Career Fire Lieutenant Killed By Roof/Ceiling Collapse During Overhaul—Georgia

Executive Summary

On December 15, 2013, a 50-year-old male career fire lieutenant died after being struck by a roof and ceiling collapse during overhaul of a vacant residential structural fire. The lieutenant was one of two fire fighters that had re-entered the structure to extinguish hot spots during overhaul. Fire fighters had been on scene for 1½–1¾ hours and had knocked down the majority of the fire. The lieutenant and the other fire fighter re-entered the house to perform overhaul and a ceiling and part of the roof assembly collapsed on them. One fire fighter was able to escape but the lieutenant was trapped under the ceiling assembly and had to be extricated. Fire fighters performed emergency resuscitation procedures inside the structure and then Advanced Life Support (ALS) procedures. He was removed from the structure and transported to a local hospital where he was pronounced dead.

A lieutenant was killed during overhaul after a ceiling and roof assembly collapsed in this vacant building. (*Photo by NIOSH.*)

Contributing Factors

- *Arson*
- *Extensive fire in a vacant building*
- *Risk-versus-gain analysis prior to committing to interior operations involving a vacant/abandoned structure*
- *Strategic mode changes and personnel accountability*
- *Situational awareness as related to expected building performance under fire conditions*
- *Lack of a safety officer*
- *Structure not demolished in timely manner.*

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Key Recommendations

- *Fire departments should ensure that incident commanders conduct a risk-versus-gain analysis prior to committing to interior operations in vacant/abandoned structures and continue the assessment throughout the operations.*
- *Fire departments should develop, implement, and enforce clear procedures for strategic mode changes and ensure personnel accountability is maintained.*
- *Fire departments should ensure that fire fighters are trained in situational awareness as related to expected building performance under fire conditions.*
- *Fire departments should ensure that a safety officer, independent from the incident commander, is appointed at working structure fires.*
- *Fire departments should incorporate principles of command safety into the incident management system when strategic mode changes occur, and incident commanders should maintain accountability of all assigned resources.*
- *Fire departments should ensure standard operating procedures (SOPs) are developed for fighting fires in vacant/abandoned buildings and consider an unsafe building marking system as part of an overall program to address fighting fires in these buildings.*
- *Municipalities and local authorities having jurisdiction should consider developing strategies for the prevention of and the remediation (demolition) of vacant/abandoned structures and for arson prevention.*

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Introduction

On December 15, 2013, a 50-year-old male career fire lieutenant died after he was struck by a ceiling collapse during overhaul of an abandoned residential structural fire. On December 16, 2013, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program of the incident. On January 6–10, 2014, three NIOSH investigators traveled to Georgia to conduct an investigation. The NIOSH investigators met with the fire chief and staff of the fire department. The investigators reviewed fire department standard operating procedures, training records from the department, and audio radio transmissions. During the investigation, witness statements were reviewed and interviews were conducted with the fire fighters and fire officers involved in the incident. The NIOSH investigators inspected the lieutenant's personal protective clothing (turnout gear).

Fire Department

The fire department involved in this incident is a career department consisting of 53 members that provide fire suppression and protection. There are 3 fire stations located strategically throughout the city that serve a population of approximately 14,725 in a geographic area of approximately 12 square miles. These fire stations house four engines, one aerial ladder truck, as well as one air and light truck. One battalion chief is on duty per shift. The battalion chief and fire fighters work a 24 hour on and 48 hour off tour. The department currently has an ISO rating of 2 and responded to approximately 1,100 incidents in 2013.

Training and Experience

The lieutenant in this incident had more than of 25 years of experience as a professional fire fighter with this department and also in Alabama. He had completed the department's required training including the following training documented by the Georgia Public Safety Training Center:

- 292 hours of Fire Service Training in hydraulics, fire inspection principles, hazardous materials, initial company operations, NIMS IS-300, NIMS IS-400 advanced command system, strategy and tactics, acting officer in charge, leadership 1, 2 and 3, building construction
- More than 1700 hours of fire service training documented by the department (some hours may be included in the Georgia Public Safety Training hours).

In addition to the many hours of fire training in Georgia, the lieutenant had additional training with the Alabama Fire College including:

- Fire Fighter I

- Fire Fighter II
- Fire Instructor I
- Fire Investigator
- Incident Management
- Hazardous Materials Technician
- Pumper Operations
- Natural Gas Fire Fighting
- Emergency Medical Technician (P)

The state of Georgia has minimum training requirements for full-time fire fighters. This minimum training is the Georgia Basic Firefighter Training Course as taught by the Georgia Fire Academy or accepted equivalent. The department in this incident participates in the certification process for state certifications and ProBoard certifications tested by the Georgia Firefighter Standards and Training Council.

Equipment and Personnel

Units that initially responded to the structure fire:

- Engine 1 with three personnel including an acting officer
- Engine 2 with three personnel including an officer
- Engine 4 with three personnel including an officer and a recruit (the lieutenant was the victim)
- Ladder 1 with one fire fighter (responded in place of air and light truck)
- Battalion Chief 1 (captain acting as battalion chief).

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. Some of the times have been rounded to the nearest minute. This timeline is not intended, nor should it be used, as a formal record of events.

Incident and Fireground Conditions	Time	Response & Fireground Operations
Time of alarm (received by dispatcher)	0024:55	Reported house fire flames showing.
Time of dispatch	0026:40	Engine 1, Engine 2, EMS, Air 1, Battalion Chief 1 (603).
	0028:09	FD units responding. Engine 4 added themselves to the dispatch.
Engine 1, Engine 2, Engine 4, Battalion Chief 1 (Command) on-scene.	0031-0034	Arrival order was Battalion Chief 1 (Command), Engine 1, Engine 4, Engine 2.

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Incident and Fireground Conditions	Time	Response & Fireground Operations
		Engine 1 arrived and set up on Side D, Engine 4 arrived and set up behind Engine 1 closer to Side A.
Battalion Chief 1 was told by civilian on scene "**Sir, you got somebody in there.**"	0031	*(Note: The civilian who provided this information, along with another civilian, was later convicted of arson and involuntary manslaughter for this incident.)*
Battalion Chief 1 established command on Side A/B and gave initial report of large, single-family, one-half involved with possibly someone inside; ordered a fire attack and search and rescue.	0032	Engine 1 stretched 1¾ inch and attacked fire in rear (Side C).
Command (Battalion Chief 1) ordered Engine 4 to pull a line off of Engine 1.	0033	Engine 4 crew stretched 1¾ inch into Side A to search (second 1¾ inch off Engine 1).
		Engine 2 arrived and assisted by pulling 5-inch LDH from Engine 1 to hydrant at cross street and established water supply; Engine 2 then stretched another 1¾-inch to back up Engine 4 crew.
Command (Battalion Chief 1) called Engine 1 and told them someone is possibly inside.	0034	Command asked Engine 4 if they copy this transmission. No radio response from Engine 1.
Fire Chief (601) arrived on-scene.	0035-0036	Request police department for traffic control. Ladder 1 arrived on-scene.
Engine 4 lieutenant radioed Engine 1 twice (no response).	0037-0040	Command (Battalion Chief 1) called Engine 1 to charge a third pre-connect.
Command called the Fire Chief (601) on radio and told them the fire is over their heads and in the attic.	0044	Engine 4 and Engine 2 crews were inside searching for victims and fighting fire while Engine 1 crew was flowing water from the outside (Side C).
Engine 4 lieutenant called the Fire Chief (601) on radio.	0058	Engine 4 lieutenant tried to call the Fire Chief again (601) and then called command (603).

Incident and Fireground Conditions	Time	Response & Fireground Operations
Engine 4 lieutenant radioed Command that he was on the (street name) side of the house and the roof was sagging pretty bad.	0058	
Someone inside called on radio for an A-frame ladder.	0100	Crews used the A-frame ladder to access the overhead.
Engine 1 officer asked for another line on Side C and another fire fighter.	0134	
Command radioed Engine 1 crew to come around front and relieve the crews inside (overhaul).	0142	
Command called Dispatch and placed fire under control.	0142:47	
Command asked Dispatch to tone out fire marshal.	0146-0149	Fire marshal notified.
	0200	Fire marshal responded to fire head-quarters.
Someone radioed for Engine 4 recruit (name) to come to "this front line."	0205	The front area of the structure had been cleared of victims in the tenable areas and crews were working under the premise that victim(s) still could have been in there (no longer alive) and they were trying to preserve evidence. Fire Chief (with Battalion Chief 1) instructed officers from Engine 4 and Engine 2 to exit and rehab and not to re-enter the structure.
Fire Marshal radioed that he was responding to scene.	0209	All crews were now outside the structure on Side A taking a break. Engine 4 crew (lieutenant and fire fighter) left informal rehab and went inside the structure.
Collapse occurs.	Between 0209-0212	

Incident and Fireground Conditions	Time	Response & Fireground Operations
	0212	Engine 3 dispatched for fire fighter trapped/roof collapse.
	0213	Engine 3 responded.
	0215	Fire marshal arrived on-scene.
Dispatch tried to call Command twice.	0223-0224	
	From time of collapse to-0225	Fire crews worked to extricate the lieutenant. He was uncovered and resuscitation started inside the structure. He was placed on a backboard on the front porch and EMS took over patient care. BLS and ALS procedures instituted by EMS: 0225:14. ALS cardiac monitor placed on patient and other ALS procedures began.
Air Ambulance requested.	0223:09	Declined due to weather.
Dispatch notified of CPR in progress.	0226:44	
EMS transport en route to hospital with lieutenant.	0236	
EMS transport arrived at hospital.	0240	Resuscitation efforts continued at hospital for quite some time, but they were not able to save the lieutenant and he was later pronounced dead at the hospital.
County Station 3 and 4 put on standby and then dispatched.	0256	
	0418	Battalion Chief 1, Engines 1, 2, 3, 4 clear from scene. Mutual aid department on-scene. Command transferred.

Weather

At approximately 0035 hours, the weather in the immediate area was reported to be 68 degrees Fahrenheit, a dew point of 66.2 degrees F., and the relative humidity was 94%. Wind conditions were 4–6 miles per hour from the west-southwest and overcast [Weather Underground 2013].

Structure

Building Construction and Occupancy

Note: Much of the following description of the fire structure and subsequent building construction information is based on material provided by Chief Christopher J. Naum, SFPE (NY). His full report of the building construction analysis and insights and predictive risk for collapse of the structure is included in Appendix 1.

The building was a single-story, residential structure consisting of 2,360 square feet sited on a single corner lot in a residential neighborhood location. Built in 1949, its design and layout was of the craftsman style, a popular style for this era for smaller, single residential structures (also referred to with variations as a California or Chicago Bungalow, Modified Craftsman Cape) and classified as legacy construction [Naum 2012a], incorporating a structural system of Type V, wood frame, fully dimensioned lumber [NFPA 2012].

Built upon a raised crawl space, the structural wood framing system incorporated conventionally full dimensioned 2-inch x 4-inch construction with limited fire stopping (balloon-frame like) with a cross-gable style roof. The low pitched cross-gable roof was constructed of full dimensioned wood rafters conventionally spaced with a 1-inch x 6-inch plank roof deck covered with asphalt shingles creating multiple roof lines and slopes. The three cross-gable roofs had louvered panels located at each end gable, providing ventilation to the concealed roof underdeck attic space. Roof rafters extended beyond the roof edge, creating extended eave lines. The perimeter walls were wood clad clapboard with a large allocation of double hung windows on all building sides, characteristic of this house style. A typical entry porch and entry door were present on Side A with a glass enclosed porch addition constructed in 1958 added to Side B. A small, attached garage was present on Side B (see Photos 1, 2).

Photo 1. Street view in 2008.
(*Google Maps*)

Photo 2. Street view in 2013.
(*Google Maps*)

A single family residential occupancy at the time of the fire, the structure was considered an abandoned home. The property was in a state of disrepair and had a heavy overgrowth of vegetation, brush, and trees, limiting access on Side D. The structure was heavily involved in fire on arrival (see Photo 3). The local jurisdiction had issued a number of "notice of unsafe structure" notices sent to the property owners dating back to 2008 and a "certification of unsafe building" was issued by the local building official in 2011. It was also noted in the records of the Authority Having Jurisdiction (AHJ) on October 11, 2011, that the structure was to be demolished as unsafe. There were no power or utilities active at the time of the fire. The electric power was turned off in 2006 and the water turned off in 2004.

Photo 3. Arrival photo Side B taken by chief of department.
(*Photo courtesy of the fire department/ fire marshal.*)

Construction and occupancy characteristics prevalent in this house style and vintage include:

- Small compact house foot print
- Accessible and predicated floor plan
- Fully dimensional lumber and structural framing system
- Low pitch roof lines
- Compartmentation of rooms
- Limited number of rooms
- Smaller room volume and square footage
- Limited corridors (flow/vent paths)
- Plaster and wood lath interior room finishes; walls and ceilings
- Large allocation of exterior windows along perimeter walls
- Limited attic concealed spaces
- Building accessibility from street-curb side

Post incident observations in the building concluded that past renovations and alternations were found to be evident with the ceiling system assembly. At the time the residence was constructed (ca. 1949), the installation of a plaster and lath wall finish was a common architectural feature in many homes.

The presence of a plaster and lath ceiling system and its impact on fire-fighting operations was widely recognized and accounted for throughout the 1900s up to about the mid-1950s when the prevailing use of plasterboards, sandwich boards, and gypsum wallboards or sheetrock® boards took the place of field-installed plaster and lath construction.

Maintenance, age, and damage and the desire for modernization usually resulted in renovations and alternations of many residential interiors. As was the case here, the ceiling system present at the time of the fire had multiple layers of materials added over time that consisted of original plaster and lath attached directly to the dimensioned lumber ceiling joists, wood tongue and grove panel boards, and gypsum wallboard attached to previous layers (see Figures 1 and 2).

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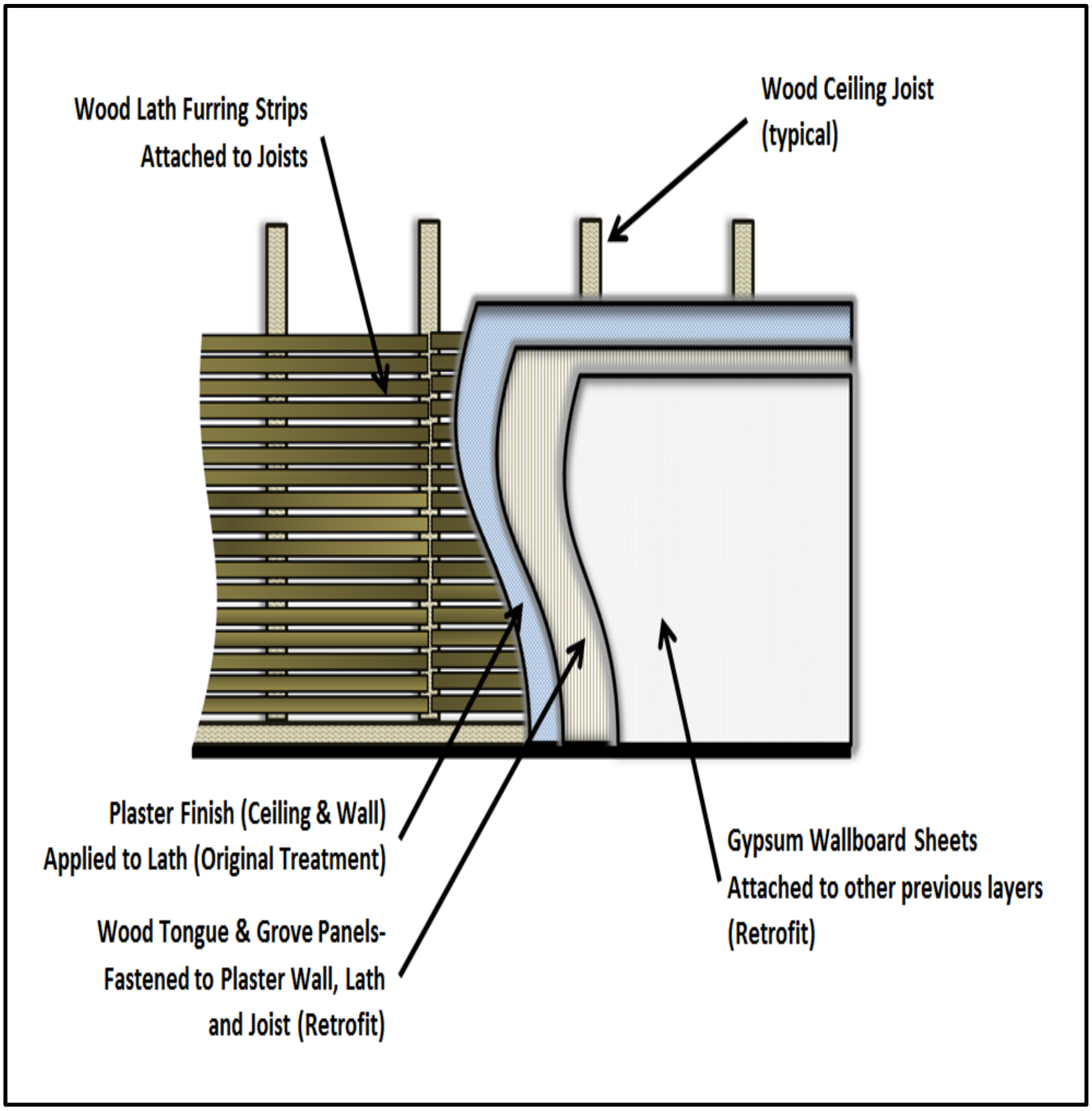

Figure 1. Ceiling retrofits—Layers
(Diagram courtesy of Buildingsonfire.com | C.J. Naum)

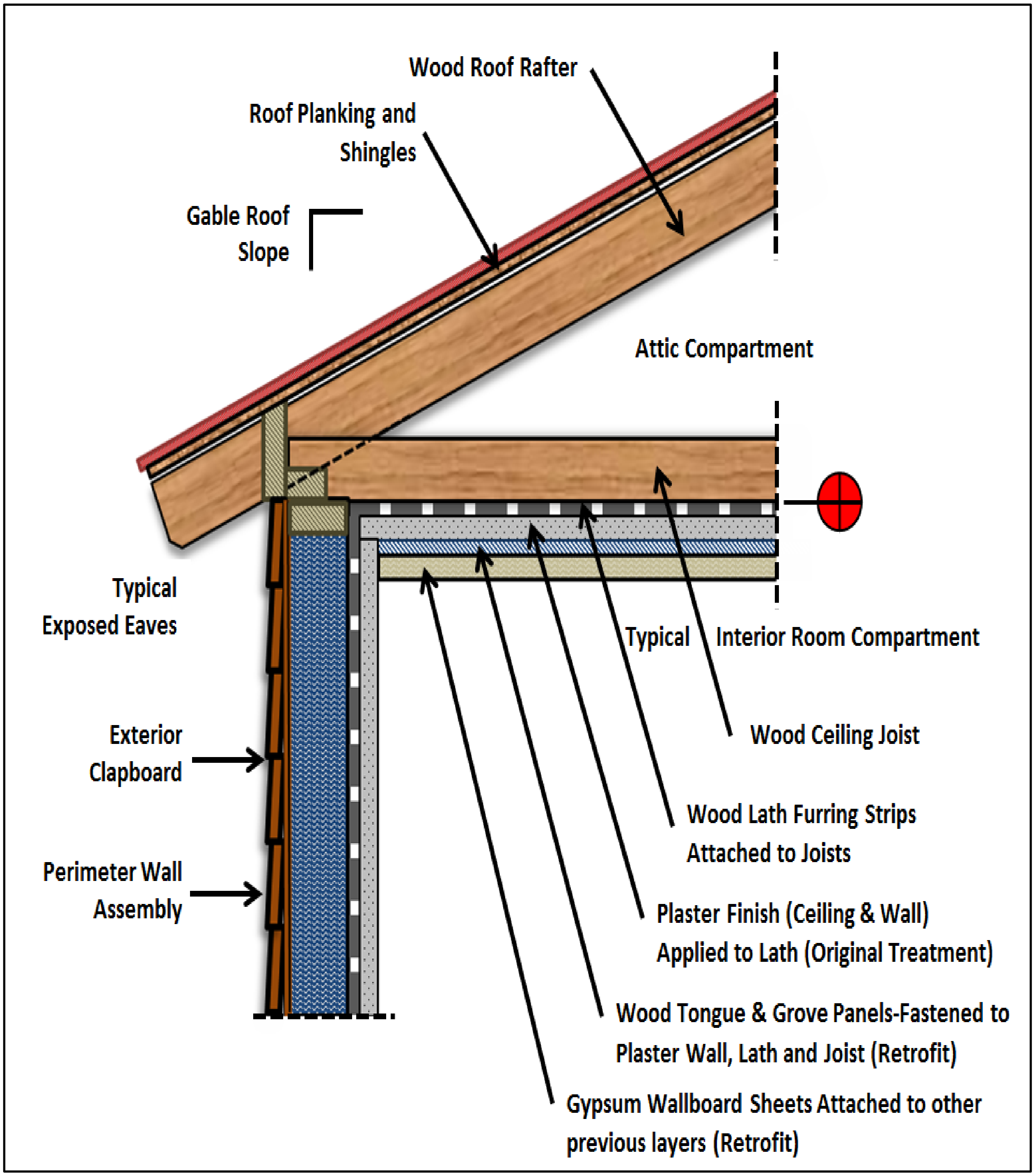

Figure 2. Typical Roof-Ceiling Assemblies with Ceiling Retrofits
(*Diagram courtesy of Buildingsonfire.com | C.J. Naum*)

The subsequent layers of building materials resulted in an integral ceiling diaphragm that ultimately relied on its structural integrity with the method, resiliency, and stability of the mechanical fastenings systems and finally with the integrity of the lath that was originally attached to the wood ceiling joists. This became the weakest link in the assembly and one that was the most affected by flame propagation and fire impingement with fire travel in the attic compartment [Naum 2011a,b,c; NIOSH 2013]. Each building material and component is affected differently (over time) based on their material characteristics and fire resistance or vulnerability. This includes such factors as applied structural load intensity, member/component type, structural member dimensions and boundary type, incident heat flux from the fire on the structural member or assembly, type of wood construction and effects of temperature rise and impingement on the structural member or assembly, and the relevant properties of the members. Building materials, finishes, construction systems, and assemblies will react differently and at different intervals when exposed to elevated temperature gradients and will individually or collectively react to fire, heat, and physical load stresses, transfers, and resiliencies, leading to restraint, movement, or loss of material integrity (see full report on building construction analysis and insights in Appendix 1).

Investigation

On December 15, 2013, a 50-year-old male career fire lieutenant died after being struck by a roof and ceiling assembly collapse during overhaul of a vacant residential structural fire. The victim (lieutenant) was one of two fire fighters that had re-entered the structure to extinguish hot spots during overhaul.

The local dispatcher received a report of a house fire with flames showing at 0024 hours and dispatched 2 engines, EMS, an air support truck, and the duty battalion chief. Engine 4 (victim's engine) added themselves to the incident and all units reported responding at 0028 hours. Arrival order was acting Battalion Chief 1, Engine 1, Engine 4 and Engine 2. *Note: The air support truck was out of service so the ladder truck responded in it's place with one fire fighter and parked on the scene out of the way.*

Battalion Chief 1 (acting battalion chief) arrived on the scene first at 0031 hours and was told by two males that there was someone inside the structure and stated that they had heard someone inside the house before the fire units arrived. The Battalion Chief 1 established command and radioed a size-up, stating that they had a large, single-family dwelling, smoke and flames visible at the rear of the structure. He reported that it appeared to be one-half involved (in fire). Battalion Chief 1 also reported on the radio that he established a fire attack using two 1¾ inch handlines to attack the fire and perform a search.

The Fire Chief (601) responded and arrived at 0035. During NIOSH interviews the chief stated that during his response he heard on the radio that there may be someone inside the structure. He heard the acting battalion chief (Battalion Chief 1) arrive and radio heavy fire showing and establish command and that crews would be pulling a 1¾ inch handline for search and rescue.

Engine 1 was a PAR 3 (PAR 3 refers to the number of fire fighters on the crew) that evening and arrived, staged on Side D (close to Side C), and stretched a 1¾-inch handline toward Side C. The crew had to break through a fence (see Photo 4) to gain access and attacked a large volume of fire from the exterior. This crew stated that walls and roof on Side C were burned away and that much of the fire was eventually knocked down. However, the fire was still burning in the attic spaces toward Side A. Ladder Truck 1 arrived (PAR 1) and staged out of the way on side–A. The driver joined the crew of Engine 1 and staffed a booster line on the exterior of Side D next to Engine 1.

Photo 4. Pre-fire, Side D, where Engine 1 staged and had to cross fence with 1¾-inch handline to attack Side C.
(*Google Maps, streetview.*)

Engine 4 was a PAR 3 this evening and arrived and staged behind Engine 1 on Side D but closer to Side A. The crew was ordered to stretch a 1¾-inch hoseline from Engine 1 into Side A. The Engine 4 driver helped the Engine 2 driver pull lines and get the water supply established for Engine 1. The lieutenant and recruit pulled the 1¾-inch cross lay off of Engine 1 and stretched it to Side A to prepare for search and fire attack on Side A.

Engine 2 arrived and the driver of Engine 2 assisted the driver of Engine 4 and stretched a 5-inch supply line from Engine 1 to the hydrant at the cross streets of Side A and Side D.

Engine 2 was also a PAR 3 this evening and arrived and stretched an 1¾-inch (adding a 50 foot section) also off of Engine 1 to Side A. They stretched the 1¾ inch over to the Bravo side initially and attacked the fire in the exterior garage. The crews forced the front door (which was a sheet of plywood) entered and searched and then fought the fire in the attic area. They reported multiple layers of ceiling and difficulty pulling the ceilings. They were able to open up a 4 foot by 6 foot opening and using a 6-foot ladder continued to operate inside flowing into the attic area. The crews reported that the multiple layers of ceiling included tongue and groove, plaster of paris, and sheetrock. They then repeated the ceiling and attic operation in an adjacent room closest to Side A/D to try and stop the spread of fire by getting ahead of it. They were successful and reported to the Battalion Chief 1 that the fire was controlled (see Diagram 1).

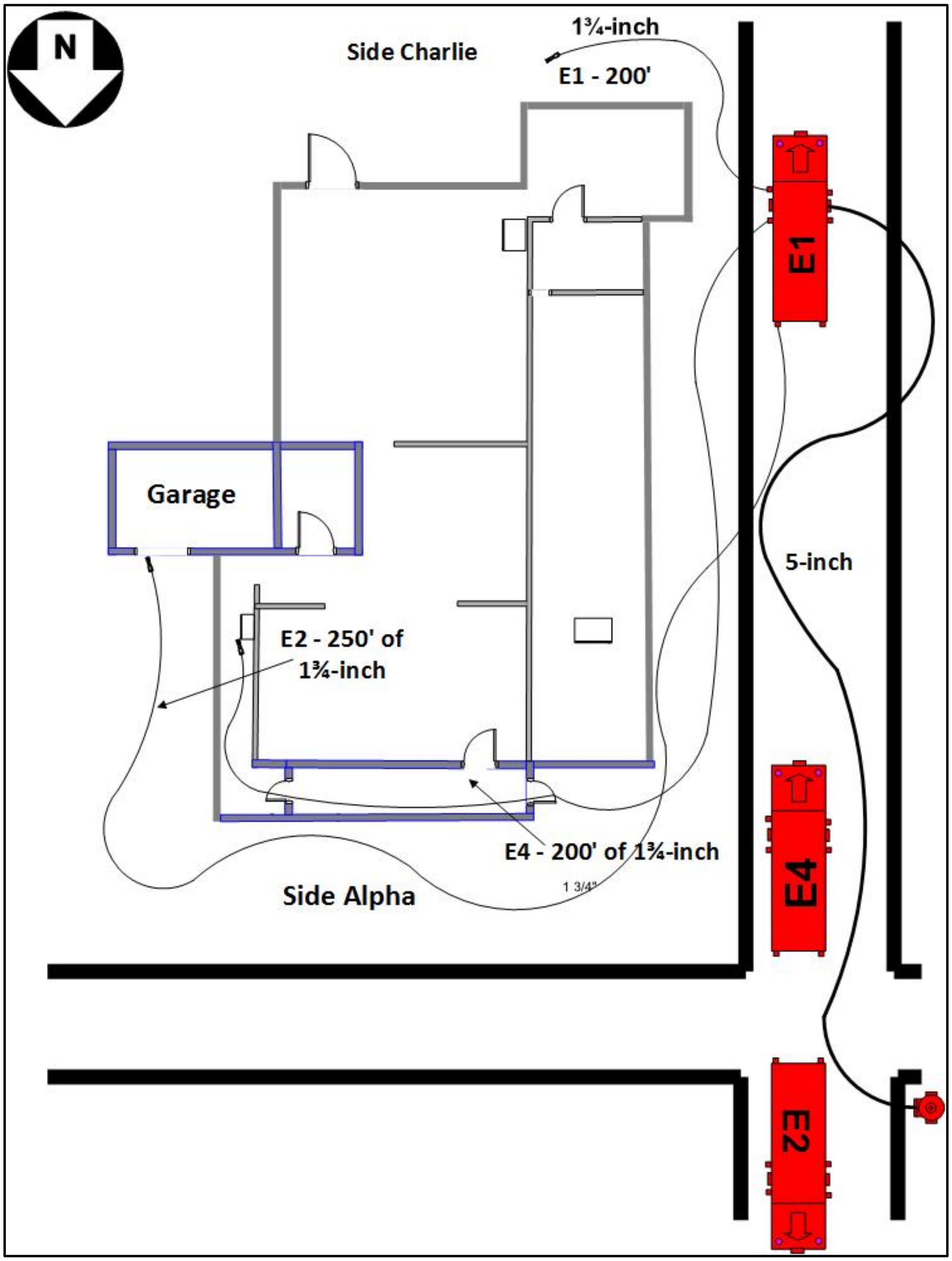

Diagram 1. Initial apparatus and hose placement.

Photo 5. Photo of lieutenant attacking fire. Photo taken by chief of department from Side B closed-in porch.
(Photo courtesy of fire department.)

Engine 4's crew entered Side A and used the left door on the Side A porch that took them down the enclosed porch on Side Bravo.

Battalion Chief 1 reported that the home was cleared of any possible victims and the fire attack continued. Engine 4's lieutenant and his recruit flowed a 1¾-inch hoseline until the crew became separated. The chief reported during interviews that he observed the lieutenant by himself on the handline and that he had a brief conversation with the lieutenant and then took a photo (see Photo 5). The recruit from Engine 4 then re-joined the lieutenant on the hoseline, and they advanced further into the center of the room trying to hit the fire on the Side C/D interior.

The recruit stated during interviews that he and the lieutenant were in full PPE with SCBA and on air when they first entered the structure and were inside for approximately 10–15 minutes, flowing water at the visible fire in the ceiling area toward C/D interior. After a 10–15 minute period, both he and the lieutenant left and went outside to change cylinders. They then went back in to pull ceilings and continued to attack the fire in the attic. They were joined by the Engine 2 crew pulling ceilings and overhauling. On this second entry the crew was still in full PPE including SCBA and on air. The recruit described visibility as very good with little smoke.

The fire was reported under control at 0142, and fire fighters were operating in a overhaul mode. Crews reported during interviews great difficulty trying to pull ceilings to access the fire in the attic space. There were reported to be multiple layers of ceiling material that consisted of original plaster and lath attached directly to the dimensioned lumber ceiling joists, wood tongue and grove panel boards, and gypsum wallboard attached to previous layers (see ceiling example Photo 6 and Figures 1,2). This was a labor-intensive overhaul and the fire continued to smolder and burn in the attic area.

Photo 6. Example photo of ceiling load in adjacent room.
(*NIOSH photo.*)

Engine 4 and Engine 2 crews pulled ceilings and overhauled for a while until they were told to go outside and take a break (Engine 2 crew was also told to go and tell the Engine 1 crew to come around from Side C and relieve the crews inside performing overhaul). The Fire Chief instructed the officers of Engine 4 and Engine 2 (with the acting Battalion Chief) to go outside and rehab and not to re-enter the structure. This was communicated twice in the presence of the acting Battalion Chief.

The Engine 1 crew operated the 1¾-inch handline as well as a booster line (by the Ladder driver) for a period of time on Side C flowing from the exterior until they were requested to relieve other crews and perform overhaul on Side A. The Engine 1 crew was getting ready to go to perform overhaul, but first needed to exchange SCBA cylinders before they reported to Side A.

The Engine 4 lieutenant was taking a break in the front yard on Side A with other fire fighters. The Engine 1 crew had not yet come around to relieve the crews overhauling and the Engine 4 lieutenant and his recruit got up from rehab and re-entered the structure.

Between 0209 and 0212 hours, while the Engine 4 crew was inside the dining room, a large section of the ceiling assembly fell on them and trapped the lieutenant under the debris. Crews outside heard the crash and rushed in and assisted the second fire fighter from Engine 4 to escape. The Engine 4 driver helped the Engine 4 fire fighter out of the structure (see Diagram 2).

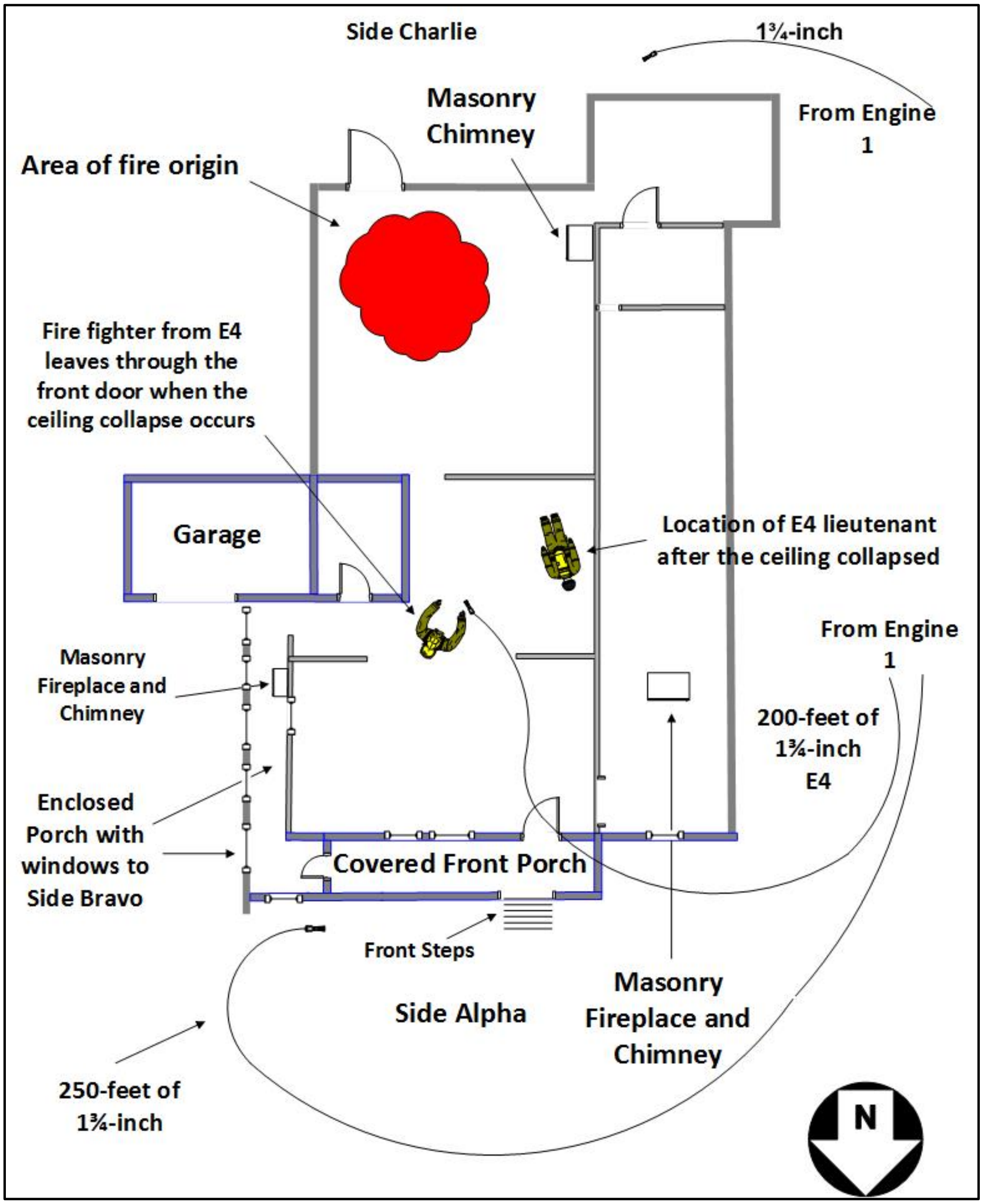

Diagram 2. Floor plan and handline positioning just prior to collapse. Note: the abandoned structure was severely damaged and many wall and room delineations are estimated from after damage photographs and are not to scale. Some room delineations are not depicted. The exterior building lines are taken from property records.

Engine 3 was dispatched after the collapse to the scene at 0212 to assist with rescue efforts and arrived at 0218.

Crews entered the structure to uncover the lieutenant and remove him from the structure. The debris and smoldering material that collapsed ignited, and a handline was used to extinguish and protect the crews who worked to uncover and free the lieutenant. The crews were hampered by the amount and weight of materials that were on top of the lieutenant. Resuscitation was started on the lieutenant inside the structure while they were trying to get him free from the debris. He was removed to the front porch and then to an EMS unit with continued resuscitation and ALS efforts during the transport to the hospital. He was later pronounced dead at the hospital from a crushing injury to the chest.

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 fatality:

- Arson
- Extensive fire in a vacant building
- Risk-versus-gain analysis prior to committing to interior operations involving a vacant/abandoned structure
- Strategic mode changes and personnel accountability
- Situational awareness as related to expected building performance under fire conditions
- Lack of a safety officer
- Structure not demolished in timely mannor.

Cause of Death

According to the autopsy report, the victim died from a crushing injury to the chest.

Recommendations

Recommendation #1: Fire departments should ensure that incident commanders conduct a risk-versus-gain analysis prior to committing to interior operations in vacant/abandoned structures and continue the assessment throughout the operations.

Discussion: Vacant building fires pose a threat to fire fighters. Based on NFPA statistics, during the 10-year period 1998–2007, a total of 15 fire fighters were fatally injured at the scene of vacant structure fires. On average, 4,500 fire fighters were injured at vacant building fires annually during 2003–2006. These account for 13% of the reported fire fighter injuries incurred at structure fires per year during this period [NFPA 2009].

Jon C. Jones, project manager for the International Association of Arson Investigators (IAAI) and United States Fire Administration (USFA) abandoned building project, notes: "The most important concept that firefighters and command officers must understand when responding to fires involving vacant and abandoned buildings is that the buildings themselves are inherently dangerous. Hazards commonly found in these buildings include open shafts; pits and holes due to removal of equipment; structural degradation due to weather and vandalism; exposed structural members; penetrations in barriers such as walls, floors and ceilings that allow abnormal fire travel; combustible contents; maze-like configuration; blocked or damaged stairs; potential for delay in discovery of a fire; potential for multi-room fire on arrival; and potential for extension to nearby structures" [IAAI/USFA 2006].

" … Fire fighting operations in buildings that are known to be vacant should be conducted with extreme caution. Interior firefighting operations should be attempted only after a size-up has determined that these operations can be conducted safely" [Jones 2001].

"Where there are indications of structural deterioration or other hazards listed above and no known life hazard, the incident commander should consider defensive operations" [Jones 2001].

"The decision to commit interior firefighting personnel should be made on a case-by-case basis with proper risk-benefit decisions being made by the incident commander. The commitment of firefighter's lives for saving property and an unknown or marginal risk of civilian life must be balanced appropriately" [Jones 2001].

The initial size-up conducted by the first arriving officer allows the officer to make an assessment of the conditions and to assist in planning the suppression strategy. The following general factors are important considerations during a size-up: occupancy type involved; potential for civilians in the structure; smoke and fire conditions; type of construction; age of structure; exposures; and time considerations such as the time of the incident, length of time fire was burning before arrival, and time fire was burning after arrival [IFSTA 2002; NIOSH 2005]. The incident commander must perform a risk analysis to determine what hazards are present, what the risks to personnel are, how the risks can be eliminated or reduced, and the benefits to be gained from interior or offensive operations [Kipp and Loflin 1996]. The size-up must include continued assessment of risk versus gain during incident operations. NFPA 1500 §A-8.3.3 states: "The acceptable level of risk is directly related to the potential to save lives or property. Where there is no potential to save lives, the risk to the fire department members must be evaluated in proportion to the ability to save property of value. When there is no ability to save lives or property, there is no justification to expose fire department members to any avoidable risk, and defensive fire suppression operations are the appropriate strategy" [NFPA 1998, 2013]. Retired New York City Fire Chief Vincent Dunn states, "When no other person's life is in danger, the life of the firefighter has a higher priority than fire containment" [Dunn 1992].

Size-up includes assessing risk versus gain at the start and throughout the fire operations. Incident commanders should ensure that fire fighter safety is the primary consideration when switching from a defensive mode to an offensive position to perform overhaul [NIOSH 2010a]. The potential for a structural collapse is one of the most difficult circumstances to predict. During initial size-up and ongoing fire-fighting operations, the incident commander must consider numerous variables to determine the structural integrity of a burning structure and integrate these variables into the risk vs gain analysis plan.

In this incident, the building had been vacant and the utilities had been disconnected for a number of years and was scheduled to be demolished. A lime green warning sign at the front entrance was attached to the plywood sheet covering the doorway. The cause of the fire was incendiary and two individuals were arrested and later convicted of the crime.

Recommendation #2: Fire departments should develop, implement, and enforce clear procedures for strategic mode changes and ensure personnel accountability is maintained.

Discussion: Fire departments need to have clear, well established procedures for different operational modes. A risk versus gain analysis (also known as a risk/benefit evaluation) is one of the most useful tools the incident commander has for reducing the overall risk to fire fighters during an incident (thus enhancing their overall safety and health). The risk versus gain analysis guides the incident commander in determining whether operations should be offensive or defensive in nature. Clearly defined standard operating procedures for different operational modes are necessary to ensure operations are carried out safely, as the tactics for different operational modes will vary greatly. Any time the decision is made to switch from one operational mode to another, particular attention should be given to make sure that the switch is communicated to all personnel at the incident and that confirmation of the change is received [NIOSH 2010c]. It is important to receive the confirmation to ensure the communications loop is complete and accountability of all fire fighters is maintained.

The decision to employ offensive versus defensive strategies and tactics, as well as to switch between offensive and defensive strategies, must be based upon recognized risk management principles. NFPA 1561 *Standard on Emergency Services Incident Management System and Command Safety*, 2014 Edition, Chapter 5.3.15 states, "In situations where the risk to emergency services responders is excessive, as defined in 5.3.16, activities shall be limited to defensive operations" [NFPA 2014]. Chapter 5.3.19 states, "The following risk management principles shall be utilized by the incident commander:

1. Activities that present a significant risk to the safety of responders shall be limited to situations that have the potential to save endangered lives.

2. Activities that are routinely employed to protect property shall be recognized as inherent risks to the safety of responders, and actions shall be taken to reduce or avoid these risks.

3. No risk to the safety of responders shall be acceptable where there is no possibility to save lives or property.

Changes in the fireground strategy must be communicated to everyone on the fireground. This includes switching from an offensive to defensive strategy as well as switching from a defensive strategy back to an offensive operation such as overhaul. A risk assessment needs to be performed continuously throughout the fire-fighting operation and especially when changing strategies.

During a defensive fire-fighting operation, tactical discipline must be maintained to ensure that fire-fighting crews do not become involved in an offensive position. Command must communicate the incident strategy to the fire-fighting crews and update everyone on the fireground if there is a change in the strategy. If not, this can cause strategic confusion and possibly place fire-fighting crews at risk without the incident commander being aware. This can also occur when changing from a defensive fire-fight back to an offensive overhaul operation if a risk assessment is not performed and the change is not communicated to everyone on the fireground.

In this incident, the fire department had been on the scene and operating in an offensive mode to ensure the building was clear of occupants then changing to a defensive mode. Later, crews started to overhaul areas in an interior position and the change in strategy (offensive positioning for overhaul) may not have been communicated to everyone on the fireground. The victim and another fire fighter entered the structure to overhaul and the ceiling assembly collapsed on the crew, trapping the lieutenant.

Recommendation #3: Fire fighters should use extreme caution during overhaul when the structure has been subjected to extensive fire and water application and continue to use risk management principles preparing for and during overhaul.

Discussion: Prior to conducting overhaul, fire fighters should perform a risk assessment of the area(s) that they need to overhaul. The fire and fire-fighting efforts very likely may have weakened the structural elements. There may also have been a heavy water load applied that adds to the structural load and the weakened structural members may not be safe to work under. "When conducting overhaul, fire fighters must remember that fire load weakens structural members. Beyond the weakened framing elements, we have most likely introduced thousands of gallons of water to the structure in question" [Poremba 2012].

Fire fighters need to remember the goal of overhaul, which is to complete the extinguishment of the fire (for example, smoldering pockets) and stop further damage. If the overhaul risk outweighs the gain (for example, an abandoned property that has already been destroyed by fire and water), then the risk management principles should direct a defensive approach.

Overhaul of a room and contents fire in an inhabited structure has a much different goal than overhaul of an abandoned, severely damaged building (that is likely to be completely demolished). In the first scenario, an overhaul would be performed to stop any further damage and rekindle, and the structure and contents would then be salvaged and perhaps rebuilt and re-inhabited. This is not the case in the second scenario, and fire fighters need to recognize and make risk assessments accordingly. Many times with severely damaged conditions, the appropriate course of action may be to continue to apply water from a safe location and bring in additional resources and equipment to complete the overhaul. The risk principle of risking nothing to save nothing applies in this case.

Established risk management principles suggest that more caution should be exercised in abandoned, vacant, and unoccupied structures and in situations where there is no clear evidence indicating that people are trapped inside a structure and can be saved [NIOSH 2010c]. These principles are continued throughout the incident including overhaul and demobilization of fire-fighting forces.

The incident commander (IC), with input from the assigned incident safety officer (ISO) and/or division/group supervisors, is responsible for evaluating conditions at a structure fire and determining safe tactics for fighting the fire. For example, during an offensive fire fight, the fire is knocked down and salvage and overhaul may be initiated right away. On defensive fires, after the fire is knocked down, the IC needs to perform another risk assessment and decide on a strategy for overhaul before fire-fighting forces transition to an overhaul activity that places them in a position of too great a risk.

To accomplish this, the IC should use a standardized strategic decision making model. First the IC should size up the critical fireground factors [PFD 2009]. Before ordering an overhaul (or transition to an offensive position to perform salvage or overhaul), the IC must make a determination that offensive (interior) operations may be conducted without exceeding a reasonable degree of risk to fire fighters and must be prepared to discontinue if the risk evaluation changes during the operation.

The similar range of fireground factors used by the IC to begin the initial strategy and tactics should be considered before transition to overhaul, especially after a defensive fire-fighting operation. A full range of factors must be considered in making the risk evaluation including:

- Fire involvement or compromise of the building's structural components, exclusion and collapse zones (including compartment compromise, component integrity)
- A realistic evaluation of risk to fire-fighting crews and investigators (post fire building survey)
- Size, construction, and use of the building (construction type, square footage, volume)
- Age and condition of the building (building vintage, style)
- Nature and value of building contents (Is the area so greatly damaged that it may be safer to use heavy equipment along with hydraulic overhaul?)
- Location and extent of the fire within the building (degree of fire involvement, fire travel, impingement and fire exposure on structural components, assemblies, and systems)

- Considerations of fire damage and water weight and need for shoring (assessment of fire suppression operations from heavy streams, flow duration and volume)
- A realistic evaluation of the ability to execute a successful salvage and overhaul with the resources that are available [Naum 2012b, 2014, 2015b; NIOSH 2010c; PFD 2009]
- Need for heavy equipment or demolition resources.

These fireground factors must be weighed against the risk management plan. Fire fighters are routinely exposed to certain known and predictable risks while conducting operations that are directed toward saving property. The IC is responsible for recognizing and evaluating those risks and determining whether the level of risk is acceptable or unacceptable. However, risks taken to save property should always be less than those to save lives [Grorud 2009; NIOSH 2010c]. Risks to fire fighters versus gains in saving lives and property must always be considered when deciding whether to use an offensive or defensive attack. The IC should routinely evaluate and re-evaluate conditions and radio progress reports in reaching objectives to Dispatch and on-scene fire fighters. This process allows the IC to determine whether to continue or revise the strategy and attack plans. Failure to revise an inappropriate or outdated attack strategy is likely to result in an elevated risk of death or injury to fire fighters [NFPA 2013; PFD 2009].

NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, section 4.2, provides detailed information regarding the risk management plan [NFPA 2013]. Incident demands on the modern fireground, unlike those of the past, require ICs and commanding officers to have increased technical knowledge of building construction with a heightened sensitivity to fire behavior, a focus on operational structural stability, and considerations related to occupancy risk versus the occupancy type.

The first-arriving officer, as well as the IC, must make an informed judgment before and ongoing as to what is at risk—people or property. This judgment will determine the risk profile for the incident. Many fire fighters stand by the notion that all incidents are "people" events until proven otherwise. Historically, the fire service has a poor history of changing risk-taking strategies based upon the people/property issue [Dodson 2005].

Risk management principles need to be used and reinforced when preparing for overhaul. Fire fighters should use extreme caution during overhaul. The structural components may have been subjected to extensive fire and fire-fighting water application. Fire fighters should understand that the risk management principals don't end when the fire is knocked down or extinguished. The post burn building assessment should consider the risks associated with collapse. Identifying exclusion and/or collapse zones is a key risk management principle. The same considerations used during the initial fire-fighting size-up and operation should also be used when preparing for overhaul. Some of the collapse considerations are:

- Building type and characteristics
- Building structural anatomy
- Construction systems and type

- Methods and materials
- Occupancy risk profile
- Building vintage, age, and condition of use
- Identification of inherent collapse attributes
- Predictability of building performance (e.g., building size, volume and distribution, building age and physical condition, degree of compartmentation, fire load package and probability of extension, floor system characteristics)
- Degree of alteration, renovation, or modification
- Presence and operability of fixed suppression systems
- Presence of ornate architectural features or components
- Freestanding building components, treatments, or attachments
- Presence of parapets or other roof edge assemblies
- Presence of large overhangs, canopies, awnings, or expansive facades or covering
- Evidence of building damage, compromise or effects from environmental exposure
- Fire intensity, severity, magnitude, and location
- Adequacy of sustainable water supply and delivery system
- Fuel loading and potential for significant heat release rates/effects on fire suppression
- Adequacy of staffing and resources
- Operational capabilities or limitations of the organization or companies [Naum 2015a]

In this incident, the structure was abandoned and was heavily involved in fire on Side C and burning toward Side A. The arriving acting Battalion Chief was given information from two sources that there were victims inside and ordered a fire attack and search. Crews searched and cleared the tenable areas inside the structure and one crew (Engine 1) was attacking the fire in the rear or Side C. After crews fought the fire defensively from the exterior for an extended period of time, the victim's crew re-entered to perform overhaul, and the ceiling collapsed trapping the lieutenant. There were no exclusion or collapse zones established, and a post fire building assessment had not been performed.

Recommendation #4: Fire departments should ensure continued training on the objectives of safe and effective fire-fighting overhaul.

Discussion: Fire departments should ensure continued training on the objectives of effective overhaul. Training on proper overhaul may seem simplistic but may be overlooked with so many training requirements for today's fire departments. Time is on your side when considering overhaul. Overhaul is the step that follows fire attack and many times it is a seamless transition after an offensive fire fight. Considerations for the fire investigation must be provided, and then the crews begin a systematic effort to ensure the fire is completely out. Many times this overhaul is performed by the same crews, and then the scene is secured and fire fighters leave. Since time is often on your side for overhaul, fire officers should consider fresh fire crews to perform this extensive work. Overhaul can be a much more complicated and involved fire department operation. Overhaul is an inherently dangerous fireground operation. The risks need to be recognized, minimized, and trained on.

Training should be provided to fire fighters on the risks associated when fire crews have transitioned from an offensive or defensive fire fight to overhaul (which many times is in an offensive or interior position). Prior to overhaul, a highly systematic risk assessment must be performed by a limited but qualified crew. The action plan for this phase of the fire operation is referred to as the Post Fire Building Survey.

The purpose of this survey is to identify the general overall condition of the building after fire and fire-fighting effects on the structure. The post fire building survey should identify the following:

- General overall condition of the building(s) following fire and fire-fighting efforts (excess water or added water weight standing on floors or areas)
- Obvious or subtle building, system, or component impacts that dictate exclusion or additional collapse zone modifications
- Structurally compromised areas and readily identifiable hazards and unsafe conditions
- Inherent building construction deficiencies (e.g., renovations)
- Safe access and safe areas for overhaul crews to work within the structure
- Identifying proper marking needs and/or posting of necessary access control personnel
- Reporting back to the incident commander on the findings with a recommendation(s) on alternatives for overhaul if necessary (hydraulic overhaul for example, or waiting for additional resources for proper shoring and make safe measures for investigators when needed).

The post fire building survey should be led by a trained safety officer and slowly identify needs and exclusion areas both inside and outside the structure.

The team must communicate danger areas (collapse and exclusion zones) to the incident commander that may have not been identified in the initial risk assessment. These areas can then be marked as exclusion zones and communicated to everyone on the fireground. The incident commander then adjusts his/her IAP (incident action plan) for this phase of the fire operation.

Chief Peel, in an issue of *FireRescue* magazine noted: *Arguably one of the most hazardous jobs on the fireground, overhaul is also one of the least desirable jobs. It's dirty, time-consuming and dangerous, performed after all the excitement of the firefight is completed. But it's also central to our professionalism and effectiveness on the fireground. As far back as 1940, Chief Lloyd Layman identified overhaul as one of the five basic tactics of firefighting, along with rescue, exposure protection, confinement and extinguishment ("Fundamentals of Firefighting Tactics," NFPA publications, 1940)* [Peel 2008].

Fire departments need to recognize that training on overhaul is a necessary and important objective in fireground safety. Some fire departments use fresh fire crews to perform overhaul and rotate the other crews out to rehab or back in service. Fresh crews have the advantage of being able to perform overhaul in SCBA with a "fresh set of eyes" and not be in a hurry to complete the task (no staffing pressure or pressure to get them back in service). Overhaul (as well as rehab) is a realistic need for additional resources. Training on the objectives of overhaul should identify the following safety considerations beyond the ordinary overhaul objectives:

- Risk assessment (is there a value in the mission and what are the alternatives)
- Fire investigation needs
- Staffing (fire departments should consider calling for additional staffing to perform overhaul)
- Availability of resources to complete the mission (heavy equipment for demolition)
- Safety of members (working with the incident safety officer)
- Building stability (exclusion or collapse zones)
- Area stability (areas within the fire structure that have been identified as areas that need overhaul)
- Structurally compromised area identification and marking
- Walls, chimney, or other falling hazards identified
- Fall hazards (including holes in floors)
- Water weight
- Atmosphere (many times the areas needing overhaul may be IDLH or contaminated)
- Accountability and tactical discipline (fire fighters need to stay focused and not become complacent after the excitement of the fire fight is over and overhaul begins).
- Need for rehab (not optional)
- Specific training on long-term health hazards associated with overhaul (respiratory protection as well as absorption protection for fire fighter longevity and cancer prevention)

Chief Vincent Dunn (Deputy Chief FDNY Retired) noted that before salvage and overhaul begins, a safety survey should be made by a safety chief. If the building is unsafe, salvage and overhaul should not be performed and "hydraulic overhauling" should be considered. This refers to the use of streams applied from safe areas outside the structure and a safe distance from the collapse zone. This is done instead of sending fire fighters inside to extinguish small fires that flare up. The fire department may also set up a "watch line," which can consist of any necessary number of hose teams that may remain on the scene for longer periods [Dunn 2004]. If the fire has been fought defensively with a number of outside streams, extreme care must be exercised around any exclusion or collapse zones as thousands of gallons of heavy water have been added and likely strained the remaining structural elements. A demolition plan can then be instituted, possibly using heavy equipment.

Ceiling assemblies can be divided into two broad categories. Assemblies that are directly affixed to the floor above or roof joists above (as in this incident), and those that are suspended (creating a void space). In the latter, they may be suspended by vertical strips of wood, steel hangers, or wire. A directly affixed ceiling (found in older buildings such as this incident), is a lath and plaster ceiling, which has strips of wood or wire lath nailed to the under-side of the joists and several coats of wet gypsum plaster applied to the under-side of the lath. In newer buildings, a dry gypsum board four by eight feet in area and up to five-eighths inch thick is nailed directly to the under-side of the joists. During fire-fighting operations, a directly affixed ceiling assembly usually collapses in small pieces rather than in one large section [Dunn 1988].

In this incident, other ceiling materials were added over the years, increasing the weight of the ceiling on the framed assembly. The assembly (joists and ceiling materials) were subjected to a long period of burning, and the assembly collapsed down on the lieutenant and the other fire fighter. During interviews, some of the fire fighters reported that the roof was totally gone when they were trying to remove debris and extricate the lieutenant. This indicated that the remaining roof materials, attic floor, and entire ceiling framing and assembly collapsed down in one large section.

Continued training on the objectives of safe and effective fire-fighting overhaul will help fire fighters understand the hazards of overhaul and specifically pulling ceilings. After a large total fire involvement of the structure (or portion of the structure) there may be no gain in the risk vs gain analysis by placing fire fighters in dangerous positions to pull apart and overhaul smoldering wreckage that could be extinguished with heavy equipment and hydraulic overhaul. On incidents where the risk vs gain indicates a need and pulling ceilings can safely be accomplished, precautions for fire fighter safety need to be taken. Simply using a pike pole or hook to pull ceilings may seem easy enough, but there are many considerations that need to be taken into account before-hand. Some of those are:

1. Before ceiling pulling begins, is there an assessment of the structural stability and review of what might be behind the drywall before the first piece is removed?
2. Do you and your crews observe best practices when pulling ceilings (i.e., starting at the doorway and working into the room, noting the location of structural members through visual notation of nails, "shadowing" or "ghosting" of studs) before pulling ceilings?
3. Do you consider limiting the number of personnel in a room when ceilings and walls are being pulled?
4. Who is responsible for ensuring utilities have been controlled before pulling ceilings and walls?
5. How is utility control documented and confirmed before ceiling pulling begins?
6. What is the likelihood that the space above the ceiling you are pulling is being used for storage? If storage is noted, can you determine what effect pulling down the ceiling will have on the structural members resisting the weight of the storage? See more at: http://www.firegroundleadership.com/2011/08/12/gypsum-board-ceiling-systems-ceiling-collapse-and-firefigher-safety/ [Naum 2011b].

Recommendation #5: Fire departments should ensure standard operating procedures (SOPs) are developed for fighting fires in vacant/abandoned buildings and consider an unsafe building marking system as part of an overall program to address fighting fires in these buildings.

Discussion: Many fire departments have vacant/abandoned buildings in their response areas. It is important to understand the differences between vacant/abandoned buildings and fire fighting considerations for each. Fire departments and authorities having jurisdiction should develop SOPs for fighting fires and consider an unsafe building marking system to identify abandoned buildings. Fire departments should then train on the marking systems and develop procedures for fighting fires in these structures. Abandoned buildings can and do pose numerous hazards to fire fighters as well as the general public [IAAI/USFA 2006; NIOSH 2010a, 2011].

Philadelphia Deputy Fire Chief James Smith (retired) described two basic types of vacant buildings. The first type is awaiting resale and is basically the same as any other building. The second type (abandoned or derelict) has been vacant for a longer period of time and has been stripped of items that could be sold, such as piping and cabinetry. This type of building could not be used for legitimate occupancy without extensive renovation and may be abandoned by the owner. These properties are particularly dangerous to fire fighters [Smith 2004]. An abandoned or derelict building has been defined by the International Code Council (ICC) [ICC 2009] as buildings, structures, and premises for which an owner cannot be identified or located by certified mailing to the last known or registered address, which persistently or repeatedly become unprotected or unsecured. They may also have been occupied by unauthorized persons or for illegal purposes. They may present a danger of structural collapse or fire spread to adjacent properties. They shall be considered abandoned and declared unsafe and abated by demolition or rehabilitation in accordance with the building and building maintenance codes [ICC 2009].

When fire departments encounter these structures, they should work with the local building officials and consider an unsafe building marking system to help fire fighters recognize and plan for fire suppression operations. Hazards should be identified and warning placards affixed to entrance doorways or other openings to warn fire fighters of the potential dangers. Such hazards can be structural as the result of building deterioration or damage from previous fires. Gutted interiors also increase the amount of exposed burnable materials and contain open pathways for rapid flame spread. Structural hazards can occur when building owners or salvage workers remove components of the building such as supporting walls, doors, railings, windows, electric wiring, utility pipes, etc. Abandoned materials such as wood, paper, and flammable or hazardous substances, as well as collapse hazards, constitute additional dangers fire fighters may encounter. Collapse hazards can include chimney tops; parapet walls; slate and tile roof shingles; metal and wood fire escapes; heating, ventilation, and air conditioning (HVAC) units; or other mechanical equipment such as solar electrical collectors and cells, advertising signs, and entrance canopies.

Prior to implementing operations, the incident commander must perform a risk assessment considering life safety and the safety of fire fighters. At large and/or advanced fires in vacant or abandoned buildings, exterior operations should be the primary tactical consideration.

A warning placard should be at least 18 inches x 18 inches and marked with 2-inch-wide lines on reflective background (see Figure 3). The reflective sign indicates to fire fighters that hazards exist inside the building. Fire departments should consult with fire prevention, code enforcement, and/or building departments to consider requiring an exterior placard or markings on abandoned and vacant structures to inform fire fighters of the structure's status and identify potential hazards [Dunn 2000b; Terpak 2000]. Figure 3 illustrates symbols used on warning placards developed and used by the New York City Fire Department (FDNY) and other departments [NIOSH 2010a]. Fire departments should develop additional policies that specifically cover the hazards encountered with these structures, such as training in size-up, building construction features present in typical buildings and construction methodologies characteristic of this era, safety considerations, tactics and strategy, and risk-versus-gain profiles [Center for Community Progress 2016; Naum 2013].

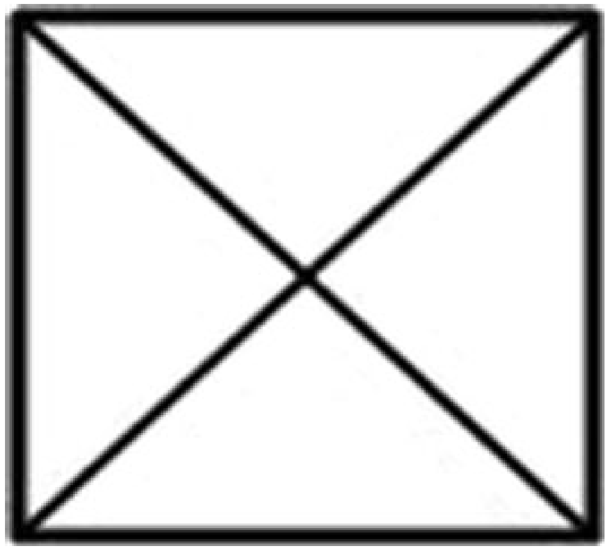

Figure 3. Warning placard used by FDNY to identify hazards in vacant buildings. This 18-inch by 18-inch square box with 2-inch wide lines is only a small portion of the FDNY Vacant Building Fires Procedures. Departments should consider building marking as part of their overall strategy for fighting fires in vacant buildings

Fire departments should work with city and local authorities to develop and implement a strategy to identify, mark, secure, and where possible, demolish unsafe structures within their jurisdictions. The IAAI / USFA Abandoned Building Project, conducted by the International Association of Arson Investigators and the U.S. Fire Administration, is one example of a program that can be utilized to aid and assist fire-fighter safety and health by identifying, marking, and removing unsafe structures [IAAI/USFA 2006]. The Abandoned Building Project Toolbox can be found at http://www.interfire.org/features/AbandonedBuildingProjectToolBox.asp.

The toolbox contains the Abandoned Building Project Report, *Managing Vacant and Abandoned Properties in Your Community*, and other reference materials. This report includes recommendations on how fire departments can work with authorities having jurisdictions to reduce the public safety hazard created by unsafe and abandoned buildings. A number of locations across the country have developed laws and regulations that address the public safety hazards created by vacant and abandoned buildings. Examples are the Commonwealth of Massachusetts Abandoned or Dangerous Building Regulations 780 CMR and 527 CMR [Commonwealth of Massachusetts 2008] and the City of Cincinnati Vacated Building Maintenance License [City of Cincinnati 2006]. NFPA 1, Fire Code, Annex Q Fire Fighter Safety Building Marking System, makes direct reference to the potential resolution to identifying hazardous structures and contents through building marking programs [NFPA 2015a].

In this incident the building had been vacant and the utilities had been disconnected for a number of years and was scheduled to be demolished. The cause of the fire was incendiary and two individuals were arrested and later convicted of the crime.

Recommendation #6: Fire departments should ensure that fire fighters are trained in situational awareness and expected building performance under fire conditions.

Discussion: All officers and fire fighters operating at an incident should maintain situational awareness and conduct a continuous risk assessment throughout the incident, reporting unsafe or changing conditions to the incident commander. It is important to train fire fighters and officers to maintain their situational awareness especially regarding expected building performance under fire conditions. The training should include what general situational awareness is and the addition of maintaining situational awareness in relation to the expected building performance under fire conditions.

Chief Christopher Naum, SFPE (Command Institute) notes, "The potential for structural collapse in a building on fire can be predicated by a building's inherent susceptibility to a variety of factors that include fire dynamics and behavior, fire exposure and extension, environmental impact, fire suppression activities and age, deterioration and occupancy use factors. The predictability of a building's performance and risk to structural collapse, compromise or failure must be foremost in the development and execution of incident action plans (IAP) with collapse precursors or indicators identified."

"In most situations involving a structure fire, the probability of and anticipation for structural collapse or compromise are inevitably minimized, overlooked or at times disregarded until the catastrophic conditions present themselves with little to no time to react accordingly. The loss of situational awareness coupled with distracted attention to subtle or obvious pre-collapse building indicators and gaps in building and construction system knowledge combine to elevate operational risks to personnel on the fireground at structure fires" [Naum 2012a].

It is keenly important during strategy changes and during overhaul that fire fighters are trained to recognize deteriorating and/or degraded building conditions and maintain their situational awareness at all times. Even after a post fire building assessment, conditions can change and place fire fighters at risk.

Fire fighters and officers need to resist the temptation to provide training for newer members by performing offensive task-level operations while in a defensive strategy. This includes placing crews inside a collapse zone or an area that has not had a risk assessment performed. This can be a daunting challenge depending on the size and scope of the incident, but effective command safety discipline, communication, and situational awareness of all fire fighters and officers can provide effective personnel safety and accountability. Fire fighters need to understand the importance of situational awareness and personal safety on the incident scene.

The book *Essentials of Fire Fighting and Fire Department Operations* [IFSTA 2013] defines situational awareness as an awareness of the immediate surroundings. On all fire and emergency incidents, all fire fighters and emergency responders should be trained to be constantly alert for changing and unsafe conditions. Even though a safety officer may have been designated for the incident, it is the obligation of all personnel to remain alert to their immediate surroundings. They must maintain their situational awareness and be alert for unsafe building conditions.

Situational awareness can be described as a heightened consciousness of what is currently developing or occurring. One of the most critical aspects of coordination between fireground crews is maintaining situational awareness. A danger for the less experienced fire fighter in the initial stages of the event is tunnel vision where they become so focused on operational assignments that they fail to sense changes in their environment. Other barriers can include distractions, adrenaline triggers that can narrow focus (e.g., Mayday or urgent traffic over the radio), and complacency, especially after a long duration fire or the event is winding down.

The International Association of Fire Chiefs (IAFC), Safety, Health and Survival section developed the "Rules of Engagement for Structural Fire Fighting." The fireground creates a significant risk to fire fighters and other emergency responders, and it is the responsibility of the incident commander and command organization officers to minimize emergency responder exposure to unsafe conditions and stop unsafe practices [IAFC 2013].

The rules of engagement can assist the incident commander, company officers, fire fighters, and emergency responders (who are at the highest level of risk) in assessing their situational awareness.

One principle applied in the rules of engagement is fire fighters and the company officers are the members most at risk for injury or death and will be the first to identify unsafe conditions and practices. The rules integrate the fire fighter into the risk assessment decision-making process. These members should be the ultimate decision maker as to whether it's safe to proceed with assigned objectives. Where it is not safe to proceed, the rules allow a process for that decision to be made while still maintaining command unity and discipline. The following are excerpts from the IAFC rules of engagement:

Rules of Engagement for Fire Fighter Survival:

- Size-up your tactical area of operation. (Causes the company officer and fire fighters to pause for a moment, look over their area of operation, evaluate their individual risk exposure, and determine a safe approach to completing their tactical objectives.)
- Go in together, stay together, and come out together. (Ensures two or more fire fighters operate as a team.)
- Maintain continuous awareness of your situation, location, and emergency scene conditions.
- Constantly monitor communications for critical radio reports.

- You are required to report unsafe conditions or practices that can harm you. Stop, evaluate, decide. (Prevents exposure to unsafe conditions or practices that can harm them, allows any member to raise an alert about a safety concern without penalty, mandates the supervisor addresses the question to ensure safe operations.)
- You are required to abandon your position and retreat before deteriorating conditions can harm you. (Ensures awareness and causes an early exit to a safe area when they are exposed to deteriorating conditions, unacceptable risk, and a life-threatening situation.)
- Declare a Mayday as soon as you think you *(or another fire fighter)* are in danger. (Ensures the fire fighter is comfortable with declaring a Mayday as soon as they think they are in trouble.) [IAFC 2013]

The Incident Commander's Rules of Engagement for Fire Fighter Safety:
- Rapidly conduct or obtain a 360-degree situational size-up of the incident. (Determine the safest approach to tactical operations as part of the risk assessment plan and action development plan before fire fighters are placed at substantial risk.)
- Conduct an initial risk assessment and implement a safe action plan. (Utilize a safety officer and all command staff to perform a continuing risk assessment; Develop a safe action plan by conducting a size-up, assessing the survival profile, and completing a risk assessment before fire fighters are placed in high-risk positions on the emergency scene.)
- If you do not have the resources to safely support and protect fire fighters, seriously consider a defensive strategy. (Do not commit fire fighters to high-risk tactical objectives that cannot be accomplished safely due to inadequate resources on the scene.)
- Maintain frequent two-way communications and keep interior crews informed of changing conditions.
- Obtain frequent progress reports and revise the action plan.
- Ensure accountability of every fire fighter, their location, and status (Maintain a constant and accurate accountability of the locations and status of all fire fighters within a small geographic area of accuracy within the hazard zone and be aware of who is presently in or out of the building or zone) [IAFC 2013].

It can be difficult to maintain the accountability discipline on long duration events, but it is a necessary and vital role for command as well as all officers and fire fighters.

During overhaul, the building is most certainly in a weaker condition. Crews may be tired and more apt to take a chance by working in a dangerous area to perform an operation that may not have had a proper risk assessment. A partial or full collapse is a primary danger that requires full situational awareness of all personnel.

Recommendation #7: Fire departments should ensure that collapse zones are established, marked, maintained, and complied with throughout long-duration incidents, this includes interior collapse or exclusion zones.

Discussion: Fire fighters are at significant risk for injury or death due to structural collapse during fire-fighting operations. The United States Fire Administration and the National Fire Protection Association (NFPA) report that 984 fire fighters died between 2000 and 2010. Structural collapse caused 134 of these fire fighter line-of-duty deaths (13.7%). Structural collapse often results in multiple fire fighter injuries and fatalities. While structural collapse is a significant cause of injury and death to fire fighters, the potential for a structural collapse is one of the most difficult circumstances to predict.

During initial size-up and ongoing fire-fighting operations, the incident commander must consider numerous variables to determine the structural integrity of a burning structure. A collapse zone is defined as the area around a structure that would contain debris if the building were to collapse. This is generally 1½ times the height of the structure. A collapse zone, when established, should be identified by colored tape, signage cones, flashing beacons, fences, or other appropriate means. "No Entry" should be enforced by the incident commander, incident safety officer, division/group supervisors, and company officers. When it is not possible or practical to mark a collapse zone, the incident commander should identify the collapse zone area to all fire ground personnel via radio or other communication methods [NIOSH 2014]. The collapse zone can be enforced by personnel positioned at entry points. No personnel or apparatus should be allowed to operate in the collapse zone except to cautiously place unmanned master stream devices and then immediately withdraw once they are in operation [IFSTA 2008].

Understanding the influence that building design and construction have on structural collapse has a direct correlation to safe fire-fighting operations and fire fighter survivability. In virtually every case, structural collapse results from damage to the structural system of the building caused by the fire or by fire-fighting operations. The longer a fire burns in a building, the more likely the building will collapse. Older buildings that have been exposed to weather and that have been poorly maintained are more likely to collapse than newer, well-maintained buildings.

At times fire fighters may have no choice but to pass through a collapse zone. They should spend as little time there as possible [IFSTA 2008]. An exclusion zone is an area that has been defined as extremely hazardous and no one is allowed to enter. **An exclusion zone should not be passed through, worked in, or entered without a risk assessment first being performed. This is especially important when an exclusion zone has been established inside of a severely weakened structure.**

Based upon continuous risk assessments being conducted, coupled with pre-incident planning information, a collapse zone should be established if factors indicate the potential for a building collapse. Fire departments should not rely solely on the amount of time a fire has been burning as a collapse indicator. An external load—such as a parapet wall, steeple, overhanging porch roof, awning, sign, or large electrical service connections—may cause a structural collapse. The following factors should all be considered:

- fuel loads
- fire behavior and building ventilation characteristics

- fire duration, size, and location
- pre-existing structural damage/deterioration
- renovation/modifications to structure
- presence of wall anchor plates or stars
- height and age of the building
- types of doors and windows
- engineered load systems/lightweight truss construction
- roof design and covering
- fire protection features such as sprinkler systems, standpipe systems, automatic fire alarm system [NIOSH 2014]

Establishing a collapse zone is critical when structural stability is the reason for a defensive fire attack. Construction features combined with fire factors indicate the most probable type of structural failure [Klaene et al. 2007].

Given the fact that the incident commander is always working with incomplete and imperfect information, it is difficult to accurately predict the type of collapse and resultant collapse zone. The only safe collapse zone is one that is equal to the height of the building plus an allowance for scattering debris. A good rule of thumb for setting a collapse zone for most buildings is to establish an area 1½ times the height of the fire building. This sometimes presents a dilemma when the safe zone is beyond the street width, meaning that effective defensive positions are within the collapse zone. A risk-versus-benefit analysis is essential. The crucial question that any incident commander must ask is, "What could I potentially save in relation to the risk being taken?" Obviously, no building is worth a fire fighter's life. Therefore, imminent risk to a fire fighter's life to save a building is unacceptable [Klaene et al. 2007].

When a defensive operation represents a reasonable risk, positions at the corners of the buildings are normally safer than those on the flat side of a wall. Consideration should also be given to using unstaffed ground monitors to reduce the risk of placing personnel in exposed positions. When total collapse is imminent, collapse zones represent exclusion zones that no one is permitted to enter regardless of the level of protective clothing [Klaene et al. 2007].

Exclusion zones can also exist or extend into buildings, especially when roof structures are suspect (as in this incident). In addition, exclusion zones would include other areas containing imminent hazards—such as falling glass, areas containing atmospheres within or near the flammable range—and any other area that the incident commander or incident safety officer deems too hazardous to enter. Collapse and exclusion zones are not the only safety considerations regarding access. The concept of limiting access to the fire scene is defined in a variety of ways. The safe area around the fire building(s) is normally staffed by police who keep unauthorized personnel out of the inner zones.

Incident conditions must be considered when determining the dimensions of the fire perimeter. A good rule of thumb for approximating a fire perimeter is 2 blocks beyond the fire building in all directions

[Klaene et al. 2007]. Inside of a fire perimeter there can be a number of zones much like a hazardous materials incident scene. A cold zone would be an area where personal protective equipment is not required and is usually where the command post is established and other functions such as rehabilitation and medical treatment areas. The hot zone would be an operating area considered safe only when wearing appropriate levels of personal protective equipment. The incident commander and the safety officer have a responsibility to establish and enforce the hot zone.

Everyone has a responsibility to abide by the decisions made for the established collapse and exclusion zones. If the fire is not contained and an exterior (defensive) attack becomes necessary, the hot zone is moved far enough away from the structure to place the fire fighters outside the collapse zone. The collapse zone then becomes an exclusion zone. In large or extended fire-fighting events, these zones must be continually adjusted as necessary and all personnel at the scene must be made aware of the locations of the exclusion or collapse zones. For incidents in which the transfer of command occurs multiple times, the incident is of long duration, or the incident scene covers a large geographical area, the collapse zones need to be continuously re-enforced [NIOSH 2014]. It is important for division supervisors and officers to not only adjust and enforce collapse or exclusion zones with their own personnel, but to also communicate changes with the incident commander.

Establishing collapse and exclusion zones are a critical role of the incident commander and equally important is identifying, marking, and communicating them, as well as their maintenance. Frequently these zones must be adjusted due to fireground conditions.

In this incident, the incident commander and other officers stated during NIOSH interviews that a defensive strategy was established after the all clear of the search. There were no exclusion zones established and crews re-entered the structure to try and overhaul underneath a severely compromised roof and ceiling grid. The long-burning fire in the attic area burned away the supporting members that held up the multiple layers of ceiling materials that had been added through the years. Fire fighters should understand that a lath and plaster ceiling is much harder to “hook and pull” during overhaul. In this incident there were multiple layers of sheetrock and plaster and fastener assemblies along with structural members that fell down all at once and trapped the lieutenant.

Recommendation #8: Fire departments should ensure incident commanders communicate the strategy and incident action plan to all members assigned to an incident, including updating and reaffirming as needed.

Discussion: When establishing command at any incident, one of the most important responsibilities of the incident commander is to create an appropriate incident action plan (IAP). Based upon the initial size-up, the incident commander has to absorb and process a lot of information in a very short period of time and develop an initial IAP that is based upon the department’s standard operating procedure/guideline, encompasses effective strategy and tactics, and incorporates the incident priorities (life safety, incident stabilization, and property conservation) [Klaene 2000].

In order for resources assigned to an incident to work together effectively and in a coordinated effort, the resources must all work from the same plan. Each resource must know what the incident objectives are and what their individual roles are in achieving those objectives. If fire fighters are working in an offensive position in a defensive strategy, they may put themselves in danger and Command may be unaware of what they are doing. Officers and fire fighters need to be aware of the strategy and IAP throughout the incident and that they are clearly communicated to all levels of the command structure.

The development and management of the overall strategy (situation evaluation, operational risk management plan, and evaluation and decision-making process) become the basis for the incident action plan (tactics). *Note: For most Type V and Type IV incidents, these incidents most often will not have a formal (written) incident action plan due to the short duration of the incident. In this case, the tactics serve as the incident action plan.* The basic order of development is strategy first and incident action plan, second. Connecting the strategic, tactical, and task levels so they all operate within the same basic plan is a major goal of the incident management system.

Changes in strategy and/or tactics need to be communicated clearly to all personnel on the fireground. Additionally, changes in fireground conditions (such as impending collapse hazards) need to be communicated back to the incident commander by division and task-level officers and fire fighters.

NFPA 1500 and NFPA1561 state that "emergency traffic" shall be used to communicate this type of information to members at the incident. It states: "To ensure that clear text is used for an emergency condition at an incident, the Emergency Service Organization shall have an SOP that uses the radio term emergency traffic as a designator to clear radio traffic. The communication system shall provide a standard method to give priority to the transmission of emergency message and notification of imminent hazards over that of routine communications to all levels of the incident command structure. This procedure shall have direction on cancelling the emergency traffic transmission at the conclusion of the broadcast" [NFPA 2013, 2014].

It is important to note during long-term incidents that the communication of the strategy and incident action plan needs to be reaffirmed and understood. This is especially true if there has been any changes to the strategy. Switching from a defensive strategy back to an offensive strategy (interior overhaul) needs to be communicated and closely coordinated only after a risk assessment has been performed and exclusion zones identified and marked.

Recommendation #9: Fire departments should ensure that a stationary command post is established and the command team communicates effectively.

Discussion: Fire departments should train their command officers to establish a stationary command post and effectively communicate with the command team members. It is very easy for a command officer to effectively command a fire ground from the front yard when everything is going well. However, when critical communications occur or significant events occur it is very easy to miss those communications with all of the fireground noise and confusion that occurs on many firegrounds.

In some cases, officers are comfortable with operating outside of the command vehicle or command post because they may have a very good comfort level developed from past experience. This comfort level can easily be challenged when faced with unexpected fireground conditions such as collapse, rapid fire growth or a Mayday transmission.

It is a critical function of Command to allow for clear communications with his/her divisions, Dispatch, and other agencies.

In the rare instances of a Mayday transmission, it is imperative that those communications are communicated to the incident commander. If the incident commander is mobile and a Mayday transmission is made by radio on a different channel, the incident commander may miss the transmission and a delay in taking action will occur.

In addition to a stationary command post, effective communication can assist the incident commander to formulate a rescue plan. In many instances, an already established RIT can be put into action and managed by the incident commander. However, in most cases, the responsibilities may be divided and a rescue group established and given direction by a division commander. The incident commander may take the direction role or pass it to another officer at the command post. The fire-fighting units need to be coordinated and those resources not directly involved in the rescue or fire-fighting close by may be moved to a different channel.

Many things need to be coordinated once a Mayday has occurred. If the incident commander is trying to perform all of these functions in the front yard (by themselves), they can be quickly over tasked and may overlook critical needs. A command team that is properly set up can provide direction, assign responsibilities, and have the advantage of clear communications.

A properly set up command organization has the advantage of being able to be quickly expanded to meet the needs of the incident response. However, if the officer in command is mobile, much time may be lost in recognizing the significant event and developing a plan and assigning resources to overcome the event. Fire officers need to understand that while they may be comfortable commanding from the front yard, they may not understand the reasoning for establishing a stationary command post. Just because they have commanded many fires from the front yard and committed accountability and tactics to memory, when a significant event occurs, those actions committed to memory may be challenged. An incident action plan and command of an emergency incident scene is best performed by a command team at a stationary command post with functions written down. In the rare event such as a Mayday, a checklist may help to trigger response functions. We have included an example Mayday checksheet in Appendix 2.

Muscle memory/repetitive skill training is just as important for an incident commander as it is for fire fighters "knowing their SCBA." This ability to command emergency incidents is learned not only through didactic training but skill development with hands-on training. Fire officers need to resist the temptation to command from the front yard even on minor incidents. Command skill can be built by establishing command on smaller incidents. This can benefit the experienced incident commander, however, it is a critical skill-building process for newer officers or those "acting" in the roles. Everyone on the fireground benefits from repetition including the command officers, and while many officers can effectively command from the front yard or hallway, when a significant event such as a building collapse or Mayday occurs, a properly set up command structure is much more able to adapt and expand as needed.

Once a significant event (like a Mayday has occurred), Command needs to obtain the critical information and assign the correct resources to manage the event. 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 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 [NFPA 2013, 2014].

A checklist is provided in **Appendix 2, Incident Commander's Tactical Worksheet for Mayday,** which can assist the incident commander in the necessary steps for clearing 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 checklist 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.

The intent of a 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 ensure that a safety officer, independent from the incident commander, is appointed at working structure fires.

Discussion: A trained incident safety officer should always be established on a working structure fire. Having a predesignated incident safety officer can help to ensure that the safety officer is trained and experienced to operate effectively and assist the incident commander on the fireground. An incident safety officer can monitor the incident action plan, conditions, activities, and operations to determine whether they fall within the criteria as defined by the fire department's risk management plan.

NFPA 1561 *Standard on Emergency Services Incident Management System* states in Paragraph 5.3.1 that "the incident commander shall have overall authority for management of the incident" [NFPA 2014]. NFPA 1561 Paragraph 5.3.2 states, "The incident commander shall ensure that adequate safety measures are in place" [NFPA 2014]. With the advent of the incident command system, the goal is to ensure that the incident commander is responsible for the safety and welfare of all members and other first responders that were on-scene at an incident.

Based upon the size and complexity (e.g., abandoned structure) of an incident, the incident commander should delegate responsibilities that include safety to trained and capable officers. The incident command system can be expanded to include functions necessary to effectively command and control an incident. Though the incident commander is still responsible for the safety and welfare of all members and first responders on-scene, this responsibility is delegated to the incident safety officer [NFPA 2013]. A predesignated incident safety officer, independent of the incident commander, responds automatically to incidents as defined by the fire department. Upon arrival at the incident, the safety officer should meet with the incident commander to confirm the incident safety officer assignment and be integrated into the personnel accountability system. Upon confirmation, the incident safety officer should obtain the following information:

- Overall situation status and resource status
- Strategy and incident action plan
- Known hazards and concerns plus the establishment of control zones
- Status or rapid intervention crews
- Establishment of the rehabilitation group
- Confirmation of established radio communication channels (command channel, tactical channels)

Once the information is obtained, the incident safety officer should don the personal protective equipment appropriate for the potential hazards that he/she will be exposed to. Also, the incident safety officer should be identified by a vest or helmet. The incident safety officer should perform a reconnaissance of the incident and begin initiating functions of this position.

NFPA 1521 *Standard for Fire Department Safety Officer* defines the role of the incident safety officer (ISO) at an incident scene and identifies duties such as recon of the fire ground and reporting pertinent information back to the incident commander; ensuring the department's accountability system is in place and operational; monitoring radio transmissions and identifying barriers to effective communications; and ensuring established safety zones, collapse zones, hot zones, and other designated hazard areas are communicated to all members on scene [NFPA 2015b].

Larger fire departments should consider one or more full-time, dedicated incident safety officers who are on-duty and can routinely respond to working fires (e.g., full-time shift safety officers). In smaller departments, every officer should be prepared to function as the incident safety officer when assigned by the incident commander. The presence of an incident safety officer does not diminish the responsibility of individual fire fighters and fire officers for their own safety and the safety of others. The dedicated incident safety officer adds a higher level of training, attention, and expertise to help the incident commander, division commanders, as well as the fire fighters and fire officers. The incident safety officer must have particular expertise in analyzing safety hazards and must know the particular uses and limitations of protective equipment [Dodson 2007; Dunn 2000a; NIOSH 2010b].

Experience is an extremely valuable resource. The incident safety officer must understand the effects of fires on materials and building construction types [NIOSH 2012]. One of the important functions of an incident safety officer is to offer judgment about the collapse potential of buildings during incidents. To do this, incident safety officers must front-load their building construction knowledge so that they can "read" the building and predict collapse potential. This ability comes from a long-term commitment to reading and studying information on building construction. Knowledge of building construction starts with an understanding of the loads, forces, and materials found in the structural makeup of buildings.

The Incident safety officer can provide a fire department with a higher level of expertise to perform the necessary incident scene functions and assist the incident commander with fireground safety.

Some incident commanders believe that any fire officer should be able to fill the fire department incident safety officer function at any time under any circumstance, and therefore believe their agency really does not need a predesignated incident safety officer. Just as incident commanders have various levels of knowledge and expertise, so do other fire officers. Likewise, the requirements necessary to be a fire officer may change from department to department, a problem if mutual aid situations arise. Additionally, the emphasis placed on safety may vary from one incident commander to another [Dodson 1999].

Chief Stephen Raynis (Chief of Safety with the New York City Fire Department) notes, “If a fire officer is not usually assigned as an ISO, it is very difficult to remove ones’ self from the thought process of being a tactical officer and concentrate on safety concerns only.”

In this incident, the department did not have a predesignated incident safety officer and the incident safety officer role was not formally established on the fireground until after the collapse by the fire marshal.

Recommendation #11: Fire departments should ensure that incident commanders incorporate 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 Fire Chief (Retired) Alan V. Brunacini. Command Safety is designed to describe 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 way and ensures a close connection between incident safety and incident command.

The eight functions of command are:

- Assumption/confirmation/positioning
- Situation evaluation
- Communications
- Deployment
- Strategy/incident action planning
- Organization
- Review/revision
- Transfer/continuation/termination [Brunacini 2002; NFPA 2014]

The incident commander must follow each of these functions in order without skipping or missing any function. Each function does its own part for both the command and safety processes. Automatically connecting and integrating safety with command becomes a simple and essential way that the incident management system protects assigned resources at an incident. These functions serve as a practical performance foundation for how the incident commander completes their responsibility as the strategic-level incident manager and the overall incident safety manager [Brunacini 2002].

A major command function involves the incident commander using the initial scene size-up, consideration of critical factors (building type, occupancy, life safety, fire conditions, and available resources), the standard risk management plan, the forecast of incident conditions, and a standardized decision-making process. Overall operational strategy is divided into only two categories: offensive or defensive.

- Offensive operations are conducted inside a hazard zone.
- Defensive operations are conducted outside of the hazard zone—in safe locations [Brunacini 2002; MABAS 2015].

The two separate strategies create a simple, *understandable* plan that describes in basic terms how close the emergency responders will get to the incident's hazards. The incident's overall strategic decision is based on the incident's critical factors weighed against the risk management plan. The incident commander should avoid taking unnecessary risks to save property when fire fighters are the only life safety threat in the hazard zone. Declaring the incident strategy up front, as part of the initial radio report will:

- Announce to everybody the overall incident strategy
- Eliminates any question on where fire fighters will be operating on the incident scene (inside or outside the hazard zone) [MABAS 2015].

All fire fighters operating on a scene should be clear on the strategy that is underway. It is the responsibility of the command organization to effectively communicate any changes in strategy. Accordingly, if a company or division officer needs to perform a task that is outside of the overall strategy, the incident commander must be notified. This level of discipline is necessary, especially when a marginal situation exists or the strategy needs to be changed from offensive to defensive or back.

Once the overall incident strategy has been determined and the incident action plan developed, the incident commander should manage the completion of the tactical priorities for the chosen strategy. Each strategy has a different set of tactical priorities to complete. Tactical priorities provide the incident commander with a simple, short list of major categories that are designed to act as a practical guideline during the difficult initial stages of fireground planning. The incident action plan must be short and simple. A complicated incident action plan tends to break down during this critical time.

Generally, the incident commander tries to achieve the same basic objectives from one incident to the next. Tactical priorities offer a regular set of tools on which the incident commander can utilize for tactical activities in order to develop a standard approach to solving incident problems. With this standard approach, the incident commander can manage the basic work sequence at every incident, in the same manner.

Dispatch centers should contact the incident commander every 10–15 minutes on the assigned fireground tactical channel with elapsed-time reminders known as 10–15-minute notifications. These reminders serve as cues for the incident commander to re-evaluate conditions, restate the current strategy, and consider the length of time fire fighters have been operating in the hazard zone. The incident commander develops the strategy and the incident action plan based on the initial size-up of the incident's critical factors. These critical factors are very dynamic. They are either getting better, or they are getting worse, but they never stay the same. The incident conditions drive the strategy, the incident action plan, and the risk-management plan [NFPA 2014; MABAS 2015].

When a change occurs in the strategic mode—going from offensive mode to defensive mode—the incident commander needs to ensure that the accountability system or resource status accounts for all assigned resources. Assigned resources are fire fighters that have been entered in the accountability system and assigned work tasks on an incident. The system is designed to ensure that fire fighters do not become lost or missing in the hazard zone. An integral part of the accountability system is to make sure that all assigned resources working in the hazard zone are initially accounted for based upon the system that a fire department utilizes for accountability (e.g., PASSPORT System). Periodically throughout the incident, a personnel accountability report is conducted to ensure that all assigned resources are accounted for by the accountability officer.

The accountability officer should conduct a personnel accountability report from each division or group supervisor whenever there is a change in conditions that could create an unsafe operation such as an "emergency traffic" announcement to "all companies evacuate the building." When a tactical-level management component supervisor is requested to conduct a personnel accountability report, this supervisor is responsible for reporting on the accountability of all companies or members working within their area of responsibility [NFPA 2014].

With a strategic mode change, a personnel accountability report should occur to ensure that all assigned resources are accounted for and are out of the hazard zone. Defensive operations should not start until the personnel accountability report is completed and all members are accounted for by the accountability officer.

In this incident, the arriving acting battalion chief and crews were faced with a large fire in an abandoned structure with civilians on the scene reporting that there were people inside the structure. The incident commander established command and choose an offensive attack strategy that supported a search for victims.

The first arriving crew stretched a handline to the exterior on Side C and flowed in from the outside on the main body of fire. The next two crews that arrived stretched inside the structure via Side A to search. They had good reason to believe that there were possible victims and were attempting to stop the spread of fire and preserve evidence. Once a building has been cleared of possible residents, the incident commander should conduct a post fire building assessment as part of the risk assessment to consider the risk to personnel and consider a defensive strategy if necessary with exclusion zones established and communicated.

Incident commanders should use a command team including a safety officer and division officers to assist him/her in making strategic decisions such as performing a post fire building survey, changing operational modes, and continuous evaluation of the fire-fighting efforts and deteriorating conditions. Care must be exercised when transitioning from an offensive to defensive and then perhaps back to an operation such as overhaul that places them in an offensive position.

***Recommendation #12: Ensure adequate rehabilitation 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* [NFPA 2015c] 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. 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, and relief from extreme climatic conditions.

Effective emergency incident rehabilitation is an important element of fire-fighter health and safety. Quoting Gregory Cade, former U.S. Fire Administrator: “Emergency responder rehabilitation is designed to ensure that the physical and mental well-being of members operating at the scene of an emergency do not deteriorate to the point where it effects their safety. It can prevent serious and life-threatening conditions such as heat stroke and heart attacks from occurring.” The International Association of Fire Chiefs (IAFC), Safety, Health and Survival section developed the Rules of Engagement for Structural Fire Fighting.

One of the rules for an incident commander is to always have fire-fighter rehab services in place at all working fires. This ensures all fire fighters who endured strenuous physical activities at a working fire are rehabilitated and medically evaluated for continued duty and before being released from the scene [IAFC 2013]. NFPA 1584 [NFPA 2015c] states that an incident commander should establish rehabilitation operations when emergency operations pose a safety or health risk to fire fighters and other responders.

Criteria for implementation of incident scene rehabilitation are described in NFPA 1584 [NFPA 2015c] Chapter 6. Rehabilitation operations should be provided in accordance with fire department SOPs, NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program* [NFPA 2013], and NFPA 1561 *Standard on Emergency Services Incident Management System* [NFPA 2014].

Rehabilitation efforts shall include the following:

1. Relief from climatic conditions
2. Rest and recovery
3. Active and/or passive cooling or warming as needed for incident type and climate conditions
4. Rehydration (fluid replacement)
5. Calorie and electrolyte replacement as appropriate for longer duration incidents
6. Medical monitoring
7. Member accountability
8. Release from rehab [NFPA 2015c]

Fireground rehab is the 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.

Fireground rehab includes medical evaluation, treatment and monitoring, food and fluid replenishment, mental rest, and relief from extreme climatic conditions [NIOSH 2009; USFA 2008]. 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 [NFPA 2015c].

Site designations could include but not be limited to the following:

- A nearby garage, building lobby, or other structure
- Several floors below a fire in a high-rise building
- A school or municipal bus
- The cabs of fire apparatus or any other enclosed area of emergency vehicles at the scene
- Inflatable tents
- An open area in which a rehab area can be created using tarps, fans, etc. [USFA 2008]

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 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 portable batteries recharged or exchanged [USFA 2008].

The rehab group supervisor shall secure all necessary resources required to adequately staff and supply the rehabilitation area. The supplies should include the items listed below.

- 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, smoke ejectors, 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 for long-term operations [USFA 2008]

If fire fighters are continuously exposed to smoke conditions and performing strenuous tasks for hours at a time, fireground rehab should be formalized to ensure members are evaluated for continued duty [USFA 2008].

As stated above, quoting Gregory Cade, former U.S. Fire Administrator: “Emergency responder rehabilitation is designed to ensure that the physical and mental well-being of members operating at the scene of an emergency do not deteriorate to the point where it effects their safety. It can prevent serious and life-threatening conditions such as heat stroke and heart attacks from occurring.” Another advantage of a formal rehab is the accountability of who is in rehab and who has been released and ready for an assignment. This ensures that the strategy and incident action plan are maintained and crews are assigned to meet the plan. Fire departments should plan for adequate resources to cover the incident action plan and include rehab in the resource determination. If additional resources are needed, the department should plan for means of obtaining additional resources to meet the needs.

In this incident, the crews had been working for over an hour and were taking a break on the front lawn area (Side A). This was an informal rehab. The lieutenant and another fire fighter left rehab and went back into the structure when the collapse occurred. A formal rehab helps to ensure accountability of fire-fighting forces that are in rehab and those who have been released to go back to work or released from the scene. Additionally, formal rehab provides another level of medical assessment for members on an emergency scene. Departments can also consider training non-fire EMS providers in formal rehab roles and assist with medical monitoring and accountability.

Recommendation #13: Fire departments should ensure adequate staffing and deployment of resources based on the community’s risk assessment.

Discussion: Fire departments need to ensure not only adequate staffing, but also consider the deployment strategy to ensure adequate resources are on-scene to conduct fire suppression operations for the likely hazards in their jurisdiction. The deployment model should have allowances for mutual aid for large fires and maintaining adequate coverage for smaller incidents in their jurisdiction in cooperation with neighboring departments.

Many cities struggle with staffing and deployment challenges, however, NFPA and best practices have suggested a minimum of 15 fire fighters (3 engines, a ladder, and a battalion chief) for a single-family residential structure fire. This deployment model example may or may not meet some fire departments' needs. Rapid intervention teams and rehabilitation also need to be taken into consideration in the deployment model.

NFPA 1710 *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* contains recommended guidelines for minimum staffing of career fire departments [NFPA 2010].

NFPA 1710 states the following: "On-duty fire suppression personnel shall be comprised of the numbers necessary for fire-fighting performance relative to the expected fire-fighting conditions. These numbers shall be determined through task analyses that take the following factors into consideration:

1. Life hazard to the populace protected.
2. Provisions of safe and effective fire-fighting performance conditions for the fire fighters.
3. Potential property loss.
4. Nature, configuration, hazards, and internal protection of the properties involved.
5. Types of fireground tactics and evolutions employed as standard procedure, type of apparatus used, and results expected to be obtained at the fire scene" [NFPA 2010].

NFPA 1710 states that both engine companies and truck companies shall be staffed with a minimum of four on-duty personnel. The standard also states that companies shall be staffed with a minimum of five or six on-duty members in jurisdictions with tactical hazards, high-hazard occupancies, high-incident frequencies, geographical restrictions, or other pertinent factors identified by the authority having jurisdiction.

Staffing studies have concluded that four-person crews were more effective versus three-person crews once a water supply from an external source is established [NFPA 2010; PFD 1991]. Such additional tasks that may be accomplished by a four-person crew include:

- Two-person interior search and rescue with no hand-held back-up line
- Two-person interior structural fire-fighting with no rescue component and no hand-held back-up line
- Limited roof-level ventilation operations
- Laddering operations
- Salvage operations

Four-person crews, depending on the circumstances, may also be capable of completing the following:

- Use of 2½-inch handline

- Establishment of a water supply from a static source
- Establishment of a second point of entry and approach to the fire location in the structure
- Preparing for a second area of search and rescue for person(s) in need of rescue [PFD 1991]

NFPA 1710 sets a standard for delivering a full first-alarm assignment to lower-risk occupancies (e.g., single-family dwelling). This requires a minimum of 15 fire fighters to be on the scene of a structure fire within 8 minutes. Using the specified minimum staffing level of four members per engine company and ladder company, this would require four companies (e.g., three engine companies and one truck company) plus a battalion chief and staff assistant/incident command technician.

The requirements for moderate risk occupancies (typically multifamily residential and small commercial buildings) are based on performing the same basic functions that are listed for low-risk occupancies, however, the scale of the required operation demands additional resources. NFPA 1710 does not specify minimum requirements, leaving it up to the individual fire department to make this determination. Staffing studies have determined that a minimum of 20 fire fighters should be included in the first alarm assignment for moderate-risk occupancies. This combined force would require a total of five companies plus a battalion chief, staff assistant, and a safety officer [NIST 2013].

The requirements for higher-risk occupancies are also based on performing the same basic functions on a larger scale. These occupancies would be classified as apartment buildings, hotels, and similar structures over two stories in height; schools; hospitals; nursing homes; and larger commercial buildings. Staffing studies have determined that a minimum of 29 fire fighters should be deployed on the first alarm assignment for a high-risk occupancy. This combined force would require a total of six companies plus two battalion chiefs with staff assistants and an incident safety officer [NIST 2013].

Many communities are struggling to ensure adequate staffing. However, deployment studies have determined that certain occupancies require more personnel to effectively fight a fire and stop the spread of fire. Once an incident expands in size or complexity, a properly staffed and equipped rapid intervention crew (RIC) or team (RIT) should be immediately available to respond to rescue incidents. This formal RIC is beyond the initial RIC considerations of 2 in 2 out. It is a much more capable and equipped crew or team.

If the available staffing and deployment are insufficient for the situation encountered, the risk assessment should steer the initial strategy toward a defensive posture until additional resources arrive. During this time, the fire will continue to grow and have negative impacts on the structural integrity of the building, making an offensive attack much less desirable and certainly more dangerous. If the initial fire-fighting forces and deployment ability don’t match the hazard or fire, the incident commander should consider a defensive strategy.

Recommendation #14: Municipalities and local authorities having jurisdiction should consider developing strategies for the prevention of and the remediation of vacant/abandoned structures and for arson prevention and have programs in place to address abandoned building abatement and demolition.

Discussion: The best way to prevent vacant building fires is to prevent vacant buildings [NFPA 2009]. According to the NFPA, fires in vacant buildings have become a matter of increasing concern as the economy has weakened. The NFPA released a detailed report on vacant building fires that is available at http://www.nfpa.org/press-room/news-releases/2009/nfpa-releases-new-report-on-vacant-building-fires.

The National Vacant Properties Campaign describes a number of strategies to address the problem of vacant properties and provides examples of how these strategies have been used. Strategies include the following:

- Vacant property registration ordinances that provide contact information and may generate fees to cover municipal cost associated with these properties.
- Land banks for property seized for nonpayment of taxes.
- Rental and point-of-sale inspection ordinances that ensure the property has been maintained when the occupants change.
- Rehabilitation programs for owner-occupied housing and home repair programs.
- Homeownership and landlord training programs.
- Foreclosure prevention.
- Information systems capturing data about individual properties and neighborhoods that allow developing problems to be identified, tracked, and addressed.
- Code enforcement that is typically complaint-driven but may be institutionalized.
- Vacant property coordinators who interact with owners and municipal departments, emphasizing compliance more than enforcement.
- Property maintenance codes related to occupied housing that reduce the likelihood a property will fall into serious disrepair and abandonment.
- Nuisance abatement authority that allows municipalities to address threats to the general public, typically through administrative hearings rather than courts.
- Receivership (legal action that places property in dispute under the control of an independent person).

On its website, Interfire provides a draft ordinance [Interfire 2016] to address blighted structures and vacant lots based on the Anti-Blight Law of Bridgeport, Connecticut, and the vacant lot ordinance of Aberdeen, Texas, and procedures to secure buildings developed by the Department of Housing and Urban Development and the Federal Emergency Management Agency [Center for Community Progress 2016].

InterFire has several other items from various sources relating to vacant buildings (www.interfire.org/features/vacantbuildings.asp), including materials developed by the International Association of Arson Investigators and the U.S. Fire Administration [Center for Community Progress 2016].

Since the Event Occurred

Since this event occurred, the fire department initiated a number of policy changes. Within 6 months, the department revised and reinstituted their incident command system standard operating procedure (SOP) and are applying it on all emergency scenes and training scenarios. The department has taken steps to ensure a stationary incident commander is established. They have improved their communications training and instituted an accountability system. The accountability SOP utilizes the ID tag system and details responsibilities for its use on the emergency scene. The SOP also defines action items such as when a personnel accountability report (PAR) is used and a comprehensive description of what is to be included. The department has also developed and implemented a Mayday policy with guidelines for fire fighters, officers, and command staff.

As of the writing of this report, two defendants pled guilty to arson and involuntary manslaughter. The remains of the structure were demolished.

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Investigator Information

This incident was investigated by Stephen Miles, Investigator/Safety and Occupational Health Specialist, Tim Merinar, Safety Engineer and Jay Tarley, Safety and Occupational Health Specialist with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, located in Morgantown, West Vriginia. An expert technical review was provided by Chief Christopher J. Naum, SFPE (NY). Chief Naum also provided information on building construction, performance, and predictive risk and insights on structural collapse and compromise. His full report is included in Appendix 1. A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division. This report was authored by Stephen Miles.

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Disclaimer

Appendix 1

NIOSH DRAFT F2013-27

Fire Fighter LODD

Residential Fire & Collapse
December 15, 2013

BUILDING CONSTRUCTION ANALYSIS AND INSIGHTS

Prepared for;
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NIOSH Fire Fighter Fatality
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Submitted June 15, 2016
FINAL

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I. Building Construction and Occupancy

Note: This is an expanded version that you have starting on page 6 of the draft report **(Structure)**

Building Construction and Occupancy

The building was a single story residential structure consisting of 2,360 square feet sited on a single corner lot in a residential neighborhood location. Built in 1949 its design and layout was of the craftsman style, a popular style for this era for smaller single residential structures (Also referred to with variations as a California or Chicago Bungalow, Modified Craftsman Cape) and classified as legacy construction[1] incorporating a structural system of Type V wood frame fully dimensioned lumber[2].

Built upon a raised crawl space, the structural wood framing system incorporated conventionally full dimensioned 2 inch x 4 inch construction with limited fire stopping (balloon-frame like) with a cross-gable style roof. The low pitched cross-gable roof was constructed of full dimensioned wood rafters conventionally spaced with a 1 inch x 6 inch plank roof deck and asphalt shingle covering creating multiple roof lines and slopes. The three cross-gable roofs had louvered panels located at each end gable providing ventilation to the concealed roof underdeck attic space. Roof rafters extended beyond the roof edge creating extended eave lines. The perimeter walls were wood clad clapboard with a large allocation of double hung windows on all building sides characteristic of this house style. A typical entry porch and entry door was present on Side A with a glass enclosed porch addition constructed in 1958 added to the Bravo side. A small attached garage was present on the Bravo side. (Refer to Photo A)

Photo A
Courtesy of Google Maps Street View-circa 2008

A single family residential occupancy, at the time of the fire the structure was considered an abandoned home. The property was in a state of disrepair and had a heavy overgrowth of vegetation, brush and trees limiting access on the D side. The structure was heavily involved in fire on arrival (see photos 1, 2). The local jurisdiction had noted a number of "notice of unsafe structure" notices being sent to the property owners dating back to 2008 and a "certification of unsafe building was issues by the local building official in 2011. It was also noted in the AHJ records on 10/11/2011, the structure was noted to be demolished as unsafe. There was no power or utilities active at the time of the fire. The electric power was shut off in 2006 and the water shut off in 2004.

Construction and occupancy characteristic prevalent in this house style and vintage includes;

- Small compact house foot print
- Accessible and predicated floor plan
- Fully dimensional lumber and structural framing system
- Low pitch roof lines
- Compartmentation of rooms
- Limited number of rooms
- Smaller room volume and square footage
- Limited corridors (flow/vent paths)
- Plaster and wood lath interior room finishes; Wall and Ceilings
- Large allocation of exterior windows along perimeter walls
- Limited attic concealed spaces
- Building accessibility from street-curb side

II. Fire-Fighter Risk Profile and Insights

Occupancy Risk Profile

The inherent building, construction, design and characteristics in this structure have a recognizable predictability of expected building performance under fire conditions. [3]
The building's anatomy and fire conditions upon arrival and during initial fireground operations have defined and expected performance, risks and hazards that define the conduct of fireground operations.

This predictability of building performance had 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 time-demand identification and selection of tactical measures is borne with the arrival of the first-due company: the effectiveness and suitability of those tactical measures are validated or alter by the assuming command officer or incident commander.

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. [4]

The building's long standing known status as abandoned coupled with the degree of visible fire showing upon arrival and observed fire growth in both intensity and magnitude support the premise of a higher probability of expected fire development in multiple room compartments, rapid fire extension and probable building component and assembly compromise, deterioration, failure and collapse. [5]

The on-scene arrival conditions depicted in Photo A taken by the Chief of Department, exhibit a rapidly developing and extending fire, with evidence of fire extension into the attic compartment of the Bravo side cross-gable roof and direct degradation of roofing supports. The distinctive small volume attic compartment found in this building type and house style has a predictable building performance characteristic when fire impingement or direct flame propagation has progressed. Generally, when operating companies are confronted with intense fire conditions within an attic compartment(s) in similar craftsman's style or bungalow house configurations and those fire conditions have either impacted the compartment for an extended period of time prior to arrival or during fireground operations, it is highly probable and predictable that the structural integrity of the roof assembly, roof supports and ceiling joists will be compromised and subject to varying degrees of degradation. This will directly affect structural integrity that will lead to a limited compromised assembly, isolated or catastrophic collapse. This must be anticipated by safety officers, company officers and commanders and considered in tactical plans and task assignments both within the interior and exterior of the structure. [10,11]

The potential and probability of an isolated or catastrophic structural collapse of the roof, attic compartment or ceiling diaphragm would be considered a predominate building performance consideration and predictability variable for operations, if identified by command or company officers and assimilated as such into the initial on-scene size-up and incident risk assessment process during tactical plan development.

The on-going operations and transitions from offensive interior to defensive exterior fire attach and suppression, leading back to an interior operations incorporating building overhaul created a situation of decreasing managed defenses, high probability for error-likely conditions and operations proceeding in a high risk environment. The degree of fire involvement of the roof and attic compartment, the length of time of fire growth and impingement and concurrent fire suppression operations created building conditions that were highly predictable. The probability of a collapse was foreseeable, should have been anticipated and operational task assignments adjusted.

The challenge for today's incident commanders and operating companies on the modern fireground is to clearly recognize building performance factors and inherent characteristics fundamental to the manner in which a building's anatomy (and fire conditions) presents itself at an evolving incident and to ascertain and distinguish how it will subsequently perform during fire duress and the continuum of elapsed incident time.[4,5]

> *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, fuel load, etc., makes the task nearly impossible. However key building considerations and fireground indicators were present, had they been recognized and identified for their relevance and importance to operational safety.*

The residential building anatomy, operational risk and probability of performance for operating firefighting personnel and in the management of the incident is Normal-Marginal, with a higher emphasis toward the Marginal band primarily due to the inherent building's use status and physical condition. The occupancy's severity of risk would be considered marginal-critical with the operational probability of an adverse event to be High (H) resulting in a likely event to occur during operational times. The severity and magnitude of fire, building volume and size and structural support system characteristics increase the occupancy risk.

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

Building Risk and Severity Considerations [4,5]
- Building Age, Vintage, Condition and use status
- Likelihood of renovations and alternations affecting operations
- Building Construction System and Type
- Building Size and Volume: and compartments characteristics
- Structural Collapse characteristics of Raftered Roofing Systems; structural integrity and collapse considerations
- Inherent Structural Compromise and Collapse potential
- 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 and selected tactics
- Probability of Rapid Fire Travel and Extension growth
- 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

Figure 1 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 to not only 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. [4, 6]

The Identified Severity of Risk Level for postulated incident conditions for the fire building suggests a defined level of:

Marginal; May cause or result in personnel injury, prominent property loss or degraded and compromised conditions.

- This is based on two primary factors; the presence of heavy fire impacting the attic compartment and roof assembly system upon arrival and the known building condition and state at the time of the incident.

An increased focused situational awareness and application of predictable building performance considerations based on the building's relative unsafe conditions, occupancy use, construction and understanding and application of its building anatomy along with the presenting fire conditions upon arrival may have contributed towards increased operational and incident management efficiencies, operational effectiveness, control and amplified managed risks.

III. Operational Factors and Considerations

Rood and Attic Compartment: Fire Impingement

Of the many variables and factors that influence the fireground during the conduct of fire suppression operations, there are three (3) integral factors that can have the greatest impact on operational integrity, effectiveness and firefighter safety: 1) The Building; 2) The Compartment, and 3) The Company. [4,5,6]

Lack of building knowledge, ineffective building and fire profiling and size-up assessment, inadequate situational awareness, diminished sensitivity to time, intervention and compromise-collapse susceptibility can lead to adverse fireground conditions, operations and command compression. The ability to effectively and efficiently Read the Building and apply Predictive Indicators, must be tempered with past experiences and outcomes (favorable and detrimental), initiative thinking, critical thinking and rapid tactical-risked based decision making.

Roof -Attic Compartment Considerations

The low pitched cross-gable roof was constructed of full dimensioned wood rafters conventionally spaced with a 1 inch x 6 inch plank roof deck and asphalt shingle covering creating multiple roof lines and slopes. Construction, occupancy and fireground considerations;

- The three cross-gable roofs had louvered panels located at each end gable providing ventilation to the concealed roof underdeck attic space.
- Roof rafters extended beyond the roof edge creating extended eave lines.
- The perimeter walls were wood clad clapboard with a large allocation of double hung windows on all building sides characteristic of this house style
- Fully dimensional lumber and structural wood rafter framing system
- Low pitch roof lines
- Limited Attic Compartmentation volume: concealed spaces
- Fully dimensional lumber Ceiling Joists
- Plaster and wood lath interior room finish: Ceilings
- Likelihood of renovations and alternations affecting operations
- Degree of fire involvement within the attic compartment
- Effects of fire on wood structural members (stability, integrity and resiliency)
- Effects of fire impingement and hose streams on the interior room compartment (stability, integrity and resiliency)
- Operational Considerations during overhaul of structural integrity assessment
- Operational Considerations for interior collapse zone management during overhaul
- Command Management of risk for tactical assignments

The probability for isolated and catastrophic building compromise and structural collapse should have been readily apparent to all operating personnel and should have been fundamentally recognized as one of the foremost operational considerations during the incident management, command and control and in the overhaul tactical assignment.

It was documented early in the evolving incident upon the on-scene arrival of the first-due Engine Company at 00:24 hours that heavy fire was emanating from the building and roof areas, defense operations were implemented at 00:44 hours, reports of a sagging roof conditions at 00:58 hours. Interior operations were apparently continuing with the use of an A-frame ladder and degree of overhaul at 01:00 hours. Continuing overhaul operations were in place at 02:09 and the subsequent collapse between 02:09 and 02:12 hours.

The roof configuration, structural support system and presence of an attached plaster and lath finished wall/ceiling system has a series of key fireground and building considerations that provide insights that suggest possible causal factors that could lead to a similar condition where a structural may be prone to isolated or catastrophic interior collapse.

- The ceiling and related roof system failed in a catastrophic manner approximately 108 minutes after the first call was reported to the residence was on fire and 101 minutes from on-scene arrival of the engine to the time of the interior collapse.
- At the time in which observations and reports of a sagging roof were made at 00:58 hours, the collapse occurred approximately 71-74 minutes after this key observation.

The performance characteristics of wood when exposed to fire are readily known. Thermal degradation of structural wood components and the effects of fire impingement on wood members and assemblies responding to heating; decompose or pyrolyzes into volatiles and char. As wood burns and chars the loss of wood cross-section (mass) of single or multiple structural wood members such as roof rafters and ceiling joists continue in direct fire growth phases leading to the loss of redundancy capabilities a structural component, assembly or system, resulting in deflection, loss of load carrying capacity, compromise or collapse.

Operational safety considerations during initial or subsequent fire operations when confronted with attic compartment or concealed ceiling space fire impingement, extension and structural stability very fluid demanding command and tactical decision-points that can dramatically change in an instant transitioning from benchmarking tactical progress by operating companies to that of a highly demanding and rapidly escalating collapse, mayday, rapid intervention team deployment and rescue efforts. [7,8,9]

The complete loss of wood cross-section of rafters or joists due to flame impingement results in structural compromise of the component to perform as designed to carry and transfer loads or to carry attached loads such as the case of the plaster ceiling system present within this structure at the time of the fire. Uneven deterioration or burn thru of wood ceiling joists and the possible loss of roof rafter stability would lead to structural compromise. This would result in the collapse of the ceiling joists and the corresponding collapse of the plaster ceiling diaphragm into the room below. [9]

In many building and structures that have had a long life cycle, the likelihood of renovations and alternations affecting predictable building performance and fireground operations should be anticipated and considered in any incident action plans, tactical plans and task assignments. Certainly at the divisional and company supervisory level, task assignments must consider the implementation of area safety risk surveys and focused observations to identify subtle or obvious building anatomy, structural, architectural, engineering or aesthetic conditions or features that may have an impact on assignments, tasks or the simple presence in an area or establishment of exclusion zone restricting or limiting personnel access or operations. [10, 11]

Post incident observations in the building concluded that past renovations and alternations were found to be evident with the ceiling system assembly. At the time in which the residence was constructed (ca 1949), the installation of a plaster and lath wall finish was a common architectural feature in many homes. The presence of a plaster and lath ceiling system and its impact on firefighting operations was widely recognized and accounted for throughout the 1900's up to about the mid-1950's when the prevailing use of plasterboards, sandwich boards and gypsum wallboards or sheetrock® boards took the place of field installed plaster and lath construction.

Maintenance, age and damage and the desire for modernization usually resulted in renovations and alternations of many residential interiors. As was the case here, the ceiling system present at the time of the fire had multiple layers of materials added over time that consisted of original plaster and lath attached directly to the dimensioned lumber ceiling joists, wood tongue & grove panel boards, and gypsum wallboard.

The subsequent layers of building materials resulted in an integral ceiling diaphragm that ultimately relied on its structural integrity with the method, resiliency and stability of the mechanical fastenings systems and finally with the integrity of the lath that was originally attached to the wood ceiling joist. This becomes the weakest link in the assembly and one that is the most affected by flame propagation and fire impingement with fire travel in the attic compartment. [9,12,13,14]

Each building material and component is affected differently (over time) based on their material characteristics and fire resistance or vulnerability. This includes such factors as; applied structural load intensity, member/component type, structural member dimensions and boundary type, incident heat flux from the fire on the structural member or assembly, type of wood construction and effects of temperature rise and impingement on the structural member or assembly and the relevant properties of the members. Building materials, finishes, construction systems and assemblies will react differently and at different intervals when exposed to elevated temperature gradients and will individually or collectively react to fire, heat and physical load stresses, transfers and resiliencies leading to restraint, movement or loss of material integrity.

The degree of fire involvement in the attic compartment during the course of fireground operations most likely degrade and burnt through the highly combustible wood lath furring strips that are nailed to the ceiling joist and from which the plaster (and plaster keys) rely on for adheres and structural stability. As the wood ceiling joists burn, car and loose cross-sectional mass and deflect, coupled with the loss of limited mass the wood lath furring strips may have, the resulting effects of combined material weights (est. 16-18 PSF), the overall imposed loads and both gravity, water absorption and hose stream impact all combine to be precursors to and result in catastrophic and monolith ceiling and structural member collapse.

The addition of the outermost layer of attached gypsum wallboard created a unified diaphragm and surface area encompassing a large percentage of the affected room's ceiling area resulting in a monolithic and larger square footage collapse zone and collapse area affecting the firefighting working under.

The probable sequence and causal factors that led to the ceiling and partial roof collapse and subsequent entrapment of the firefighter were directly related to rapidly escalating fire and heat exposure in the attic compartment and the lack of fire endurance of both wood lath furring strips and wood ceiling joists that affected structural integrity of the overall ceiling system and diaphragm and loss of weight carrying capacity to remain stable and attached in the overhead during the time in which interior fire overhaul operations were underway.

Multiple ceiling systems (loading) and duress on the wood joist supporting assemblies and degraded rafter supports and roof decking was a contributor for escalating the adverse stability conditions and subsequent catastrophic collapse.

Refer to Fire Performance Characteristics of Wood and Fire Impingement[9]: National Institute of Occupational Safety and Health, Death in the Line of Duty: 4 Career fire fighters killed and 16 fire fighters injured at commercial structure fire –Texas. F2013-16 (2013)

Also refer to: Additional insights on ceiling operational considerations. [12, 13, 14]

- http://www.firegroundleadership.com/2011/04/08/roof-and-ceiling-collapses/
- http://www.firegroundleadership.com/2011/08/12/gypsum-board-ceiling-systems-ceiling-collapse-and-firefigher-safety/

- http://buildingsonfire.com/gypsum-board-ceiling-systems-and-firefigher-safety

Inherent building characteristics, predictability of performance under fireground conditions, occupancy risk profile and physical conditions as previously described, collectively provide crucial performance indicators that when recognized and managed suggest a need for a higher degree of operational safety and execution in terms of selected tactics, tasks and work practices during overhaul within a fire affected occupancy with fire impacted structural assemblies systems and components.

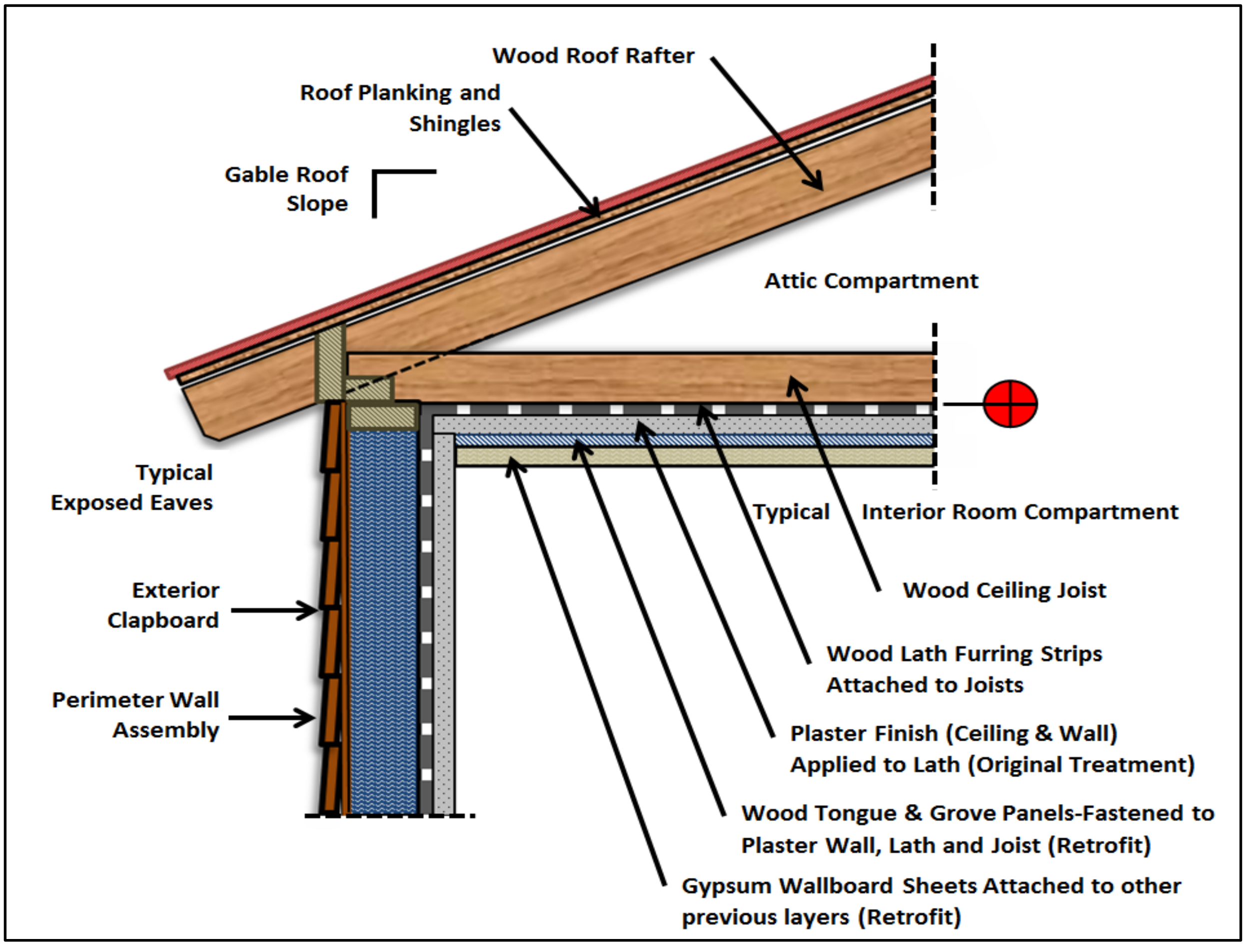

Figure 2 Typical Roof-Ceiling Assemblies with Ceiling Retrofits
Diagram Courtesy of Buildingsonfire.com | C.J. Naum

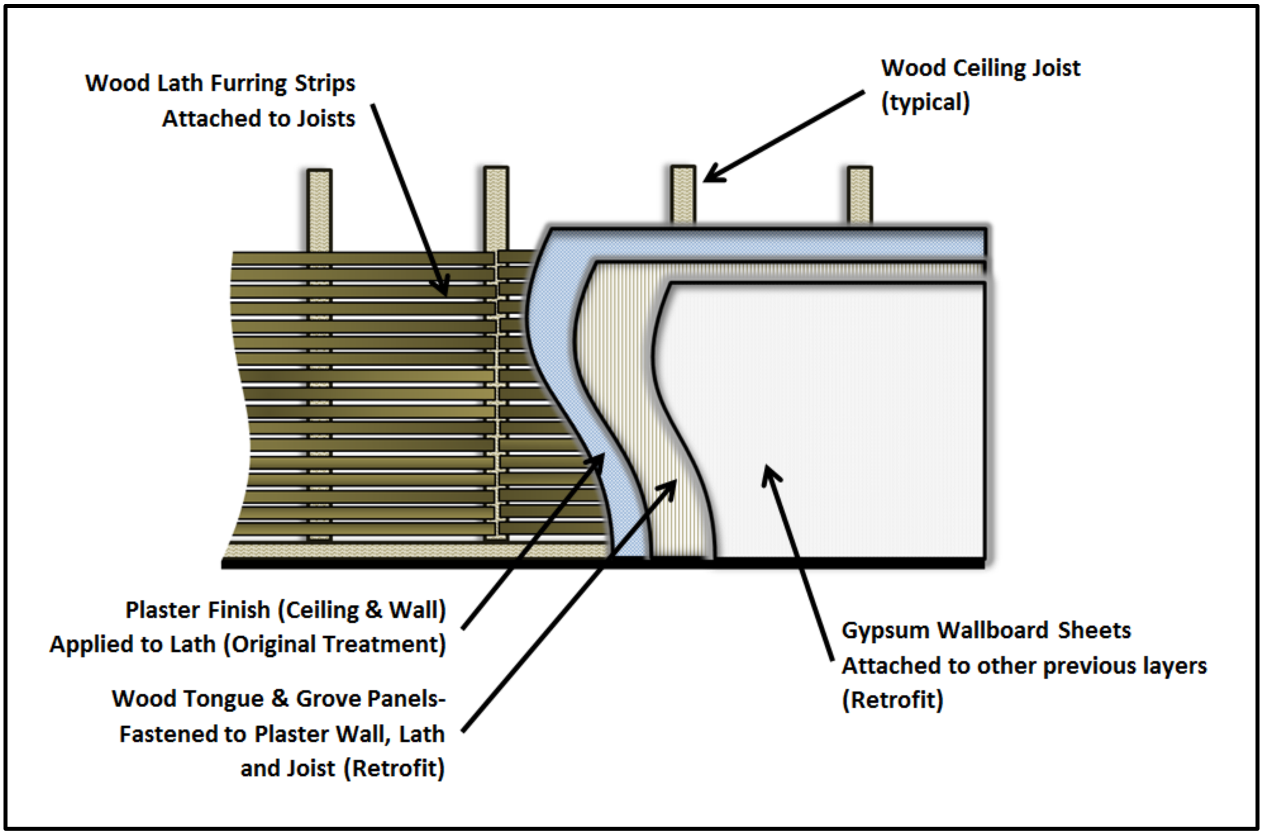

Figure 2 Ceiling Retrofits - Layers
Diagram Courtesy of Buildingsonfire.com | C.J. Naum

Learnings

- Intuitive, tactically-driven versus risk assessed operations where rapid deployment or operational complacency may lack in critical thinking when confronted with an active of post fire in a residential building space - that may require alternate tactics and increased operational safety considerations.
- Rapid Tactical Decision-making leading to Tactical driven operations must include Risk-Based influences
- Occupancy Risk Considerations versus Occupancy Type precursors
- Understand building construction, fire dynamics and company capabilities
- Understand the effects of fire on structural stability and resiliency of residential buildings of various vintage and architectural styles
- Lack of building knowledge, ineffective profiling and size-up assessment, inadequate situational awareness, diminished sensitivity to time, intervention and compromise-collapse susceptibility and negligible formulation of predictable building, occupancy,

systems feature effects can lead to adverse fireground conditions, operations and command compression.

- Understand a building's anatomy, occupancy risks and the characteristic of the building's internal compartments (occupied rooms and space use) they are integral to effective and efficient firefighting operations within buildings on fire and are essential for all phases of fire engagement and suppression.
- Conduct a Risk Assessment Profile and Size-up of the Building and Fire Conditions at all incidents
- Identify and manage Interior and Exterior Collapse Management Zones
- Identify secondary collapse potential and don't allow tunnel vision, distractions or command compression to disregard intervention or restriction before they occur; the results could be detrimental
- Understand the concept of building volume, space, connectivity, fire load package, occupancy load risks, and fire dynamics; they drive tactical options and selection
- Understand building, system, assembly, component; structural integrity and collapse predictability, precursors and operational considerations; they lead to preparedness, vigilance and actions before bad things occur
- Subsequent post fire or under-control status actions by company may not identify critical structural integrity considerations, assessment profiling or risks
- Building type, style, size, age, condition and any subsequent alterations, renovations and modifications may alter expected building conditions or features and performance under fireground operations.
- With specific construction systems, features and vintage, various types and styles of residential buildings and occupancies have defined predictable performance factors-that when recognized, assimilated and applied to adaptive tactical models for operations, a favorable balance of risk and incident demands may be correlated by command and company officers to achieve both operational excellence and mission requirements.
- Learn to Read the Building and comprehend what you see, with required actions; don't let the experience of past successes disguise and mask the distinctive characteristics of the building
- Catastrophic roof system-diaphragm compromise or failure can occur without warning just as companies are commencing with initial interior operations within a building or space or during overhaul operations. Other historical incidents in which fire and collapse of roof and ceiling systems that led to LODDs provide additional lessons learned.

IV. Appendix 1 References

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Appendix 2

COMMAND WORKSHEET FOR "MAY-DAY"

◘ **Gather**

- Location ______________________________
- Unit______________________________
- Name______________________________
- Air Supply______________________________
- Resources Needed______________________________

◘ **Are other crew members or crews involved?**

◘ **Deploy RIT to area reported or last known work area**

◘ **Announce URGENT radio traffic only**

◘ **Have Dispatch:**

Initiate the May-Day Protocol

□ Send one additional alarm

□ Send tech rescue vehicle

□ Send one more ambulance than the number of missing or trapped Fire Fighters

□ Duty Officer (duty officer will callback other chief officers to support operation)

□ Contact special rescue teams if requested

□ Monitor all radio channels

◘ **Change the Incident Action Plan to high priority rescue effort**

□ Tell fire fighter(s) calling May-Day, crew members' nearby and the RIT team to stay on the fire ground channel. The I/C will become the Rescue Branch Director

□ Announce the name________________of the new I/C and tell everyone else to move to channel____________

◘ New IC

□ Assure that everyone changes to the new fire ground channel and conduct a PAR – withdraw only if NECESSARY – DO NOT abandon fire fighting positions

□ Move up or Reinforce fire fighting efforts to support the Rescue Branch

□ Backup RIT for deployed RIT

□ Coordinate a staging area with Rescue Branch for equipment and 2nd alarm companies

□ Next Chief Officer on scene will take COMMAND

□ Assign a Safety Officer

◘ Monitor Structural Stability of Building

□ Consider the Pro's and Con's on ventilation, forcible entry and fire stream placement on the rescue

□ Consider writing off parts of the building or pushing or drawing the fire into uninvolved areas to support rescue

□ Consider a secondary means of egress for the rescue operation – *while considering how opening the building may negatively affect rescue efforts*

◘ Rescue Support

□ Rescue Branch Director will have a support person log times of personnel entering and exiting rescue area

□ Stage equipment near the entry/exit point

□ Stage EMS and ambulances near the entry/exit point

□ Stage crews to support the RIT/Rescue operation near the entry/exit point

□ Provide lighting at the entry/exit point

◘ Changes on the Fireground

□ Conduct a PAR after the rescue operation is completed

□ Conduct a PAR if an emergency retreat is ordered due to structural stability or fire condition issues

Career Fire Lieutenant Killed By Roof/Ceiling Collapse During Overhaul—Georgia

◘ **Assign PIO**

- □ Chief Officer
- □ Set-up Media Area
- □ Control information releases