, fire fighter survival, mass casualty incidents, fire protection systems, strategy and tactics, situational awareness, master streams, physical fitness, ground ladders, live fire training – multi-company drills, customer service, portable radio training, BLS continuing education, Grace Accountability System, Officer Development Program for Newly Promoted Captains (80 hours), and rapid intervention team (RIT). In April of 2013, the captain was awarded the Unit Meritorious medal for saving a female victim who had been trapped in an apartment fire.

The engineer operator from Ladder 51, was hired by the department on August 6, 2001. He successfully completed recruit school at the department's Recruit Training Program and was certified as a fire fighter and EMT/B as of August 6, 2001. He was promoted to engineer operator on December 29, 2007. Other training courses and certifications included: area familiarization, hydraulics, ground ladders, building construction, water supply, high-rise fire-fighting operations, customer service, personnel accountability system, pump operations, fire protection systems, aerial operations, gasoline emergencies, hoseline operations, overhaul, vehicle fires, water rescue, tunnel rescue, review of departmental Orders and Bulletins, vehicle extrication, ventilation, high angle rescue, weapons of mass destruction (WMD), NIMS 700 – *An Introduction to NIMS*, quarterly operational risk management training, hose testing, master stream operations, live fire multi-company drills, physical fitness, rapid intervention team (RIT), physical fitness, propane and natural gas emergencies, fire fighter survival training, radio communications, portable radios, inspection and care of PPE, radio communications, wind driven fires, apparatus familiarization, and the Grace Accountability System.

The fire fighter from Engine 68 (E68C) was hired by the department on June 29, 2010. He successfully completed recruit school at the department's Recruit Training Program and was certified as a fire fighter and EMT/B as of June 29, 2011. Other training courses and certifications included: radio communications, area familiarization, turnout gear care and use, ground ladders, driving safety, apparatus familiarization, water supply, hoseline operations, the Grace Accountability System, water rescue, thermal imaging camera, incident scene rehabilitation, foam operations, live fire multi-company drills, review of departmental Orders and Bulletins, "Mayday" and RIT operations, post incident analysis, building construction, physical fitness, hydraulics, driver/operator course (80 hours), fire protection systems, personnel accountability system, master streams, forcible entry, fire cause and determination, stokes basket operations, high-rise fire-fighting, wind-driven fires, portable radios, truck company operations.

The fire fighter from Engine 68 (E68B) was hired on January 7, 2013. After graduating in April 2013, she was assigned to Fire Station 68 as a Probationary Fire Fighter. Other training courses and certifications included: area familiarization, turnout gear care and use, apparatus familiarization, hydraulics, physical fitness, and water supply.

Equipment and Personnel

The Office of Emergency Communications (OEC) is the city's communication center whose primary duties are to receive calls for fire, EMS, and law enforcement assistance. OEC immediately dispatches the appropriate personnel and equipment to the incident and record pertinent incident information. From the fire and EMS perspective, OEC is staffed by uniformed fire department members. OEC dispatches the following assignments to a reported or confirmed fire:

- **Residential Structure Fire (Heavy Box):**
  - 3 Engines
  - 2 Ladders
  - 1 Ambulance
  - 1 Medic Unit
  - 2 District Chiefs

- **Commercial Structure Fire (Heavy Box):**
  - 4 Engines
  - 2 Ladders
  - 1 Medic Unit
  - 1 Safety Officer
  - 2 District Chiefs

- **High-Rise Structure Fire (Heavy Box):**
  - 6 Engines
  - 4 Ladders
  - 1 Rescue Company
  - 1 Medic Unit
  - 2 Safety Officers

- 4 District Chiefs

- **Vehicle Fire, Brush Fire, or Still Alarm**
  - 1 Engine or,
  - 1 Engine and 1 Ladder

- **1-11 (Working Fire Dispatch)**
  - 1 Engine
  - 1 Ladder
  - 1 Rescue Company
  - 1 District Chief

- **2-11 (2nd Alarm)**
  - 4 Engines
  - 2 Ladders
  - 1 Heavy Rescue
  - 1 Medic Unit
  - 1 Safety Officer
  - 1 Air Cascade Unit
  - 1 "Rehab" Unit
  - 2 District Chiefs
  - 1 Deputy Chief (Shift Supervisor)
  - 1 EMS Supervisor
  - 1 Command Van

The department typically employs fast attack offensive operations at structure fires. Generally, fast attack or offensive operations at this department involve the first due engine company attacking the fire with a hoseline charged with water from the engine's booster tank while water supply is being established from a hydrant. The first due engine company searches for possible victims in the immediate area. The first due ladder company initiates ventilation procedures. The second due engine company pulls a second hoseline to back up the first due engine company. The second due ladder company assists the first-in engine company with search and rescue operations. The third due engine company is assigned as the rapid intervention team (RIT). Other arriving units are assigned to assist with establishing water supply, back-up the initial engine company, search and rescue, RIT operations, assist with accountability and other duties as designated by the incident commander.

Timeline

This timeline is provided to set out, to the extent possible, the sequence of events according to recorded radio transmissions. Times are approximate and were obtained from review of the dispatch records, witness interviews, and other available information. Times have been rounded to the nearest minute. NIOSH investigators have attempted to include all radio transmissions. This timeline is not intended, nor should it be used, as a formal record of events.

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The following timeline is a summary of events that occurred as the incident evolved from 1207 hours to 1645 hours on May 31, 2013. Not all incident events are included in this timeline. This timeline also lists the changing fire behavior indicators and conditions reported, as well as fire department response and fireground operations. All times are approximate and rounded to the closest minute.

Incident and Fireground Communications	Time	Response & Fireground Operations
OEC dispatched District 68, District 28, Engine 51, Engine 68, Engine 60, Engine 82, Ladder 68, Ladder 69, Safety 57, and Medic 10 for a restaurant fire.	**1207 Hours**	
D68 requested a Tac Channel; OEC assigned Tac Channel SW11.	**1209 Hours**	
D68 requested a 1-11 (working fire dispatch) for the incident at the "Freeway"; "This is due to the heavy smoke showing from the structure."	**1210 Hours**	Engine 51 reported "heavy smoke showing" on Tac Channel 11; District 68 acknowledged that Engine 51 had heavy smoke showing;
District 68 requested traffic control for the city street next to freeway; OEC acknowledged the request for traffic control. OEC dispatched a 1-11 for a different working fire; District 68 acknowledged the 1-11.	**1211 Hours**	Engine 51 arrived on scene and stated, "We got a one story restaurant; we got heavy smoke showing from the attic of the restaurant; we'll be going in making an offensive attack; we'll be pulling a 2½-inch attack line".
	1212 Hours	District 68 on scene; "District 68 is assuming "Command"".

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Incident and Fireground Communications	Time	Response & Fireground Operations
OEC advised District 68 that the previous 1-11 was for an incident with District 78 and District 83; Stand-by for your 1-11. OEC dispatched the 1-11 for the restaurant fire; "District 21, Engine 48, Ladder 33 and Heavy Rescue 11 respond on the 1-11".	**1213 Hours**	Engine 51 to 2nd due engine company (Engine 68); "We need you to lay us a line". Engine 68 on scene; "We are looking for a hydrant."
	1214 Hours	"Engine 68 has found a hydrant and will be laying into the 1st due engine (E51)." District 28 on scene; "Command" assigned District 28 as Alpha Division; Ladder 68 on scene;
"Command" called OEC to advise the accountability system is in place and operational.	**1215 Hours**	Engine 51 to "Command", "We have an 184ºF reading the door – thermal imager reading."
OEC advised Ladder 51 was added to the incident and was responding.	**1216 Hours**	Engine 60 staged.
"Command" called OEC and requested a 2-11 for this incident. OEC acknowledged the request.	**1218 Hours**	Engine 82 on scene. Engine 51D called Engine 51A and advised him that Engine 51 was down to a quarter tank of water; "Command" advised Engine 51A to back the line out of the building until a water supply has been established. Engine 51A acknowledged; Engine 51 reported out of the building.

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Incident and Fireground Communications	Time	Response & Fireground Operations
OEC dispatched the 2-11. Units dispatched on the 2-11 were: District 59, District 5, Engine 28, Engine 2, Engine 16, Engine 59, Ladder 21, Mutual Aid Ladder 1, Rescue 42, and Safety 30.	**1219 Hours**	"Command" advised L68, "Get to the roof and cut a hole in the roof between the main fire building and the motel". Ladder 68A acknowledged the order regarding cutting a hole in the roof between the main fire building and the motel.
	1220 Hours	Engine 51 was backing out of the structure. "Command" sent Engine 82 to assist Engine 51. Engine 51D advised "Command" that Engine 51 had an established water supply. E51 went back inside the restaurant. "Command" assigned E68 to "Fire Attack" with Engine 51 and Engine 82. "Command" confirmed with Engine 60A that Engine 60 had been assigned as RIT; Engine 60A acknowledged that Engine 60 had established RIT.
	1221 Hours	Ladder 69 and Engine 48 are on location.
	1222 Hours	"Command" called Alpha Division and advised him that he had Engine 51, Engine 68, and Engine 82 assigned to Alpha Division.
"Command" called OEC. "We have a "Mayday" at our location; give me a 3-11." OEC confirmed the 3-11. OEC dispatched units for the 3-11 (3rd Alarm). Units dispatched were District 8, District 46, Engine 33, Engine 38, Engine 49, Engine 5, Ladder 28, and Ladder 16.	**1223 Hours**	***Engine 82 "A" called a "Mayday"; "We have roof collapse, "Mayday", roof collapse, Engine 51 is inside."*** "Command" deployed Engine 60 (RIT).

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Incident and Fireground Communications	Time	Response & Fireground Operations
	1225 Hours	Alpha Division called "Command" and advised that E60 (RIT) was going in the front door. E48 was assigned the secondary RIT.
	1227 Hours	Rescue 10 (R10) arrived on scene. Rescue 10 assigned to RIT with Alpha Division, E60, and E48.
	1228 Hours	Ladder 51 arrived on scene. L51 ordered to report to Alpha Division.
	1230 Hours	Safety 57 (SF57) arrived on scene; SF57 advised "Command" that the light and power company needed to respond for utility control. SF57 asked "Command" to consider another Tac Channel for the "Mayday" operations.
"Command" contacted OEC regarding the use of another Tac Channel. OEC replied that Tac Channel 12 can be used for the fireground operations. The "Mayday" operations will stay on Tac Channel 11. OEC dispatched the 4th Alarm (4-11) for the restaurant fire: District 6, District 4, Engine 73, Engine 7, Engine 508, Engine 8, Ladder 59, and Ladder 38.	1231 Hours	Rescue 11 (R11) arrived on scene. "Command" ordered R11 to assist R10 with the "Mayday".
	1235 Hours	"Command" ordered all companies not involved with the "Mayday" to switch to Tac Channel 12.
	1237 Hours	District 21B (Staff Assistant) "to all 3-11 companies and 4-11 companies, switch over to Tac Channel 12; stage on the feeder (road), stage on the feeder (road)."

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Incident and Fireground Communications	Time	Response & Fireground Operations
	1239 Hours	Rescue 10A reported to Alpha Division, “We got two accounted for. They are pinned right here by this window sill. We need to get somebody on the edge to start cutting this roof away from them.”
	1244 Hours	L69 advised they are able to cut through the roof to access one of the trapped fire fighters.
	1247 Hours	“Command” is transferred to District 21(D21); D68 is assigned to manage the Rescue Group
	1252 Hours	***Alpha Division advised “Command” that one missing fire fighter (E68A) has been removed from the building.***
“Command” requested a 5th Alarm for this incident.	**1259 Hours**	Shift Commander 37 (South Division) assumed “Command”. D21 assigned as “Operations”. E508A advises “Command” that E508 has located a missing fire fighter (E51B).
“Command” requested a 5th Alarm. OEC dispatches the 5th Alarm (5-11) for the restaurant fire: District 19, District 26, Engine 37, Engine 47, Engine 62, Engine 80, Ladder 7, and Ladder 55.	**1301 Hours**	
	1303 Hours	***Alpha Division called “Command” to advised that the front facade on Alpha Division collapsed;*** Fire fighters picked up the wall to remove the injured fire fighters who are treated by EMS.
	1304 Hours	***Alpha Division advised “Command”, “RIT removed another missing fire fighter (E51B) from the interior.”*** ***The Incident Action Plan is changed by “Command” from “Rescue” to “Recovery”.***

Incident and Fireground Communications	Time	Response & Fireground Operations
	1309 Hours	Rescue Group Supervisor (D68) contacted Alpha Division regarding a PAR for E68 and E51.
	1407 Hours	"Command" advised "Operations" that a request for heavy equipment has been made.
	1420 Hours	The Rescue Group Supervisor advised "Operations" that one of the missing fire fighters had been located (E51A).
	1432 Hours	The Rescue Group located the two other missing fire fighters (E68B and E68C).
	1438 Hours	The Rescue Group and the arson investigators prepared to remove E51A from the building.
	1501 Hours	The Rescue Group removed E51A to Ambulance 83.
	1537 Hours	The Rescue Group Supervisor called "Operations" and advised that the other two missing fire fighters (E68B and E68C) were being prepared for removal.
	1554 Hours	Ladder 7 assisted with preparing the fire fighters from L68 for recovery. The crew from L68 removed the two missing fire fighters (E68B and E68C) from the structure to awaiting ambulances.
	1605 Hours	The Rescue Group Supervisor advised "Command" that the recovery process was completed.
"Command" to OEC, "7-1 the incident (declared under control) involving the restaurant fire. Holding all companies."	1645 Hours	

Building Construction and History

Fire officers and fire fighters must recognize and comprehend the significance that building construction including renovation and modifications, have on the risk assessment portion of their initial size-up and deployment tactics. Many experienced fire officers and fire fighters may have found themselves in the same position as these fire officers and fire fighters when building compromise and collapse occurred in the early phases of fire suppression operations. A thorough understanding of building construction and the effects of fire dynamics within a renovated building is necessary for the officers to correctly complete an initial size-up, assess building integrity and formulate applicable strategies.

It is easy to just say a defensive strategy should be employed in a fire that cannot be controlled with an offensive attack. This incident had considerations unknown to the responding fire officers and fire fighters that caused a collapse of the structure. The following information on the particular construction and alterations made will give both experienced and developing fire officers and fire fighters a better understanding of considerations for risk assessment and the predictability of performance in similar buildings in their locality.

The structures on the property were constructed in 1966 and were built under adopted building codes that were in effect at the time. The structures on the property consisted of a motel, restaurant, and a sports bar consisting of more than 26,000 square feet. The restaurant and sports bar were one-story structures attached to a two-story facility which housed the lobby, offices, banquet rooms, and meeting rooms for the motel. The property had seven stand-alone buildings that were two-story structures containing motel guest rooms. These buildings were not attached to the main fire building. (**See Diagram 1.)**

According to records from the city's Building Inspections Office, the structure was built on a concrete slab with no basement or sub-levels. The building classification was based on its usage and determined to be an "*A-2 Assembly occupancy intended for food and drink*". The structure was considered to be a *Type V – Wood Frame* building in accordance with NFPA 220, *Standard on Types of Building Construction*.[5] When this facility was constructed in 1966, the building code did not require the installation of a sprinkler system.

The restaurant, banquet facilities, and motel lobby area had undergone several renovations. Available information on these renovations was limited in the documentation provided by the city's Building Inspections Office. The dates, permits, and modifications that were obtained indicate the following renovations were made as follows:

- 1995: Commercial electrical work;
  Re-roof and sheetrock repairs: permit issued but no inspections made of this work;
- 1996: A new front canopy (remodel flat roof canopy to tower roof canopy design– no plans

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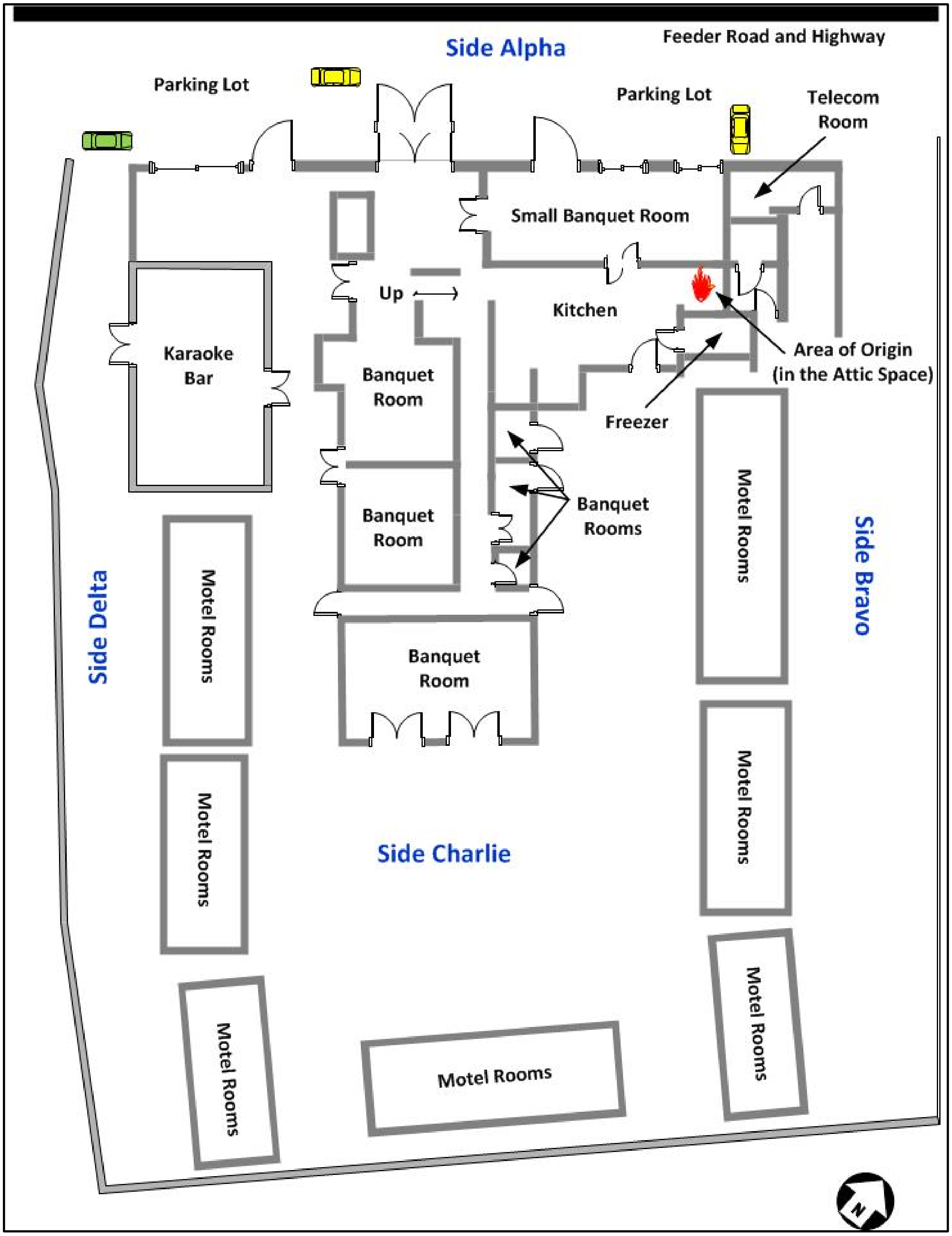

Diagram 1. The site plan for the motel, restaurant, and bar. The area of origin was determined to be in the attic/crawlspace above the kitchen.

were approved and no permit was issued);
- 1998: A fire occurred on the premises but there was no available information; Restaurant sold and name change occurred;
- 2004: Occupancy sold to current owner; No major renovations per the department's Arson Bureau;

The city's Building Inspection Office routinely conducts inspections of commercial occupancies to enforce the municipal electrical, mechanical, plumbing, and construction codes. The fire department's Fire Marshal's Office conducts fire inspections of commercial occupancies using the 2006 edition of the International Code Council (ICC) Fire Code.[6]

According to the department's Assistant Chief of the Fire Marshal's Office, the restaurant, hotel, and sports bar were on a 3-year inspection cycle. The last inspection occurred in 2012 and the occupancy was fully compliant with the fire code requirements. Fire department records showed that a fire occurred in the restaurant kitchen in November 2012. The range hood system in the kitchen contained and extinguished the fire. The incident was reported as a "fire out" and Engine 51 was the only fire department resource dispatched. The Fire Marshal's Office was notified as was the city's health department to inspect the kitchen. This was to insure the necessary repairs were made and the necessary cleanup was completed before the facility could re-open. The last Alarm Permit was issued by the Fire Marshal's Office on April 07, 2013.

Construction and Materials

Note: *The description of the building construction and collapse scenario was provided to NIOSH FFFIPP investigators by Christopher J. Naum. This material is based upon information obtained by NIOSH FFFIPP investigators during this investigation and from publicly available sources.*

Building alterations over the period of 1966-2013 varied distinctly with different building materials, structural components and roof lines added to the original building footprint. Various additions were added or areas expanded based on the varying gable roofs observed from aerial views of the building. The presence of infill flat roofs appeared to have been integrated with existing building compartments and roof lines. Large and small area gable-style roofs were common with engineered wood trussed systems (engineered structural systems) being incorporated along with flat roofs constructed on both wood and non-combustible materials, load bearing walls, steel beams and columns and masonry, wood frame and veneer construction features.

The primary roof support systems for the gable roofs were metal-plate-connected (MPC) wood truss systems of varying spans, and roof pitch, except for the restaurant roof that is suggested to have been constructed utilizing a lap-nailed wood truss system. A lap-nailed wood truss system utilizes nails (versus MPC) as the mechanical fastener to secure the truss components together in an assembly to provide structural support as a configured truss component. Another predominate architectural feature was the incorporation of extruded concrete interlocking roof tiles as a roof covering on the main building fronting on Side Alpha. ***Note:*** *According to the report issued by an independent structural engineering firm hired by the city, the additional weight added by the cement clay tiles did create an* *eccentric/dead load***.** The remaining buildings incorporated asphalt roofing shingles as the roof covering. All of the roof assemblies appear to have incorporated wood sheathing and underlayment. (**See Diagram 2.**)

Restaurant Roof Design

The restaurant facility located at the east side of the main entrance (lobby building) with its main entrance on Division Alpha, had a gable-style roof assembly constructed of an engineered wood truss components incorporating a lap-nailed truss configuration. This type of truss configuration is not commonly found or referenced in fire service case studies or incidents. Unlike other conventional engineered gable truss systems that utilize sized wood components that are fastened and secured utilizing a metal-plate-connected (MPC) that result in an engineered truss, the lap-nailed wood truss system utilizes nails (versus MPC) as the mechanical fastener to secure the truss components together in an assembly to provide structural support as a configured truss component. The truss webs and cords are configured in their defined orientation and angles and fastened utilizing a defined quality and sized metal nail fasteners and connected on the vertical face of the corresponding truss component.

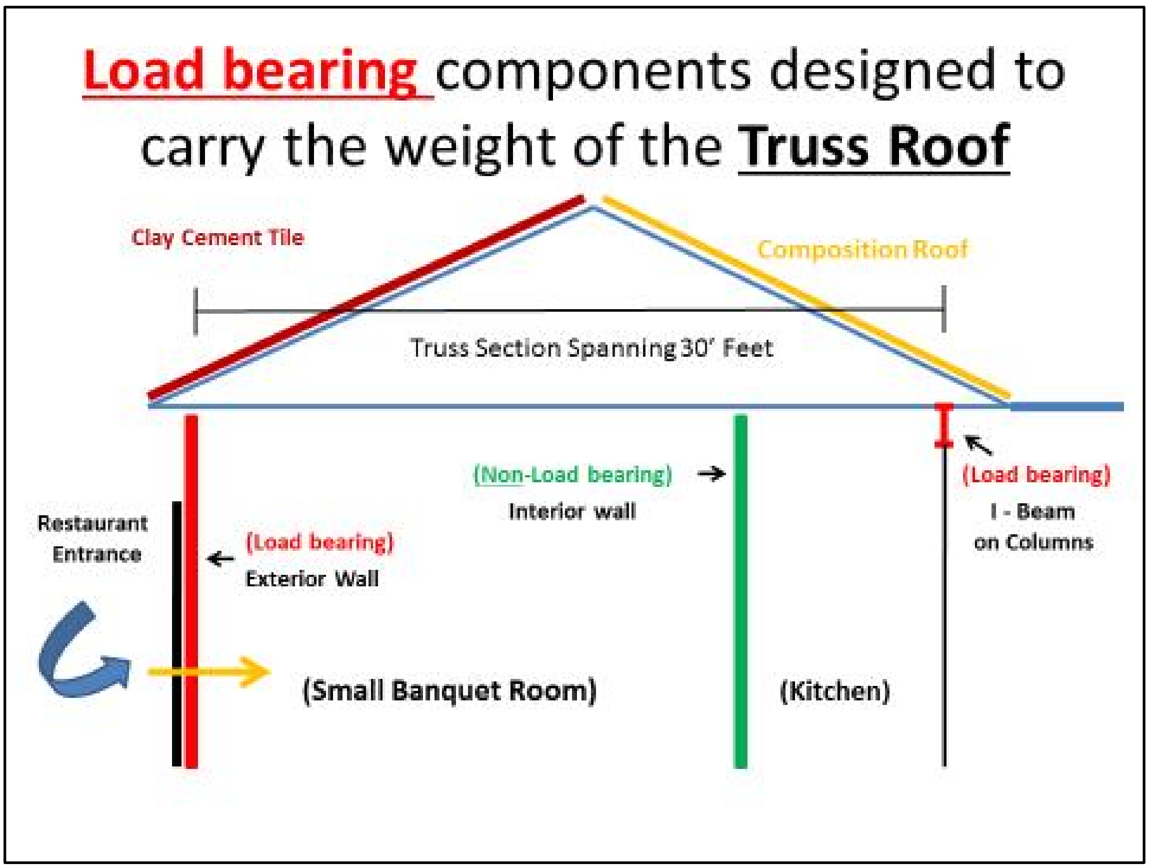

Diagram 2. The truss roof design of the small Banquet Room and the Kitchen.
(Diagram courtesy of the fire department)

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Early in the 1960s, the development of wood roof trusses for residential type construction and applications provided alternatives for contractors and designers. Using the strength of the triangle—the simplest geometric shape—designers were able to come up with space frames made of smaller, light weight framing members, which could span greater distances and could support ceiling finishes. When wood roof trusses were first built, wood plates (gussets) and nails held the joints of the truss together. Soon, these joints became metal plates with nails and finally, stamped metal plates and metal plate connectors to connect the truss components together.[7]

Adequate connection of the framing members and structural systems is a critical design and construction consideration. Regardless of the type of structure or type of material, structures and components are only as strong as their connections, and structural systems can behave as a unit only with proper interconnection of the components and assemblies.[8, 9]

The city hired an independent structural engineering firm to determine if the roof structure collapsed due to being overloaded or collapsed due to the fire. The conclusion from the independent structural engineering firm was the roof collapsed due to the fire and not due to insufficient structural capacity of the roof truss. This determination was made based on the observance of post-fire structural framing components (e.g. lumber, supports, connections, etc.) as well as additional internal and external construction material that was salvaged from the site.

Note: *The large number of individual roof systems comprised of flat and gable pitch roofs represent the ongoing process of renovations, alterations and expansions that the property and buildings shared over its 45 year history. The gable roofs were constructed of truss assemblies, with large clear spans in the main building. These incorporated a number of different vintage style metal plate connectors (MPC) for the fastening method on truss webs and chords. This was in contrast to the lap-nailed truss assembly found in the roof assembly of the restaurant occupancy.*

The restaurant's perimeter wall (resulting secondary collapse) is visible with the underside of the roof decking and the remnants of roof truss bottom cords. The edge of the roofing tiles can be seen along upper lateral roof edge. (**See Photo 1.**)

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Photo 1. View of Division Alpha Perimeter Wall & Lean-To Roof Collapse
(*Fire Department Photo/ Diagram Courtesy of Buildingsonfire.com)*

[1] Roof Sheathing-underside
[2] Edge of Roof Truss Bottom Cords (24 inch on-center)
[3] Edge of Roofing Tiles
[4] Charring from flame impingement
[5] Restaurant Perimeter wall
[6] Secondary Collapse Management Zone (SCMZ)

Concrete Tile Roofing System
An extruded concrete interlocking roof tile system was installed over the existing roofing surface and deck that comprised the restaurant roof. This was a similar tile system that was installed on both the large entry portico and the main entrance/lobby gable roof. The extruded concrete roof tiles are interlocking elements having the dimensions and configurations shown in the accompanying table and figures. Accessory tile units are available for ridge, hip and gable areas. The regular-weight tiles are composed of Portland cement and selected sand aggregates. The mix proportions are accurately maintained to ensure tile production in accordance with the specifications. Anchor lugs, located on the

underside of the tiles overlap wood battens fastened to the roof deck or surface for anchorage in the plane of the roof. Holes are provided in each tile for fastening where required by the installation.

Interlocking ribs are provided on the longitudinal edges of the tiles to restrict lateral movement and provide a water stop. In addition, transverse bars are provided on the underside to serve as weather checks. Mineral coloring oxides are either applied to the exposed surface in a cementitious material or mixed integrally with the tile mix to produce a through-colored product. Concrete interlocking roof tile profiles and details are provided based on technical literature. [10, 11, 12] (**See Photo 2 and Diagram 3**.)

Photo 2. Concrete Roofing Tiles - Post Fire
(NIOSH Photograph)

Due to the absence of historical construction records and specifications, the roofing tile was identified based on the roofing tile manufacturer imprint. This is typically found on the underside of each tile unit. A likely tile unit style was identified, which is consistent with the figures developed and specifications.

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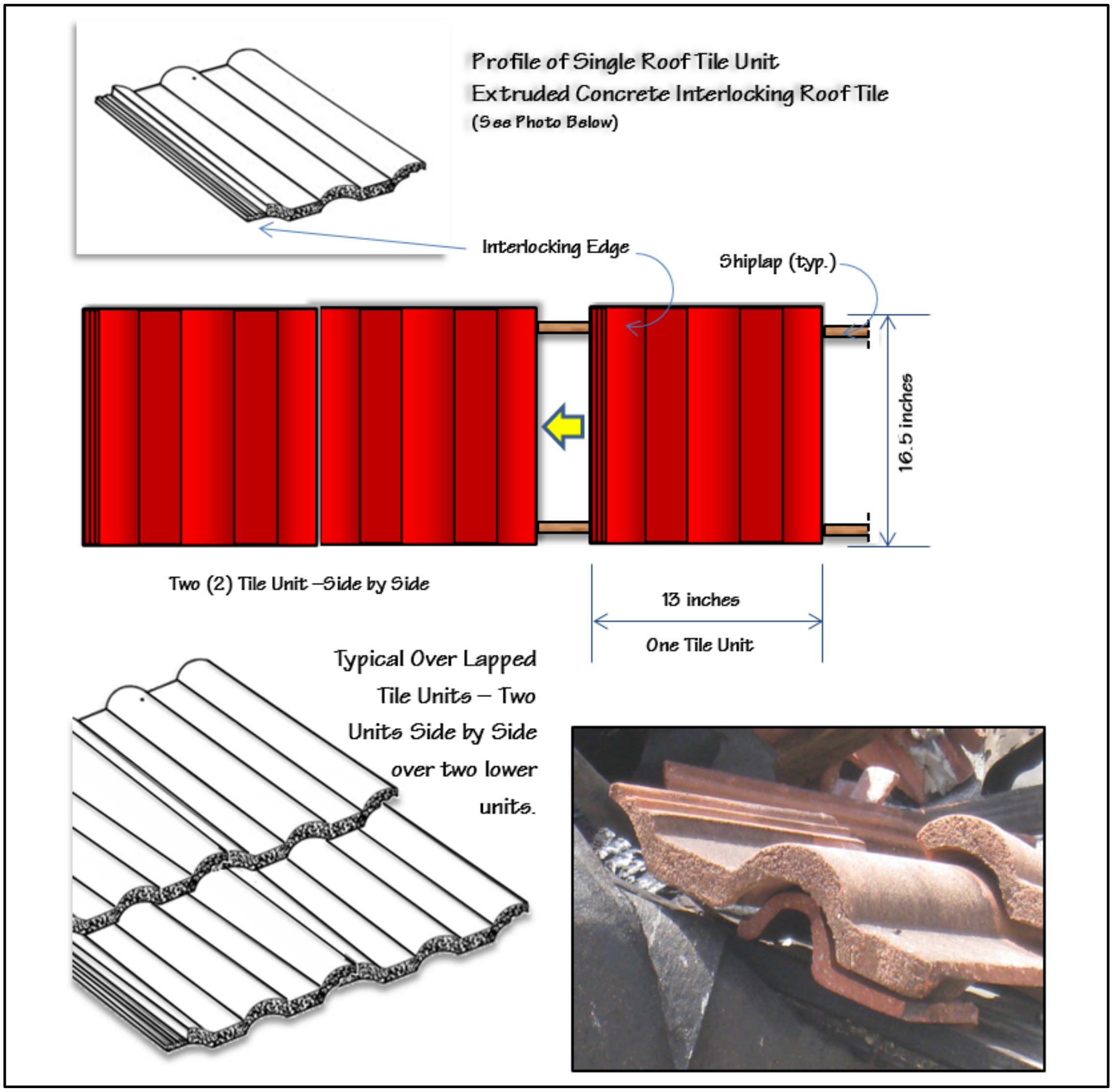

Diagram 3. The concrete roofing tile details which were on Side Alpha of the Small Banquet Room.
(Photo: NIOSH/ Diagrams Courtesy of Buildingsonfire.com)

It is highly probable the exiting extruded concrete interlocking roof tiles present on the roof assembly consisted of Roma Style, regular-weight tiles. The individual tile units measured 16.5-inches in length x 13-inches in width x 2-inches in height. The single unit installed weight was 9.3 pounds per square foot (psf.).[10]

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This weight is in slight contrast to the weight identified in the independent structural engineering firm's report that indicated a weight of 10.8 psf. For the purpose of this report, calculations and discussions related to roof tile weights area based on 10.8 psf.

The use of extruded concrete interlocking roof tiles is a common architectural treatment and is ubiquitous to a number of geographical areas in the United States. These roof tiles can be found anywhere in the regional and local level due to the component's popularity and consumer demands. It could be expected to be found on residential, commercial, and retails occupancies.

The presence of extruded concrete roof tiles presents significant increased dead loading to a roof diagram and structural system. This places additional dynamics to the roof system based on day to day performance that can also be affected by age, time, exposure, and ambient temperature gradients within the truss loft compartment-attic area. Research has shown that extended duration of time (years), duration of load for longtime truss performance, and the effects of elevated temperatures within the truss loft space suggest quantifiable structural wood member strength loss. This includes for both tension and compression that affect overall system performance in both pre-incident and during fireground operations for projected or actual fire exposures .[13, 14, 15]

Based on initial engineering reviews, and subsequent analysis the following insights are provided on the exiting restaurant roof;

• Plywood Roof Deck	1.00 lbs. psf.
• Existing Shingles	2.70 lbs. psf.
• Asphalt Felt Rolls	0.40 lbs. psf.
• Wood Shiplap	2.30 lbs. psf.
• Concrete Roof Tiles	10.80 lbs. psf.
Total	**17.20 lbs. psf.**

- **Roof System with Extruded Concrete Tiles at 17.20 lbs. psf. @1280 SF = 22,016 lbs. load**
- **Roof System with Shingles only (No Tiles) at 4.10 lbs. psf. @1280 SF = 5,248 lbs. load**
  (Adding roofing tiles increases roof load by 13.1 lbs. psf. resulting in a 76.2% increase)

Collapse Predictions:
A roof and structural support system when insulted by heat and fire impingement, exposure and wood consumption will degrade and have overall structural integrity and load-carrying capacity weakened in a relative time frame under different load factors. Given relatively similar variables such as roof foot print, volume, structural support and fire intensity:

- The heavier the load; the higher probability for a decreased time-to-collapse window during the conduct of fireground operations.
- A lighter roof system (total pounds per square foot) with a clear span will likely fail in a compromising fashion resulting in a probable isolated compromise (sagging or bending) collapse configuration. (Based on integrity of the bottom chord and degree of web weakening)
- A roof system with a significant overall load (total pounds per square foot) with a clear span will likely fail in a catastrophic collapse configuration in a shorter time span.

- Small foot print (square foot), open span roofs comprised of a variation of structural systems: conventional, engineered and materials: wood, non-combustible, steel etc., have typically failed in catastrophic manner due to the loss of structural resiliency, redundancy, load carrying and transfer capacity and loss of diagram or deck integrity. [16, 17, 18, 19]

Fire Performance Characteristics of Wood and Fire Impingement

Wood will burn when exposed to heat and air. Thermal degradation of wood occurs in stages. The degradation process and the exact products of thermal degradation depend upon the rate of heating as well as the temperatures. This concept has direct relevancy to the sequence of events at the complex and the suggested impact on the roof compromise and collapse. The sequence of events for wood combustion is as follows:

- The wood, responding to heating, decomposes or pyrolyzes into volatiles and char. Char is the dominant product at internal temperatures less than 572°F (300°C), whereas volatiles become much more pronounced above 572°F.
- The volatiles, some of which are flammable, can be ignited if the volatile–air mixture is of the right composition in a temperature range of about 752°F to 932°CF (400°C to 500°C) within the mixture. This gas-phase combustion appears as flames.
- With air ventilation, the char oxidation becomes significant around 392°CF (200°C) with two peaks in intensity reported at 680°F and 968°F (360°C and 520°C). This char oxidation is seen as glowing or smoldering combustion until only ash residue remains. This solid-phase combustion will not proceed if flaming combustion prevents a supply of fresh air to the char surfaces.

Several characteristics are used to quantify this burning behavior of wood, including ignition from heat sources, growing rate of heat release leading to room flashover, flame spread in heated environments, smoke and toxic gases, flashover, and charring rates in a contained room. [8, 13, 20, 21, 22] Ignition of wood takes place when wood is subject to sufficient heat and within compartment atmospheres that have sufficient oxygen. Ignition can be of two types: piloted or unpiloted.

- *Piloted ignition* occurs in the presence of an ignition source (such as a spark or a flame).
- *Unpiloted ignition* is ignition that occurs where no pilot source is available. The wood surface is ignited by the flow of energy or heat flux from a fire or other heated objects. This flow of energy or heat flux can have both convective and radiative components.
- The surface temperature of wood materials has been measured somewhere between 572°F and 752°F (300°C to 400°C) prior to piloted ignition.

Surface temperature at ignition is an elusive quantity that is experimentally difficult to obtain. From such tests, values of ignition temperature, critical ignition flux (heat flux below which ignition would not occur), and thermo-physical properties have been derived using a transient heat conduction theory. These properties are material dependent; they depend heavily on density of the material and moisture content. A range of wood products tested have ignition surface temperatures of 572°F and 752°F (300°C to 400°C) and a critical ignition flux of between 10 and 13 kW/m2 in the cone calorimeter. The ignition surface temperature is lower for low density woods.

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The Southern Yellow Pine wood used in the truss assembly has a 130 - 195 *Flame Spread Index* (FSI) in accordance with Underwriters Laboratories (UL) and a Char Contraction Factor of 0.60 (wood exposed to ASTM E119 exposure) and an average mass loss rate (g m^2 s^1) of 3.8 and 8.6 for exposure to a constant heat flux of 18 kW m^2 and 55 kW m^2 respectively. This is based on an initial moisture content of 8-9%. The "Char Contraction Factor" is the thickness of the char layer at end of fire exposure divided by the original thickness of charred wood layer (char depth).[23]

Heat Release Rate (HRR) is the rate at which fire releases energy - this is known as power. HRR is measured in units of Watts (W), which is an International System unit equal to one Joule per second. Depending on the size of the fire, HRR is measured in Kilowatts (equal to 1,000 Watts) or Megawatts (equal 1,000,000 Watts). Heat Flux is the rate of heat energy transferred per surface unit area - kW/m2:

- 2.5 kW/ m^2: Typical firefighter exposure
- 3-5 kW/ m^2: Pain to skin within seconds
- 20 kW/ m^2: Threshold flux to floor at flashover
- *84 kW/ m^2: Thermal Protective Performance (TPP) Test (NFPA 1971)*
- 60 - 200 kW/m^2: Flames over surface

Select wood construction systems and members have long been recognized for their ability to maintain structural integrity while exposed to fire. This is attributed to the charring effect of wood. As wood members are exposed to fire, an insulating layer is formed that protects the core of the section. Fire exposure and resistance are defined in both ASTM E119 and internationally in ISO 834.[20] The concept of wood charring, fire resistance and building integrity are rooted in heavy timber, mill and semi-mill construction.[24]

The importance of understanding the principle of charring, the potential for reduction in a wood material's cross section, considerations for fire impingement, exposure, fire duration, intensity and the material compositions, characteristics, age, physical properties and the construction system(s) utilized are important fireground factors. These factors must be understood, recognized and considered during fire operations in buildings with heritage, legacy, conventional, or engineered structural system or wood frame components.

Important factors for fire officers and fire fighters.

- This understanding and correlation is fundamental to the impact of fire to the wood truss loft of the restaurant occupancy of the complex.
- Given the suggested timeline of events and the prolonged elapsed time from the first notice of a burning odor to the time in which both smoke and flames were self-revealing, it is highly probable a smoldering condition was present within the truss-loft compartment. This condition may have led to the exposed wood truss components (chords and webs) responding to heating, decomposition and pyrolyzes into volatiles and char.
- Sufficient oxygen is introduced and air ventilation in the compartment space
- The wood components ultimately ignite and the sustained fire grows in intensity, severity and direct and scale.

- The loss of wood cross-section (mass) continued both in the smoldering phase and fire growth phase leading to the loss of redundancy capabilities of the truss assembly, possible buckling and excessive deflection of truss members. [8, 9, 25] **(See Diagrams 4, 5, 6, and 7**.)
  - Soft wood pyrolysis and charring = 1 inch per 40-45 minutes at 1400°F to 1600°F
  - 1.5 inches per 60 minutes
  - 0.9 mm per minute
- Complete loss of wood cross-section due to flame impingement results in structural compromise of the truss component to perform as designed to carry and transfer loads. Uneven deterioration or burn thru of webs (loss of tension and compression) and the possible loss of the bottom chord's stability would lead to structural compromise.
- If the roof diaphragm and compromised trusses continue to be affected by degradation, then the significant dead load from the extruded concrete roof tiles would hasten the time to collapse. The potential for monolithic and catastrophic collapse would impact the entire roof.
- The surface to mass ratio of the exposed wood truss members with the increased surface area results in increased consumption and degradation of the wood, leading to decreased cross sectional dimensions and decreased load-bearing capacity of the structural components. [8, 9, 21] (**See Diagram 4.**)
- The configured lap-nailed wood truss system utilizes nails (versus metal plate connected) as the mechanical fastener to secure the truss components together in an assembly to provide structural support as a configured truss component.
  - There is little accessible research or case studies that provide insights as to performance and structural integrity of lap-nailed wood truss systems that could be correlated to this incident.
  - The unique truss system coupled with the significant load presented by the tile roof suggests and the mechanics of the roof collapse presents questions that cannot be ascertained with present data or information.

Connections are arguably the most important part of a light-frame wood structure. They hold structural components together and transfer forces from one to another. The response of nail connections under applied loads is normally non-linear and is dependent on various factors such as moisture content, wood species, load direction and fastening geometry and configuration.[26]

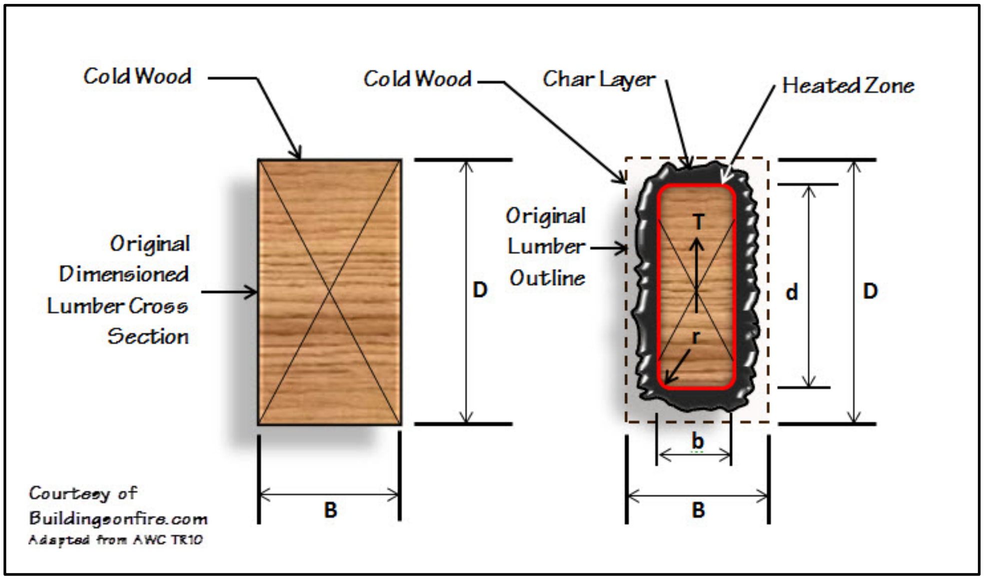

Diagram 4. Reduction in Wood Component Breadth and Depth over time,
(Diagram Courtesy of Buildingsonfire.com)
[Adapted from AWC Technical Report #10 (2012)]

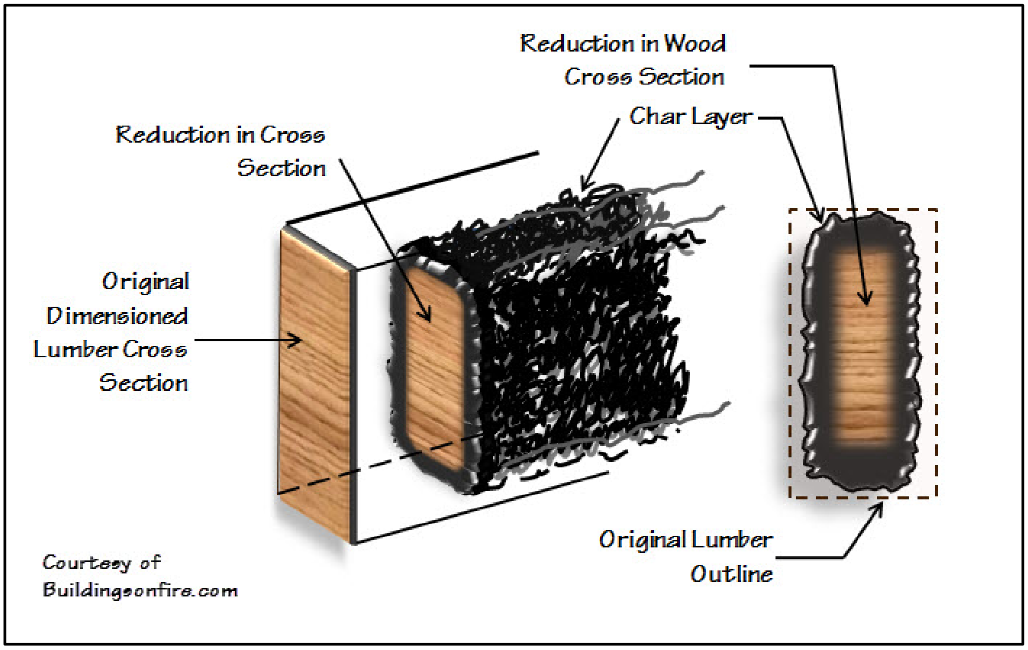

Diagram 5. Charring Effect on Wood Component and Cross Section
(Diagram Courtesy of Buildingsonfire.com)

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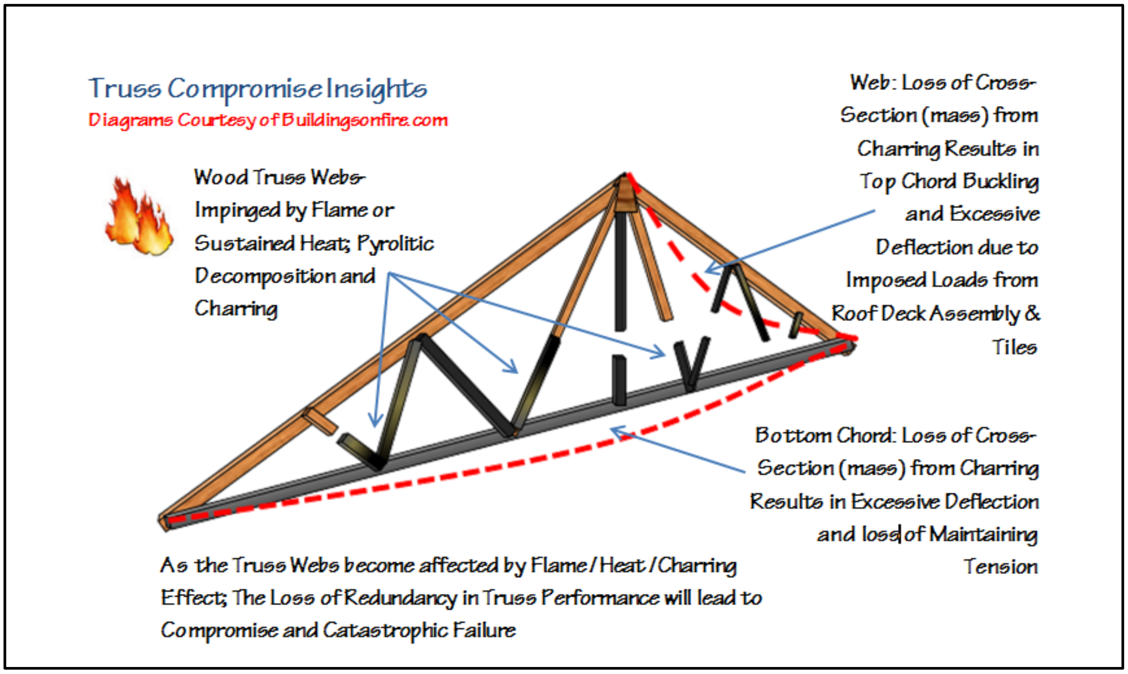

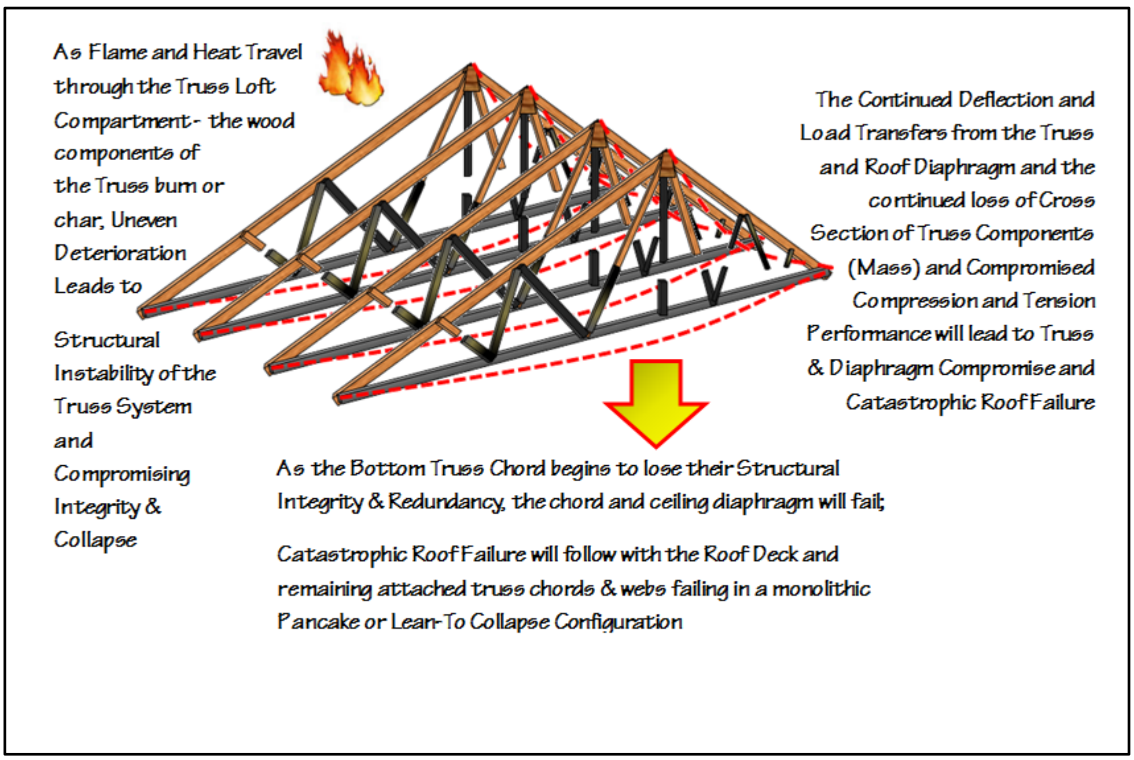

Diagrams 6 and 7. Anatomy of a Truss - Assembly Compromise and Collapse
(Diagram Courtesy of Buildingsonfire.com)

Other Collapse Contributors

- Age of the roof system and loss of moisture content and susceptibly to heat and ignition sources and lack of resistance and resiliency to impingement and exposure; vulnerability of truss web members to flame spread based on age and FSI of the wood species. The degree of time (years) the roof system has imposed loading with the effects of wood fatigue and resiliency. [9, 21, 23, 26]
- Based on the postulated mechanism of collapse and the resulting lean-to collapse configuration of the partial roof diaphragm along the Alpha Division (North perimeter wall), the condition of post-fire truss components likely generated uneven burning and increased structural compromise of the truss components occurred along the south perimeter or area of the restaurant roof than did along the north perimeter.
- This increased level of deterioration and/or loss of web performance or materials (due to fire) would cause the wood truss to fold in on its self-downward, and forward toward the front perimeter wall. This series of structural compromise and failure results in a mechanism of collapse that pulls and deflects the roof diaphragm downward, bucking remaining truss components with momentum that results in a pancake collapse of the southern roof deck from the ridge to the south eave line and a lean-to collapse of the roof deck from the ridge to the north eave line. (**See Diagrams 8, 9, 10, and 11.)**
- The effects of fire and the impact on structural stability of wood truss components and collapse timelines has been researched in two distinguished research studies.[19, 27, 28] It should be noted both referenced studies involved initial compartment fires below the ceiling membrane.

Additional information on Building Construction related to this incident is provided in **Appendix One: Additional Building Information** and **Appendix Two: Fire Fighter Risk Profile and Insights**.

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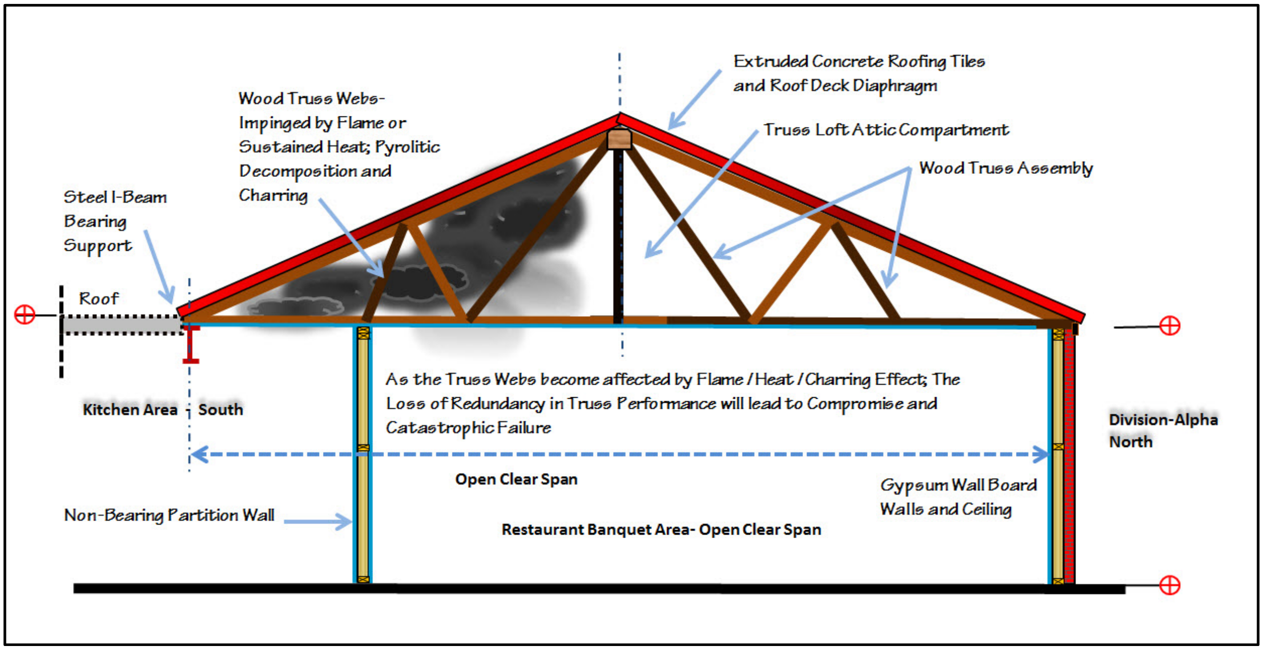

Diagram 8. Anatomy of the Restaurant Roof Collapse
(Diagram Courtesy of Buildingsonfire.com)

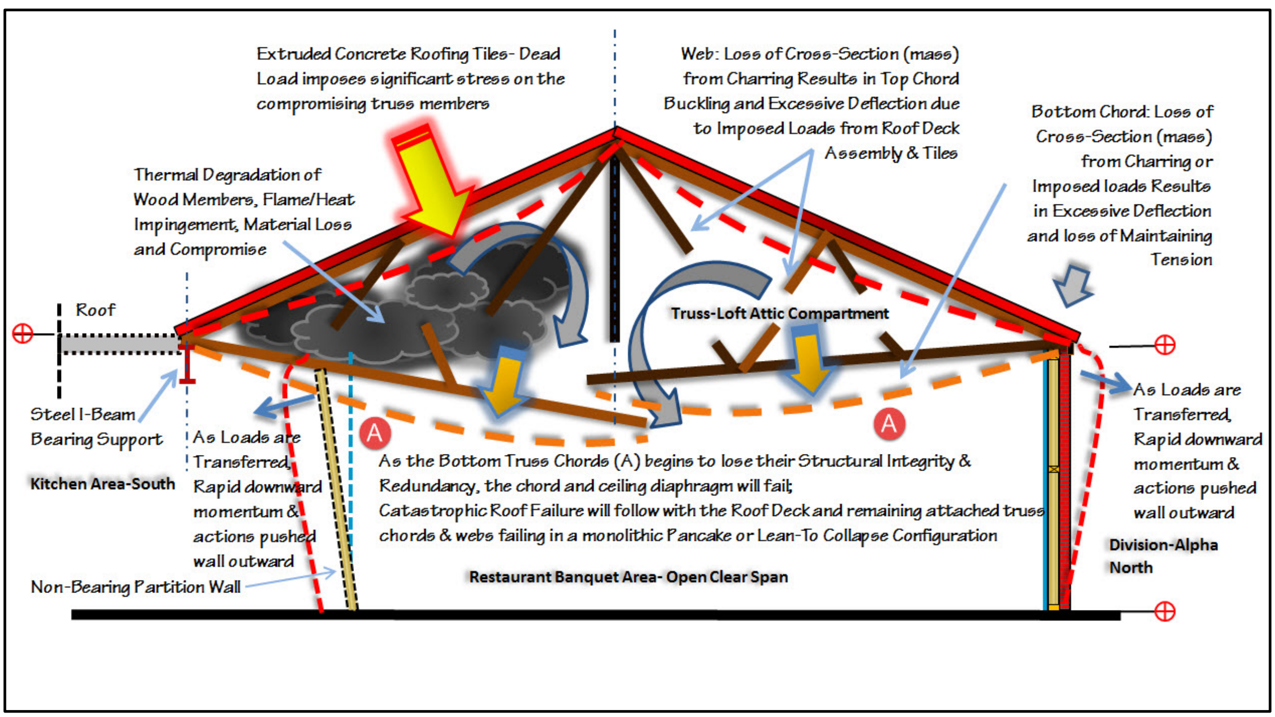

Diagram 9. Anatomy of the Restaurant Roof Collapse
(Diagram Courtesy of Buildingsonfire.com)

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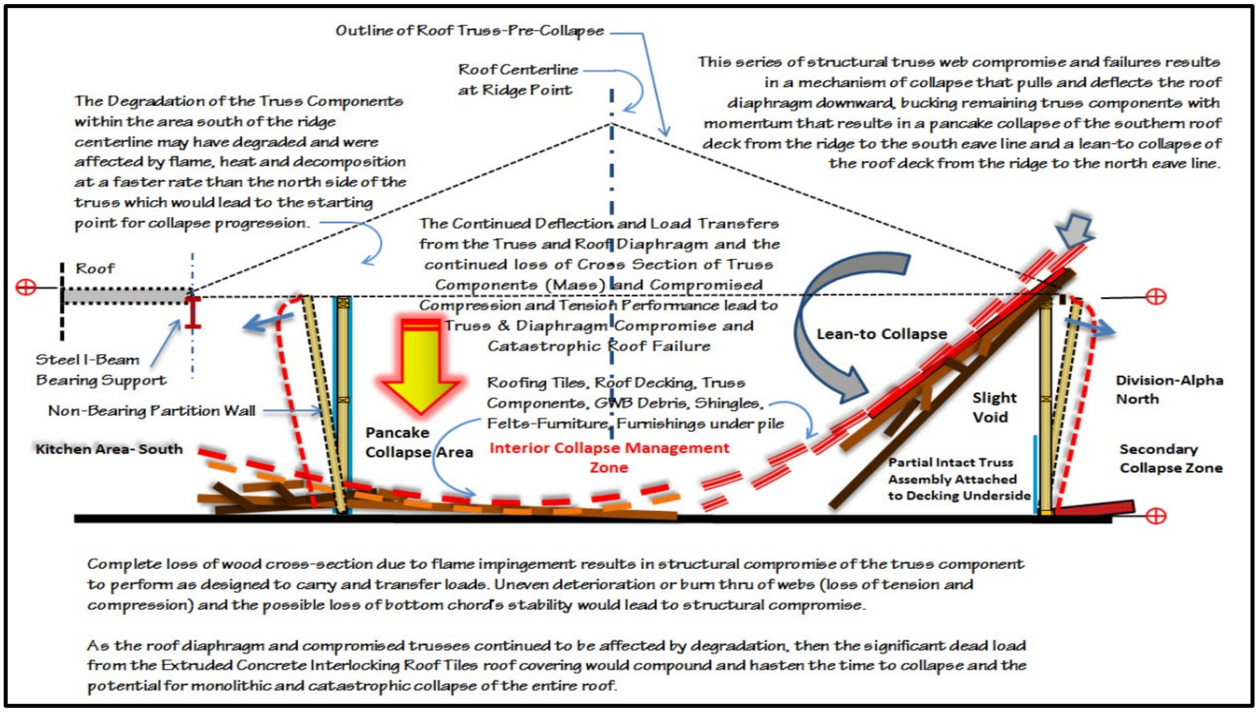

Diagram 10. Anatomy of the Restaurant Roof Collapse
(Diagram Courtesy of Buildingsonfire.com)

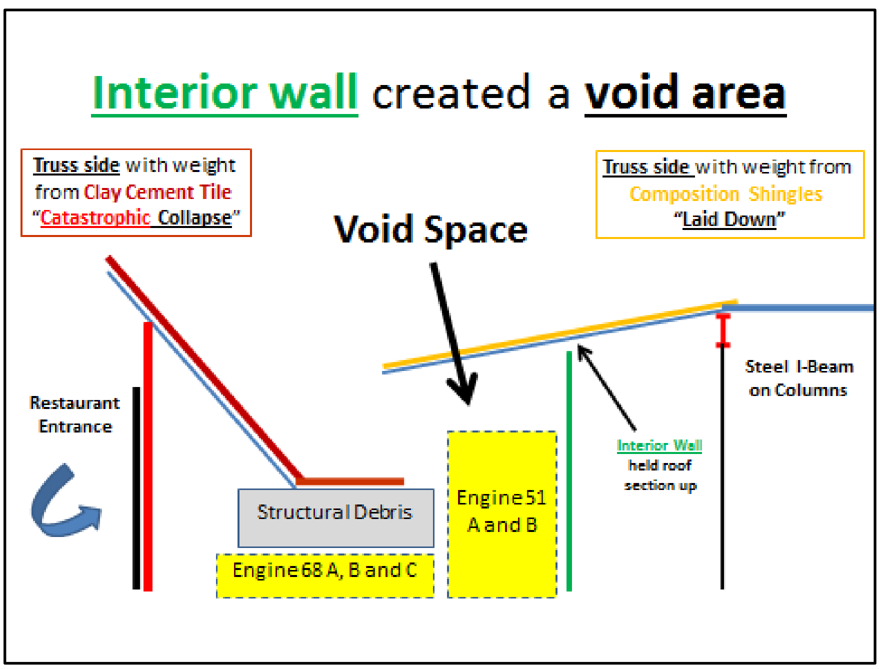

Diagram 11. When the collapse of the roof occurred, it formed a void area trapping fire fighters from E51 and E68
(Diagram courtesy of the fire department)

Secondary Collapse of Perimeter Wall

Perimeter wall areas that have wall penetrations in the form of windows, doorways, openings for service equipment such as wall mounted heating, ventilation, and air conditioning (HVAC), or mechanical equipment are highly susceptible to compromise and collapse when structural load transfers occur.

At 1303 hours, during the search and rescue operations for the trapped fire fighters, a secondary collapse occurred on the exterior side of the building on Division Alpha. The resulting collapse of the entire roof deck diaphragm and structural support system plus the dynamic downward and lateral momentum and movement of the roof system resulted in an outward bowing and push-out of the north perimeter wall. The greatest risk of collapse in the immediate area was between the north entrance door and the wall area between the two exiting windows. The decking, north of the ridge centerline, came downward in a more monolithic and intact manner than that of the south roof deck surface. It was reported the entire roof along the centerline of the peak came downward in a monolithic manner, with the resulting impact on the floor in a pre-dominate pancake configured collapse. (**See Photo 3.)**

The roof deck came to rest in a slight lean-to configuration creating lateral forces acting upon the outer (north) perimeter wall. This degraded the integrity of the gypsum wall board and wood stud frame wall and caused cracking along the outer wall. Since the primary entry point to the interior of the restaurant was located on the Side Alpha, this was the entry point for the initial handline taken in the building.

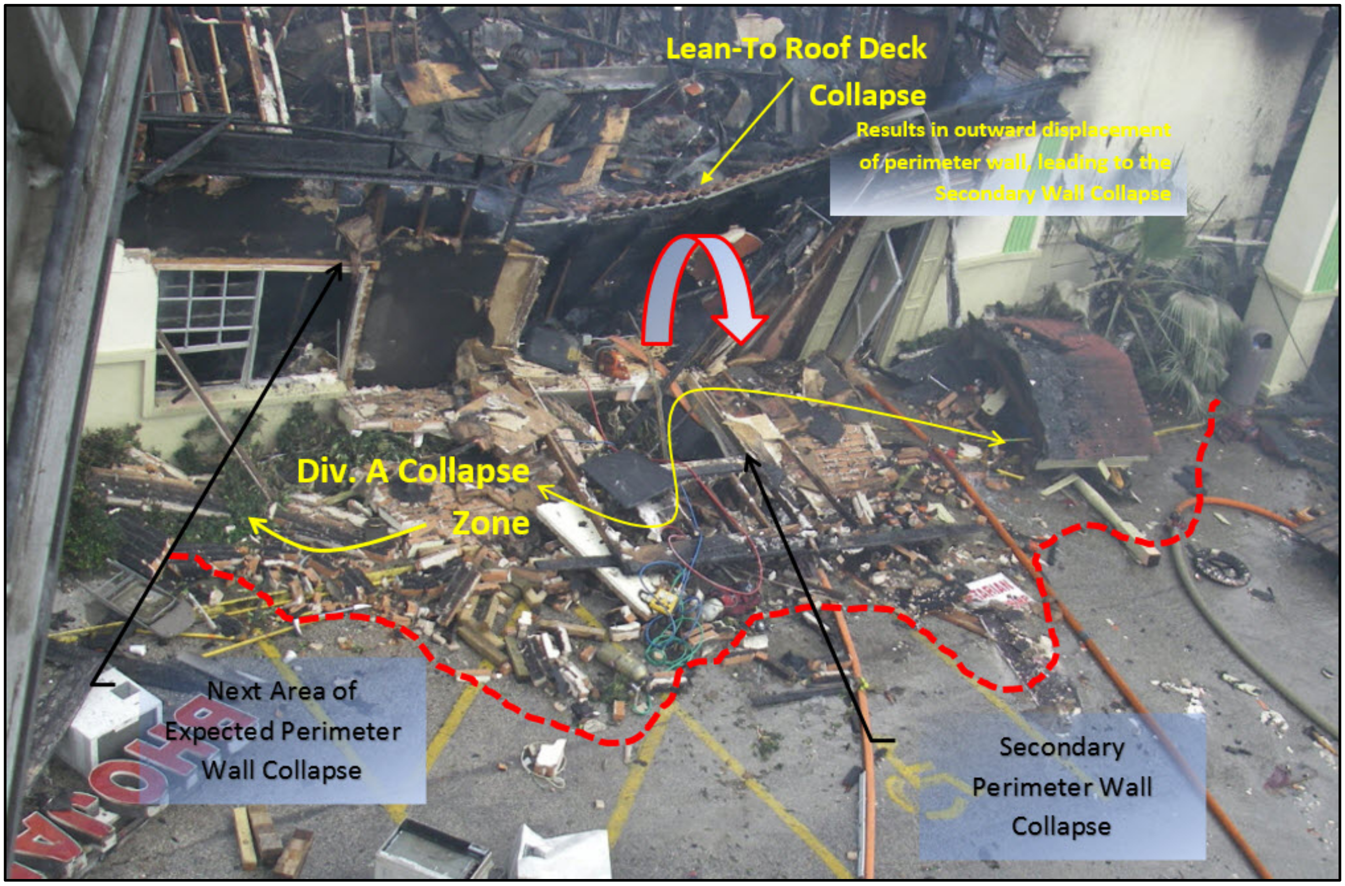

Photo 3. Details of the secondary collapse on Side Alpha.
(Photo courtesy of the fire department/Analysis Diagram Courtesy of Buildingsonfire.com)

Fire Behavior and Extension

The department's Arson Bureau determined that the fire started three hours prior to the 9-1-1 call at 1205 hours on May 31, 2013. During that time the fire had a chance to spread into the area above the first floor. There was an office and open area on the second floor of the hotel. The open void space was accessible through the 2nd floor office. This area went from Side Bravo to Side Delta or at least to the Sports Bar. The ATF agents interviewed maintenance workers that had performed work and had accessed this area. This open void space provided an avenue for fire spread. (**See Photo 4.)**

Photo 4. The arrows indicate the support system for the 2nd floor and void space above the restaurant and lobby area of the motel.
(Photo courtesy of the fire department)

Personal Protective Equipment

At this incident, each officer and fire fighter were wearing a station/work uniform, turnout pants, turnout coat, hood, helmet, boots and a self-contained breathing apparatus (SCBA) with integrated personal alert safety system (PASS) meeting current NFPA requirements. Each SCBA is equipped with a TPASS, which is a two-way personal alert safety system (PASS) that transmits alarms and receives evacuation signals.

NIOSH investigators inspected and photographed the officer and each fire fighter's personal protective equipment at the Arson Division office. The SCBA and turnout gear inspected had sustained a variety of thermal damage as the result of the exposure to the fire and damage from the collapse in the restaurant. Four SCBA units were shipped to the NIOSH National Personal Protection Technology Laboratory (NPPTL) in Pittsburgh, Pennsylvania for evaluation.

On February 20, 2014, NPPTL personnel in Pittsburgh evaluated the SCBA and the summary evaluation report is included as **Appendix Three: Summary of Personal Protective Equipment Evaluation – SCBA**.

On January 30, 2014, an independent contractor inspected and evaluated the personal protective equipment (PPE). The independent contractor was retained by the fire department. The summary evaluation report is included as **Appendix Four: Summary of Personal Protective Equipment Evaluation – Fire Fighter Protective Ensemble**.

The TPASS system was shipped back to the manufacturer for testing and evaluation. Due to a problem with the unit's battery, no information could be downloaded.

Weather Conditions

At 1153 hours, the temperature was 86 degrees Fahrenheit (86° F), the humidity was at 65%, the barometric pressure was 29.92 inches, visibility was 10 miles, the wind was from the South at 13.8 miles per hour, with gusts to 23 miles per hour and there were scattered clouds. There had been no precipitation in the past 24 hours.[29]

Wind-Driven Fire

During this investigation, NIOSH Investigators determined, through interviews and discussion with the chairman and members of the department's Recovery Committee, that a higher than normal wind speed had occurred on this date. A determination was made that this was a contributing factor to the spread and difficulties faced by the fire department at this fire.

The front of the building (Side Alpha) faced northwest. Engine 51 arrived on scene and entered the restaurant through the front door of the restaurant, which was the northwest side. This entry point would become Division Alpha. It is believed that the wind coming from the southwest at a constant speed of 17+ miles per hour (MPH) and gusting to 23+ MPH clearly affected the tactics that took place at the beginning of the fire. Another theory is that the high-rise structure (commercial hotel) located to the southwest of the fire building also created a wind break. This in turn forced high wind patterns to be channeled around both sides of the structure. The wind then funneled down towards the hotel directly into Division Charlie.

The National Institute of Standards and Technology (NIST) has conducted research and testing on the impact of wind-driven fires and fireground operations. Adjusting fire-fighting tactics to account for wind conditions in structural fire-fighting is critical to enhancing the safety and the effectiveness of fire fighters. Studies have demonstrated that applying water from the exterior, into the upwind side of the structure can have a significant impact on controlling the fire prior to beginning interior operations. It should be made clear that in a wind-driven fire, it is most important to use the wind to your advantage and attack the fire from the upwind side of the structure, especially if the upwind side is the burned side. Interior operations needs to be aware of the potential for rapidly changing conditions.[30]

During the initial attack, and well into the rescue, the direction of these strong winds made Division Charlie the intake side of the structure and placed Division Alpha as the exhaust point. The smoke was blowing across the fireground vertically limiting the visibility of members conducting fire attack, ventilation, and rescue. Crews were faced with extreme heat and smoke conditions that would continue to increase and hamper their efforts. (**See Photo 5**.)

Photo 5. The smoke conditions encountered by the 1st Alarm companies. This picture is looking north on the feeder road and the freeway. E82 is parked on the shoulder of the freeway and Rescue 10 is on scene. The time is approximately 1224 hours.
(Photo courtesy of the fire department)

Investigation

On Friday, May 31, 2013, at 1205 hours, the first 9-1-1 telephone call was made to the city's Office of Emergency Communications (OEC) (9-1-1 Call Center) reporting a fire in a restaurant. The OEC would receive 16 more calls reporting this structure fire.

At 1207 hours, the Office of Emergency Communications dispatched District 68, District 28, Engine 51, Engine 68, Engine 60, Engine 82, Ladder 68, Ladder 69, Safety 57, and Medic 10 for a report of a restaurant fire. ***Note:*** *The engineer/operator from Ladder 51 was detailed to Engine 51 and assigned as E51B. Ladder 51 was assigned to a meeting and the engineer/operator switched with a fire fighter on E51*. Several companies reported dark gray and brown smoke showing while enroute. At 1210 hours, District 68 requested a 1-11 (working fire dispatch) for the incident due to the heavy smoke showing from the structure. (**See Photo 5.**)

Engine 51 arrived on scene at 1211 hours and the captain stated, "We got a one story restaurant; we got heavy smoke showing from the attic of the restaurant; we'll be going in making an offensive attack; we'll be pulling a 2½-inch attack line." E51 originally pulled into the parking lot near Side Delta upon arrival. E51was then directed by an employee to move towards the restaurant Side Alpha. The crew from E51 pulled a 2½-inch pre-connect from the rear of E51. The hoseline was charged using water from the E51's booster tank (750 gallons). D68 ordered Engine 68 to lay dual 4" supply lines from E51 to the hydrant. The hydrant which E68 used was located on the feeder road northwest of the restaurant near a moving and storage facility.

At 1213 hours, District 68 arrived on scene and assumed "Command". OEC advised "Command" that 1-11 companies would be District 21 (D21), Engine 48 (E48), Ladder 33 (L33) and Heavy Rescue 11 (HR11). At 1214 hours, District 28 (D28) and Ladder 68 (L68) arrived on scene. D28 contacted "Command" about L68 wanting to cut a vent hole on Side Delta of the building. "Command" instructed D28 not to cut a vent hole until the fire was located. "Command" assigned D28 as "Alpha Division". At 1215 hours, the captain from E51 began to make entry with two fire fighters from E51 with a charged 2½-inch handline. The captain advised "Command" of "a thermal imager reading of 184ºF at the door before entering the structure." At 1216 hours, Ladder 51 (L51) was added to the incident record and responded. "Command" asked Alpha Division if the restaurant was attached to the motel and the response was "Yes". At 1217 hours, "Command" contacted L68 about cutting a ventilation hole in the roof between the restaurant and the motel. This communication was not acknowledged for almost two minutes.

At 1218 hours, Engine 82 (E82) arrived on scene and requested an assignment. Also, Rescue 10 (R10) was added to the incident record and responded. "Command" ordered Engine 60 to be the rapid intervention team (RIT). E82 again tried to contact "Command" by radio about an assignment. The officer from E82 did a face-to-face with "Command" about an assignment and was told to assist E51 with fire attack. The engineer/operator of E51 (E51D) advised the captain of E51 (E51A) that E51 has less than a quarter tank of water. "Command" ordered E51 to back out of the building until a water supply could be established. **Note:** *During the interview with the fire fighter from E51 (E51C),* *he described conditions inside the building. He stated it was very difficult to move in the banquet room due to the tile floor being wet from condensation and water from the hoseline.*

"Command" contacted OEC and requested a 2-11 (2nd Alarm) for this incident. At 1219 hours, OEC dispatched District 59, District 5, Engine 28, Engine 2, Engine 16, Engine 59, Ladder 21, Automatic Aid Ladder 1(a truck company from a municipality located within this city), Rescue 42, Safety 30, Rehab 17, and Shift Commander 37 (South Command). "Command" acknowledged the dispatch of the 2-11. E68 contacted "Command" for an assignment. At 1220 hours, E51A contacted "Command" and advised that E51 would re-enter the building. "Command" acknowledged E51A and advised that E82 would be assisting E51 with fire attack. (**See Diagram 12.**) E68A attempted to contact "Command" again for an assignment. "Command advised E68A to assist E51 with fire attack and E68A acknowledged the assignment. At 1221 hours "Command" contacted E60 to confirm that E60 had assumed RIT and E60A confirms the assignment. Also, L69 and E48 arrived on scene.

Due to the heavy smoke conditions, "Command" contacted E51A and asked which side of the building they entered. E51A advised "Command" that E51 had entered on Side Alpha. At 1222 hours, "Command" contacted Alpha Division (D28) and advised him to remain on Side Alpha of the building. "Command" asked if he had E51, E82, and E68 operating in Alpha Division? Alpha Division reported back to "Command" that E68, E82, and E51 were in Alpha Division. Alpha Division advised there was heavy fire showing from Side Bravo and entry was made into the building on Side Alpha.

At 1223 hours, E82A reported to "Command" "that a roof collapse had occurred and there was a "Mayday" with E51 inside. E82A repeated "E82 "Mayday" "Mayday"". "Command" immediately requested a 3-11 (3rd Alarm) for the restaurant fire. OEC immediately dispatched: District 8, District 46, Engine 33, Engine 38, Engine 49, Engine 5, Ladder 28, Ladder 16, and EMS11 for the 3-11.

The time from dispatch of this incident until the roof collapsed was 15 minutes and 29 seconds. E51 arrived on scene at 12:11:25 and the roof collapse occurred at 12:23:24, which was 11 minutes and 59 seconds.

At 1224 hours, "Command" radioed for all companies to evacuate the building due to a "Mayday" in progress. OEC also announced the following message, ""Mayday", a "Mayday" has been called; all units sound your air horns for 30 seconds." OEC announced, "All units need an immediate PAR, all units need an immediate PAR." "Command" called E51 and asked if they could provide a location. "Command" assigned E48 to RIT and advised Alpha Division. At 1225 hours, "Command" (District 68) announced, ""Command" to all companies, we're in Rescue Mode. We have a "Mayday" at our location, RIT companies can you give me any information." At 1226 hours, Alpha Division reported that "the crews" were just inside the front door and Engine 60 was inside looking for E51 and E82. At 1227 hours, Alpha Division reported that the RIT couldn't access the area where E51 was thought to be located through the front door. RIT crews tried to gain access through the two front windows. Engine 28 and Rescue 10 arrived on scene. "Command" assigned R10 to Alpha Division to assist with RIT operations. The Accountability Officer attempted to contact E51, E60, and E68 by ordering them to "check PAR".

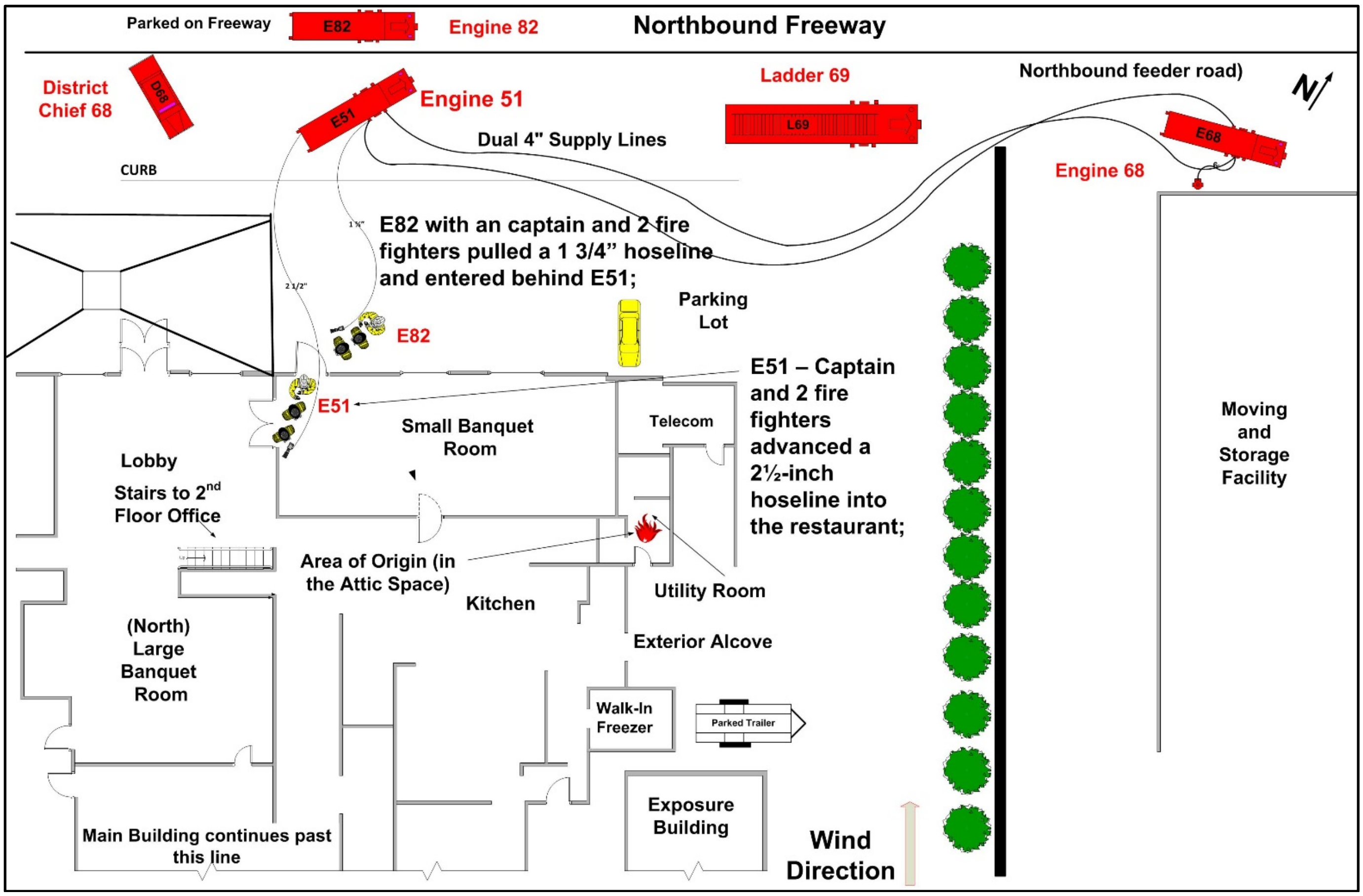

Diagram 12. The initial fire attack by the crews of Engine 51 and Engine 82. The time is approximately 1215 hours.

At 1228 hours, E82 reported to "Command" that they were out of the building and were not the ones trapped. E82A reported that he didn't know where E51 was located. After about 45 seconds, E82A then advised "Command" that E51 was located inside the front door of Side Alpha and to the left of the doorway. (**See Diagram 13**.) At 1229 hours, Alpha Division requested two additional companies to assist with RIT operations. At 1230 hours, Safety 57 (SF57) arrived on scene and requested that "Command" contact the power company to secure the power to the building. "Command" reported, "the "Mayday" would stay on the current channel and the Main Command should go to another channel." District 68 announced" D68 would stay on Tac Channel 11 with the "Mayday" companies (*designated as Rescue Operations Section*). ***Note:*** *The proper ICS term is Rescue Group Supervisor*. "Command" called District 21 (D21) and ordered him to go to another Tac Channel and assume "Command" of the fire". OEC advised "Command" companies should use Tac Channel 12 for the incident and the "Mayday" should stay on Tac Channel 11. At 1231 hours, the *Rescue Group Supervisor* (*using the designation "Command"*) requested a 4-11 assignment (4th Alarm). OEC dispatched District 6, District 4, Engine 73, Engine 7, Engine 508, Engine 8, Ladder 59, and Ladder 38. Heavy Rescue 11 reported on scene at 1231 hours.

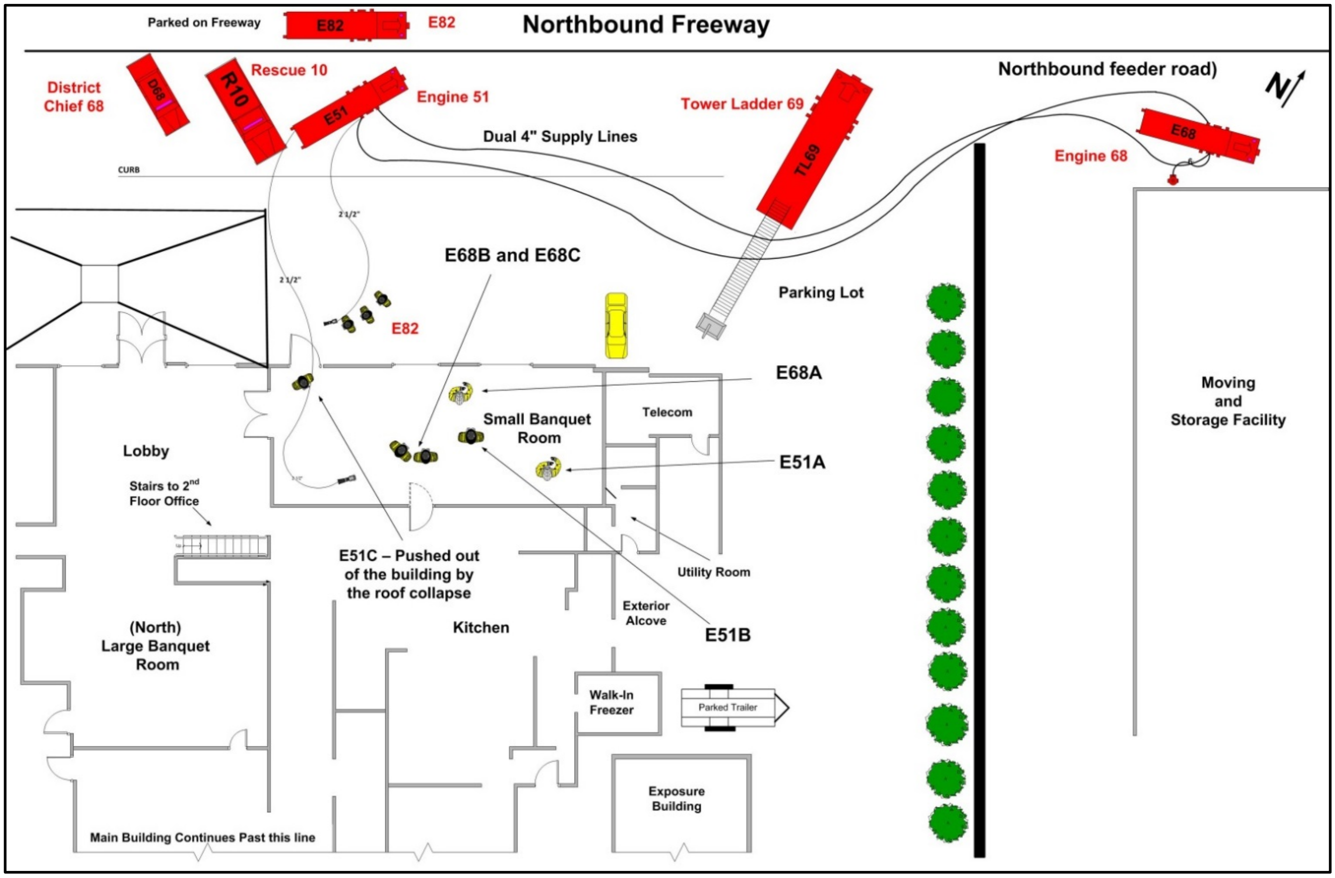

Diagram 13. The location of the officers and fire fighters of Engine 51 and Engine 68 when the roof collapse occurred in the Small Banquet Room and Kitchen area at 12:23:24 hours.

At 1232 hours, Engine 48 reported to "Command" that they had a member on their crew collapse due to heat exhaustion. The crew of E48 would get the member out of the structure through the front window. Once E48 had the member outside, the fire fighter was taken to the Medical Group for treatment and transport. E51B's portable radio keyed up with no transmission. ***Note:*** *E51B's portable radio would key up intermittently for the next 32 minutes until he was removed from the structure. The approximately 20 transmissions would last as short as 2 seconds and as long as 66 seconds. The department's investigation determined the cause of these transmissions was caused by the radio accessory on the SCBA failing due to the radiant heat. The wires would inadvertently touch and key the radio.* At 1233 hours, Alpha Division (D28) reported that RIT crews don't appear to be in the correct location. Crews were going into the building with saws to cut through the roofing material.

Crews operating inside as Rescue Group were E60, E48, E82, E508, L33, L51, L28, TL69, Rescue 10, Rescue 42, and Heavy Rescue 11. District 68 was the *Rescue Group Supervisor*. At 1234 hours, L68 reported to "Command" "that the fire is running the roof and the apartment complex is in the process of being evacuated." ***Note:*** *L68 is referring to the two-story motel rooms located on Side Charlie of the facility*. (**See Diagram 1.**)

At 1236 hours, the *Rescue Group Supervisor* (District 68) announced on Tac Channel 11, "Command" to all companies, go to Tac Channel 12, if you are not involved in the "Mayday". One minute later, "Command" announced that all companies assigned to the 3-11 and 4-11 switch to Tac Channel 12 and stage on the feeder road. At 1238 hours, Alpha Division requested that "Command" assign additional resources to Charlie Division so that an attempt could be made to gain access to the "Mayday" crews from a different location.

At 1239 hours, Rescue 10 contacted Alpha Division with "Emergency Traffic". R10 located two of the missing fire fighters (E68B and E68C) near the front of the "Small Banquet Room". R10A detailed the necessary steps that needed to be taken to reach these two fire fighters. ***Note:*** *At this point in the incident, radio communications were severely hampered due to significant radio traffic which overloaded the radio system.* Alpha Division contacted "Command" regarding the use of an aerial ladder above the roof to assist with the rescue of E68A. At 1242 hours, Charlie Division (District 59) attempted to contact "Command" regarding the use of a handline to attack the fire from Side Charlie. This generated a response from the *Rescue Group Supervisor* and "Command" regarding the effect of the hoseline on the rescue operations. Charlie Division had Ladder 76 trying to get a handline in operation at the Bravo/Charlie corner. Charlie Division requested a ladder company be moved to this area to set-up a ladder pipe.

At 1247 hours, the *Rescue Group Supervisor* contacted Alpha Division (D28) regarding a possible collapse of the front façade on Side Alpha of the restaurant. Alpha Division replied back that there was a possibility of collapse based upon the cracks in the façade and the front wall being pushed out by the roof collapse. (**See Photo 6.**) Alpha Division requested that L69 start flowing their ladder pipe in order to keep the fire off the rescue operations. Alpha Division requested another handline be brought to Side Alpha. At 1249 hours, Charlie Division requested an engine company be moved to the Bravo/Charlie side to stop the fire from moving into Charlie Division. The *Rescue Group Supervisor* advised Charlie Division to standby as the main focus was on the RIT operations. At 1251 hours, the ladder pipe from L69 was opened. The stream struck several fire fighters and officers in the parking lot before the ladder pipe could be directed onto the fire.

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Photo 6. A 20 ft. x 8 ft. foot section (160 SF) of compromised perimeter wall collapse into the immediate area directly in front of the structure. Three members from the Rescue Group became trapped under falling debris that resulted from the secondary collapse. These firefighters were quickly removed by other members in the immediate area and then taken to awaiting EMS crews. The time is approximately 1225 hours.
(Photograph courtesy of the fire department)

At 1252 hours, Alpha Division reported to "Command" that one missing fire fighter had been removed from the structure (the captain from E68). At 1259 hours, Engine 508 (E508) reported to "Command" that another fire fighter (E51B) had been located and was in the process of being removed from the structure. Shift Commander 37 (South Division) announced he had assumed "Command" and District 21 was assigned as "Operations." "Command" requested OEC dispatch a 5-11 (5^{th} Alarm) for this incident. At 1301 hours, OEC dispatched District 19, District 26, Engine 37, Engine 47, Engine 62, Engine 80, Ladder 7 and Ladder 55. All companies assigned to the 5-11 were ordered to switch to Tac Channel 12 and report to Staging. At 1303 hours, the front façade collapsed on Side Alpha trapping several fire fighters and fire officers assigned to the Rescue Group. (**See Photo 7.**) At 1304 hours, Alpha Division reported to "Command" that a second fire fighter had been removed from the structure (E51B).

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Photo 7. The front façade collapsed at 1303 hours striking fire fighters and officers assigned to the Rescue Group. These members were quickly removed by other fire fighters who picked up the façade and pulled the trapped fire fighters and officers out. ***(Photo courtesy of the fire department)***

At 1304 hours, after E51B was removed from the structure, “Command” made the difficult decision to change the Incident Action Plan from “Rescue” to “Recovery”. (**See Diagram 14.**) **Note:** *“Command” developed an **Incident Organizational Chart - ICS 207** for this incident. The **Incident Organization Chart** (ICS 207) provides a means of depicting the ICS organization position assignments for the incident and to indicate what ICS organizational elements are currently activated and the names of personnel staffing each element. The size of the organization is dependent on the specifics and magnitude of the incident and is scalable and flexible.*

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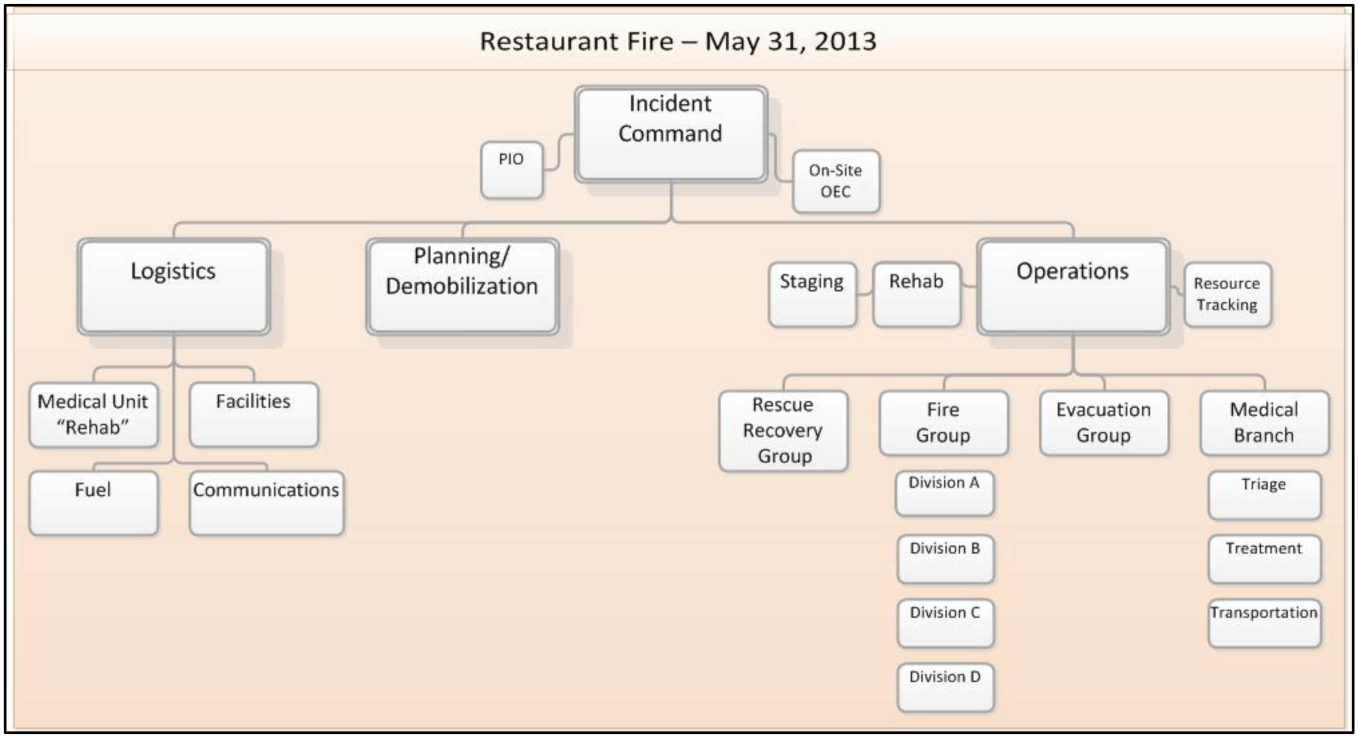

Diagram 14. The Incident Organization Chart developed by "Command" for the restaurant fire.

At 1309 hours, "Operations" called Alpha Division trying to verify the number of fire fighters involved in the "Mayday". The *Rescue Group Supervisor* called Alpha Division and advised that he was still trying to verify the actual number of missing fire fighters. E68 and E51 didn't answer the PAR.

A personnel accountability report was conducted on all companies operating at the restaurant fire. Due to issues with the radio system, it took the Accountability Officer 44 minutes to complete the PAR. At 1354 hours, the Accountability Officer (Ambulance 28B) tried to contact E68 and advised that E68B was "in alarm". At 1356 hours, "Command" contacted Alpha Division (#13 - Assistant Chief who had relieved District 29) regarding the operational mode. Alpha Division responded that companies were still operating inside the structure on Side Alpha. (**See Diagram 15.**)

At 1406 hours, the Rescue Group consisted of Ladder 7, Rescue 10, Rescue 11, Tower Ladder 21, Engine 37 and Engine 49. At 1420 hours, the Rescue Group called "Operations" and advised, "We've located E51 Alpha" (the officer from E51). At 1432 hours, the two fire fighters from Engine 68 (E68B and E68C) were located in the Small Banquet Room approximately 10 feet – 15 feet from the captain of E51. The captain of E51 was removed at 1507 hours and the two fire fighters from E68 were removed at 1554 hours.

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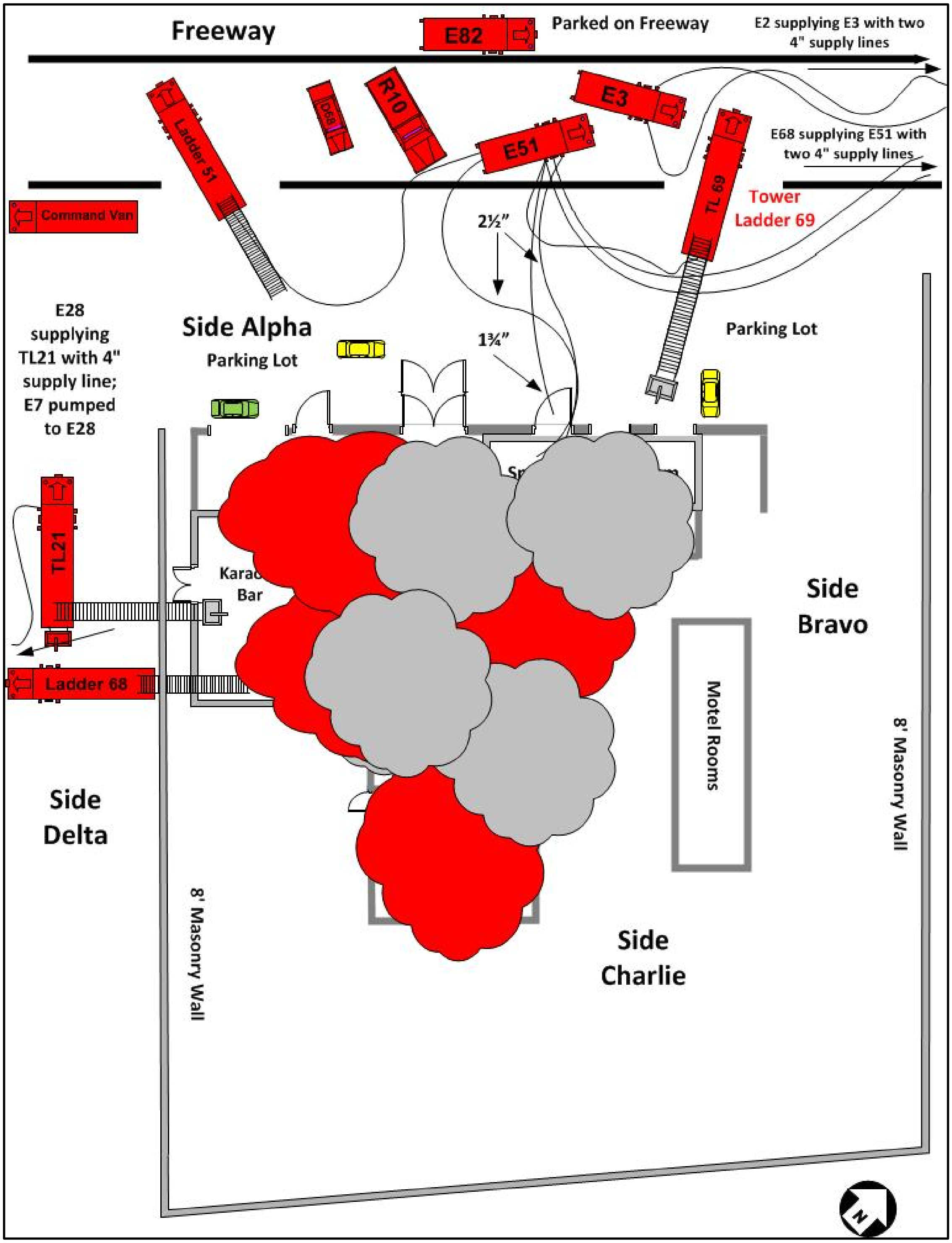

Diagram 15. The placement of apparatus and hoselines on Side Alpha and Side Delta. The hotel, banquet rooms, and sports bar are heavily involved with fire. The time is approximately 1400 hours.

The recovery process was completed at 1605 hours. At 1645 hours, “Command” notified OEC to 7-1 the incident (declared under control).

Rapid Intervention Team (RIT) Operation

At 1223 hours, E82 announced a “Mayday” due to a collapse of the roof in the Small Banquet Room and kitchen areas. “Command” immediately deployed Engine 60 as the initial RIT crew and requested a 3-11 (3rd Alarm). Also, “Command” ordered all companies out of the building.

Engine 60 entered the front door of the restaurant and found a fire fighter from Engine 51 (E51”C”). This fire fighter was pushed into the doorway by the collapse. E60 assisted the fire fighter out of the structure and sent him to Alpha Division (District 28). E60 reentered the building and found a void area between the front wall of the building and the roof area. When the roof collapse occurred, the roof came straight down. The remaining part of the roof was resting on the top of the exterior wall.

The RIT process was expanded over the next several minutes to include Engine 82, Engine 48, Engine 508, Tower Ladder 69, Ladder 33, Ladder 51, Rescue 10 and Rescue 11. As these RIT companies were deployed, they found it difficult to access the area of the Small Banquet Room due to getting through the roof material. Fire fighters interviewed during the investigation stated that initially they tried to gain access to the area using axes and halligan tools. **Note:** *The investigation revealed that the roof had 3 layers of roofing material. When re-roofing occurred, instead of removing the existing roof materials, the new roof was placed on top of the existing roof materials. The roofing material consisted of asphalt shingles installed on ½-inch thick plywood roof decking which was nailed to the top chords of the trusses. Clay (cement) tiles were added to the roof on Side Alpha for decorative purposes.* RIT companies then attempted to cut access holes through the roofing material with chain saws. Access to the trapped fire fighters was tried through the windows in Side Alpha plus entry from Side Bravo and Side Charlie.

At 1239 hours, R10 “A” notified Alpha Division using “R10 Division Alpha Emergency Traffic” to let him know that they had located two fire fighters in the building. Alpha Division (D28A) then notified “Command” to advise him that two of the “Mayday” fire fighters (E68B and E68C) had been located. E508”A” went into the hole and could see the fire fighter from E51 (E51B) lying on top of the clay (cement) tiles.

The RIT crews were trying to gain access to these two fire fighters. Tower Ladder 69 made an access hole into the collapse area which was barely a 2-foot x 2-foot hole. Rescue 10 entered the area where E68A was located. The captain from R10 tried to gain access to the officer from E68. There was fire around the officer and the RIT crews were trying to get water on the fire. Members from R10 were cutting the roof rafters to gain access to the officer (E68A). Members of R10 deployed a RIT pack to get a fresh air supply for E68A. Members of R10 worked on their hands and knees clearing debris away from the captain on E68 (E68A). They were also trying to get an air supply established using a RIT Pack. The RIT Pack was brought in as close as possible, but it still did not reach the captain of E68, because the hose attached to the RIT pack was not long enough. The team placed an extension on the hose and the engineer/operator from R10 then made the decision to try and get the RIT Pack closer to the captain by crawling deeper into the hole. This member did so without the use or protection of his own SCBA and helmet. At that point, the captain on E68 was able to reach out for the regulator and put it on his face. At first, he wasn't getting any air but the regulator was re-adjusted and then locked into his mask.

With E68A "on-air", members of R10 used cribbing and air bags to remove him from the debris. At 1252 hours, the Rescue Group removed E68A from the building and placed him in an ambulance for transport to the nearest trauma center.

E508 widened the access hole and then the officer of E508 crawled through the access hole. He located the fire fighter from E51 (E51B). E508A crawled in about 15' – 20' to get E51B. The roofing tiles were all around him. E508A started trying to get him out of the building. He was in-line with the front window. The officer from E508 stated he could hear PASS alarms from E51A E68B, and E68C. With the help from E508B, E508C, Safety 30, Ladder 33, and other members of the Rescue Group, E51B was brought out of the building at 1304 hours.

This RIT operation was performed successfully under extremely difficult conditions. Members of the Rescue Group operated in extreme heat and smoke conditions trying to access the trapped fire fighters in a very tight and cramped environment. (**See Recommendation #11**.)

Fire Origin and Cause

Published reports suggest that a burning odor had been detected by workers in the building upwards of three hours prior to the report of the fire at 1205 hours. Restaurant employees noticed a burning smell around 0900 hours and attempted to identify the source with maintenance workers. Nothing could be identified or determined and no call was made for the fire department. As the morning progressed, restaurant employees eventually noticed dark smoke coming from nearby vents, a restaurant worker called 9-1-1 at 1205 hours when visible flames became evident. The fire originated in the attic/crawl space above the kitchen area adjacent to the utility room.

The department's Arson Bureau, the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), and the Texas State Fire Marshal's Office listed the classification of this fire as "undetermined" because investigators were unable to identify the exact cause of the fire. Although the exact cause of the fire was not determined, all agencies involved agreed there was no evidence to indicate the fire was deliberately started.

Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that ultimately led to the fatalities:

- Fire burning unreported for 3 hours

- Delayed notification of the fire department
- Building construction
- Wind impacted fire
- Scene size-up
- Personnel accountability
- Fireground communications
- Lack of fire sprinkler system.

Cause of Death

According to the death certificates, the medical examiner listed the cause of death for the captain of E51 due to smoke inhalation; the engineer/operator (E51B) was due to smoke inhalation with thermal injuries; the fire fighter from E68 (E68B) was due to compressional asphyxia, blunt head trauma, and smoke inhalation; and the other fire fighter from E68 (E68C) died due to compressional asphyxia. ***Note:*** *The captain of Engine 68 (E68A) died on March 7, 2017 from complications of the severe injuries suffered in the restaurant fire on May 31, 2013.*

Recommendations

Recommendation #1: Based upon fire department procedures, the strategy and tactics for an occupancy should be defined by the organization for fire-fighting operations. The Incident Commander should ensure that the strategy and tactics match the conditions encountered during initial operations and throughout the incident.

Discussion: Occupancies define the space inside the class of building. Construction types/classes of construction define how the building is constructed with either combustible or non-combustible materials. Occupancies exist inside the constructed building. SOPs must consider numerous factors that affect fire-fighting operations. This will ensure essential strategic, tactical, and task level functions are performed by the Incident Commander, division/group supervisors, and fire fighters. Additionally, this process compliments the defined knowledge, skills, abilities, competencies, and fireground experience to assist:

- the Incident Commander to plan and implement an effective strategy and Incident Action Plan;
- division/group supervisors to formulate and follow tactics;
- company officers to successfully carry out assigned tasks,
- and, the individual members to effectively perform their duties.[32]

At any incident, life safety is always the first priority followed by incident stabilization (second priority), and then property conservation (third priority). The ability to ensure for the safety of fire fighters is a continuous process throughout the incident. A sound risk management plan ensures that the risks are evaluated and matched with the actions and conditions. The following risk management principles shall be utilized by the Incident Commander:

- activities that present a significant risk to the safety of fire fighters shall be limited to situations that have the potential to save endangered lives;
- activities that are routinely employed to protect property shall be recognized as inherent risks to the safety of fire fighters, and the actions shall be taken to reduce or avoid these risks;

- no risk to the safety of fire fighters shall be acceptable where there is no possibility to save lives or property.[33]

The strategy and tactics of an incident are dictated by the size-up, initial risk assessment, and situational report by the first arriving officer. The priority is to get a fire department unit to the rear of the structure on Side Charlie. However, unless an obvious life safety issue exists (e.g., visible victims requiring immediate assistance), interior fire-fighting operations should not commence until a report from Side Charlie is received. If physical barriers make the 360° size-up impractical for the first arriving officer, the size-up of Side Bravo, Side Charlie, and Side Delta may be delegated to another engine company on the 1st Alarm. Even if a 360° can be conducted, the 2nd due engine company or 3rd engine company and the 2nd due truck company should be assigned to Side Charlie.

A radio report of conditions, including those on Side Charlie, should be transmitted over the assigned tactical channel to the Incident Commander and the dispatch center. The transmission should include the following:

- Smoke and fire conditions, with an emphasis on identifying the seat of the fire; The initial radio report from the first arriving unit for a structural fire should include the signal for a working fire, the number of stories, type of occupancy and location of fire. This lays the foundation for additional reports and serves as notification to responding units as to the type of SOP to implement.
- If there were critical building description information through the critical incident dispatch system *(CIDS)* for the address, then this information would aid in implementing or adjusting SOPs. CIDS could contain information that would necessitate alternative action to fulfill said operational goals.
- Building features – e.g., number of stories (particularly if there is a difference between Sides Alpha and Charlie;
- Basement access and type;
- Any other life or safety hazards.

Any change to operational priorities or responsibilities based on the above size-up shall be clearly communicated to "Command", all responding units, and the dispatch center via the assigned tactical radio channel.[34, 35] "Command is then obligated to re-broadcast and receive acknowledgement from all operating companies.

There are necessary tasks which need to occur at any fire regardless of the occupancy such as initial on scene report upon arrival, initial risk assessment, situational report, water supply, deployment of handlines and back-up handlines, search and rescue, ventilation, rapid intervention crews (IRIC), ground and aerial ladder placement, fire attack and extinguishment, and salvage and overhaul. Over the past few years, fire fighters have adopted an acronym that details the steps to take when confronted with a fire: *SLICERS*.

- **S**ize up all scenes;
- **L**ocate the fire;
- **I**dentify & control the flow path (if possible);
- **C**ool the heated space from a safe location;

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- **E**xtinguish the fire;
- **R**escue and **S**alvage are actions of opportunity that may occur at any time. [35]

The "flow path" of a fire is how a fire moves determined by incoming and outgoing vents for air (since air is what lets a fire burn). Identifying and controlling the flow path is about knowing where the air comes from and where it's headed. The importance of identifying and using flow path information cannot be underestimated. The identification of flow path is an item that should find its way into every after-action review. While trying to locate the fire, cool the heated space from a safe location while ensuring for the safety of the fire fighters is important. Once the fire is under control, the fire can be completely extinguished. The rescue and salvage operations are self-explanatory—if anything can be saved, save it. These two actions are always active, right from sizing up to extinguishing.

Establishing a continuous and uninterrupted water supply is a vital and one of the most critical elements of fireground operations. This must be done before or in conjunction with committing crews to interior operations. To ensure a water supply is secured, many fire departments require, per standard operating procedure (SOP), that the 2nd due engine company and 4th due engine company secure a water supply for the 1st due engine company and 3rd due engine company. [36]

Procedures developed for fireground operations should be flexible enough to allow the change due to:
- Life hazard (must be given first priority);
- Problems with water supply and water application;
- Volume and extent of fire, requiring large caliber streams;
- Location of the fire, inaccessible for hand-line operations;
- Materials involved in the fire and explosion potential compounding the problem;
- Exposure problems where further fire spread would be a major concern;
- Stability of the structure, which would be dependent on the condition of the structural components of the building, the intensity and duration of the fire.[33]

At this incident, the initial Incident Commander was the captain of E51. His initial scene size-up was "smoke showing, working fire, offensive fire, and we are stretching a 2½-inch handline". Based upon the time of day and type of occupancy, the captain based his strategy and tactics on the possibility of occupants were still inside the restaurant and kitchen. District 68 then assumed "Command" upon his arrival and maintained the same strategy and tactics.

Based upon the type of occupancy, the department did not pre-plan this building based on the risk assessment. The initial on-scene size-up and evaluation was made as the first alarm companies arrived on scene. The arriving units were able to view Side Delta and Side Alpha. The view of Side Alpha was very limited due to the amount of smoke. It is essential that during the initial stages of an incident, at least one company is designated to Side Charlie of a structure, even if a 360º walk-around is conducted. The first units to be assigned to Side Charlie were during RIT Operations and Charlie Division was established, which was approximately 20 minutes into the incident. This ensures that "Command" has a complete initial assessment of the fireground. "Command" is assured that a continuous risk assessment and situational report is available from Side Charlie.

Moreover, the Incident Commander must continually match the actions against the conditions based upon continuous reports from all operating companies. This gives the Incident Commander the ability to control the situation by forecasting and staying ahead, rather than the fire dictating the actions taken. Additionally, due to problems with the radio communications, this greatly hindered "Command's" ability to ensure this occurred.

Recommendation #2: Fire departments should review and update standard operating procedures on wind-driven fires which are incorporated into fireground tactics.

Discussion: Based on the analysis of this fire incident and results from current research and field studies, adjusting fire-fighting tactics to account for wind conditions in structural fire-fighting is critical to enhancing the safety and the effectiveness of fire fighters. Previous studies demonstrated that applying water from the exterior, into the upwind side of the structure can have a significant impact on controlling the fire prior to beginning interior operations.[37] It should be made clear that in a wind-driven fire, it is most important to use the wind to your advantage and attack the fire from the upwind side of the structure, especially if the upwind side is the burned side. Crews operating on the interior need to be aware of the potential for rapidly changing conditions.

Fire departments should develop standard operating procedures (SOPs) for incidents with high-wind conditions including defensive attack. It is important that fire officers and fire fighters develop an understanding of how wind conditions influence fire behavior and impact fireground tactics. Wind conditions can have a major influence on structural fire behavior. When wind speeds exceed 10 mph (16 km/hr.) the Incident Commander, division/group supervisors, company officers, and fire fighters should use caution and take wind direction and speed into account when selecting a strategy and developing tactics. The National Institute of Standards and Technology and Underwriter's Laboratories have determined that wind speeds as low as 10 mph (16 km/hr.) are sufficient to create wind-driven fire conditions if the flow path is uncontrolled.[30] NIST, in a recent study on wind-driven fires in structures, has shown that wind speeds as low as 10 mph can turn a routine "room and contents fire" into a floor to ceiling fire storm or "blowtorch effect," generating untenable conditions for fire fighters, even outside of the room of origin. Temperatures in excess of 600 ºC (1100 ºF) and total heat fluxes in excess of 70 kW/m² were measured at 4 feet above the floor along the flow path between the fire room and the downwind exit vent. These conditions were attained within 30 seconds of the flow path being formed by an open vent on the upwind side of the structure and an open vent on the downwind side of the structure.[30]

Fire departments are encouraged to develop and implement a standard operating procedure (SOP) addressing such issues as obtaining the wind speed and direction, considering the possible fuel load associated with a particular occupancy. This information can be used to determine the proper strategy and tactics for wind-driven fireground operations. Further, consideration of ventilation plus predicting and forecasting fire conditions associated with the wind speed based upon risk assessment. Under wind-driven conditions an exterior attack from the upwind side of the fire may be necessary to reduce fire intensity so fire fighters can successfully and safely gain access to the involved compartments.[38]

4 Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

A fire department should incorporate the following considerations into their training and education component on wind impacted fires:

- Ensure that an adequate initial size-up and risk assessment of the incident scene is conducted before beginning interior fire-fighting operations;
- Ensure that fire fighters, company officers, division/group supervisors, and the Incident Commander have a sound understanding of fire behavior and the ability to recognize indicators of fire development and the potential for extreme fire behavior such as smoke color, velocity, density, visible fire, and heat;
- Ensure that fire fighters and company officers are trained to recognize the potential impact of windy conditions on fire behavior and implement appropriate tactics to mitigate the potential hazards of wind-driven fire;
- Ensure the Incident Commander's strategy considers high wind conditions, if present;
- Ensure that fire fighters understand the influence of ventilation on fire behavior and effectively apply ventilation and fire control tactics in a coordinated manner;
- Ensure that fire fighters and officers understand the capabilities and limitations of thermal imager;
- Ensure a thermal imager is used as part of the size-up process;
- Ensure that fire fighters are trained to check for fire in overhead voids upon entry and as charged hoselines are advanced;
- Develop, train and educate, implement, and enforce a comprehensive "Mayday" SOP to insure that fire fighters clearly understand the process and know how to initiate a "Mayday";
- Ensure fire fighters are trained in fireground survival procedures;
- Ensure all fire fighters on the fire ground are equipped with radios capable of communicating with the Incident Commander and the dispatch center.[37]

At this incident, when the 1st Alarm companies arrived on scene, the smoke was pushing towards the northwest directly across the parking lot of the restaurant. Visibility proved to be very difficult for all companies operating on the scene. The captain of Ladder 51 stated during his interview, L51 went to Side Charlie, opened a door going to the Banquet rooms, and the opening "was sucking air". Ladder 51 arrived on-scene at 1228 hours and went to Side Bravo and Side Charlie. L51 may have been one of the first companies on Side Charlie.

The strategy and tactics of an incident are dictated by the size-up, initial risk assessment, and situational report by the first arriving officer. If physical barriers make the 360° size-up impractical for the first arriving officer, the size-up of Side Charlie should be delegated to the 2nd due engine company or 3rd due engine company and the 2nd due truck company. However, unless an obvious life safety issue exists (e.g., visible victims requiring immediate assistance), interior fire-fighting operations should not commence until a report from Side Charlie is received.

The fire department has made numerous changes in standard operating procedures and fireground tactics as it relates to wind-driven fires since the incident on May 31, 2013.

Recommendation #3: Fire departments should integrate current fire behavior research findings developed by the National Institute of Standards and Technology (NIST) and Underwriter's Laboratories (U.L.) into operational procedures by developing standard operating procedures, conducting live fire training, and revising fireground tactics.

Discussion: The National Institute of Standards and Technology (NIST) and Underwriters Laboratories (UL) have conducted a series of live burn experiments designed to replicate conditions in modern homes and residential structures and to validate previous testing done in laboratory settings. The results of these experiments will enable fire fighters to better predict and react to effects of new materials and construction on fire. The fire research experiments were conducted in cooperation with the Fire Department of New York, Chicago Fire Department, Spartanburg SC Fire and Rescue and other agencies. The live burn tests are aimed at quantifying emerging theories about how fires are different today, largely due to new building construction and the composition of home furnishings and products. In the past, these products were mainly composed of natural materials, such as wood and cotton, but now contain large quantities of petroleum-based products and synthetic materials that burn faster and hotter and generate large volumes of fuel-rich smoke. Where a fire in a room once took approximately 20 minutes to "flashover" — igniting all the contents — this can happen with today's furnishings in as little as four to five minutes.[39]

In addition, modern living spaces tend to be more open, less compartmentalized and are better insulated than homes built years ago. As a result, interior residential fires can generate oxygen depleted, fuel rich environment within minutes. This fire condition of hot, fuel rich smoke is highly reactive to the introduction of oxygen. Introducing oxygen to this environment by opening a door or venting a window may result in a rapid transition to flashover. These same conditions can occur in commercial structures as seen in the Charleston, SC *Sofa Super Store fire*.[40]

The NIST and UL experiments evaluated individual and combinations of methods for strategically ventilating and isolating fires to prevent flashover—or at least delay it. In contrast, kicking a door open or breaking a window without knowledge of conditions inside could create a portal for air that can literally fan the flames by introducing oxygen into an oxygen-limited fire environment.

Traditionally, fire suppression operations were conducted from the interior of the structure as a means to reduce water damage and limit fire damage to structures. These operations must be coordinated with the ventilation operations. Previous research and examinations of line of duty deaths have shown that ventilation events occurring with fire fighters in the structure prior to suppression have led to tragic results.[40. 41, 42] One means of eliminating the possibilities of this occurrence would be a transitional attack, in which water is directed into the structure from the exterior to cool the fire gases and reduce the heat release rate of the fire, prior to the fire fighters entering the building. The major concern with this type of operation is the potential harm that might occur to people trapped in the structure or the amount of water damage to the structure. Therefore, measurements are needed to document the changes of the thermal environment within the structure and the impact on the viability of people, who might be trapped in the structure.[39]

Based upon the NIST and UL research, the following fireground operations should be considered for implementation.

- **Size-Up**
  Size-up must occur at every fire. Consideration must be given to the resources available and situational conditions, such as weather, fire location, size of the fire and building, and the construction features. Ensure a 360-degree size-up is conducted whenever possible. A tactical plan for each fire must be developed, communicated and implemented.

- **Ventilation**
  Fire departments should manage and control the openings to the structure to limit fire growth and spread, and to control the flow path of inlet air and fire gases during tactical operations. All ventilation must be coordinated with suppression activities. Uncontrolled ventilation allows additional oxygen into the structure which may result in a rapid increase in the fire development and increased risk to fire fighters due to increased heat release rates within the flow path.

- **Fire-fighting Operations**
  Given the fuel rich environment that the fire service operates in today, water should be applied to the fire as soon as possible. In many cases, water application through an exterior opening into a fire compartment may be the best first action, prior to committing firefighting resources to the interior. Fire departments should cool the interior spaces of a fire building with water from the safest location possible, prior to committing personnel into spaces with, or adjacent to, fully developed or smoldering (ventilation limited) fire conditions.

- **Rapid Intervention**
  Fire department rapid intervention procedures should be updated to provide water on the fire as soon as possible and ventilation openings controlled during fire fighter "Mayday" incidents.[39]

This information is presented to educate the fire service and to ensure that fire departments consider a change in fireground tactics based upon the current research presented by NIST and UL. Much of this research has been directed toward developing a better understanding of the characteristics of the modern fire. This modern research provides members of the fire service with the information and knowledge needed to modify essential fire-fighting tactics. While fire-fighting will never be without risk, this research represents a vital contribution to overall efforts to reduce risks and to save lives.

***Recommendation #4: Fire departments should consider implementing a pre-incident planning program which complies with NFPA 1620, Standard for Pre-Incident Planning*.**

Discussion: Pre-incident planning is the process of gathering and documenting information that could be critical for making life-saving decisions at an incident such as a structure fire. Pre-fire planning is essential, no matter the size of a fire department. Even the smallest towns contain buildings or sites that require pre-incident plans based upon a community risk assessment. These occupancies can include but are not limited to schools, high-rise occupancies, hospitals, nursing homes, medical clinics, hazardous materials manufacturer or shipper, transportation agency (e.g., a railroad), or any other businesses that is deemed by the fire department to be a high-risk occupancy or target hazard. NFPA 1620, *Standard for Pre-incident Planning* serves as the foundation for this process. The purpose of NFPA 1620 is to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment.[43] Moreover, NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* requires fire departments to develop pre-incident plans as determined by the authority having jurisdiction which complies with NFPA 1620, *Standard for Pre-incident Planning*.[44]

The pre-incident plan is designed based upon an emergency occurring in the occupancy, which can assist the Incident Commander in developing the strategy and Incident Action Plan.[43]

A detailed pre-incident plan highlights all aspects of the structure including:

- A site plan
- Floor plans
- Construction type
- age and condition of the building
- Ingress and egress
- Pre-existing structural damage/deterioration
- Presence of wall anchor plates or stars
- Engineered load systems/lightweight construction
- Types of doors and windows
- Roof construction and covering including HVAC units
- Renovation/modifications to structure
- Height of the building
- Fuel loads
- Fire protection features such as sprinkler systems, standpipe system, fire alarm system, and hydrant locations
- Stairwells
- Utility shut-offs
- Occupant contact information
- Any other pertinent information.[45]

A pre-incident plan identifies deviations from normal operations and can be complex such as a formal notation about a particular problem, to include the storage of flammable liquids, explosive hazards, lack of hydrants, or modifications to structural building components.

Another consideration of the pre-incident planning process is that strategy and tactics which need to be utilized for a target hazard occupancy. Based upon the potential risks encountered at target hazard occupancies, the pre-incident plan should outline the deployment of resources (front-loading the incident), type of strategy to be considered, and how to deploy resources once fire-fighting operations are initiated.

Another benefit of this program is the ability to provide information to company officers and chief officers responding from other battalions or from different jurisdictions that may not be familiar with a specific occupancy. Moreover, a jurisdiction's building and permit office or department may have information that the fire department does not have. Information should be routed to the department's dispatch center to ensure vital information about a structure is available. For example a target hazard is included in the comments of the CAD system dispatch. Information should include the number and type of code violations and whether the building has been abandoned or vacant, or is undergoing extensive renovation. Additionally, the CAD system can provide a real-time view of an occupancy from mapping programs that are available on the internet. [42]

Pre-incident information, pre-fire plans and building knowledge are mission critical - at a minimum for the first-due area response. Understanding building construction and related engineering, reading key building indictors and having the skills to apply predictive modeling and projected outcomes is essential. The tactical objectives and incident action plan thus increases exponentially the safety margin to have a successful incident outcome and not unexpected events.

At this incident, there was no information available for first due or first alarm companies due to the fact this occupancy was not considered a high-risk occupancy. As part of the department's recovery process, they have developed a program which will provide the ability for electronic storage and retrieval of building assessments for suppression personnel plus offering real-time information. The pre-incident plans (Tactical Evaluation and Assessment Plans (TEAPS)) that are on file in the department are being entered into this system. Future plans include entering information that is shared by other city departments and regional agencies.

Recommendation #5: Fire departments should consider implementing a critical building information system which is available to responding units to enhance situational awareness.

Discussion: Coupled with the Pre-Incident Planning program, the critical incident dispatch system (CIDS) program provides critical building information which may not be readily apparent to responding companies upon arrival. This program also provides accurate and consistent information for required radio progress reports and indicates where standard operating procedure variations would be necessary due to previously known features found at this location.

The process starts with input from the company officers who must consider all buildings in their first-due area as potential CIDS buildings. In considering a building, the company officer must look for conditions that would not be immediately apparent to arriving companies assigned to the initial alarm assignment. Additionally, there are key building factors which should automatically be included in CIDS. Examples could be bowstring truss, major alterations have occurred, or if a pre-incident plan exists for the building. Other examples that should be included or considered for inclusion in the CIDS program are:

- Hazardous chemicals, liquids and substances. This information should always indicate floor and location of these hazards;

- High voltage equipment including transformers containing PCBs and always indicate floor and location of such equipment;
- Interconnected odd or unusually shaped buildings and indicate which floors are interconnected.
- Buildings with structural hazards or heavy fire loading;
- Renovated buildings with hidden voids, or duplex apartments. Indicate which floors give access to duplex apartments;
- Truss buildings (describe type of truss);
- Metal bar joist and other lightweight construction materials;
- Q-deck roofs or floors, steel plated buildings;
- Handicapped, bedridden, or incapacitated individuals. Where possible, specify the location;
- Schools with handicapped students;
- Special extinguishing systems, and the location of related controls;
- Siamese locations, if not in a normal location or readily visible;
- The location of OS&Y (outside screw and yoke) valves or alarm panels, if not located in an easily found location;
- Sub-cellar levels and access locations;
- Location of guard dogs;
- Telephone numbers of knowledgeable persons, such as the owner, building engineer or superintendent;
- Vacant buildings. [46]

This list is not intended to be all-inclusive. Company officers should be encouraged to include other items if they feel that the condition or hazard should be identified.[46]

Fire departments can utilize a variety of methods to ensure critical building information is available during response to an incident. Mobile data terminals or mobile computer terminals, hand-held computers or tablets, information from station response printers, or printed pre-incident plans can provide location specific data triggered by place, address, and/or name. This information can be a valuable tool for the fire officers and command officers, especially when the jurisdiction has a large number of defined target hazard occupancies. This information assists the Incident Commander in implementing the strategy and Incident Action Plan for a defined building.[47]

As part of the department's recovery process, the organization has developed a program which will provide the ability for electronic storage and retrieval of building assessments for district chiefs and company officers as well as offer real-time information. The department is entering pre-incident plans (Tactical Evaluation and Assessment Plans (TEAPS)) into this system. Future use will include information that is shared by other city departments and regional agencies.

***Recommendation #6: Fire departments should ensure that the radio communication system is capable of providing adequate coverage based upon the demands of an incident which complies with NFPA 1561, Standard on Emergency Services Incident Management System and Command Safety*.**

Discussion: Effective fireground radio communication is an important tool to ensure fireground command and control as well as helping to enhance fire fighter safety and health. The radio system must be dependable, consistent, and functional to ensure that effective communications are maintained especially during emergency incidents. Fire departments should have a "Communications" standard operating procedure (SOP) which outlines the communication procedures for fireground operations. Fire departments should ensure that the Communications Division and Communication Center is part of this process. Another important aspect of this process is an effective education and training program for all members of the department.

Radio frequency usually refers to the radio frequency of the assigned channel. A radio channel is defined as the width of the channel depending on the type of transmissions and the tolerance for the frequency of emission. A radio channel is normally allocated for radio transmission in a specified type of service or by a specified transmitter. Fire department should ensure that an adequate number of radio channels are available. Multiple radio channels are necessary at large-scale or complex incidents such as a commercial structure fire, mass-casualty incident, hazardous materials incident, or special operations incident.[48, 49]

Fire departments should preplan for not only large-scale or complex incidents, but also for the ability to handle daily operations. Standard operating procedures, radio equipment (e.g. mobile radios, portable radios, mobile data terminals, laptop computers), other hardware (e.g. CAD system), and dispatch and communications protocols should be in place to ensure that these additional channels are available when needed.[48]

Every fire fighter and company officer should take responsibility to ensure radios are properly used. Ensuring appropriate radio use involves both taking personal responsibility (to have your portable radio, having the portable radio turned on, and on the correct channel). A company officer's responsibility is to ensure that all members of the crew comply with these requirements. Portable radios should be designed and positioned to allow a fire fighter to monitor and transmit a clear message.[50, 51]

A fire department should provide the necessary number of radio channels relating to complex or large scale incidents needing multiple tactical channels. NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety* states in Paragraph 6.1.4, "the communications system shall provide reserve capacity for complex or multiple incidents." This would require fire departments to preplan radio channel usage for all incident levels based upon the needs of an emergency incident including large-scale or complex incidents.[48]

When a fire department responds to an incident, the Incident Commander should forecast for the incident to determine if there is potential for being a complex or long term operations that may require additional resources including demands on the communications system. As incidents increase in size, the communication system has to keep up with the demands of the incident. The Incident Commander must be able to communicate with company officers and division/group supervisors.[49] Before communications become an issue, the Incident Commander must consider options for alleviating excessive radio traffic. Several options are:

- assigning non-fireground resources (e.g. Staging, "Rehab") to a separate tactical channel or talk-group channel;
- designate a "Command Channel" which is a radio channel designated by the fire department to provide for communications between the Incident Commander and the division/group supervisors or branch directors during an emergency incident;[48]
- for incidents involving large geographical areas, designate tactical channel or talk-group for each division.

In this incident, the Emergency Communications Center had switched to a digital radio system a approximately one month earlier. This fire was the first significant incident at which the fire department operated with this new system. As noted in the report, radio communication issues were quickly identified as an issue. Since this incident, the department has addressed many of the radio issues through changes in hardware, re-programming, training, and standard operating procedures. This is an on-going process for the department.

Recommendation #7: Fire Departments should review standard operating procedures regarding the use and operations of the thermal imagers.

Discussion: Another valuable tool that enhances situational awareness is the thermal imager. The thermal imager provides a technology with potential to enhance fire fighter safety and improve the ability to perform tasks such as size-up, search and rescue, fire attack, and ventilation. Thermal imagers should be used in a timely manner. Fire fighters should be properly trained in the use of a thermal imager and be aware of their limitations.[52, 53]

The application of thermal imaging on the fire ground may help fire departments accomplish their primary mission, which is saving lives. This mission can be accomplished in many ways. First and foremost, in near zero visibility conditions, primary searches may be completed quickly and with an added degree of safety. The use of thermal imaging technology may also be invaluable when fire fighters are confronted with larger floor areas or unusual floor plans.[52] Searching for trapped civilians is part of a fire department's primary mission. Thermal imagers may provide a method for fire fighters to track and locate other fire fighters in very limited visibility conditions. This process can enhance fire fighter accountability before an issue arises.[52]

While the use of a thermal imager is important, research by Underwriters Laboratories has shown that there are significant limitations in the ability of these devices to detect temperature differences behind structural materials, such as the exterior finish of a building or outside compartment linings (i.e., walls, ceilings, and floors).[53] The most common misconception about temperature measurement is that it estimates air temperatures. Thermal imagers do not read air temperatures; they read surface temperatures. Thermal imagers operate solely based on differences in surface temperatures. Although occasionally a thermal imager may show superheated or cryogenic gases, in general, thermal imagers do not "see" or measure gases. Fire fighters should not be lulled into a mistaken sense of security because the temperature measurement on the thermal imager seems relatively low or has not reached its scale maximum.[54]

At a structure fire, the thermal imager may help identify the location of the fire or the extent of fire involvement prior to fire fighters being deployed into a structure. Knowing the location of the fire may help fire fighters determine the best approach to the fire. The thermal imager may provide additional information for a crew(s) making the fire attack that they would not previously have had due to poor visibility and building construction. Using this information, fire fighters may be able to locate the fire more quickly and may also ensure that the water application is effective. From a ventilation perspective, fire fighters can use the thermal imager to identify areas of heat accumulation, possible ventilation points, and significant building construction features. This helps ensure proper and effective ventilation that successfully removes smoke and heat from a building.[52, 55]

Per department protocol, the first arriving officer provides a temperature reading as they enter the structure as part of the initial size-up. Most thermal imagers only read surface temperature. Therefore a thermal imager can only estimate the air temperature and products of combustion. The thermal imager does not provide an accurate assessment of the total room temperature. In all reality, the temperature readings and color variations of a thermal imager provides are best suited to establish differences of an area being entered, rather than the true atmospheric temperature.[52, 55]

The intent of this recommendation and the appendix material is to ensure that the fire service clearly understands the concept, use, and limitations of thermal imagers. This does not reflect on the operations of the fire department in this investigation.

The fire department did utilize thermal imagers in a positive manner.

- The first-in officer (E51A) provided a thermal imager reading per department guidelines;
- A thermal imager was used to locate the heat source by the crew making entry (E51A) while advancing a 2 ½-inch handline and pulling ceiling as they made forward progress;
- The officer on E82 used a thermal imager as a tool to size-up the exterior and relayed that information to Division A (D28)
- The officer on E60 used the thermal imager as a tool to size-up the exterior as part of the Rescue Group (RIT).

Additional information is provided in **Appendix Five: Use and Operations of Thermal Imagers**

Recommendation #8: Fire Departments should ensure that the Incident Commander incorporates "Command Safety" into the incident management system.

Discussion: The purpose of "Command Safety" is to provide the Incident Commander with the necessary resources on how to use, follow, and incorporate safety into the incident management system at all incidents. "Command Safety" is used as part of the eight functions of command developed by (Retired) Fire Chief Alan V. Brunacini. "Command Safety" defines how the Incident Commander must use the regular, everyday command functions to complete the strategic level safety responsibilities during incident operations. Using the command functions creates an effective and close connection between the safety officer and the Incident Command. The eight functions of command are:

- Assumption/confirmation/positioning
- Situation evaluation which includes risk management
- Communications
- Deployment
- Strategy/incident action planning
- Organization
- Review/revision
- Transfer/continuation/termination.[33, 56]

A major objective of the incident management system is to create, support, and integrate an Incident Commander who will direct the geographical and functional needs of the entire incident on the strategic, tactical, and task level. Issues develop for the Incident Commander when these three standard levels are not in place, operating, and are effectively connected. One of the most important components is to ensure the Incident Commander operates on the strategic level from the very beginning of the incident and stays on the strategic level as long as fire fighters are operating in an immediately dangerous to life and health (IDLH) environment. [33, 56]

The Incident Commander uses the incident management system as the basic foundation for managing the strategic level safety function. "Command Safety" ensures the highest level of safety for fire department members operating at emergency incidents. The Incident Commander completes the operational and safety responsibility to the fire fighters by performing the eight command functions. These functions serve as a very practical performance foundation for how the Incident Commander completes their responsibility as the strategic level incident manager and the overall incident safety manager.[48]

At this incident, there were several "Command Safety" issues which are being addressed by the fire department as part of their recovery process. These issues included fireground communications, personnel accountability, use of a tactical worksheet (which compliments personnel accountability and crew integrity), and a continuous scene size-up and evaluation.

Recommendation #9: Fire Departments should provide a checklist for the Incident Commander regarding procedures in the event of "Mayday".

Discussion: When a "Mayday" is transmitted for whatever reason, the Incident Commander has a very narrow window of opportunity to locate the lost, trapped, or injured member(s). The Incident Commander must restructure the strategy and Incident Action Plan (tactics) to include a priority rescue.[48]

Some departments have adopted the term "LUNAR" – location, unit assigned, name, assistance needed, and resources needed - to gain additional information in identifying a fire fighter who is in trouble and in needs assistance. The Incident Commander, division/group supervisors, company officers, and fire fighters need to understand the seriousness of the situation. It is important to have the available resources on scene and to have a plan established prior to the "Mayday".[48. 56]

A checklist is provided in **Appendix Six: Incident Commander's Tactical Worksheet for "Mayday"** which can assist the Incident Commander to ensure the necessary steps are taken to clear the "Mayday" as quickly and safely possible. This checklist serves as a guide and can be tailored to any fire department's "Mayday" procedures. The intent of the checklist is to provide the Incident Commander with the essential actions to be taken in the event of "Mayday". This format allows the Incident Commander to follow a structured worksheet. This process is too important to operate from memory and risk missing a vital step that could jeopardize the outcome of the rescue of a fire fighter who is missing, trapped, or injured.

At this incident, when the "Mayday" occurred, the Incident Commander quickly called for additional resources and conducted a personnel accountability report to determine if any companies were lost or missing. Due to the influx of resources, the Incident Commander was quickly overwhelmed mostly due to the issues dealing with radio communications. The intent of this "Mayday" worksheet, like the tactical worksheet, is to assist the Incident Commander during a very difficult and stressful time on the fireground.

Recommendation #10: Fire departments should review standard operating procedures used to account for all fire fighters and first responders assigned to an incident.

Discussion: A personnel accountability system is a system that readily identifies both the location and function of all members operating at an incident scene.[44, 48] The philosophy of the personnel accountability system starts with the same principles of an incident management system company unity and unity of command. Unity can be fulfilled initially and maintained throughout the incident by documenting the situation status and resource status on a tactical worksheet.

One of the most important functions of "Command Safety" is for the Incident Commander to initiate an accountability system that includes the functional and geographical assignments at the beginning of operations until the termination of the incident. It is very important for the first on-scene officer to initiate an accountability system. This initial system allows the passing or transfer of information to the next officer who assumes "Command" upon his/her arrival. [48]

A functional personnel accountability system requires the following:
- Development and implementation of a departmental SOP;
- Necessary components and hardware;
- Training and education program including practical applications for all members on the operation of the system;
- Strict enforcement during emergency incidents.

There are many different methods and tools for resource accountability. Some examples are:
- Electronic accountability system;
- Tactical worksheets;
- Command boards;
- Apparatus riding lists;
- Company responding boards;
- Electronic bar-coding systems;
- Accountability tags or keys (e.g., PASSPORT System).[48]

At a large scale incident such as this, the accountability process may have to be assigned to an Accountability Group. Each division and group would be responsible for maintaining the accountability of all members assigned to their division and group. This would be very similar to the accountability process used during high-rise fire-fighting operations. The personnel accountability system should comply with the requirements of NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety*. [48]

The fire department utilizes both the personal alert safety system (PASS) and a fireground electronic accountability system (EAS). As part of "Resource Status", the Incident Commander assigns an "Accountability Officer" to maintain an accurate and continuous status of all members operating at the incident. This individual is usually the second Incident Command Technician (ICT) on scene. The first due district chief's ICT maintains accountability until an "Accountability Officer" is appointed. The "Accountability Officer" is responsible for monitoring the EAS when members are operating in an immediately dangerous to life and health (IDLH) atmosphere.

The "Accountability Officer" is responsible for monitoring the EAS display for the following items:
- "Mayday" alarm indications,
- Loss of signal indications,
- Continual display of all crewmembers from each unit on scene - apparatus on scene (engine, ladder, and rescue) will display four activated riding positions.

The "Accountability Officer" will advise the Incident Commander of any alarms that cannot be cleared or verified.

These components can be used in conjunction with one another to facilitate the tracking of responders by both location and function. The components of the personnel accountability system should be modular and expand with the size and complexity of the incident.[48]

At this incident, the electronic accountability system became quickly overwhelmed when the "Mayday" occurred. Due to radio communication issues, the "Accountability Officer" could not contact individual fire fighters whose EAS was in alarm. As the incident escalated, fire fighters removed their SCBA without turning off the EAS, thus causing the EAS to go into alarm and adding to the confusion.

The department has been implementing several changes in their personnel accountability process. For example, as an incident escalates, the Incident Commander would consider assigning an "Accountability Group" to assist the "Accountability Officer" in maintaining situational awareness and helping to expand this important function at every fire. The electronic accountability system can be used to conduct a personnel accountability report (PAR) which greatly reduces radio traffic. The Incident Commander would announce over the radio that an "Electronic PAR" will be conducted. All members would acknowledge the "Accountability Officer" and then "clear" the signal from their unit.

Recommendation #11: Fire departments should review the standard operating procedure for Rapid Intervention Team (RIT) operations including the RIT bag and air supply to trapped or downed fire fighter(s).

Discussion: During the incident, fire department members performed a successful rescue of the captain of E68 from the restaurant after the roof collapse of the restaurant and small banquet area. Due to the configuration of the RIT Pack, the airline was not long enough to reach the captain. The RIT Pack had to be moved closer to the officer under very difficult conditions. (**See Rapid Intervention Team Operations section.**)

Many fire departments have a defined response plan for the dispatch of additional companies (engine, truck, squad, and/or rescue company) to respond to an incident and standby as the rapid intervention team. Based upon the complexity, magnitude, configuration of the structure or geographical layout of the incident, the Incident Commander may deploy additional rapid intervention teams by location or function.[57]

Upon arrival or upon appointment, the RIT officer should confer with the Incident Commander. The RIT officer should establish an area to stage the rapid intervention team and the necessary RIT equipment. The RIT equipment should include:

- A tool staging tarp;
- Rescue SCBA (RIT Pack);
- Forcible entry tools such as a Halligan bar or other pry tool;
- Thermal imager;
- Stokes basket;
- 150' long rope for search and rescue;

- Wire cutters;
- Rebar cutter;
- Life-saving rope/life belt;
- Elevator keys for buildings with elevators. [58, 69, 60]

It is important to stage all necessary RIT equipment in an expedient manner. The RIT officer, accompanied by one member of the RIT, should perform an incident scene survey while the remaining RIT members assemble the RIT equipment. If the size of the structure negates a 360-degree survey of the building, this fact shall be relayed to the Incident Commander as soon as possible. This should be a benchmark for "Command" to designate another RIT in order to effectively cover all sides of the building.

During the survey or a "360" of the structure, the RIT Officer and RIT members will coordinate with the Incident Commander or Operations Section Chief (if established) to formulate rescue plan contingencies and continue to monitor the radio and fire ground conditions. RIT protection is not a passive assignment. This is a process of ongoing information gathering and diligent scene monitoring until the unit is released by the Incident Commander. RIT is a critical component for ensuring fire fighter safety while operating on the fireground. Rapid Intervention Team (RIT) duties should include establishing a means of egress on all sides of a structure.[61]

Another consideration for "Command" is to request the response of an advanced life support (ALS) engine company or truck company as a component of the RIT Group including a medic unit or ambulance for transportation capabilities. The members of the ALS company are trained to operate in an IDLH, can function as part of the RIT, and provide advanced life support to affected fire fighters.[59]

In January 2014, the fire department issued a ***Special Bulletin*** outlining the necessary changes that need to occur based upon the events of this incident. Some of the changes which have occurred include:

- New RIT bags or packs were fitted with two air-lines, which can be stored separately and deployed independently or together based upon the needs of the situation.
- Removing miscellaneous tools from the RIT pack;
- A new style quick disconnect couplings were added;
- RIT masks were upgraded by the department's Mask Service Unit for easier donning with gloved hands;
- All RIT bags were fitted with one hour air cylinders. (**See Photo 8.**)

4 Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

Photo 8. The RIT Pack that the department has redesigned based upon this incident.
(Photo courtesy of the fire department)

The members, assigned to the Rescue Group during this incident, performed extraordinarily under very difficult and dangerous conditions during the rescue of the captain from Engine 68 and the removal of the engineer/operator from Engine 51 (E51B). The changes made by the department for RIT operations will improve an already effective and efficient rapid intervention team process.

Recommendation #12: Fire departments should ensure adequate incident scene rehabilitation is established in accordance with NFPA 1584, Standard on the Rehabilitation Process for Members during Emergency Operations and Training Exercises.

Discussion: NFPA 1584, *Standard on the Rehabilitation Process for Members during Emergency Operations and Training Exercises* establishes the minimum criteria for developing and implementing a rehabilitation process for fire department members at incident scene operations and training exercises operating within an incident management system.[62] The physical and mental condition of personnel should be monitored to ensure their health does not deteriorate to the point it affects the safety of each fire fighter or endangers the safety and integrity of the operation. An Incident Commander should consider the circumstances of each incident and make suitable provisions for rest and rehabilitation for personnel. This process shall include medical evaluation and treatment, food and fluid replenishment, rest and relief from extreme climatic conditions.

NFPA 1584 states an Incident Commander should establish rehabilitation operations when emergency operations pose a safety or health risk to fire fighters and other responders. Rehabilitation operations should be provided in accordance with fire department SOPs, NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, and NFPA 1561 *Standard on Emergency Services Incident Management System and Command Safety*. [44, 48]

Incident scene rehabilitation ("Rehab") is a term often used for the care given to fire fighters and other responders while performing their duties at an emergency scene. The Incident Commander shall consider the circumstances of each incident for the rest and rehabilitation for all personnel operating at the scene. "Rehab" includes medical evaluation, treatment and monitoring, food and fluid replenishment, mental rest, and relief from extreme climatic conditions. [44, 62, 63] When the size of the operation or geographic barriers limit member's access to the rehabilitation area, the Incident Commander shall establish more than one rehabilitation area. The site shall be a sufficient distance from the effects of the operation where members can safely remove their personal protective equipment and can be afforded physical and mental rest.[63] Once "Rehab" area(s) have been established, this information must be communicated over the radio, so all members know the location of "Rehab" or know where to report when assigned to "Rehab".

Several considerations for rehabilitation sites are as follows:

- Should be in a location that will provide physical rest by allowing the body to recuperate from the demands and hazards of the emergency or training evolution.
- Should be far enough away from the scene that personnel may safely remove their turnout gear and SCBA and be afforded physical and mental rest from the stress and pressure of the emergency or training evolution. Provisions should be available to have SCBA cylinders refilled.
- Should provide suitable protection from the prevailing environmental conditions. During hot weather it should be in a cool, shaded area and during cold weather it should be in a warm, dry area.
- Should enable personnel to be free of exhaust fumes and noise from apparatus, vehicles, or equipment, including those involved in the rehabilitation group operations.
- Should be large enough to accommodate multiple crews based on the size of the incident.
- Should be easily accessible by EMS units.
- Should allow prompt re-entry back into the emergency operation upon complete recuperation.
- Crews assigned to rehab will be instructed to turn portable radios off and/or have radio and thermal imager portable batteries recharged or exchanged.[63] (**See Diagram 16.**)

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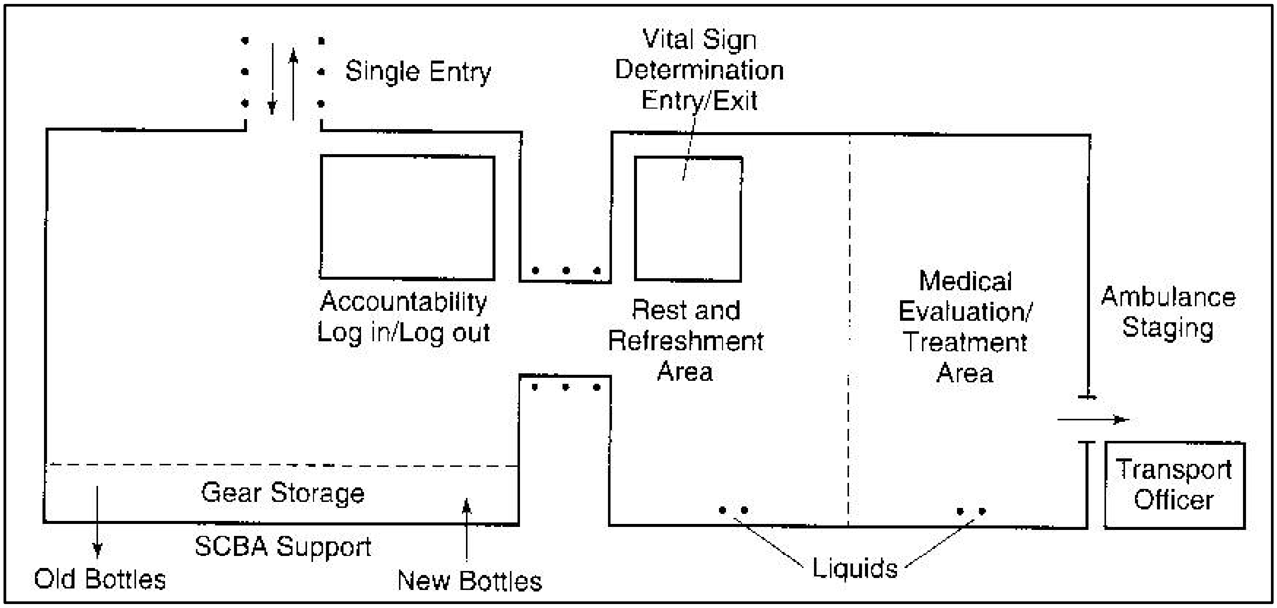

Diagram 16. An example of how a "Rehab" area can be organized. There are many ways to establish an effective "Rehab" area.

The Rehab Group Supervisor should secure all necessary resources required to adequately staff and supply the rehabilitation area. The supplies should include the following items:

- Fluids: water, activity beverage, oral electrolyte solutions, and ice;
- Food: soup, broth, or stew in hot/cold cups;
- Medical devices: blood pressure cuffs, stethoscopes, oxygen administration devices, cardiac monitors, intravenous solutions, and thermometers;
- Other: awnings, fans, tarps, fans, heaters, dry clothing, extra equipment, floodlights, blankets and towels, traffic cones, and fire line tape (to identify the entrance and exit of the rehabilitation area);
- Hygiene facilities to decontaminate all exposed skin surfaces;
- Restroom facilities.[63]

The fire department operates an "informal" Rehab at every incident. As members are relieved from their current assignment and report their assigned apparatus, the informal "Rehab" process starts. The informal "Rehab" includes short breaks (e.g. SCBA cylinder changes, hydration of water, which is carried on every heavy apparatus). A formal "Rehab" is usually established when the "Rehab" vehicle (Rehab 17) is dispatched (e.g. Special Called or on all 2-11 fires).

For this incident, Rehab 17 was dispatched on the 2nd Alarm (2-11) at 1219 hours. However, Rehab 17 was not fully operational at the scene until 1313 hours. Logistical problems were encountered throughout the process which included the distance the Rehab 17 had to travel (response distance); the same traffic conditions that most of the other responding companies were faced with as they traveled to the incident; and radio problems prevented the transmission of when and where Rehab 17 was finally set-up. Additional problems included rotating crews through "Rehab" and making it known that

"Rehab" was not a choice but an actual assignment. The emotional stress that was faced by the members on scene that day also had a tremendous effect on how members perceived a formal "Rehab". Many crews wanted to be directly involved in the rescue and/or recovery process. Crews shortened their time in "Rehab" or even deferred this assignment so they could be available to assist on the fireground.

Recommendation #13: Fire departments should consider upgrading SCBA to the current edition of NFPA 1981, Standard on Open-Circuit SCBA which includes the enhanced heat and flame testing criteria.

Discussion: A number of recent NIOSH investigations, including this incident, suggested that the facepiece lens material may have melted before other components of the fire fighter's self-contained breathing apparatus and personal protective equipment ensemble degraded. [32, 64, 65, 66] Additionally, a number of documented near-miss incidents also identify the potential for thermal damage to facepiece lenses is greater than commonly believed.[67, 68, 69, 70]

SCBA manufactured to the 2007 edition of NFPA 1981 *Standard on Open-Circuit Self-Contained Breathing Apparatus* included a "Heat and Flame Test," which included placing a complete SCBA unit in an oven at 95 degrees C (approximately 203 degrees F) for 15 minutes, followed by exposure to direct flame impingement for 10 seconds. These NFPA certification requirements covering SCBA dictated that facepiece lens materials were evaluated at lower temperatures than electronic and other protective ensemble components.[71]

The NFPA Respiratory Protective Equipment Technical Committee worked with the United States Fire Administration (USFA), National Institute of Standards and Technology (NIST), and the NFPA Research Foundation to better understand the environments faced by fire fighters. This led the Respiratory Protective Equipment Technical Committee to add more rigorous testing requirements to NFPA 1981, especially requirements that would increase the SCBA's resistance to thermal degradation.

Two new performance tests were proposed and adopted for the 2013 edition of NFPA1981:

- A radiant heat panel test
- A convection heat performance test, in addition to the current heat and flame test in the standard.

Additionally, other changes to the 2013 edition of NFPA 1981 include enhanced communications testing and use of the Emergency Breathing Safety System (EBSS).[71]

Fire departments should consult with their SCBA manufacturer to inquire if upgrade kits are available for their SCBA that would allow them to benefit from improved components that pass the enhanced heat and flame tests.

At this incident, although there was no indication of any manufacturer defect with any of the fire fighters' SCBA, the conditions encountered likely exceeded the thermal performance limitations of the SCBA facepiece lens worn by E51B. E51B had his SCBA facepiece in place and functioning during fire-fighting operations. During the collapse, his facepiece became thermally degraded and exposed him to products of combustion. The medical examiner's report identified his injuries that were consistent with being exposed to the products of combustion. It is likely that the conditions encountered exceeded the capabilities of the SCBA facepiece lens.

Recommendation #14: Fire departments should implement a Restricted Access SOP which provides the mechanism for the chain of custody of personal protective equipment and/or SCBA in the event of a fire fighter fatality or serious injury.

Discussion: When a fire fighter fatality or serious fire fighter injury occurs, a fire department must have procedures in place to ensure that the personal protective equipment (PPE) - (turnout gear) and/or self-contained breathing apparatus (SCBA) is properly isolated. This insures the PPE and/or SCBA is in as close to the same condition as at the time of the incident. Information gathered from this process will assist the investigating officer(s) and investigating agency(s) in cause determination.[72]

The process entails that a fire department have a waterproof evidence bag which is carried in chiefs' vehicles such as a battalion chief, district chief, duty chief, and/or the safety officer's vehicle. The evidence bags should have a seal which requires a signature once items are secured. These bags also contain a chain of custody form that identifies who secured the item(s), the individual who transported the item(s) to the evidence locker, and the date and time the item(s) were entered as evidence.
A sample standard operating procedure (SOP) is provided in **Appendix Seven: Sample SOP – Restricted Access for PPE/SCBA/Equipment**. This SOP which details all necessary actions to take in the event of any PPE (turnout gear) and/or SCBA fails to operate in its designed and prescribed fashion, whether in training or on an emergency incident.[72]

This is a very important fire fighter safety process which allows a fire department to have an understanding of the performance of the PPE and/or SCBA. Also, this process documents a likely sequence of events of the user. It is so important that the PPE and/or SCBA be collected and secured on the incident scene, which can protect valuable information. Newer SCBA and personal alert safety systems (PASS) contain electronic and pneumatic data which can provide important information about the performance of the equipment and actions of the user.

At this incident, the process of securing the PPE and SCBA from the officer of E68 and the fire fighter from E51was conducted at the scene and at the hospital. The PPE and SCBA from both fire fighters from E68 were removed at the hospital. There was no documentation about the process of who secured each of the fire fighter's turnout gear and SCBA.

Additionally,
Recommendation #15: States and municipalities should consider adopting and enforcing regulations for automatic fire sprinkler protection in renovated structures.

Discussion: This recommendation focuses on fire prevention and minimizing the impact of a fire if one does occur. The National Fire Protection Association (NFPA) *Fire Protection Handbook* states "Throughout history there have been building regulations for preventing fire and restricting its spread. Over the years these regulations have evolved into the codes and standards developed by committees concerned with fire protection. The requirements contained in building codes are generally based upon the known properties of materials, the hazards presented by various occupancies, and the lessons learned from previous experiences, such as fire and natural disasters."[73] Although municipalities have adopted specific codes and standards for the design and construction of buildings, structures erected prior to the enactment of these building codes may not be compliant. Such new and improved codes can improve the safety of existing structures.[73] Sprinkler systems are one example of a safety feature that can be retrofitted into older structures. Sprinkler systems can reduce fire fighter and civilian fatalities since such systems can contain and may even extinguish fires prior to the arrival of the fire department.

Fire development beyond the incipient stage presents one of the greatest risks fire fighters are exposed to during fireground operations. This risk exposure to fire fighters can be dramatically reduced when fires are controlled or extinguished by automatic sprinkler systems.

NFPA statistics show that most fires in sprinklered buildings are controlled by the activation of one or two sprinkler heads prior to fire department arrival.[74] An automatic fire sprinkler system also reduces the exposure risk to fire fighters during all phases of fireground operation and allows the safe egress of building occupants before the fire department arrives on scene. Finally, by controlling fire development, the risks associated with the potential for structural collapse and during overhaul operations are greatly reduced, if not eliminated.

Fire Department Actions Taken Since the Incident

During the course of the investigation, the fire department advised NIOSH FFFIPP investigators that they had implemented a number of changes in department equipment, procedures, and training as the direct result of these fatalities. A description of these efforts can be found in **Appendix Eight: Fire Department Update**.

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Investigator Information

This incident was investigated by Murrey E. Loflin, Matt Bowyer, Stephen T. Miles, and Paul H. Moore with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. The report was authored by Murrey E. Loflin. The information provided in the *Building Construction and History* section was authored by Christopher J. Naum, SFPE (Command Institute). Chief Naum provided information on building construction and materials, complex construction demographics, the restaurant roof design, the concrete tile roofing system, fire performance characteristics of wood and fire impingement, occupancy risk profile, building risk and severity considerations, and assessment matrix. An expert technical review was provided by Mario D. Rueda, Deputy Chief, Bureau of Emergency Services with Los Angeles Fire Department and Dennis L. Rubin, Fire Chief, City of De Pere, WI Fire Department. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Information

Modern Fire Behavior

This site is meant to serve as a clearinghouse of news and training information related to Modern Fire Behavior and Modern Building Construction Research, Tactics, and Practices along with actual street experiences. http://modernfirebehavior.com/

National Institute for Standards and Technology and Underwriters Laboratory
These two agencies provide information including training videos showing the findings from NIST and UL research conducted in cooperation with the Fire Department of New York on Governor's Island in 2012.
http://www.firecompanies.com/modernfirebehavior/governorsislandonlinecourse/story.html.

Flashover TV sponsored by FireRescue.com includes a series of training presentations by NIST researcher Dan Madrzykowski.
http://flashovertv.firerescue1.com/videos/1875870-nist-and-ul-research-on-fire-dynamic-case-studies-part-4/

Information on completed fire-fighting research studies available at the National institute of Standards and Technology website at http://www.nist.gov/el/fire_research/firetech/index.cfm

The information on completed fire-fighting research studies available at the UL Firefighter Safety Research Institute website at www.ULfirefightersafety.com.

IAFC Rules of Engagement for Firefighter Survival
The International Association of Fire Chiefs (IAFC) is committed to reducing fire fighter fatalities and injuries. As part of that effort the nearly 1,000 member Safety, Health and Survival Section of the IAFC has developed DRAFT "*Rules of Engagement for Structural Firefighting*" to provide guidance to individual fire fighters, and incident commanders, regarding risk and safety issues when operating on the fireground. The intent is to provide a set of "model procedures" for structural fire-fighting to be made available by the IAFC to fire departments as a guide for their own standard operating procedure development. http://www.iafcsafety.org/downloads/Rules_of_Engagement.

IAFF Fire Ground Survival Program
The purpose of the International Association of Fire Fighters (IAFF) Fire Ground Survival Program is to ensure that training for "Mayday" prevention and "Mayday" operations are consistent between all fire fighters, company officers and chief officers. Fire fighters must be trained to perform potentially life-saving actions if they become lost, disoriented, injured, low on air or trapped. Funded by the IAFF and assisted by a grant from the U.S. Department of Homeland Security through the Assistance to Firefighters (FIRE Act) grant program, this *comprehensive fire ground survival training program* applies the lessons learned from fire fighter fatality investigations conducted by the National Institute for Occupational Safety and Health (NIOSH) and has been developed by a committee of subject matter experts from the IAFF, the International Association of Fire Chiefs (IAFC) and NIOSH.
http://www.iaff.org/HS/FGS/FGSIndex.htm

NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety* (2014 edition)
The primary focus of the revision to NFPA 1561 in the 2014 edition is develop requirements directly aimed at reducing and eliminating fireground injuries and fireground deaths of fire department members. The most apparent change addition to this edition has been the document title to include

"Command Safety" and the creation of a new chapter, *Command Safety*. This chapter is intended to provide a foundation on how to incorporate the incident management system at all emergency incidents especially *Type V* and *Type IV* incidents.

The chapter on "Command Safety" clearly defines the requirements for the Incident Commander to meet including establishing a fixed Command Post, personnel accountability, the use of staff aides, rapid intervention crews, and the appointment of a safety officer and assistant safety officer(s)(as needed) plus the expectations and authority of the safety officer. There are annexes that cover *Functional Assignments for High-Rise Building Incidents*, *Development of Subordinate Officers or Implementing a More Efficient Management System, Incident Management for the Fire Service on Type 5 or Type 4 Incidents,* and *Structural Fire Fighting — Risk Assessment and Operational Expectation.*

NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety (2014 edition)* can be purchased from the National Fire Protection Association at http://www.nfpa.org.

Buildingsonfire.com
A reference and informational site, with extensive documentation, insights, research and studies dedicated to building construction, engineering, fireground risk management and fire-fighting operations. http://buildingsonfire.com

Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites.

Appendix One
Additional Building Construction Information

Overall Hotel Complex Construction Demographics (See Photo 9.)

Constructed: circa 1966

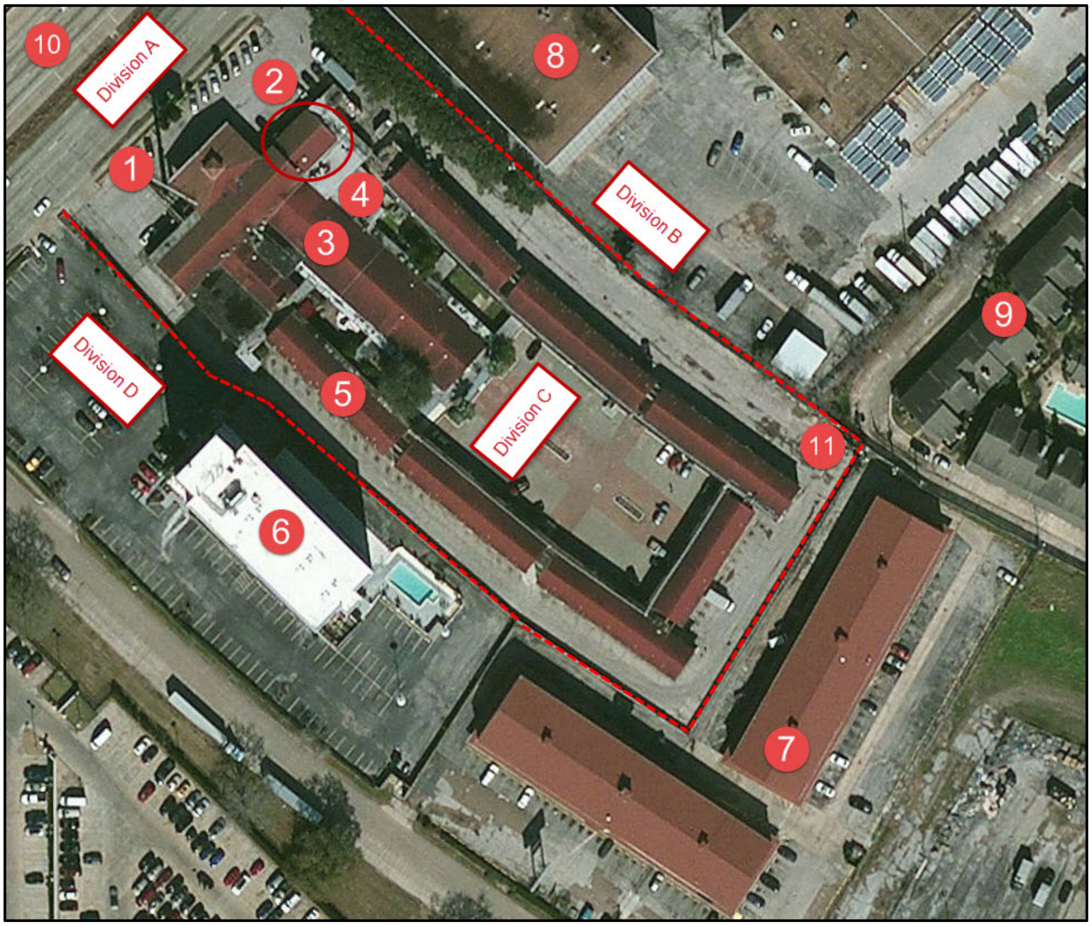

Photo 9: Aerial View of Building Complex and Exposures
(Bing.com Maps/ Analysis Diagram Courtesy of Buildingsonfire.com)

Incident Site, buildings and exposures.

- [1] Main Entry and Lobby
- [2] Restaurant – **Red Circle**
- [3] Banquet Rooms,
- [4] Kitchen
- [5] Lodging Units (typical)
- [6] Low Rise Hotel

[7] Motel
[8] Commercial Occupancies
[9] Multiple Occupancy Apartments
[10] Freeway
[11] Perimeter fencing

- **Construction Type:** 5B
- **NFPA 220 Type:** Type V- Wood Frame [5]
- **Occupancy:** R2/ A2
- **State Class Code:** Commercial
- **Land Use:** Hotel/ Motel Low Rise 1- 3 Stories
- **Land Area:** 149,210 square feet (SF)
- **Building Area:** 69,284 SF
- **Building Class:** D
- **Total Units:** 110
- **Total Number of Buildings:** Eight (8)
  - **Bldg.** 1 6,350 SF
  - **Bldg.** 2 6,350 SF
  - **Bldg.** 3 6,350 SF
  - **Bldg.** 4 6,350 SF
  - **Bldg.** 5 6,250 SF
  - **Bldg.** 6 5,100 SF
  - **Bldg.** 7 26,284 SF
  - **Bldg.** 8 6,250 SF

Construction System:

- **Floor Area:** Primary Building: 26,284 square feet.
- **Perimeter Walls:** Wood frame, masonry block, brick masonry veneer and combined stucco finish: Load bearing walls, steel beams and columns and masonry, wood frame and veneer construction features.
- **Roof:** Various: gable-style roof with engineered wood trussed systems (engineered structural systems) being incorporated along with flat roofs constructed on both wood and non-combustible materials. Specific construction details not determined. The gable roofs and truss loft attic space appear to have had connectivity due to the fire extension and travel experienced during fire-fighting operations resulting in fire communicating to other building sections and compartments, resulting in a large scale collapse.
- The presence, absence or integrity of any fire stopping in the truss loft attic space is unknown.
- **Protective Systems**: None – No fixed sprinkler system present.
- **Building Additions**: Numerous renovations, alterations, roofing systems & additions.

Restaurant

- **Construction Type:** 5B
- **NFPA 220 Type:** Type V - Wood Frame [5]
- **Occupancy:** R2/A2
- **Building Area:**
  - Small Banquet Area: approximately 1100 square feet (primary roof collapse zone)
  - Kitchen Area: approximately 5200 square feet (adjacent to and connected to the Small Banquet Room)
- **Building Class:** D
- **Construction System:**
  - **Columns: None –** 30 feet clear span in restaurant area from north to south (front bearing wall to steel beam - kitchen area)
  - **Floor:** Concrete slab on grade**.** Finish: Carpet, vinyl tile, or exposed concrete
- **Floor Area:** Primary building: open floor plan, ~ 1920 square feet (40 ft. x 48 ft.)
- **Perimeter Walls:** Wood Frame: 2-inch x 4-inch nominal wood stud construction at 16-inch on center with 5/8 inch gypsum wall board, some masonry block, brick masonry veneer, and combined stucco finish.
- **Roof:** Gable-style lap nail wood truss – Modified Fink Design with approximately 20 each (24-inch on center); ***Note:*** *The Modified Fink Design can usually span up to about 20 feet in length, before additional webbing is required. Top and bottom chords generally are made with 2-inch x4-inch Southern Yellow Pine (SYP) or Spruce (SPF). The most unique aspect with this profile is its "W" web structure.*[74] (**See Diagram 17**.)
  - Truss: Suggested to have been constructed utilizing a lap-nailed wood truss system. A lap-nailed wood truss system utilizes nails (versus MPC) as the mechanical fastener to secure the truss components together in an assembly to provide structural support as a configured truss component. (**See Diagram 17.**)
  - Engineered Structural System: Wood (southern yellow pine): 2-inch x 6-inch nominal top chords with 2-inch x 4-inch nominal bottom chord and diagonal web members. 2-inch x 4-inch nominal vertical strut at center line of truss. Mechanically fastened with nails and connected at the ridge with plywood gusset plate. Spaced 24-inches on center. ***Note:*** *The presence of any bridging could not be determined.*
  - Slope Ratio: 4:12 (18.5 degrees) Rise: approximately 6 feet. Run: approximately 15 feet.
  - Deck: ½ inch plywood deck sheathing nailed directly to truss cord, two (2) layers asphalt felt underlayment, multiple layers of aged asphalt shingles (nominal size – unknown)
  - Covering: Extruded concrete interlocking roof tiles with shiplap as a roof covering on the Restaurant roof and on the main building and entry portico fronting Side Alpha. (**See Photo 10.**)
  - Total Dead Load Roof Weight: 17.20 pounds per square foot (PSF) equaling 22,016 pounds
  - Approximate Roof Surface Area: 1280 Square Feet (SF);
  - Approximate Roof/ Truss Loft Attic Space: 3000 Cubic Feet (CF);
  - 5/8 inch Gypsum wall board (GWB) ceiling attached to bottom chord of truss with acoustic mineral fiber tile ceiling attached to the GWB;

  - The presence, absence or integrity of any fire stopping in the truss loft attic space: unknown;
  - Exposed Wood Surface Area of Truss Assembly: > 1700 Square Feet;
- **Protective Systems**: None – no fixed sprinkler protection system present;
- **Building Additions**: Numerous renovations, alterations, roofing systems and additions. The restaurant has connectivity to the main entry lobby area to the west and the main kitchen to the south. The restaurant appears to have a different construction vintage than the adjacent kitchen area when assessing aerial views of the Side Alpha and Side Bravo areas. The gable roof of the restaurant appears to be nested into the kitchen and front façade while it appears to be contiguous to the end of the main entrance lobby building it adjoins.

Lap Nail Truss Component

The wood web and nail configuration are as follows for the lap-nailed truss. (**See Diagram 18 and Diagram 19.**)

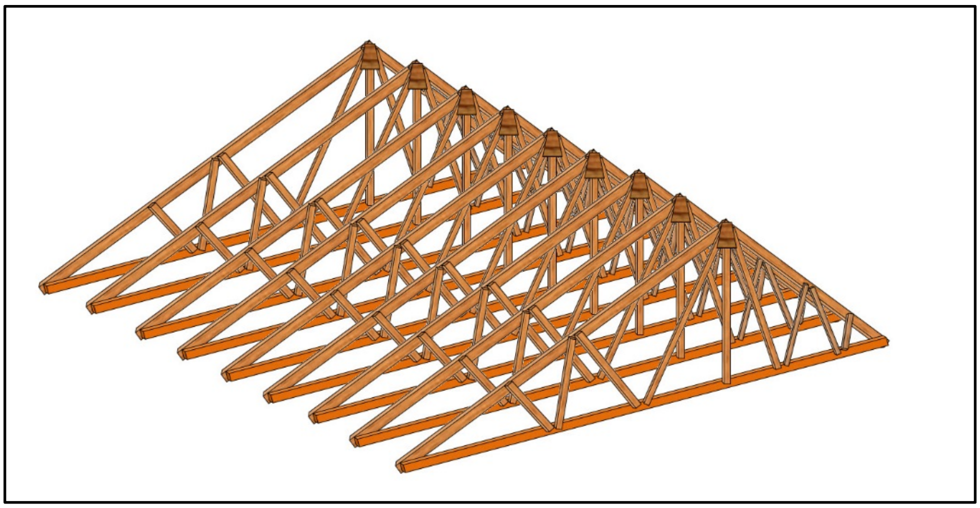

Diagram 17. Lap-Nailed Truss Assembly Configurations (Partial Detail)
(Diagram Courtesy of Buildingsonfire.com)

4 Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

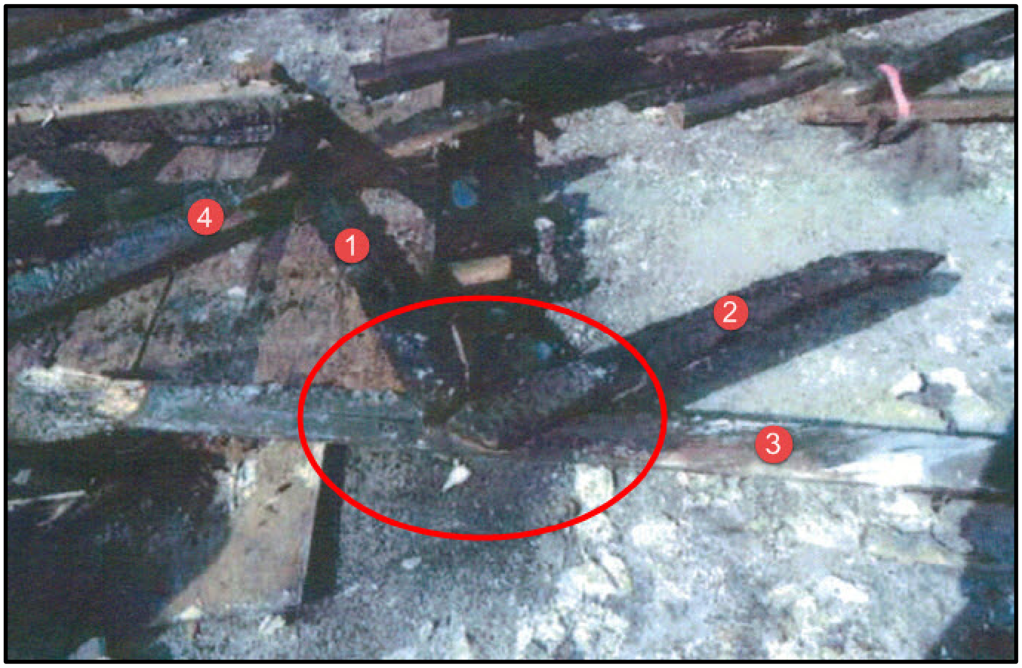

Photo 10. Bottom Truss Cord and Two-Web
(Photo courtesy of the fire department/ Diagram Courtesy of Buildingsonfire.com)

[1] 2 in. x 4 in. Wood Web;
[2] 2 in. x 4 in. Wood Web; ***Note****: See loss of remaining web material*
[3] 2 in. x 4 in. Wood Bottom Chord;
[4] 2 in. x 6 in. Wood Top Chord;
[5] **Circle** depicts the typical surface connection point of the truss webs as they are mechanically fastened with nails to the cord, (absent is any MCP, which is typical of most fabricated truss assemblies of that period, and today).

4 Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

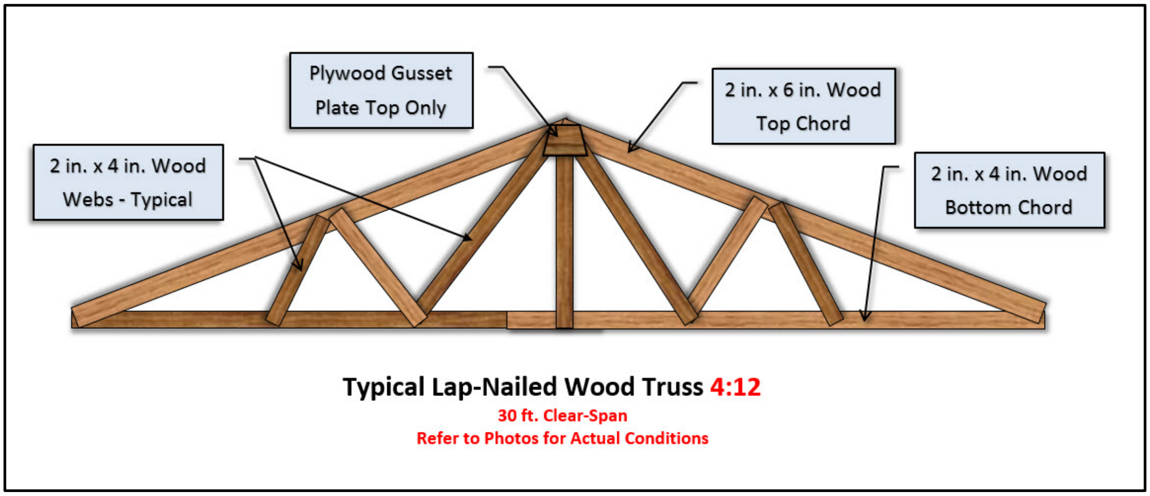

Diagram 18. Truss Configuration
(Diagram Courtesy of Buildingsonfire.com)

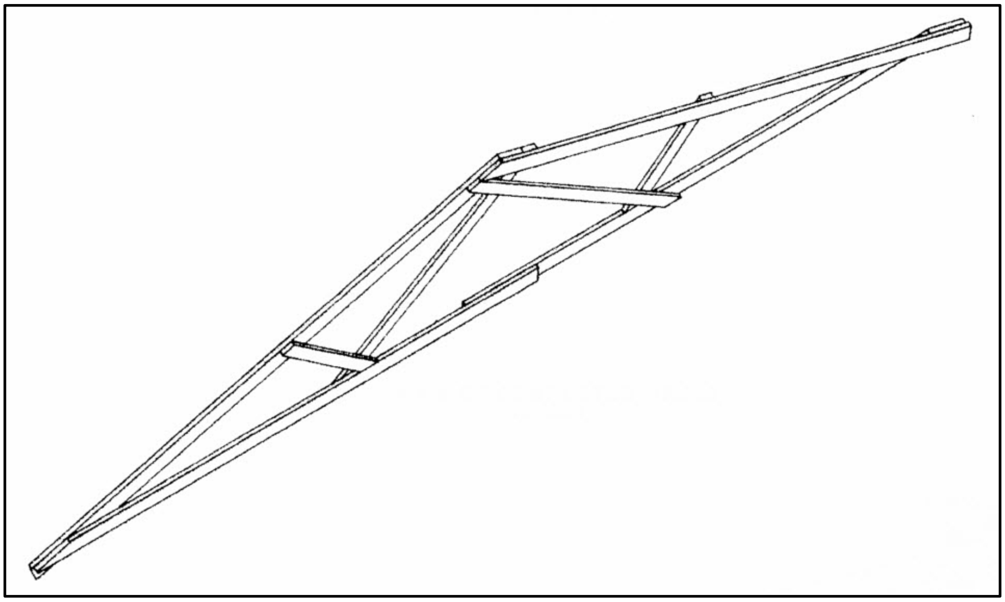

Diagram 19. Typical Lap-Nailed Truss
(Diagram Courtesy of Buildingsonfire.com)
[Adapted from USDA LSU AgCenter Diagram EX5923 circa 1961]

The gable roof profile of the restaurant and the main building can be seen from an aerial view which consists of extruded concrete interlocking roof tiles with shiplap as a roof covering fronting Division Alpha. (**See Photo 11**).

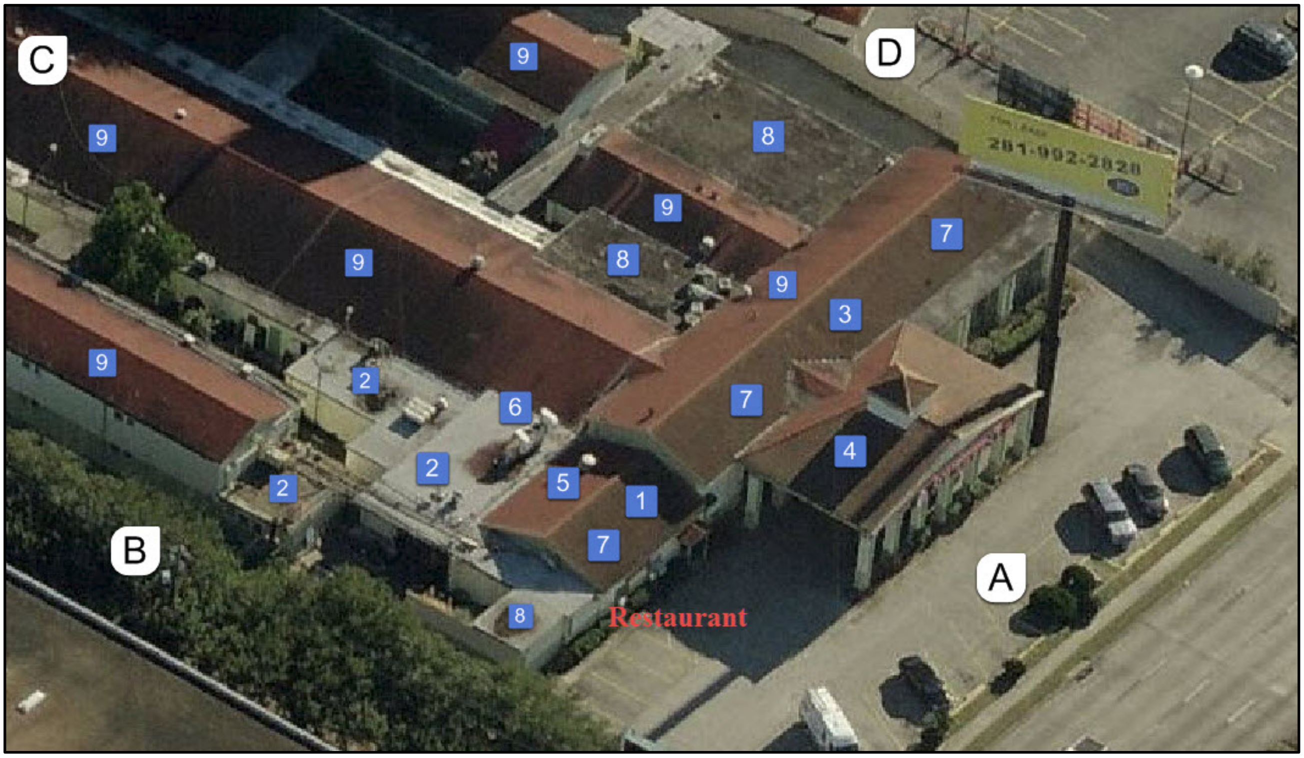

Photo 11. Pre-fire Aerial View of Building Complex (North-East Geographical/Division Alpha-Bravo)
(Bing.com Maps/ Diagram Courtesy of Buildingsonfire.com)

[1] Restaurant Gable Roof
[2] Kitchen Flat Roof
[3] Main Entrance and Lobby Gable Roof
[4] Main Portico Canopy Roof
[5] Ventilation Fan Housing (assumed)
[6] Roof-top mounted Mechanical Units & Ventilator/Fans (type unknown)
[7] Extruded Concrete Interlocking Roof Tiles with shiplap as a roof covering
[8] Flat Roof Areas
[9] Gable Roofs

4 Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

The post-fire profile of the complex after the collapse of the roof and walls focusing on Side Alpha and Side Bravo of the structure. (**See Photo 12)**.

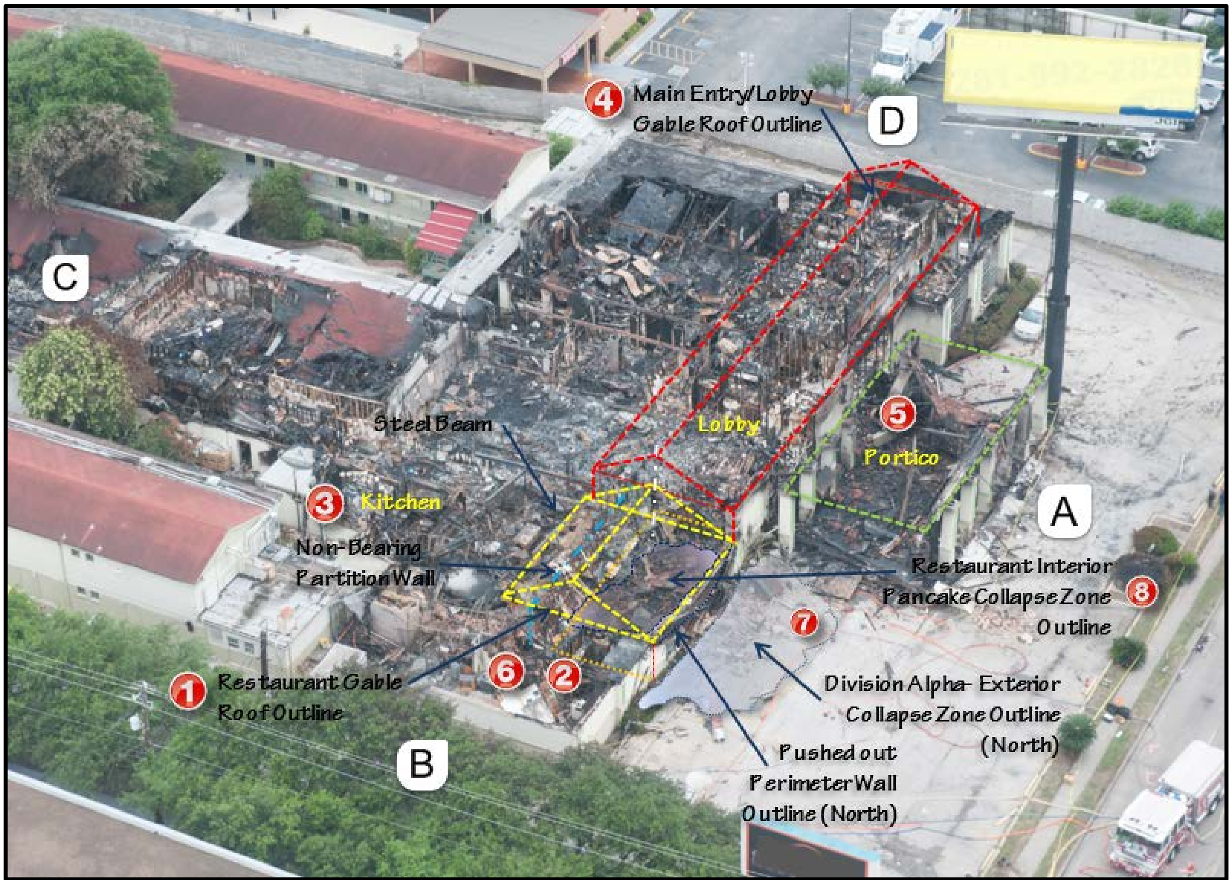

Photo 12. Post Fire-Collapse Aerial View of Building Complex
(Photo courtesy of the fire department/ Diagram Courtesy of Buildingsonfire.com)

[1] Restaurant Gable Roof - Outline
[2] Restaurant Floor Outline
[3] Kitchen Area
[4] Main Entry and Lobby Gable Roof-Outline
[5] Main Portico - Canopy Roof Destroyed
[6] Adjacent Rooms
[7] Secondary Wall Collapse Zone
[8] Interior Pancake Collapse Zone

Appendix Two
Fire Fighter Risk Profile and Insights

Occupancy Risk Profile

The complex of buildings that comprised the property at the Southwest Inn (SWI) had common inherent building, construction, design features and characteristics that provided a recognizable predictability of expected building performance. This predictability of building performance have definable degrees of risk potential that once identified and assessed against an evolving fireground scenario can be align with recognized strategic and tactical measures that must be considered and implemented in order to increase the probability of a safe and effective incident stabilization and mitigation.

The significance of the extent and degree of renovations, alterations and modifications over the complex's forty plus years of use cannot be underscored and contribute highly towards the overall projected probabilities of risk and impacts on fire department operations.

Understanding the building's anatomy, its current occupancy use and the characteristic of the building's internal compartments (occupied rooms and space use) are integral to effective and efficient firefighting operations within buildings on fire and are essential for all phases of fire engagement and suppression.[26]

The challenge for today's command officer, fire officers, and fire fighters on the modern fireground is to clearly recognize building performance factors and inherent characteristics. These are issues fundamental to the manner in which a building's anatomy presents itself at an evolving incident. Moreover, to ascertain and distinguish how it will subsequently perform during fire duress and the continuum of elapsed incident time.[16, 17]

The prevailing building characteristics present, for the restaurant occupancy and the main lobby/entrance buildings and adjacent kitchen areas consisted of; conventional construction features with related performance parameters with an average building age exceeding over 40 years, wood frame construction, some masonry veneer and wood perimeter wall construction, and engineered gabled truss roof assembly construction systems, flat roofs and integrated unprotected steel beam, and column structural support systems integrated into past renovations and additions.

Additional proximal buildings comprised of transient hotel/motel occupancy use. These are not included in this discussion section. Overall building anatomy, operational risk, and probability of performance for operating fire-fighting personnel, and in the management of the incident is normal-marginal. A higher emphasis toward the marginal band primarily due to the inherent wood frame construction, interconnected buildings and roofing systems, large span/open floor areas and the lack of a fixed fire protection system.

The inherent building materials in the form of the light-frame wood structural systems, roofing diaphragms with some structural steel components coupled with a moderate interior fuel load package would contribute towards fire growth. This supports the premise of a higher probability of expected fire development in a compartment and rapid fire extension in the event of a fire incident.

The restaurant occupancy and the main lobby/entrance buildings and adjacent kitchen areas were adjoining and contiguous creating interconnectivity of varying volume compartment spaces. The restaurant space was nestled on three sides with the front of the buildings accessing directly to the parking lot. The other three sides connected to the main lobby/entrance building (west), ancillary rooms (east) and kitchen (south). The restaurant structure appears to have been part of the original construction circa 1966, with the ancillary rooms and kitchen areas added at an unknown later time period.

The roof construction configuration when identified on the fireground should be considered an indication that the structural supporting systems in this area may have been radically modified. The roof diaphragm supporting system has been modified revealing the presence of large open span area is probable. Caution must be exercised and considered if fire or fire-indictors are present. Structural stability and integrity must be closely monitored or considered a high risk factor. Overall operations conducted under this area may be consider at-risk deployments that require fluid and concise risk-benefit assessment and close monitoring. This is based on incident priorities, immediate or deferrable operational demands associated with life hazards and fire severity, growth or propagation.

The street view of the restaurant clearly reflects the difference in building anatomy with a predominate gable roof with cement tile roofing treatment. This distinctive feature and the manner in which it is physically situated present operational barriers that could have adverse effects on subsequent incident operations in terms of access, size-up and assessment, smoke tunneling, compartment ventilation, multiple flow paths routes, ventilation-limited or fuel-limited conditions, structural integrity and collapse considerations, tenability and connectivity of spaces and fire dynamics.

Predicting a potential structural collapse is one of the most challenging tasks facing an Incident Commander at a fire scene. Usually the lack of information on the construction of the building, fire size, fire location, fire burn time, condition of the building, and fuel load, makes the task very difficult

Building Risk and Severity Considerations

- Building construction system and type;
- Building size and volume: number of large open span assembly spaces and individual occupancy compartments (rooms);
- Building age, vintage and condition;
- Degree of alterations, renovations and make-overs over an extended period of decades
- Degree of roof compartmentation: connectivity of roof truss-loft (attic spaces) compartments and high probability for unstopped concealed spaces;
- Structural collapse characteristics of wood truss roofing systems; structural integrity and collapse considerations;
- Presence of extruded concrete interlocking roof tiles;

- Inherent structural compromise and collapse potential-internal due to mixed-construction systems, materials and structural assemblies;
- Physical arrangement of primary occupancy (restaurant) and impacts from smoke tunneling, compartment ventilation, multiple flow paths routes, ventilation-limited or fuel-limited conditions, tenability and connectivity of spaces-fire dynamics;
- Fire loading and potential for significant heat release rates/effects on fire suppression;
- Identifiable and measurable safety parameters;
- Adequacy of fire flow rates based on postulated fire growth;
- Probability of rapid fire travel and extension growth;
- Uncertainty of civilian occupancy load;
- Uncertainty of civilian occupancy reaction time and responsiveness to emergencies;
- Probability of fire department life hazard and risk threat;
- Resource intensive deployment requirements;
- Identified severity of risk level and acceptability of risk to organization;

Buildings on Fire Risk Assessment Matrix

Levels	Severity of Risk
Catastrophic	May Result in personnel Death; grave personnel injury; large scale destruction and perilous conditions
Critical	May cause severe personnel injury, possible death; major property loss or significant degraded conditions
Marginal	May cause or result in personnel injury, prominent property loss or degraded and compromised conditions
Normal	Hazards and conditions are consistent with generally accepted Fire Service work practices and operational parameters for adequately resourced and trained companies. Operations may cause or result in some personnel injury, corresponding property loss or damage conditions consist with firefighting principle & practices
Negligible	Conditions have minimal threat to the safety and wellbeing of companies operating under generally accepted Fire Service work practices and parameters

4 Fire Fighters Killed and 16 Fire Fighters Injured at Commercial Structure Fire – Texas

Buildings on Fire Risk Assessment Matrix
Courtesy of Buildingsonfire.com and the Command Institute, additional information can be accessed at http://buildingsonfire.com/buildings-on-fire-risk-assessment-matrix

Based on potential severity and urgency factors given a fire of any great magnitude or other initiating event, this would require judicious and thoughtful pre-fire planning. This is not only to identify postulated incident events and occurrences, but to also assess the potential demands for escalating incidents, resource needs and suggested incident management scenarios, situations, and consequences.

The probability for an impending multiple-alarm fire occurring in this complex creating limiting conditions of operations, high resource demands, operational severity, urgency and escalating incident growth issues were highly probable and could be expected. Therefore, precautions and instituted pre-fire plans could have been identified, formulated and implemented prior to the initiating incident that may have contributed towards increased operational and incident management efficiencies, operational effectiveness, control and amplified managed risks.

Appendix Three
Summary of Personal Protective Equipment Evaluation
Status Investigation Report of four Self-Contained Breathing Apparatus Submitted By the Fire Department NIOSH Task Number TN-19199

(***Note:*** *Full report is available upon request*)

Background

The National Institute for Occupational Safety and Health (NIOSH) has concluded its investigation conducted under NIOSH Task Number TN-19199. This investigation consisted of the inspection of four Scott Health and Safety AirPak 4.5, 45 minute, 4500 psig, Self-Contained Breathing Apparatus (SCBA). The SCBA units in question were contained inside individual cardboard shipping boxes and were delivered to the NIOSH facility in Bruceton, Pennsylvania, on June 13, 2013. The packages were taken to the NPPTL, Technology Evaluation Branch (TEB) Respirator Equipment Storage Area (Building 20) and stored under lock until the time of the examination and evaluation.

SCBA Inspection

An initial general inspection of the SCBA units was conducted on June 14, 2013. The units were identified as the Scott Health and Safety AirPak 4.5 models. In addition, Scott Health and Safety performed a down loading of the data logger present on one of the SCBA's with NIOSH personnel present.

A complete visual inspection of the SCBA units was conducted on October 30, 2013 and February 11, 2014. The units were examined, component by component in the condition received, to determine conformance to the NIOSH-approved configuration. The visual inspection process was photographed.

The complete SCBA inspections are summarized in Appendix I of the enclosed Status Investigation Report. The condition of each major component was photographed with a digital camera. Images of the SCBA units are contained in the Appendix III of the report.

The SCBA units in question, Unit #1, Unit #2, Unit #3 and Unit #4 suffered heat damage, but exhibited other signs of wear and tear; and the units were covered lightly with general dirt, grime, foreign particulate material and soot. The cylinder valves as received on all units were in the opened position. The cylinder gauges that could be read as assembled to the backframe were approximately 0 psig for Units #2 and #3. The other gauges were un-readable.

The cylinder valve hand-wheels could be turned easily. The regulator and facepiece mating and sealing areas on the units were clean on Units #2 and #3. The mating and sealing areas on Units #1 and #4 were damaged. The facepiece and lens on all the units were damaged. Units #1 and #4 had extensive damage to the facepiece and lens. The harness webbing on the units was in fair to poor condition with some fraying on some of the units, heat damage on other but all the head harnesses were dirty. The PASS device on the Units #2 and #3 functioned. The NFPA approval label on Unit #3 was present and readable Units #1 and #4 could not be read and Unit #2 did not have a label. Visibility through the lenses of Units #1 and #4 were poor due to the extensive damage of the lens. Visibility through the lenses of Unit #2 and #3 were fair with some slight damage present.

Personal Alert Safety System (PASS) Device

The Personal Alert Safety System (PASS) devices on Units #2 and #3 were operable and functional. The PASS devices were activated and appeared to function normally. The other PASS units did not function. However, the units were not tested against the specific performance requirements of NFPA 1982, *Standard on Personal Alert Safety Systems, (PASS)*, 1998 Edition. Because NIOSH does not certify PASS devices, no further evaluation was performed.

SCBA Compressed Air Cylinder Contents

During the inspection, it was noted that the compressed air cylinders of all the units were empty. No air sample was collected for analysis.

SCBA Testing

The purpose of the testing was to determine the SCBA conformance to the approval performance requirements of Title 42, *Code of Federal Regulations*, Part 84 (42 CFR 84). Further testing was conducted to provide an indication of the SCBA conformance to the National Fire Protection Association (NFPA) Air Flow Performance requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, 1997 Edition.

NIOSH SCBA Certification Tests (in accordance with the performance requirements of 42 CFR 84):

1. Positive Pressure Test [§ 84.70(a)(2)(ii)]
2. Rated Service Time Test (duration) [§ 84.95]
3. Static Pressure Test [§ 84.91(d)]
4. Gas Flow Test [§ 84.93]
5. Exhalation Resistance Test [§ 84.91(c)]
6. Remaining Service Life Indicator Test (low-air alarm) [§ 84.83(f)]

National Fire Protection Association (NFPA) Tests (in accordance with NFPA 1981, 1997 Edition**):**

7. Air Flow Performance Test [Chapter 5, 5-1.1]

The testing of Units #2 and #3 were conducted on February 20 and 21, 2014, using substitute compressed air cylinders and facepiece supplied by the fire department. Neither SCBA Units #2 or #3 passed all the testing. Units #1 and #4 were not tested as they had extensive damage and could not be tested safely.

Summary and Conclusions

Four SCBA units were submitted to NIOSH by the NIOSH Division of Safety Research for the affected fire department for evaluation on June 13, 2013. The SCBA's were initially inspected on June 14, 2013. The units were identified as a Scott Health and Safety AirPak 4.5, 45 minute, 4500 psig SCBA (NIOSH approval number, TC-13F-212CBRN Unit #3 and unknown approvals for Units #1, #2 and #4). In addition on June 14, 2013, the SCBA data logger for SCBA Unit #3 was downloaded by personnel from Scott Health and Safety with NIOSH personnel present. In-depth inspections of the SCBA's were conducted on October 30, 2013 and February 11, 2014. Two of the units were in mostly fair condition and two of the units in poor condition, with all the units having various levels of damage to the facepiece lens. The compressed air cylinders from Units #1 and #4 could not be determined to be in specification as the cylinders where discolored and the labels were unreadable. The cylinders for Units #2 and #3 were determined to be within specification. All these cylinders are required to be recertified every 5 years.

The integrated PASS unit on Units #2 and #3 were activated and appeared to function normally.

No air remained in the cylinders so no air samples were taken and analyzed.

The SCBA Units #2 and #3 were tested on February 20 and 21, 2013, utilizing replacement cylinders and facepiece that were supplied by the fire department. Units #1 and #4 were not tested due to the level of damage to each of the units. The Units #2 and #3 did not meet all the requirements as tested.

After the inspections and testing of the SCBA units, the respirators were placed back into storage pending the final disposition from the fire department. At the request of the fire department, Unit #2 was sent to Scott Health and Safety for further evaluation.

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Inspection and Test of SCBA #2
Scott Safety, Monroe, NC
April 1, 2014

Discussion:
NIOSH personnel provided an overview of the incident with a focus on SCBA #2. The results of the NIOSH testing of SCBA #2 were discussed. It was agreed to verify the performance of SCBA #2 on a Posi Check in the Scott Engineering lab and determine on the next step after reviewing the Posi Check results.

Initial Inspection
The SCBA less facepiece was visually inspected and photographs supplied by NIOSH of the SCBA and facepiece were reviewed.

Testing
SCBA #2 was installed on the Posi-Check using an AV3000 HT facepiece, the SCBA was pressurized slowly utilizing shop air (4500 psi).

Noise was detected from the area of the RIC/UAC/ High Pressure relief Valve /1st stage reducer; the noise is best described as a squealing sound.

A leak was detected at the High pressure Relief Valve.

The Vibralert EOSTI functioned.

The Posi-Check test was repeated two more times, erratic Vibralert operation was noted which may be caused by improper operation of the secondary circuit, also the “Press to Test” button was found to stick.

SCBA #2 remained positive through all Posi-Check tests performed at Scott for both NIOSH (40l/min) and NFPA (103L/min) breathing rates.

1st Stage Reducer disassembly and inspection
It was agreed the next step is to disassemble the reducer and inspect the components for damage and debris in the air passages.

The primary and secondary seat plugs were found to be loose and were removed. The primary seat and shims were removed, the seat removed and debris noted on the seat and in the airway. The filter was removed with great difficulty and was found to be collapsed.

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Appendix Four
Personal Protective Equipment Evaluation
Examination of Fire Fighter Protective Ensemble Items

An examination was made of the personal protective equipment items worn by the captain of Engine 51, the Engineer/Operator detailed to Engine 51, and the two fire fighters assigned to Engine 68, who died in the restaurant fire on May 31, 2013. The examination was made at the department's Arson Division on January 30, 2014.

A detailed review of the protective clothing and equipment items showed a range of different conditions of the clothing and equipment items with no specific patterns indicated. The degree of thermal damage observed on the clothing was attributed to extreme fireground conditions with the majority of firefighters (with the exception of the fire fighter assigned as E68C) facing thermal conditions in excess of 1000^{o}F for at least short periods of time. These exposures caused significant damage for portions of their protective clothing and equipment, including some areas of severe thermal degradation involving extensive charring and break open of all clothing principal protective layers. The orientation of the fire fighters during the ensuing period of collapse and recovery affected how their protective clothing and equipment fared.

The following is an evaluation of the personal protective equipment of each fire fighter:

- The captain of E51 experienced the worst thermal conditions as evidenced by the condition of his protective clothing and equipment with portions of front of his ensemble (helmet, coat, pants, and footwear) completely destroyed and missing.
- The protective clothing and equipment of the Engineer/Operator detailed to E51 sustained relatively severe thermal exposure conditions principally to the back of his clothing.
- The fire fighter, assigned to E68 (E68C), his personal protective equipment showed several areas of localized destruction, more than likely due to specific areas of burning debris and other debris, which would have shielded his body.
- The least amount of damage was shown on the other fire fighter from E68 (E68B). Her personal protective equipment sustained minimal damage. The primary damage was in the melting of the helmet faceshield and charring of her hood face opening.

Some items of protective clothing and equipment were not available for examination. Nevertheless, there was no finding of any specific problems with any of the protective clothing and equipment items examined. The condition of these items is consistent for what would be expected for an extended exposure on the fireground during a structural collapse entrapping firefighters in a closed area with continued periodic exposure to severe thermal conditions before their recovery. All protective clothing items were designed to provide protective performance well in excess of minimum industry standards.

Appendix Five
Use and Operations of Thermal Imagers

The temperature measurement feature on fire service thermal imagers should not be used for interior structural firefighting.
Use of this feature *MAY CAUSE ERRORS IN JUDGEMENT WHICH MAY RESULT IN SERIOUS INJURY OR DEATH*.

Fire service thermal imagers may be equipped with a temperature measurement feature.
Utilizing either a bar indicator or digital readout or both this feature displays the approximate surface temperature of a targeted surface.

The temperature measurement feature is a non-contact solid surface temperature measurement device that is not accurate.

Different materials or the same materials with different composition, surface textures, color and polish will not register temperature readings in the same way resulting in variations in the temperature readings.

Several factors including but not limited to:
- how much heat
- the material being measured and its ability to absorb or reflect heat (emissivity)
- the objects temperature
- the distance from the object being measured as well as
- the angle at which the object is being viewed
- the cleanliness of the lens as a result of steam or smoke;
- the object does not fully fill the center target area then a false reading may be obtained

Users must be aware and understand that the temperature measurement feature in a thermal imager will NOT provide atmospheric or air temperature readings.

Additionally the thermal imaging camera cannot see through walls.
- When attempting to view a source of heat behind a wall or above a ceiling the heat source will not be evident if it does not heat the wall itself. Consideration must be given to the thickness of the wall or ceiling as well as any additional layers of materials that may exist and further insulate or mask the true magnitude of the heat source.

All of these factors may individually or collectively greatly affect the accuracy of the temperature measurement feature during interior structural firefighting situations.

Because interior structural firefighting is a rapidly changing dynamic environment with many unknown and uncontrolled variables the temperature measurement feature on thermal imagers should not be utilized or relied upon by fire fighters to make tactical interior structural fire-fighting decisions.

Appendix Six
Incident Commander's Tactical Worksheet for "Mayday"

INCIDENT COMMANDER'S TACTICAL WORKSHEET FOR "MAYDAY"

- ☐ MAYDAY - MAYDAY - MAYDAY Message is Transmitted;
- ☐ Announce *EMERGENCY RADIO TRAFFIC* only;
- ☐ Acknowledge Company/Member transmitting the Mayday – Obtain LUNAR information:

LOCATION ____

UNIT ____

NAME ____

ASSIGMENT AND AIR SUPPLY ____________________________

RESOURCES NEEDED____________________________________

- ☐ If no answer after two attempts conduct a PAR of all operating companies on the fire ground to isolate company/member;
- ☐ Deploy RIC to reported or last known location/assignment;
- ☐ Request an additional alarm;
- ☐ Request an additional TAC channel for fire operations TAC___
- ☐ Assure that companies not assigned to the rescue or near the rescue change to the new fire operations channel and conduct a PAR;
- ☐ Maintain fire-fighting positions. Withdraw only if necessary;
- ☐ Establish a Rescue Group with a Safety Officer;
- ☐ Review the Building Pre-Plan if available;
- ☐ Establish a Backup RIC to replace the deployed RIC;
- ☐ Establish a forward staging area for the Rescue Group and provide support with adequate staffing and equipment;
- ☐ Request additional EMS Resources/ALS Ambulances;
- ☐ Request Specialized Resources if needed – Technical Rescue;
- ☐ Conduct a PAR if an emergency evacuation is ordered (due to structural stability or fire conditions);
- ☐ Conduct a PAR after the rescue operation is completed;
- ☐ Announce the end of the Mayday;

Appendix Seven
Sample SOP – Restricted Access for PPE/SCBA/Equipment

PURPOSE
To provide the mechanism for the chain of custody, sealed access, and prevention from contamination of evidence, which may assist in determining the cause of malfunction, failure, accident or casualty.

SCOPE
This applies to all Fire Department personnel, equipment, and personal protective equipment (PPE).

CFAI REFERENCE
This policy applies to the following categories, criterion, and performance indicators of the Commission on Fire Accreditation International (CFAI): 7F.7

CONTENT
The intent of these guidelines is to isolate equipment/PPE which, for the purpose of investigation, must be sequestered in as close to the same condition as at the time of the event. Information gathered from this process will assist the investigating officer(s) or agency(s) in cause determination.

PROCEDURE
Any equipment/PPE (non-vehicular) that fails to operate in its designed and prescribed fashion, whether in training or on an emergency incident, shall be sequestered. Employees shall immediately notify either the Shift Safety Officer or a Battalion Chief to secure the item. The item(s) shall be maintained, as close as possible, in the same condition in which it malfunctioned or failed in order to preserve any evidence for investigation purposes.

When securing SCBA units the air will be turned off, the system bled down, and the "PASS" device turned off. Additionally, when sequestering a SCBA unit, the following shall be noted on the receipt: remaining air in tank; position of air cylinder valve (open/closed/1/2 open); Pass device status; and was the emergency bypass on or off. If the malfunction was due to free-flowing air, sequester the user's mask also.

All equipment sequestered will be placed into the Restricted Access Bag, zippered shut, and sealed with a "zip" tie around the zipper tabs. To prevent cross contamination, separate items should be placed in separate bags. The sequestering officer will issue a receipt with a detailed inventory (to include all identifying inventory numbers) to the supervisor responsible for the equipment/PPE.

Once an item has been sequestered, the Shift Safety Officer will take control of the bag. Any time the Restricted Access Bag changes hands, a new receipt, as outlined above, will be issued. The Battalion Chief of Safety will maintain all original receipts at Fire Administration. Entry into the bag will be limited to only those parties authorized by the Battalion Chief of Safety, the Shift Safety Officer, or the Battalion Chief of Resource Management. An inventory of the Restricted Access Bag will be conducted any time the seal is broken and recorded on the inventory form.

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RESTRICTED ACCESS BAG RECEIPT

Date: ____________ **Time:** __________ **Incident #:** ____________________

Location Item/Equipment Received: ___________________________________

Item/Equipment Sequestered: _______________________________________

City/Department ID#: ___________________________

SCBA Information: remaining air in tank; _______ psi. **PASS:** ON/OFF _______

Position of air cylinder valve (open/closed/1/2 open): _________

Emergency bypass on or off: _________

Item/Equipment Assigned To: ____

Reason for Sequestering:
(**Be as Specific as Possible**) ____

____

____

____

____

Item/Equipment Received From: _____________________________________

Date: __________ **Time:** __________

Item/Equipment Delivered To: ____

Date: __________ **Time:** __________

Seal #: __________ **Date:** __________ **Time Sealed:** __________

Comments: ____

____

____

____

____

Original: Battalion Chief of Safety **Canary:** Sequestering Officer **Pink:** Member Releasing Inventory

Appendix Eight
Fire Department Update

The department undertook a number of actions to prevent the occurrence of similar injuries. The fire chief initiated a "Recovery Committee" from all ranks to review this incident and to develop recommendations and to move the department forward. Soon after, the Recovery Committee was established to begin looking into several areas directly related to this fire and attempt to understand just how such a tragic loss could occur. The four workgroups include:

- Fireground Operations
- Rescue & Safety
- Communications & Technology
- Timeline/Process/Procedures

The core of this project is to learn as much as possible, to evaluate the department's procedures and practices, and then work to develop solutions for both the common and uncommon problems which occurred on May 31, 2013. Finally, this committee will develop a comprehensive report that narrates the events that occurred and provide sound strategic, tactical, and task level recommendations.

The department advised the investigators from the NIOSH FFFIPP that they have implemented a number of changes based on Committee recommendations.

The following is a summary of the changes reported to NIOSH:

(June 2013)

1. The Communications and Technology workgroup met with Motorola® to voice concerns about several problems that were discovered during the restaurant fire. Among the issues discussed were with the Digital delay and the need to research new technology that would provide shorter key-up time when no audio is transmitted. A follow-up meeting was scheduled for November, 2013.

(July 2013)

2. Radio Code Plug Changes and APX system re-programming occurred
   a. The Emergency Button was changed from a 1-second push to a 2-second push.
   b. The "Permission to Talk" time limit was shortened from 60 seconds to 30 seconds.

3. The city's Radio Communication Systems (RCS) division requested Motorola® to research the following features in order to shorten delays and improve emergency radio communication.
   a. Quick-Key "Bonk"
   b. Create a transmission complete tone (user un-keys the radio)
   c. Different tones be created for "Out-of-Range" warnings versus a "Busy signal"
   d. No Audio: Time-out of 5 seconds

4. An Electronic Command Board was being developed to assist Incident Commander's with tracking fireground assignments.

5. The department began to re-designing and updating the Rapid Intervention Team equipment (RIT Packs). The department's Rapid Intervention Team (RIT) standard operating guideline was also being re-evaluated and a new RIT Performance Standard was being developed.

(August 2013)
6. A new section was added to the department's *Protective Clothing Guideline II-02* to give Safety Officer's direction on how to collect fire fighters PPE and fire-fighting equipment when an injury or significant event occurs. The purpose is to ensure that any equipment damaged at an incident is properly inspected and tested before being placed back on an apparatus or in-service.

(September 2013)
7. Radio prioritization was established that would provide District Chiefs with priority communications over all other radios on the fireground. The order of priority is as follows:

a. 1st priority - OEC Dispatch Consoles / OEC Portables (Orange shell)
b. 2nd priority - Deputy / District Chief / Safety Officer Mobile Radios
c. 3rd priority - Deputy / District Chief / Safety Officer Portables (Red shell)
d. Heavy Apparatus / All other Portable radios (Yellow shell)

8. The GRACE Accountability System was upgraded:

a. Software was updated and additional training was provided to Incident Command Technicians (ICTs).
b. All T-PASS devices (individual firefighter monitoring devices) were upgraded to the TPASS4 model.

9. The department's Information Technology Unit began work on creating electronic personnel files. This measure was performed to help keep members' emergency contact information current and readily available.

(October 2013)
10. The department's Arson Bureau and the State Fire Marshal's Office (SFMO) created a process that would limit the impact on members during an interview process.

a. The SFMO provided the department's Arson Bureau with documents that can be completed concurrently with department statement interviews so that members don't have to repeat this process multiple times with different investigators.

11. A new Internal Disaster standard operating guideline was being drafted to help members during these types of events.

a. This guideline is aimed at assisting members with decision making and overall management after a significant event has occurred that affects the normal day to day operations of our department.

12. New fireground communication procedures were developed to help reduce radio transmissions.
    a. Incidents Commanders were instructed to begin using additional Talk-groups (Tac Channels) for support roles at an incident.
    b. Units that are responding on additional alarms, assigned to Staging, or in "Rehab" should be placed on a separate Talk-group.
    c. This process was designed to reduce excessive radio communication on the Fireground Talk-group.
    d. Communication on a monitored Fireground Talk-group should be reserved for Strategic and Tactical operations.

13. The city's Radio Communication Services (RCS) worked to improve the infrastructure of the new Digital APX system. Areas targeted were populated areas of the city and ones that generate considerable call volume. Others locations across the city are still in various stages of upgrades. Equipment was added or adjustments made to the system to improve in-building coverage.

14. During the first quarter of FY2014, 12 Communication Captains positions were created to increase the total staffing numbers at the Office of Communication (OEC). These additional positions were added for several reasons however one of the biggest advantages was to enhance OEC capabilities when additional Talk-groups are requested for fireground communications.

15. OEC staff members began a ride along program with District Chiefs.
    a. This arrangement was made to provide an opportunity to open up dialogue between members in the field and Communication Captains.

16. The department's training center began working on developing enhanced training in two critical areas.
    a. Incident Command Technicians (ICT)
    b. Building Collapse courses

(November 2013)
17. A follow-up meeting was held with Motorola® regarding the three items presented in June of 2013.
    a**. "Digital Cliff"**
    b. "Quick Key"
    c. A 5-second time out if no voice is transmitted

Note: *The department was informed that Engineers were still exploring these issues and new upgrades to the 700/800 Digital System may be available that address these concerns in the 3rd quarter 2014.*

(December 2013)
18. A new city ordinance was being drafted that addresses buildings with poor radio coverage. This document will outline new requirements that property owners and management companies will need to accomplish in order to meet the standards set for firefighter safety regarding in-building coverage.

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(January 2014)
19. The project of issuing the updated RIT Packs was completed by Emergency Operations.

(February 2014)
20. The department began using a new style of fire-fighting glove. This glove was approved by the Personal Protective Equipment Committee in October of 2013

21. The Office of Emergency Response - Special Projects and the department's training center established a partnership with Scott Industries® and began development of a new training video for Thermal Imaging Camera classes.

(March 2014)
22. A plan was implemented to have all Incident Command Technicians become subject matter experts (SME) for the GRACE Accountability System.
    a. Department Safety Officers conducted this training which included how to maintain routine updates to the system.

23. A department document was drafted to help the families of a deceased member for future planning after a catastrophic event.
    a. This document will be provided through the Firefighter Support Network and was originally developed by the National Fallen Firefighters Foundation.

(April 2014)
24. The Digital Sandbox program was introduced to District Chiefs in a 3-hour training session. This new platform will provide the ability for electronic storage and retrieval of building assessments in the field with as well as offer real time information. Most *Tactical Evaluation and Assessment Plans* (TEAPS) that are currently on file in the department are being entered into the system. Future use will include information that is shared by other city departments and regional agencies.

25. Grant Funding was secured to upgrade the Mobile Data Terminals (MDT's) in each emergency response vehicle to ToughPads®.

26. The Eagle-X Thermal Cameras that were returned to the department's resource management when the new model of TIC was delivered, were issued to all Incident Command Vehicles.

27. Shift Commanders on all four shifts began "Situational Awareness/Building Construction" training. This hour long presentation was given on a District level.

(May 2014)
28. A committee was formed to evaluate a "Blended Fire/EMS Response" for multiple Task level duties including IRIT and RIT.

29. Temple Transducer Headsets were purchased through Grant funding. This equipment is being issued to "Command" vehicles to enhance the communication capabilities of the Incident Commander (IC), the Incident Command Technicians (ICTs) and Accountability Officer's (AO).

30. The administration began reviewing department guidelines pertaining to on-scene video recording. The use of helmet cameras, "Dash cams" and other portable recording devices are being evaluated for future use.

(November 2014)
31. All Emergency Response deputy chiefs, district chiefs, and safety officers were provided training in Fire Fighter Safety through Advanced Research (FSTAR). This presentation focused on improving fire fighter safety by incorporating the evolving scientific research being conducted at the Underwriters Laboratories (UL) Fire Fighters Safety Research Institute and the National Institute of Standards and Technology (NIST) Fire Research Division.

(November 2014)
32. The department applied for an "Assistance to Firefighters" Grant which is a program provided through the U.S. Department of Homeland Security to fund the delivery of the International Association of Fire Fighters (IAFF) Fireground Survival training to all members of the Emergency Operations division who operate in the hazard zone. This training was scheduled to begin in November 2014 and designed to be completed in a three (3) Phase process.

- Phase I – On November 6, 2014, twenty-nine (29) members became certified instructors by completing the 32 hour IAFF-FGS Facilitator (Train-the-Trainer).
- Phase II – (January 2015): all classified members assigned to Emergency Operations and OEC were required to begin and complete the IAFF-FGS on-line Course by March 15, 2015.
- (February 2015) the first cadet class was trained in IAFF-FGS prior to graduation
- Phase III – (April 2015): the IAFF-FGS certified facilitators are slated to begin the on-duty training of all members of Emergency Operations who operate within the hazard zone. This project should be completed by the first quarter of 2016.

(January 2015)
33. The department has applied for Urban Area Security Initiatives (UASI) funding that will be used to continue the *Blue Card Command Certification Program*. This is an interactive Incident Command System training program that provides a certification for officers that function as the Incident Commander. Twenty (20) members in the department were selected to evaluate the course and it is now planned for all officers in the department to become certified.

(February 2015)
34. The city's Radio Communication Division (RCS) conducted a Radio Code Plug change and APX system re-programming after Motorola provided a new Firmware upgrade. The three of the four items presented to Motorola (July of 2013) were resolved and updates performed.

a. Quick-Key "Bonk" eliminated;
b. Different tones were created for an "Out-of-Range" signal and a "Busy" signal;

c. A 5-second time out was created when a radio was keyed but no audio was transmitted

(February 2015)
35. The department implemented an electronic version of each members Permanent Personnel Form (Electronic Form 42). This record is now accessible for each member on the department's district chief *Staffing Worksheet*. This form provides any supervisor with a members work history, attendance record, and access to emergency contact information when needed.

(February 2015)
36. The department introduced the first guideline that provides specific strategies and tactics for structural fire-fighting. The department's Guideline Volume No. II-47 "Structure Fire Incidents" is meant to develop a consistent approach and improve fireground safety. The vision is based on research and lessons learned during the Firefighter Safety through Advanced Research (FSTAR) training.

(February 2015)
37. The department scheduled a "Modern Fire Dynamics Presentation" to be one (1) of eight (8) mandatory multi-company drills for 2015. The presentation is a compilation of research conducted by Underwriters Laboratories (UL), Fire Safety Research Institute (FSRI), and the National Institute of Standards and Technology (NIST) along with the information from the Fire Fighter Safety through Advanced Research (FSTAR) training that all Chief Officers attended (November 2014). This course was developed and presented by the officers assigned to the department's Training Center.

The five (5) key areas being presented include;
- Changing Fire Environment
- Understanding of Fire Dynamics
- Fire Dynamics in Structure Fires
- Getting the "Science to the Streets"
- Putting it all together