2017
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Death in the line of duty...

National Institute for Occupational Safety and Health NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program August 13, 2018

Career Fire Fighter Dies and Another is Seriously Burned Fighting Arson Fire at a Commercial Strip Mall — Texas

Executive Summary

On May 18, 2017, a 31-year-old male career fire fighter died after fire conditions rapidly deteriorated inside a commercial strip mall. Ladder 35 was the first-apparatus on-scene at 2117 hours. The Ladder 35 captain sized up the scene, assumed incident command, and directed Engine 35, the first arriving engine company, to pull a pre-connected hose line while the two Ladder 35 fire fighters forced open the front entrance door to a fitness center where smoke was showing. The Ladder 35 captain directed the Engine 35 lieutenant to take the charged hose line inside for an offensive attack and directed the two Ladder 35 fire fighters to conduct a quick and shallow search for victims. The Ladder 35 captain then radioed dispatch and requested a second-alarm. Engine 26 arrived next and was instructed to open the Delta exposure. Engine 44 was assigned to Side Charlie. Battalion Chief 3 (BC3) arrived on-scene at 2120 hours and drove to the rear of the strip mall to do a 360-degree size up. He radioed the Ladder 35 captain and told him that he would assume Command after he completed the 360-degree sizeup. He discussed the conditions at Side Charlie with the Engine 44 crew, then drove to Side Alpha and radioed that he was assuming Command at 2122 hours, however not all fire fighters on the fireground heard the radio traffic and the Ladder 35 captain continued to direct fireground operations. At 2124 hours, the Ladder 35 Fire Fighter 2 radioed Command and reported that “he found the seat of the fire, the fire is in the attic, and have the motor crew (Engine 35) do a right hand search and bring the nozzle back here to us.” At 2125 hours, Battlion Chief 3 radioed Ladder 35 captain and stated he had Command and instructed the captain to join up with his crew. Soon after, the Engine 44 officer radioed Command and reported fire through the roof at Side Charlie and that they could open a door and put water on the fire. Command instructed Engine 44 to open the door but not to put any water on the fire yet because he didn’t want to push the fire onto the crews inside. Conditions continued to deteriorate inside the fitness center. At 2127 hours Command radioed for all interior crews to come out until ventilation was started. Command then instructed Engine 44 to open up the back door. At 2128 hours, the Ladder 35 Fire Fighter 2 radioed MayDay. BC 3 radioed for all companies to come outside and also requested a personnel accountability report

Street view of commercial strip mall where 31-year-old career fire fighter died.
(Photo adapted from Google Earth Street View)

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(PAR). Once outside, the Engine 35 lieutenant reported that the Ladder 35 fire fighters did not exit the fitness center with the Engine 35 crew. Rapid intervention Team (RIT) crews were immediately assigned to look for the missing fire fighters. During RIT operations, the missing Ladder 35 Fire Fighter 2 was found and quickly removed from the structure, and transported for treatment. During the continued search for the missing Ladder 35 Fire Fighter 1, a RIT member ran low on air and was overcome by the extreme fire conditions. He was removed from the structure and transported via ambulance for treatment. Defensive supression continued until Command called for a site shut down to listen for the missing Ladder 35 Fire Fighter 1's PASS device. While operations were shut down a fire fighter from Engine 37 saw the reflective trim of an SCBA near the Side Bravo wall. Recovery operations for Fire Fighter 1 began, and he was removed from the structure where he was pronounced dead. The cause of the fire was later determined to be arson.

Contributing Factors

- *Arson fire*
- *No sprinkler system in commercial structure*
- *High wind conditions*
- *Zero-visibility and cluttered floorspace impeded hose line advancement*
- *Freelancing Fire Tactics (Ladder company searching for fire beyond protection of hose stream)*
- *Crew integrity not maintained*
- *Uncoordinated ventilation (rear door opened at Side Charlie).*

Key Recommendations

- *Fire departments should integrate current fire behavior research findings developed by the National Institute of Standards and Technology (NIST) and Underwriter's Laboratories (UL) into operational procedures by developing or updating standard operating procedures, conducting live fire training, and revising fireground tactics including how to recognize and fight ventilation-limited fires, hose stream tactics, and wind-driven fires.*

Additionally, state, local, and municipal governments, building owners and authorities having jurisdiction should:

- *Consider requiring the use of sprinkler systems in commercial structures.*

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH Fire Fighter Fatality Investigation and Prevention Program, which examines line-of-duty deaths or on-duty deaths of fire fighters to assist fire departments, fire fighters, the fire service, and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with state or federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department, or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

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Introduction

On May 18, 2017, a 31-year-old male career fire fighter died after becoming trapped when conditions rapidly deteriorated inside a commercial strip mall that was on fire. On May 19, 2017, the Texas State Fire Marshal's Office notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. The U.S. Fire Administration notified NIOSH of this incident later that same day. On May 30, 2017, a safety engineer, a general engineer and two occupational safety and health specialists with the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Texas to conduct an investigation. The NIOSH investigation team met with chief officers and representatives of the fire department, the state fire marshal's office, and the International Association of Fire Fighters local union. The NIOSH investigators visited the incident site and took photographs and measurements. The NIOSH investigators interviewed members of the career fire department who were involved in the incident. The NIOSH investigators also met the chief officers and representatives with the fire department's tactical services division (arson bureau), training division, support division (SCBA maintenance and repair), urban services division (building codes and inspections), emergency services division (fire communications) and the emergency medical services (EMS) personnel who treated the injured fire fighters on scene and transported the victim to the hospital. The NIOSH investigation team also visited the communication center and met with the shift dispatch supervisor and dispatchers who were on duty the night of the incident. The NIOSH investigators obtained copies of the fire fighter's training records, fire department standard operating procedures, building information and the dispatch audio records for the incident. The NIOSH investigation team took possession of three SCBAs that were used by the Ladder 35 Fire Fighter 1 and two injured fire fighters (Ladder 35 Fire Fighter 2 and Aerial Platform 11 Fire Fighter 1) during the incident.

On June 19 and 20, 2017, representatives of the fire department arson bureau and representatives of the manufacturer who produced the SCBAs used by the fire department traveled to Morgantown, West Virginia to witness the evaluation and testing of the three SCBAs obtained as part of this investigation. The evaluation and testing was conducted by the NIOSH National Personal Protective Technology Laboratory staff. The data logger data from the two SCBAs used by the Ladder 35 fire fighter 1 and fire fighter 2 could not be downloaded on June 19, 2017 due to the condition of the SCBA. The data logger data from the third SCBA was successfully downloaded on June 19, 2017. Following the completion of the SCBA testing on June 20, 2017, custody of the two SCBAs used by the Ladder 35 Fire Fighter 1 and Fire Fighter 2 was transferred to the SCBA manufacturer and these two units were transported to the SCBA manufacturer's facililty in North Carolina for additional forensic evaluation. The third SCBA remained secured in the NIOSH facility in Morgantown, West Virginia until it was returned to the fire department.

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Fire Department

This career fire department employs 1714 uniformed fire fighters who serve a population of approximately 2.5 million residents in a geographical area of approximately 412 square miles [TDI, SFMO 2018].

The fire department is managed by three deputy chiefs who report directly to the fire chief. Administratively, the fire department is organized into three major divisions: administrative services, support services, and emergency services. Each division is supervised by a deputy fire chief. Within the emergency services division, the fire department operates three fire suppression shifts that work 24 hours-on and 48 hours-off with a work schedule of 56 hours per week. Each shift is supervised by a fire shift commander. Emergency medical services (EMS) personnel work 24 hours on and 72 hours off. Fire suppression staff are organized into eight battalions.

Each shift has a captain assigned as the shift safety officer. The fire department maintains a pool of lieutenants who have been trained to fulfill the duties of the shift safety officer to ensure the shift safety officer position is staffed at all times.

The Battalion Chief positions are field operations (fire suppression) positions. Every battalion chief is assigned an incident command technician. The shift commander is also assigned an incident command technician. If a battalion chief moves to an administrative position, their rank is changed to division chief.

The fire department has a passport system for personnel accountability tracking. The passport is a city-issued identification card which is given to the apparatus engineer at the start of each shift.

The fire department is rated as a Class 1 department by ISO as of the most recent rating period. In the ISO rating system, Class 1 represents exemplary fire protection, and Class 10 indicates that the area's fire-suppression program does not meet ISO's minimum criteria.

All fire department emergency and non-emergency dispatches originate from the city's joint Fire and Police Emergency Dispatch Center. The Fire Dispatch Center processes approximately 500 calls per shift. Fireground audio is recorded.

Training and Experience

The state of Texas requires individuals seeking to become a fire fighter to complete a commission-approved basic structure fire suppression training program consisting of 468 hours of basic fire protection training meeting the requirements of the Texas Commission on Fire Protection Basic Fire Suppression Curriculum. Each fire department and jurisdiction can require additional training.

The career fire department involved in this incident has established training requirements and operates its own training academy. The recruit training requirements meet or exceed the requirements of NFPA 1001 *Standard on Fire Fighter Professional Qualifications, Fire Fighter I and Fire Fighter II* [NFPA 2013a] and the Texas Commission on Fire Protection Basic Fire Suppression Curriculum.

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The fire department requires the following actions in order for an individual to become a fire fighter:

- **Step One - Application process:** Applicants must be at least 19 years old but have not reached 34 years of age by the date of their entrance examination. Other application requirements include: applicants cannot have any felony convictions or convictions of other crimes involving moral turpitude; cannot have any discharge from the Armed Services other than honorable; must be a high school graduate or equivalent (GED); and must be able to read, write and speak the English language.

- **Step Two - Candidate**: Selected applicants must pass the department's candidate physical ability test (CPAT); clear a background investigation; pass a behavioral personal assessment examination; pass a polygraph examination; clear a psychological evaluation; and clear a medical physical examination.

- **Step Three - Cadet:** Successful candidates are in the fire department's cadet training program. To advance, cadets must: complete the 28-week fire department cadet training program (fire academy); earn Texas basic structural firefighter certification; and earn a National Registry EMT-B (Emergency Medical Technician Basic) certification.

- **Step Four - Probationary Fire Fighter**: The probationary period begins with entry into the fire academy and ends one year later. After meeting requirements listed in Step Three and completing the cadet training program, probationary fire fighters are assigned to a Battalion Chief for the majority of their probationary period after graduation from the fire academy. Probationary fire fighters are assigned to a specific station and company for their first ten shifts. After ten shifts at their initial assignment, probationary fire fighters are rotated around at various stations and companies within their battalion. Probationary fire fighters are periodically detailed to the fire academy for skills training and reinforcement drills. Probationary fire fighters have a task book with checklists to be completed during their probationary period which include:
    - Engine company checklist
    - Ladder company checklist
    - SOP familiarization checklist.

The training academy is staffed by 14 employees (12 fire fighters and 2 civilians) including the training chief. An additional four fire fighters are detailed to the academy as additional training officers on one-year training details.

After one year from the date of hire (start of fire academy class), the probationary fire fighter is promoted to the rank of fire fighter. All fire fighters must complete Incident Command System (ICS) 100, ICS 200, ICS 700 and ICS 800. After three years from their date of hire, a fire fighter is eligible to take an examination for promotion to the rank of Engineer. After promotion to the rank of Engineer, eligibility for promotion to each successive rank requires two years in rank:

- Fire fighter
- Engineer

- Lieutenant
- Captain
- Battalion Chief.

Assignments to the rank of Assistant Chief and Deputy Chief are appointed by the Fire Chief.

The fire department maintains a structured officer development program. Lieutenants and above are required to earn a Fire Officer I and Fire Instructor I certification. Captains and above are required to earn Fire Officer II certification. Battalion Chiefs and above are required to earn a Fire Instructor II certification. The officer development process involves a mixture of online training modules plus three days of skillset training at the fire academy. Promotion to the fire fighter through captain rank involves passing a written test of 100 questions. Promotion to the battalion chief rank involves a test that is 50 percent written and 50 percent verbal assessment.

All fire fighters are required to complete 20 hours of continuing education courses annually. This continuing education course content is accessed through an online learning management system.

The department's records indicated that the Ladder 35 fire fighter who died in this incident had joined the fire department in January 2011 and was promoted to the rank of Fire Fighter in January 2012. He was working his normal job assignment as Fire Fighter 1 on Ladder 35, A- Shift at the time of the incident. He came on duty at 0900 hours on May 18th and responded to several non-fire related calls during the shift.

The Ladder 35 fire fighter who was seriously injured had joined the department in November 2005 and was promoted to the rank of Fire Fighter in November 2006. He was normally assigned to an engine company on C-Shift and was working an overtime shift on Ladder 35 as Fire Fighter 2 at the time of the incident.

The Ladder 35 captain had 22 years of experience with the fire department and had been a captain for almost 5 years.

Battalion Chief 3 (incident commander) had 29 years of experience with the fire department and 35 years of total fire service experience. He had been a battalion chief for the past 6 years.

Equipment and Personnel

This incident was initially dispatched for a report of smoke in a commercial structure. Per normal standard operating procedures, the following apparatus and personnel were dispatched for the first alarm assignment:

- Battalion Chief 3 (battalion chief and incident command technician)
- Engine 35 (lieutenant, engineer, and two fire fighters)
- Engine 26 (captain, engineer, and two fire fighters)
- Engine 27 (lieutenant, engineer, and two fire fighters)
- Engine 44 (captain, engineer, and two fire fighters)

- Aerial Platform 32 (captain, engineer, two fire fighters)
- Ladder 35 (captain, engineer, and two fire fighters (Fire Fighter 1 – victim, Fire Fighter 2 – injured)
- Medic 27 (two paramedics)

After the arriving crews confirmed the presence of smoke, the Ladder 35 captain assumed incident command and requested a second alarm. The second alarm assignment included:

- Engine 45 (lieutenant, engineer, and two fire fighters)
- Engine 15 (lieutenant, engineer, and two fire fighters)
- Engine 49 (lieutenant, engineer, and two fire fighters)
- Engine 33 (lieutenant, engineer, and two fire fighters)
- Aerial Platform 51 (Captain, engineer, and two fire fighters)
- Ladder 41 (lieutenant, engineer, and two fire fighters)
- Battalion Chief 8 (battalion chief and incident command technician)
- Battalion Chief 4 (battalion chief and incident command technician)
- Medic 35 (two paramedics),
- Medic Officer 2 (lieutenant)
- Engine 11 (lieutenant, engineer, two fire fighters)
- Heavy Rescue 11 (two fire fighters)
- Aerial Platform 11 (captain, engineer, two fire fighters including injured Fire Fighter 1)
  Note: Engine 11, Heavy Rescue 11 and Aerial Platform 11 are collectively known as the 11's crew. All 11's crew members are rescue trained.
- Rehab 1,
- Fire Shift Commander (Assistant Chief and incident command technician)

Timeline

See **Appendix One** for a summary timeline that outlines the sequence of events in which a 31-year-old male career fire fighter died after fire conditions rapidly deteriorated in a commercial strip mall fire. Not all incident events are included in this timeline. The times are approximate and were obtained by studying the dispatch records, audio recordings, witness statements, and information provided courtesy of the local fire and police departments and other available information.

Personal Protective Equipment

At the time of the incident, the Ladder 35 fire fighter who died, the Ladder 35 fire fighter who was injured and the Rescue 11 fire fighter who was injured were all wearing a full complement of turnout gear (coat and pants), helmet, Nomex® hood, gloves, boots, and a self-contained breathing apparatus (SCBA) with an integrated personal alert safety system (PASS). They all carried a portable radio and flashlight assigned by the fire department. The NIOSH investigators inspected and photographed the personal protective clothing and equipment at the fire department headquarters facility on May 31, 2017.

As part of this investigation, the self-contained breathing apparatus (SCBA) worn and used by the

deceased Ladder 35 fire fighter, the injured Ladder 35 fire fighter and the injured Aerial Platform 11 fire fighter were shipped to the NIOSH National Personal Protective Technology Laboratory (NPPTL) in Morgantown, West Virginia, for evaluation. A summary of the NIOSH evaluation is included in **Appendix Two**. The full evaluation report is available upon request from the NIOSH National Personal Protective Technology Laboratory. The full evaluation report can also be downloaded from the NIOSH NPPTL PPE website.

The fire fighters' turnout gear and equipment were not considered to be a contributing factor in this incident.

Weather and Road Conditions

On May 18, 2017 at 2058 hours (approximate time shortly before fire was reported), the temperature was 82 degrees Fahrenheit (82^{o} F), the humidity was at 70%, the barometric pressure was 29.67 inches, visibility was 10 miles, the wind was from the Southeast at 17.3 miles per hour with wind gusts reported up to 24.2 miles per hour, and it was clear. Winds remained in excess of 10 miles per hour until after midnight [Weather Underground 2017]. Other weather information sources recorded similar weather conditions.

Research by the National Institute of Standards and Technology has shown wind speeds on the order of 10 to 20 mph (16 to 32 km/hr) are sufficient to create wind-driven fire conditions in a structure with an uncontrolled flow path [Madrzykowski and Kerber 2009].

Structure

This incident occurred in a large, one-story, strip mall located in a commercial section of the city (See Photo 1) that enclosed approximately 86,000 square feet of floor space. The strip mall was constructed in a north-west to south-east orientation with a large parking lot located to the east. The strip-mall building contained a number of businesses including a thrift store and various businesses that sold cell phones, computers, a barber shop/beauty salon and other types of products. Other businesses in the strip mall complex not attached to the fire building included a retail tire store, restaurants and a nightclub. Some of the individual stores in the strip mall were vacant or used for storage. The thrift store included a dry stand-pipe with a Siamese Connection at Side Alpha.

The fire structure was a single-story structure that housed an exercise gymnasium and personal fitness / training business located near the center of the main strip-mall structure. (See Photo 1 and Diagram 1). The Side Bravo exposure was vacant and being used by the thrift store as a storage facility for used clothing and personal items. The Side Delta exposure housed a computer retail and repair business.

The structure where the incident occurred was not sprinklered. Local ordinances and building codes did not require a sprinkler system, based upon the expected occupancy and fuel load in the business. The front (Side Alpha) was constructed mainly of glass windows set in aluminum frames and included a double swing-out entry door. The Side Bravo and Side Delta walls were constructed of wooden 2 inch by 4 inch wall studs covered by gypsum wall board. The Side Charlie exterior wall was constructed of 8-inch concrete blocks and contained an outward-swinging metal double door. A partition wall containing double doors separated the main exercise floor area from offices and storage

areas located at the rear of the fitness center building (see Diagram 2). *Note: This partition wall became significant during the fire when the rear security doors on Side Charlie were opened.* The roof system was a flat roof supported by a metal roof deck covered by insulation, waterproof membranes, foam and asphalt (see Photo 2 and Photo 3). The roof deck was supported by lightweight metal bar joists running front to back. The bar joists were supported by 18-inch steel I-beams that ran parallel to the curb. A suspended drop ceiling was located under the beams creating a void space that hid the lightweight metal bar joists from view. A number of air conditioning and air handling units were located on top of the roof (See Photo 1 Google Earth overhead view).

None of the occupancies involved in the incident had fire suppression systems installed.

City and state fire investigators determined that the cause of the fire was arson in nature and an incendiary fire was intentionally started inside the storage area at the rear of the exercise gymnasium facility [TDI, SFMO 2018].

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Photo 1. Satellite overhead view showing large strip mall where incident occurred.
(Photo adapted from Google Earth)

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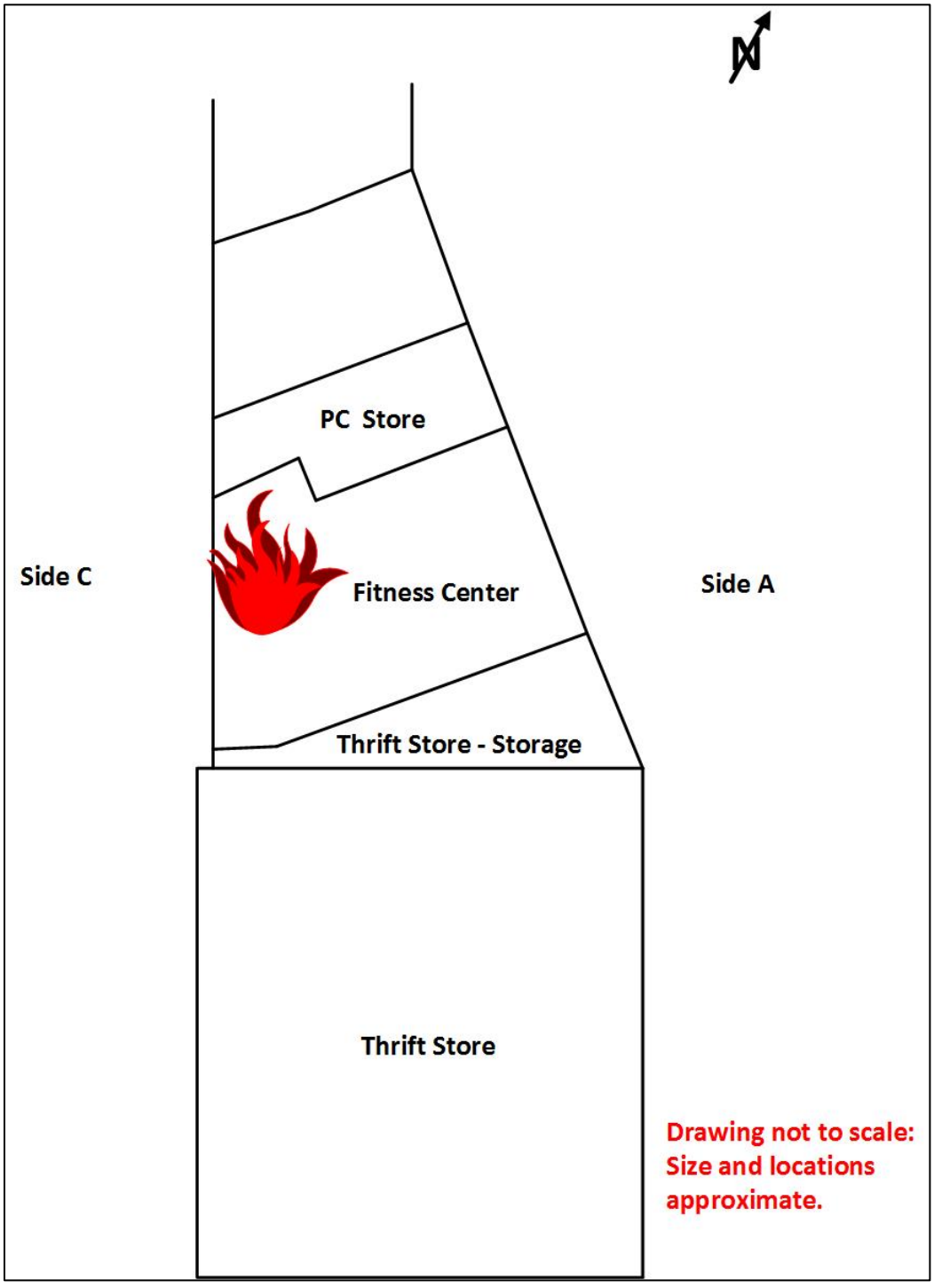

Diagram 1. Approximate layout of strip mall in area where incident occurred.
(Diagram by NIOSH)

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Photo 2. Interior of Side Delta exposure (computer business), looking from Side Alpha to Side Delta. Note roof support features including lightweight metal bar joists running from front to back supporting corrugated metal roof decking.
(NIOSH Photo)

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Photo 3. Close-up showing construction features of flat metal roof. Note layers of foam, waterproof membrane and asphalt.
(NIOSH Photo)

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Investigation

On May 18, 2017, a 31-year-old male career fire fighter died after fire conditions rapidly deteriorated in a commercial strip mall fire. The fire fighter was a member of Ladder 35, the first-apparatus to arrive on-scene. At 2110:10 hours on May 18, 2017, a call was placed to 911 reporting a structure fire in a commercial strip mall. Dispatch assigned a first alarm compliment that included Engine 35, Engine 26, Engine 27, Engine 44, Ladder 35, Aerial Platform 32 and Battalion Chief 3 at 2112:01 hours. All units were instructed to switch to radio tactical channel 2 (TAC 2). Units began going enroute at 2112:13 hours.

Ladder 35 was the first apparatus to arrive on-scene at 2117:20 hours. The Ladder 35 captain quickly sized-up the incident scene and observed light gray-brown smoke in the vicinity of the commercial fitness center. He advised Dispatch that smoke was showing (see Photo 4 and Diagram 2). He advised all companies enroute to continue and that they would be initiating an offensive mode. Engine 26 arrived on scene at 2118:22 hours and requested an assignment over TAC 2. At 2119:32 hours, the Ladder 35 captain advised Dispatch that he was assuming Command and requested a second alarm. He directed Engine 35 to pull a pre-connected hose line while the two Ladder 35 fire fighters forced open the main entrance door (on Side Alpha) to the fitness center located on the right (north) side of an 86,000 square foot commercial strip mall.

The Ladder 35 captain directed the Engine 35 lieutenant to take their charged 150 foot preconnected 1 ¾" hose line with variable-tip nozzle (set on straight stream) inside and directed the two Ladder 35 fire fighters to conduct a right hand search to look for possible victims inside. The Ladder 35 captain instructed the Engine 35 hose line crew and the Ladder 35 search crew to perform a quick and shallow search into the fitness center. The Engine 35 crew (lieutenant and 2 fire fighters) slowly advanced their hose line through the front door and turned to the right. This area contained racks of fitness equipment which coupled with the thick smoke and low visibility made forward progress with the hose line difficult. They backed out and then re-entered the front door with one fire fighter stationed at the door to assist with the hose. The fire fighters interviewed by NIOSH reported the smoke was much thicker and they felt increased heat conditions when they reentered the front door. They were only able to advance inside the structure about 10 – 15 feet due to the smoke, heat, and exercise equipment restricting movement of their hose line. Engine 35 fire fighters reported that their thermal imager screen whited out as they advanced inside. The Ladder 35 fire fighters advanced past the Engine 35 hose line crew and made their way toward Side Charlie where they began opening up ceiling tiles looking for the seat of the fire (See Photo 4 and Diagram 2). *Note: The fire department's standard operating procedure called for the first ladder company to search for victims inside a structure.*

A Second Alarm assignment was dispatched at 2119:44 hours which included Battalion Chief 8, Battalion Chief 4, Engine 45, Engine 15, Engine 49, Engine 33, Aerial Platform 51, Ladder 41, Heavy Rescue 11, Aerial Platform 11, Medic 35, Medic Officer 2, Rehab 1, AC 41 and FSC. They were assigned to radio channel TAC 3.

The Ladder 35 captain directed the next arriving engine to proceed to the rear (Side Charlie). Battalion Chief 3 arrived on-scene at 2120:35 hours and radioed to the Ladder 35 captain that he was going to

Photo 4. Incident scene. Note heavy smoke conditions on Side Alpha. Ladder 35 and Engine 35 are visible in center of photo.
(Photo provided by Fire Department member)

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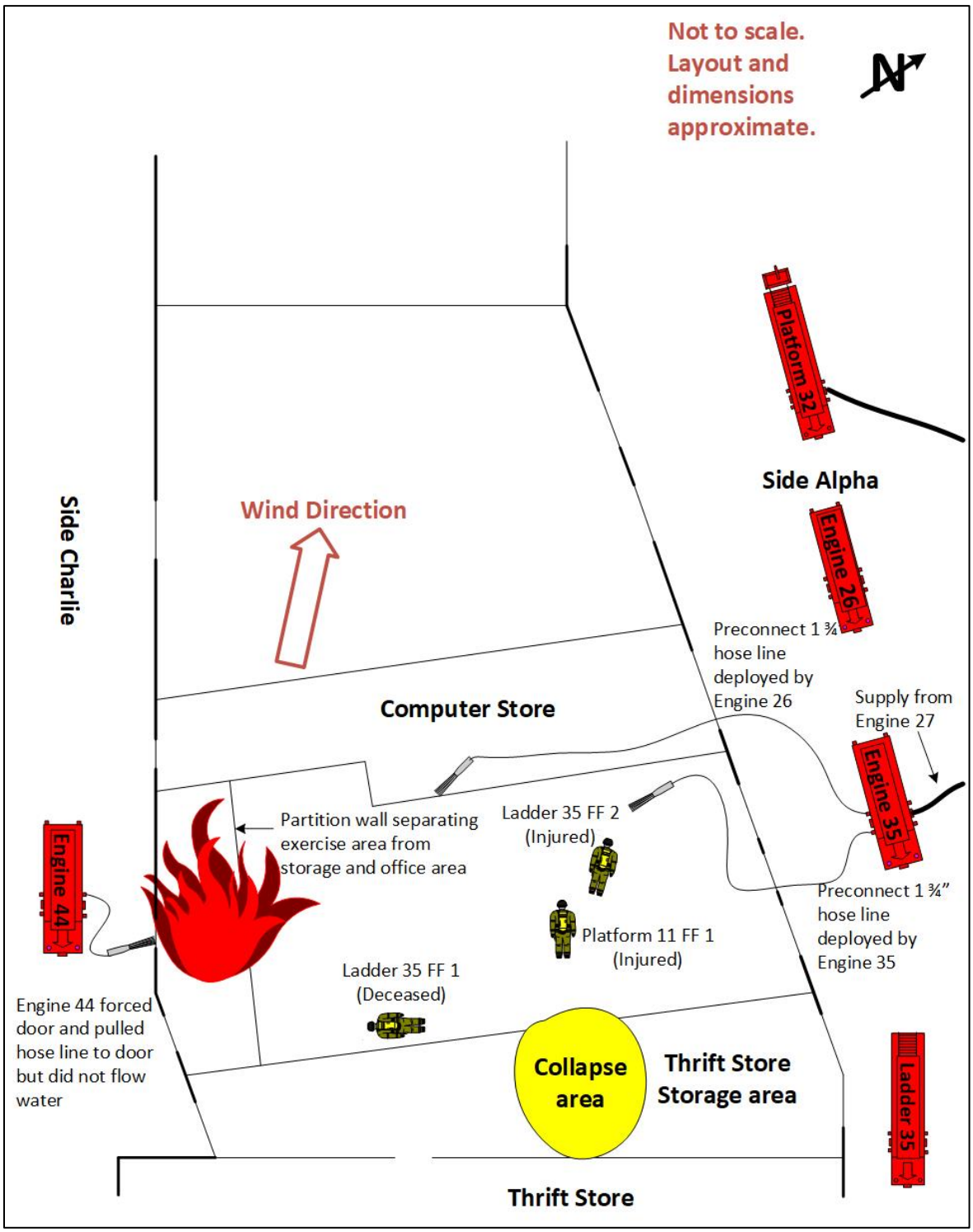

Diagram 2. Incident scene. Note locations of injured fire fighters.

drive around the complex to perform a 360 degree size-up on the structure before assuming command. He drove counter-clockwise (Side Delta – Side Charlie – Side Bravo – Side Alpha) to the front. Engine 44 arrived on-scene just behind Battalion Chief 3 and was assigned to Side Charlie.

Engine 27 arrived next and proceeded to drive to the rear of the structure from the south-west but encounterd a fence and drove back to the front. They were assigned to catch the hydrant east of the fire and lay in a five-inch supply line to Engine 35. The Engine 26 crew had to force open the locked door to the computer store (Side Delta exposure.) Engine 44 proceeded to the rear from the east. At approximately 2121:28 hours, Ladder 35 captain reported that he had a working fire with heavy smoke. He reported he had a hose line crew inside (Engine 35) with a search crew (Ladder 35) inside with Engine 26 searching for extension at the Side Delta exposure (the computer store) and Engine 44 at the rear (Side Charlie). At 2121:59 hours, Dispatch informed Command that they were at the ten-minute mark.

At 2122:47 hours, Battalion Chief 3 again radioed dispatch that he was assuming Command. He instructed Engine 27 to catch the hydrant east of the parking lot and lay a supply line to Engine 35.

Engine 27 proceeded from the rear of the structure to Side Alpha. At 2123:08 hours, the Ladder 35 Captain instructed Engine 27 to catch the hydrant beside the restaurant east of the parking lot and come in. The Engine 27 officer asked over the radio who they were to supply with water. The Ladder 35 Captain replied that after supplying Engine 35, the Engine 27 crew should protect the Side Bravo exposure. At 2123:48 hours, Dispatch radioed that Battalion Chief 3 had assumed Command. *Note: This transmission may not have been heard by everyone on the fireground.* Aerial Platform 32 reported that they were on scene. The Ladder 35 Captain instructed Aerial Platform 32 to come in behind Engine 26 and set up their aerial platform. Battalion Chief 3 drove from Side Charlie to Side Alpha to establish a command post.

At 2124:32 hours, the Ladder 35 Fire Fighter 2 radioed that they have found the fire and the fire was in the attic. The Fire Fighter 2 radioed “Have the motor crew do a right hand search and bring the nozzle back here to us.” The Ladder 35 Captain acknowledged the radio transmission from the Ladder 35 crew and stated he had a crew (Engine 26 in the Delta Exposure) checking for fire in the attic making sure that the fire doesn’t get behind them.

At 2125:13, Battalion Chief 3 radioed the Ladder 35 Captain and stated that he had Command and instructed the Captain to join up with his crew. A face-to-face transfer of command did not take place and no additional information was exchanged at this time.

At 2125:37 hours, Engine 44 radioed Command and reported that fire was through the roof at the rear of the building and there was a door that they could open and put water on the fire. Battalion Chief 3 instructed Engine 44 to go ahead and open the door but not to put any water on the fire because he didn’t want Engine 44 to push the fire onto the crews inside the building.

At 2126:13 hours, the Engine 35 lieutenant radioed Command and said that there was “zero visibility inside the structure, zero ventilation taking place, lots of heat inside the building and the building has

lightweight trusses in the roof." *Note: The building construction included a flat metal deck roof supported by lightweight metal bar joists hidden by a drop ceiling (See Photo 2).* At 2126:26, the Engine 27 officer radioed to his crew to turn on the hydrant and start flowing water. His crew immediately confirmed "water on the way."

At 2127:14, the Engine 35 lieutenant again radioed Command and repeated there was zero visibility inside the building and the fire was "in the roof where the trusses are."

At 2127:27 hours, Command acknowledged the transmission from Engine 35 and directed the Engine 35, Engine 26, Engine 27, and Ladder 35 crews to come outside until ventilation could be started. Command also directed Engine 44 to open up the back (door) so they could see what they had.

At 2128:16 hours, the Ladder 35 Fire Fighter 2 radioed "MAYDAY, MAYDAY". At 2128:29 hours, Command directed all companies on the interior to get out now and give a PAR (personal accountability report). At 2128:35 hours, the Ladder 35 Fire Fighter 2 was heard keying up his radio microphone and sounded to be in distress. Over the next few minutes, the Ladder 35 Fire Fighter 2 keyed up his radio several times and was heard yelling for someone to break out the windows because he couldn't get out.

At 2129:08 hours, Dispatch sounded an Evacuation Tone over the radio.

Over the next few minutes, Command radioed for Ladder 35 and Engine 35, asking their locations and asking for a PAR. At 2130:38 hours, Command radioed Engine 27 asked if they could go inside as a rapid intervention team (RIT) and look for the missing Ladder 35 fire fighter. *Note: At this point, it was unknown how many fire fighters were missing and who they were.* At 2130:49 hours, the Engine 27 officer confirmed they would be RIT and look for Ladder 35.

Battalion Chief 8 arrived on-scene and met face to face with Command. Battalion Chief 8 was assigned as the RIT Division Chief. He immediately proceeded to the front of the fire building. At 2132:12, Command radioed Engine 35, Engine 26 and Engine 27 and advised them to report to Battalion Chief 8 for RIT assignments.

At 2132:48 hours, the Ladder 35 Fire Fighter 2 switched to radio channel TAC 3. At 2133:03 hours, the missing fire fighter Ladder 35 Fire Fighter 2 keyed up his radio microphone on TAC 3. Over the next minute, Dispatch records showed that he keyed up his radio mic on TAC 3 at least two more times.

At 2132:51 hours, Engine 44 radioed Command and advised him that the back door to the fire building had been opened and they had heavy smoke with zero visibility inside. Engine 44 also advised Command that they had a preconnected hoseline in place outside the door and were awaiting orders. Command replied and directed Engine 44 to open up every door at the back that they could.

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At 2134:33 hours, Command radioed for Ladder 35 with no answer. *Note: At this point, Command was directing fireground operations on radio channel TAC 2 and would not have known that the Ladder 35 Fire Fighter 2 had switched over to radio channel TAC 3.*

At 2135:10 hours, Engine 26 (initial RIT) radioed Command that they had come outside the structure to change their SCBA air cylinders. Command acknowledged Engine 26. At 2135:20 hours, Battalion Chief 8 radioed Command and advised Command that he was assuming RIT Division Command and requested another engine company to back up the RIT crews inside. Command advised Battalion Chief 8 that the Aerial Platform 11 crew was on the way to assist with RIT operations.

At 2135:38 hours, Battalion Chief 8 advised Command that two fire fighters from Ladder 35 were trapped inside and their location was unknown at this time. He also reported that conditions inside were starting to get very hot and RIT crews were staged on the Leeward side (sheltered from the wind) of the building to be sheltered from the smoke. Command acknowleged the report from Battalion Chief 8. *Note: Winds blowing from the Southeast at 17-24 miles per hour caused heavy smoke conditions in front of the fire building (see Photo 4 and Diagram 2).*

Battalion Chief 8 worked over the next few minutes to assemble the Engine 27 crew and the Ladder 35 Captain as the next RIT. At 2136:41 hours, Engine 27 radioed "Emergency Traffic, Emergency Traffic, get an ambulance to the front. We've got one man down, we need an ambulance out to the front." A few seconds later, the Ladder 35 Captain radioed "We need EMS at the front. We have one out." *Note: the fire fighter pulled out was the Ladder 35 Fire Fighter 2. At this point, the location of Ladder 35 Fire Fighter 1 was still unknown.*

At 2137:01 hours Battalion Chief 3 acknowledged the reports and radioed that EMS was headed to the front of the building. At 2137:52 hours, RIT Command (Battalion Chief 8) radioed command and reported that Engine 27 brought out one fire fighter and the 11 crews were being sent in to locate the other missing fire fighter.

When the 11 crews (Heavy Rescue 11 (two fire fighters) Aerial Platform 11 (captain, engineer, two fire fighters) and Engine 11 (lieutenant, engineer, two fire fighters) arrived at Side Alpha, they were assigned as RIT by Battalion Chief 8 (RIT Command) and directed to go inside and conduct a right-hand search. Part of the 11 crew members were assigned to search the computer store (Side Delta exposure). The Aerial Platform 11 Fire Fighter 1 deployed a large-area search rope which was attached to a sign on the sidewalk outside the front door. The Aerial Platform 11 Fire Fighter 1 led the way inside the fire structure followed by the Aerial Platform 11 captain and engineer. Thick heavy smoke pushed out the front door and they immediately encountered very hot conditions. The RIT could only advance about 15 feet inside the structure before they were forced to retreat due to the intense heat. As the Aerial Platform 11 crew backed out, the Engine 11 crew (lieutenant and two fire fighters) picked up the 1 ¾-inch hose line at the front door (hose line from Engine 35) and advanced the hose line into the structure. The Engine 11 fire fighters working the nozzle on a fog pattern reported that there was no water return as the intense heat was converting all the water to steam and their Thermal Imager screen whited out due to the intense heat. The exercise equipment at the front of the structure made advancing the hoseline difficult. Aerial Platform 11 fire fighters began breaking out the front windows

as the Engine 11 and Heavy Rescue 11 entered the structure through the front door. The Aerial Platform 11 Fire Fighter 1 observed the Engine 11 and Rescue 11 fire fighters entering the structure so he followed them inside (thinking the Aerial Platform 11 crew was also going back inside), still carrying a RIT bag which continuously would get caught on the exercise equipment as he tried to advance. The RIT reported that they did a right hand search and were able to advance to the rear of the structure where they found a back room that had heavy fire in it. They were able to put water on the fire in the room but needed another handline to knock down the fire. Before their search could be completed their low air alarms began going off. As the RIT backed out, The Aerial Platform 11 Fire Fighter 1 heard the order to back out but soon became separated from the rest of the RIT. The rest of the RIT was able to back out to the front door and went outside to change their air cylinders. The RIT (11 crews) exited the structure at approximately 2154 hours. However, the Aerial Platform 11 fire fighter remained inside.

At 2138:41 hours, Aerial Platform 32 radioed command that fire was venting through the roof. Command radioed "Do not let anyone else in the building until we get everybody else out. Platform 32 and Ladder 35 put water on the fire. Don't give me a heavy stream." Aerial Platform 32 acknowledged the order. Soon after, RIT Command (Battalion Chief 8) radioed Command and asked about the status of the water on the roof. He stated that flames were coming right by the front door. He reported that the RIT was inside (11 crews) and expressed concern that flowing water on the roof would push "everything" down on the interior fire fighters. He also asked about a 360 degree size-up of the building. Command reported that all the back doors have been opened and Engine 44 had reported heavy smoke and some flames showing out the back.

At 2140:11 hours, Command radioed Aerial Platform 32 and Ladder 35 and directed them to hold off on their master streams. Both companies acknowledged the order from Command. Command also directed Aerial Platform 32 and Ladder 35 crews to set up and turn on Positive Pressure Ventilation (PPV) fans at Side Alpha to help push the smoke out the back.

After the 11 crews came outside, Engine 32 was assigned to RIT along with Engine 27. Engine 32 went inside and started a right hand search as the conditions inside continuted to deteriorate. Engine 27 was assigned to do a left hand search and stay along the Side Bravo wall. Note: At this point, Command had concerns for the safety of the roof due to the time the fire had been burning and the number of heavy air conditioning units on the roof. Fire fighters in the elevated Aerial Platform 32 reported the roof over the fire structure was beginning to sag. RIT Command (Battalion Chief 8) requested a PAR on all the 11 crews coming outside at approximately 2156 hours.

The Engine 32 crew worked to advance a 2-inch preconnected hose line into the structure. Engine 32 fire fighters reported a solid orange glow overhead as they advanced inside and immediately felt intense heat. The Aerial Platform 11 Fire Fighter 1 (who had become separated from the rest of his crew and had remained inside the structure) ran out of air and attempted to connect his SCBA to the spare air cylinder in the RIT bag. The Aerial Platform 11 Fire Fighter 1 had a working radio but never used it when he became separated from the rest of the RIT. The Engine 32 fire fighters heard a PASS device sounding and moved toward the sound of the PASS device. They soon found the Aerial Platform 11 Fire Fighter 1 who was down near the center of the structure (see Diagram 2). At 2158:52

hours, Engine 32 radioed that they had found the downed fire fighter and were backing out. The Engine 32 crew assisted the Aerial Platform 11 Fire Fighter 1 to the front door. Conditions inside the structure at this time were reported to be zero visibility, intense heat and fire overhead.

Command began making plans to move to a defensive operation and send crews with hose lines into the Side Bravo exposure to stop the fire from spreading. At approximately 2202 hours, RIT Command directed the Engine 27 crew to back out of the structure. Battalion Chief 4, at the rear of the structure (Side Charlie), reported the conditions at the rear were deteriorating with heavy thick smoke and a large fire volume. At 2203:26 hours, Aerial Platform 32 radioed Command and reported a significant increase in the flames through the roof (center to Side Alpha). At 2203:54 hours, Command requested a PAR "on everybody."

The PAR continued for several minutes while Aerial Platform 32 was directed to resume master stream operations putting water on the roof. Ladder 35 was also directed to resume operations.

At 2207:57 hours, RIT Command (Battalion Chief 8) radioed Command and advised him that the fire fighter who was just pulled outside was from Aerial Platform 11 and not from Ladder 35. RIT Command advised Command that a fire fighter was still missing inside and the interior was no longer viable. RIT Command advised that the conditions at Side Alpha were rapidly deteriorating and they needed to move apparatus away from the structure due to the fire and intense heat. Command acknowledged but stated that he did not want to give up on the missing fire fighter. At 2208:32 hours, Engine 35 was directed to begin master stream operations using their deck guns to direct water through the front window openings. At 2208:56 hours, Dispatch sounded another general evacuation tone. The Aerial Platform 11 Fire Fighter 1 was transported to a local hospital for treatment.

At 2211:58 hours, Aerial Platform 32 radioed Command to report that the roof had collapsed at the Alpha / Bravo corner. Defensive operations continued on Sides Alpha, Bravo and Delta. At approximately 2218 hours, Battalion Chief 1 was assigned to Bravo Command. A double door was located in the wall between the thrift store and the thrift store storage area (Side Bravo exposure to the fire building). Engine 10, Engine 41, Engine 15 and Ladder 41 were assigned to Bravo Command to initiate offensive operations at the double doors and use hose lines to hold the fire in the storage area.

At 2231 hours, crews were still in a defensive mode 80 minutes into the fire. At this point, the bulk of the fire had been knocked down. Crews continued to work on Side Bravo and Side Delta to limit the spread of the fire. Crews rotated in and out of rehab and RIT teams were maintained outside the front at Side Alpha.

At 2311:45 hours, Command radioed to all companies on the fireground that he was ordering all water shut down and all ventilation fans turned off so that a line of fire fighters at the front of the structure could listen for the sound of a PASS device.

At approximately 2333 hours, fire fighters at the front of the structure observed what appeared to be reflective trim on a fire fighter's personal protective equipment close to the Side Bravo wall. Search crews entered the structure and the missing Ladder 35 Fire Fighter 1 was located near the Side Bravo

wall approximately 75 feet from the front door (see Diagram 2). The Ladder 35 Fire Fighter 1 was removed from the building and pronounced dead at the scene. He was transported with fire department escort to the medical examiner's office at approximately 0030 hours.

Fire Behavior

The city fire department arson bureau along with the Texas State Fire Marshal's Office determined the fire was arson in nature.

Key factors related to fire behavior and development in this incident include the following:

- Arson fire intentionally set inside storage area at rear of fitness center.
- Fire burned for an extended time period before being reported which allowed fire to grow.
- Winds in excess of 10 miles (recorded at 17 -24 mph) per hour blowing from the Southeast.
- Ladder 35 captain reported light grey-brown smoke outside structure upon arrival.
- Thick smoke and near zero visibility inside fitness center when crews first entered**.**
- Smoke intensified to thick, heavy smoke outside structure at Side Alpha.
- Delayed water application due to exercise equipment/furnishings, low visibility and heat inside structure which impeded Engine 35 advancing initial attack hose.
- At 2126 hours, Engine 35 lieutenant reported zero visibility inside structure.
- At 2127 hours, Engine 35 lieutenant reported zero visibility inside structure and the fire was "in the roof where the trusses are."
- Thermal imagers used by Engine 35 (Side Alpha interior), Engine 26 (Side Delta exposure) and Engine 44 (Side Charlie at open rear door) all registered high heat over 300 degrees F.
- Flames 10 feet over roof line at Side Charlie when Engine 44 arrived at the rear.
- Battalion Chief 3 (incident commander) directed Engine 44 crew to open door at Side Charlie.
- Opening rear door created a flow path for winds to push fresh air to fire.
- Thick heavy smoke pushed out but no fire observed inside rear of fitness center when rear door at Side Charlie opened.
- Positive Pressure Ventilation (PPV) fans set up and turned on at Side Alpha which added additional oxygen to a ventilation-limited fire and increased the fire's heat release rate inside the fitness center.
- Ladder 35 fire fighters advanced toward rear of fitness center and opened ceiling tiles searching for fire
- Opening ceiling tiles created a flow path over top of partition wall allowing winds to push fire into main portion of fitness center
- Fire conditions rapidly intensified inside fitness center after ceiling was opened.
- At 2128 hours, Ladder 35 Fire Fighter 2 radioed Mayday as inside conditions rapidly deteriorated.
- Command directed Engine 44 to open more doors at Side Charlie.
- RIT knocked out glass windows on Side Alpha.
- RIT inside structure encountered extreme heat, near zero visibility with flames and orange glow overhead.

- RIT advanced 1 ¾-inch hoseline to rear of main exercise area where the fully envolved storage room was encountered behind the partition wall.
- Extreme fire conditions inside structure impeded rescue efforts.
- Fire breached roof on Side Bravo (roof over Thrift Store storage area)
- Extreme fire conditons (floor to ceiling fire and intense heat) forced an end to interior operations at approximately 2208 hours.
- Fire and intense heat forced crews to consider moving apparatus back away from front of structure.

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 this fatality:

- Arson fire
- No sprinkler system in commercial structure
- High wind conditions
- Zero-visibility and cluttered floorspace impeded hose line advancement
- Freelancing Fire Tactics (Ladder company searching for fire beyond protection of hose stream)
- Crew integrity not maintained
- Uncoordinated ventilation (rear door opened at Side Charlie).

Cause of Death

According to the Medical Examiner, Ladder 35 Fire Fighter 1 “died of conflagration injuries.” Measured blood carboxyhemoglobin levels were low and there were no traumatic injuries reported.

Recommendations

Recommendation #1: Fire departments should integrate current fire behavior research findings developed by the National Institute of Standards and Technology (NIST) and Underwriter’s Laboratories (UL) into operational procedures by developing or updating standard operating procedures, conducting live fire training, and revising fireground tactics including wind-driven fires.

Discussion: The National Institute of Standards and Technology (NIST) and Underwriters Laboratories (UL) have conducted a multi-year series of live burn experiments designed to replicate conditions in modern homes and residential structures to validate previous testing done in laboratory settings. The results of these experiments provide fire fighters with assessment tools to better recognize, predict, and react to fires involving new materials and construction. The fire research experiments were conducted in cooperation with the Fire Department of New York, Chicago Fire Department, Spartanburg South Carolina Fire and Rescue, and other agencies. The live burn tests are aimed at quantifying emerging theories about how fires are different today, largely due to new building construction and the composition of home furnishings and products. In the past, these products were mainly composed of

natural materials, such as wood and cotton. Today's products contain large quantities of petroleum-based products and synthetic materials that burn faster and hotter and generate large volumes of fuel-rich smoke. Where a fire in a room once took approximately 20 minutes to flashover (igniting all the contents) today's furnished rooms reaches flashover in as little as 4 to 5 minutes [Kerber 2012, Madrzykowski 2013].

Modern living spaces tend to be more open, less compartmentalized and better insulated than homes built years ago. As a result, interior residential fires can generate oxygen-depleted, fuel-rich environments within minutes. This fire condition of hot, fuel-rich smoke (also known as a ventilation-limited fire) is highly reactive to the introduction of oxygen. Opening a door or venting a window introduces massive quantities of oxygen to this environment, which promotes explosive and rapid transition to flashover. These same conditions can occur in commercial structures as seen in the fire at the Charleston, South Carolina, Sofa Super Store [NIOSH 2009].

The NIST and UL experiments evaluated individual and combinations of methods for strategically ventilating and isolating fires to delay and/or prevent flashover. In contrast, kicking a door open or breaking a window (particularly large surface windows like panes found in sliding glass doors) without knowledge of conditions inside creates a portal for air that introduces immense quantities of oxygen into an oxygen-limited, high-heat, fuel-rich, fire environment.

Fire suppression operations have traditionally been conducted using the interior attack as a means to reduce water damage and limit fire damage to structures. These operations must be coordinated with ventilation operations to reduce the risk to fire fighters working in the interior. Previous research and examinations of line-of-duty deaths have shown that uncoordinated ventilation events occurring with fire fighters in the structure prior to suppression have led to tragic results [NIOSH 2009, 2012, 2013]. One means of eliminating the possibilities of this occurrence is the use of a transitional attack. The transitional attack directs a fire stream into the structure from the exterior to cool superheated fire gases and reduce the heat release rate of the fire prior to the fire fighters entering the building. Two major concerns with the transitional attack are the potential harm that might occur to people trapped in the structure and the amount of water damage to the structure. Further research has been conducted to document the changes of the thermal environment within the structure and the impact on the viability of people who might be trapped in the structure [Zevotek, Stakes, and Willi 2018].

Based upon the NIST and UL research, the following actions regarding critical fireground operations should be taken into account at every fire scene:

- **Size-up**
  Size-up must be performed at every fire. Consideration must be given to situational conditions, such as occupied or unoccupied structure, fire location and size of the fire (fuel-limited or ventilation-limited fire condition), building geometry, building contents, construction features, weather, and available resources prior to the start of interior operations. Ensure a 360-degree

size-up is conducted whenever possible. A tactical plan must be developed, communicated, and implemented in an organized and disciplined manner for each fire.

- **Ventilation**
  Fire departments need to manage and control openings in structures during fire-fighting operations. All ventilation must be coordinated with suppression activities. Uncontrolled ventilation introduces large volumes of oxygen into the structure, resulting in a rapid increase in fire development. This increased heat release rate elevates the risk of burns to fire fighters caught in the exhaust portion of the flow path. Limiting fire growth, fire spread, controlling the flow path of inlet air and flow of fire gases during tactical operations are critical actions that reduce fire fighter exposure to untenable conditions.

- **Fire-fighting Operations**
  Water should be applied to the fire as soon as possible given the fuel-rich, high heat-release environment the fire service operates in today. Water application through an exterior opening into the fire compartment may be the best first action fire fighters take before entering the structure to conduct an interior attack.

  Fire attack teams should cool the interior spaces of a fire building during the fire attack. Water application from the safest location possible prior to committing personnel into smoldering, ventilation-limited, or fully developed spaces reduces risk and controls fires more effectively.

- **Rapid Intervention**
  Fire department rapid intervention procedures should be updated to include putting water on the fire as soon as possible and controlling ventilation openings during fire fighter Mayday incidents [ISFSI 2013].

In this incident, fire fighters had received little training based upon modern fire behavior research conducted by NIST, Underwriters Laboratories, and other research organizations. Within the past few years, recent graduates from the fire department fire academy had been exposed to the fundamentals of modern fire behavior. Fire fighters do not receive in-service live fire training. Recent research by NIST, Underwriters Laboratories, and others has shown that limiting ventilation openings and coordinating hose line deployment/water application with controlled ventilation can reduce interior temperatures. This temperature reduction makes interior conditions safer for both occupants and fire fighters [NIST, UL 2013]. In this incident, an arson fire was intentionally set in a storage area at the rear of the fitness center. When fire fighters opened the back door, with winds in excess of 10 miles per hour blowing from the Southeast, a flow path for oxygen-rich air to feed the fire was created. When the Ladder 35 fire fighters pulled ceiling tiles toward the rear of the inside of the fitness center searching for the fire, an additional flow path was created for the fire to travel from the concealed void spaces above the drop ceiling into the smoke-filled exercise area, causing the conditions in the exercise area to rapidly deteriorate, trapping the Ladder 35 fire fighters.

Recommendation #2: State, local, and municipal governments, building owners, and authorities having jurisdiction should consider requiring the use of sprinkler systems in commercial structures.

Discussion: This recommendation focuses on fire prevention and minimizing the impact of a fire if one does occur. The National Fire Protection Association (NFPA) *Fire Protection Handbook* states: "Throughout history there have been building regulations for preventing fire and restricting its spread. Over the years these regulations have evolved into the codes and standards developed by committees concerned with fire protection. The requirements contained in building codes are generally based upon the known properties of materials, the hazards presented by various occupancies, and the lessons learned from previous experiences, such as fire and natural disasters" [NFPA 2008]. Although municipalities have adopted specific codes and standards for the design and construction of buildings, structures erected prior to the enactment of these building codes may not be compliant. Such new and improved codes can improve the safety of existing structures [NFPA 2008]. Sprinkler systems are one example of a safety feature that can be retrofitted into older structures. Sprinkler systems can reduce fire fighter and civilian fatalities since such systems can contain and may even extinguish fires prior to the arrival of the fire department.

Fire development beyond the incipient stage is one of the greatest hazards that fire fighters face in today's combustible environment. This exposure and risk to fire fighters can be dramatically reduced when fires are controlled or extinguished by automatic sprinkler systems. NFPA statistics show that most fires in sprinklered buildings are controlled prior to fire department arrival by the activation of one or two sprinkler heads. The presence of automatic fire sprinklers also reduces the exposure risk to fire fighters in rescue situations by allowing the safe egress of building occupants before the fire department arrives on-scene. Finally, the exposure to hazards such as building collapse and overhaul operations are greatly reduced, if not eliminated, when fire development is arrested and controlled.

The commercial strip mall involved in this incident was constructed before sprinkler systems were required by code. The fitness center and adjoining computer store on Side Delta were not required to have sprinkler systems based upon the expected occupancy and fuel loads contained inside them. While a sprinkler system inside the main fitness center would not have initially contained the arson fire, a quick-action sprinkler system in the rear storage area (where the arson fire was intentionally set) and void space above the drop ceiling would have significantly reduced the risk of fire spread and may have contributed to a different outcome for all emergency responders.

Recommendation #3: Fire departments should define fireground strategy and tactics for an occupancy that are based upon the organization's standard operating procedures. Incident commanders should base the strategy and tactics on the community risk assessment, building occupancy, pre-incident planning, critical building information system, staffing, and available resources.

Discussion: Since no two fire departments are alike, there is no standard scale to measure and evaluate frequency and severity of risk. Some fire departments will have a greater or lesser degree of tolerance for risk than others. The intent of the risk management process is for a fire department to develop a

standard level of safety. This standard level of safety defines the parameters of the acceptable degree of risk for which members perform their job functions.

By definition, frequency is how often something does, or might, happen. Severity (risk) is a measure of the consequences if an undesirable event occurs (see Figure 1). Each risk will have its own set of factors that will dictate how a fire department will try to determine how severe the consequences might be. This scale is used to establish the degree of priority. Priority of the risk is in direct relation to inherent risks that have had a harmful effect on a fire department and its members [NFA 2004].

In this incident, the fire department responded to a working fire in a commercial strip mall. A working fire in a commercial strip mall is a low frequency event with high risk to fire fighters due to construction features that limit ingress and egress (fire walls on Side Bravo and Side Delta), make vertical ventilation difficult, may include hidden void spaces above drop ceilings and often contain showrooms full of goods and furnishings that restrict advancement of hose lines. The fire department had an outdated pre-incident plan for a previous occupancy at this structure.

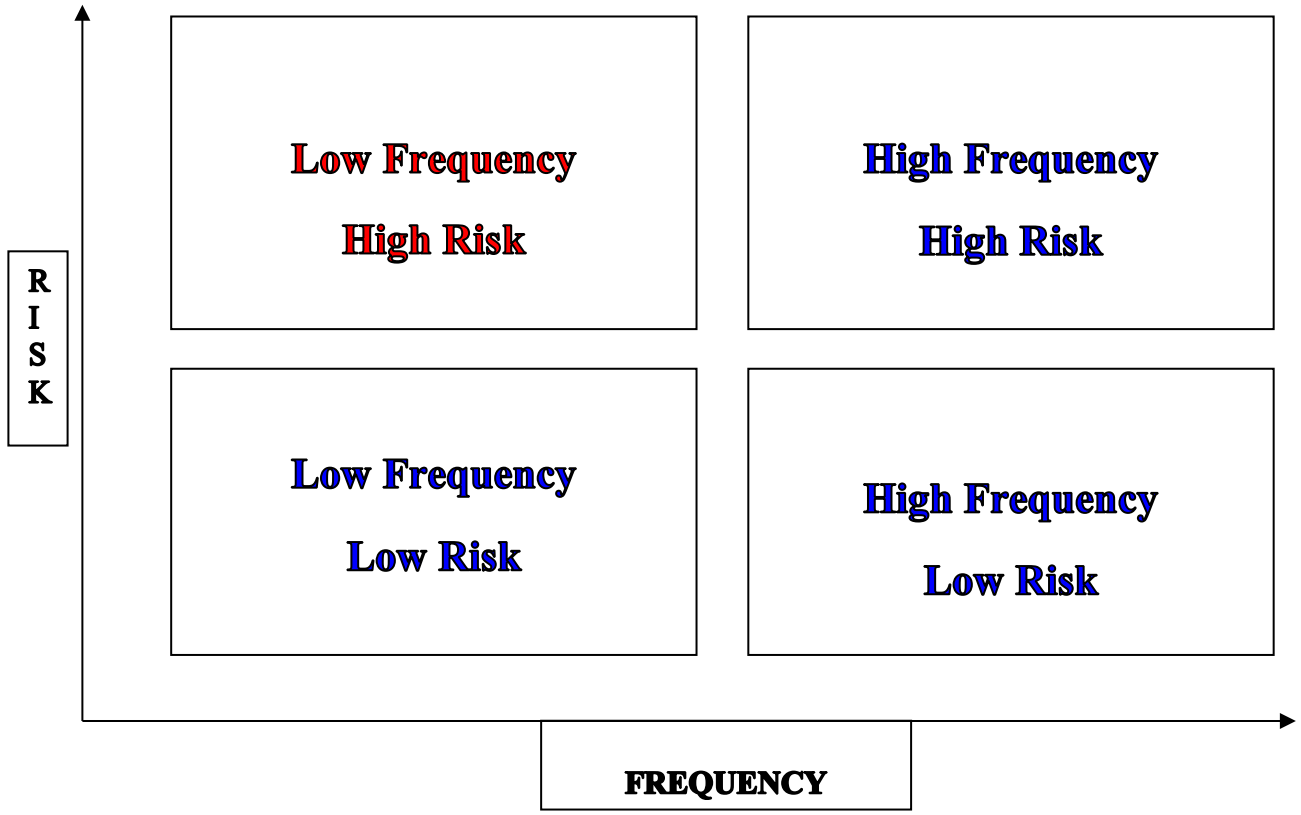

Figure 1.
Risk versus Frequency. Low frequency, high risk events can be especially hazardous to fire fighters and emergency responders.

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Recommendation #4: Fire departments should develop and implement standard operating procedures, training programs, and tactics for wind-driven fires.

Discussion: Based on the analysis of this fire incident and results from current research and field studies, adjusting fire-fighting tactics to account for wind conditions in structural fire-fighting is critical to enhancing the safety and the effectiveness of fire fighters. A wind-driven fire may be one of the most dangerous operations fire fighters will encounter. The term "wind-driven" fire is used to describe a fire in which the wind has the potential to, or is already causing, a dramatic and sudden increase in fire, heat, and smoke conditions. Experienced fire officers and fire fighters who have survived wind-driven fires have all described the following:

- Upon arrival, conditions appeared to be routine.
- Within seconds, fire, heat, and smoke conditions changed without warning "from routine to life threatening."
- An operating 2½-inch hose line flowing from the downwind position or into the exhaust portion of the flow had little or no effect on the incredible heat being produced; flowing water into the intake or inlet side (wind at your back) of the flow path is very effective.
- Directly attacking these fires with one or even two 2½-inch hose lines proved ineffective and ultimately led to fire fighters incurring serious injuries [FDNY 2013a].

When responding to a reported structure fire, an overriding consideration concerning size-up must be wind conditions and its potential effect on the fire. The key to successfully operating at wind-impacted fires in a structure depends on recognizing the wind-impacted fire conditions that may change a seemingly routine fire into a "blowtorching" fire. "Blowtorching" is the appropriate description of what will occur when fire conditions are impacted by wind conditions.

The impact of the wind will be affected by the size of the window opening, the fuel load, and the stage of the fire when the window failed. **When wind-impacted fire conditions exist in a structure, incident commanders should notify the dispatcher so this information can be relayed to all responding units. Also, incident commanders need to make an announcement on the tactical channel as well.** Once the contributing factors are identified, steps can be taken to minimize the hazards to fire fighters [FDNY 2013a].

Fire departments should develop standard operating procedures for incidents with high-wind conditions and for areas where high-wind conditions are likely. It is important that fire officers and fire fighters develop an understanding of how wind conditions influence fire behavior and impact fireground tactics that may be necessary under wind-driven conditions. Wind conditions can have a major influence on structural fire behavior. When wind speeds exceed 10 mph (16 km/hr.), incident commanders, division/group supervisors, company officers, and fire fighters should use caution and take wind direction and speed into account when selecting a strategy and developing tactics. The National Institute of Standards and Technology (NIST) has determined that wind speeds as low as 10 mph (16 km/hr) are sufficient to create wind-driven fire conditions if the flow path is uncontrolled [Madrzykowski and Kerber 2009]. NIST, in a recent study on wind-driven fires in structures, has shown that wind speeds as low as 10 mph can turn a routine "room and contents fire" into a floor to

ceiling fire storm or "blowtorch effect," generating untenable conditions for fire fighters, even outside of the room of origin. Temperatures in excess of 600 ºC (1100 ºF) and total heat fluxes in excess of 70 kW/m² were measured at 4 feet above the floor along the flow path between the fire room and the downwind exit vent. These conditions were attained within 30 seconds of the flow path being formed by an open vent on the upwind side of the structure and an open vent on the downwind side of the structure [Kerber and Madrzykowski 2009].

Fire departments are encouraged to develop and implement a standard operating procedure addressing such issues as obtaining the wind speed and direction, considering the possible fuel load associated with a particular occupancy, determining proper strategy and tactics for fireground operations, consideration of ventilation, and establishing possible scenarios associated with the wind speed based upon risk assessment. Under wind-driven conditions, an exterior attack from the upwind side of the fire may be necessary to reduce fire intensity to the extent that fire fighters can gain access to the involved compartments [Madrzykowski and Kerber 2009a, Madrzykowski and Kerber 2009b, Fire Protection Research Foundation 2013].

The strategy and tactics of an incident are dictated by the size-up, initial risk assessment, and situational report by the first arriving officer. If physical barriers make the 360-degree size-up impractical for the first arriving officer, the size-up of Side Charlie may be delegated to another fire department unit deployed to the rear of the structure. However, unless an obvious life safety issue exists (e.g., visible victims requiring immediate assistance), interior fire-fighting operations should not commence until a report from Side Charlie is received [Fire and Rescue Departments of Northern Virginia 2013].

In simulations and in previous full-scale experiments, it has been demonstrated that wind can increase the thermal hazards of a structure fire [Fire Protection Research Foundation 2013; ISFSI 2013]. Therefore, wind must be considered as part of the initial size-up of the fire conditions and must be monitored and reported throughout the fire incident. It is critical for fire fighters to not be in the exhaust portion of the fire flow path. The directional nature of the fire gas flow path results in higher temperatures than the area adjacent to the flow path or upwind of the fire. The flow path can be controlled by limiting ventilation. Previous studies demonstrated that applying water from the exterior into the upwind side of the structure can have a significant impact on controlling the fire prior to beginning interior operations [Fire Protection Research Foundation 2013; ISFSI 2013].

Current fire control training guides state, "Whenever possible, approach and attack the fire from the unburned side to keep it from spreading throughout the structure." It should be made clear that in a wind-driven fire, it is most important to use the wind to your advantage and attack the fire from the upwind side of the structure, especially if the upwind side is the burned side. The unexpected

ventilation from a broken window can suddenly change the interior thermal conditions. Interior operations must be aware of potentially rapidly changing conditions.

Fire departments should incorporate the following into their training and education component on wind-impacted fires:

- Ensure that an adequate initial size-up and risk assessment of the incident scene is conducted before beginning interior fire-fighting operations.
- Ensure that fire fighters, company officers, division/group supervisors, and the incident commander have a sound understanding of fire behavior and the ability to recognize indicators of fire development and the potential for extreme fire behavior (such as smoke [color, velocity, and density], visible fire, and heat).
- Ensure that fire fighters and company officers are trained to recognize the potential impact of windy conditions on fire behavior and implement appropriate tactics to mitigate the potential hazards of wind-driven fire.
- Ensure the incident commander's strategy considers high-wind conditions, if present.
- Ensure that fire fighters understand the influence of ventilation on fire behavior and effectively apply ventilation and fire control tactics in a coordinated manner.
- Ensure that fire fighters and officers understand the capabilities and limitations of thermal imagers.
- Ensure a thermal imager is used as part of the size-up process.
- Ensure that fire fighters are trained to check for fire in overhead voids upon entry and as charged hose lines are advanced.
- Develop, implement, and enforce a comprehensive Mayday standard operating procedure and train and educate fire fighters to ensure they understand the process and know how to initiate a Mayday.
- Ensure fire fighters are trained in fireground survival procedures.
- Ensure all fire fighters on the fire ground are equipped with radios capable of communicating with the incident commander and the dispatch center [FDNY 2013b].

Whenever possible, fire departments should consider attacking a wind-driven fire from the up-wind side of the building. Fire fighters should enter the structure with the wind at their back, making sure that fire fighters do not get on the down-wind side of the fire and avoid potential flow paths.

At this incident, the wind was blowing from the Southeast. Once the door to the fitness center on Side Charlie was opened an unrestricted flow path was created allowing fresh air to feed the fire inside the structure. Positive pressure ventilation fans were placed in service on Side Alpha, introducing additional air (more oxygen) to the fire. The initial crews entered a smoke-filled compartment from Side Alpha. As fire fighters pulled ceiling tiles at the rear of the fitness center to search for the fire, an additional flow path for the fire to travel from rear storage area and the concealed void spaces above

the drop ceiling into the smoke-filled exercise area was created, causing the conditions in the exercise area to rapidly deteriorate, trapping the Ladder 35 fire fighters who had advanced beyond the protection of a hose stream. A hose line was in place at the open door on Side Charlie but was never put into operation. A hose stream operated through the open door on Side Charlie may have helped cool the interior conditions.

Recommendation #5: Fire departments should ensure all fireground ventilation is coordinated with fire-fighting operations.

Discussion: Fire departments should manage and control the openings to the structure to limit fire growth and spread and to control the flow path of inlet air and fire gases during tactical operations. All ventilation must be coordinated with suppression activities. Uncontrolled ventilation allows additional oxygen into the structure, which may result in a rapid increase in the fire development and increased risk to fire fighters due to increased heat release rates within the flow path. Underwriters Laboratories (UL) released a report on the *Impact of Ventilation on Fire Behavior in Legacy and Residential Construction*. This report addressed multiple ventilation locations and the possibility of creating fuel-limited fires. The research indicated it was not possible to create fuel-limited fires with multiple ventilation openings. The report stated, "It is more likely that the fire will respond faster because the already open ventilation location is allowing the fire to maintain a higher temperature than if everything was closed" [Underwriters Laboratories 2010].

The flow path of a fire is how a fire moves through the structure as determined by incoming and outgoing vents for air, since air allows fire to sustain or grow [Underwriters Laboratories 2010]. Identifying and controlling the flow path is about knowing where the air comes from and where it's headed, and its importance cannot be underestimated. The identification of flow path is an item that should find its way into every after-action review. To ensure the safety of the fire fighters, it is important that fire fighters be in a safe location while trying to locate the fire that is cooling the heated space. Once the fire is under control, the fire can be completely extinguished. The rescue and salvage operations are self-explanatory—if anything can be saved, save it. These two actions are always active, right from sizing up to extinguishing [ISFSI 2013].

The UL research was conducted on one-story and two-story houses. The data collected from this research project provides valuable insight into the impact of ventilation on fire behavior in both legacy and contemporary residential construction [Underwriters Laboratories 2010]. Based upon the UL research, the following are tactical considerations that should be considered during fireground operations:

- **Stages of fire development**: The stages of fire development change when a fire becomes ventilation limited. It is common with today's fire environment to have a decay period prior to flashover, which emphasizes the importance of a ventilation strategy.

- **Forcing the front door is ventilation**: Forcing entry has to be thought of as ventilation as well. While forcing entry is necessary to fighting a fire, it also adds another vent that feeds air to the

fire. When this happens, the clock is ticking before either the fire gets extinguished or it grows until an untenable condition exists, jeopardizing the safety of everyone in the structure.

- **Flow paths:** Every new ventilation opening provides a new flow path for the fire. This could create very dangerous conditions when there is a ventilation-limited fire.

- **No smoke showing:** During the UL experiments, a common event was that once the fire became ventilation-limited, the smoke being forced out of the gaps of the houses greatly diminished or stopped all together. No smoke showing during size-up should increase awareness of the potential conditions inside.

- **Coordination:** If you add air to the fire and don't apply water in the appropriate time frame, the fire gets larger, the hazard to the fire fighters and potential victims increases and safety decreases. A clear and direct communication between companies or crews assigned to ventilation, fire attack, and other tactical functions that take place inside the structure are required.

- **Smoke tunneling and rapid air movement through the front door:** Once the front door is opened, attention should be given to the flow of air through the front door. A rapid inrush of air, or tunneling effect, could indicate a ventilation-limited fire.

- **Vent Enter Isolate and Search (VEIS):** During a VEIS operation, primary importance should be given to closing the door to the room to isolate the room from any flow paths to or from the room. This eliminates the impact of the open vent and increases tenability for potential occupants and firefighters while the smoke ventilates from the now isolated room [Underwriters Laboratories 2010].

Command should conduct a complete and thorough size-up at all fires to ensure that the location of the fire has been identified and communicated to all fire fighters on the scene. Once the fire location has been determined, the strategy and tactics can be addressed and communicated in order to control the incident in a safe and effective manner.

At this incident, the Ladder 35 and Engine 35 crews entered the fitness center where heavy smoke reduced visibility to near zero. Once inside, the Engine 35 lieutenant radioed Command at 2121:18 hours and requested ventilation be set up. At 2125:37 hours, the door at the back of the fitness center (Side Charlie) was opened but the Engine 44 crew was instructed not to flow any water into the structure because of the concern of pushing fire onto the interior crews. *Note: Underwriters Laboratories (UL) has demonstrated that there are hose streams and nozzle techniques that can be used to apply water into a burning compartment which can reduce and/or eliminate the concern of creating pressure with the hose stream that could push hot gases or fire ahead of the line [Weinschenk, Stakes, and Zevotek 2017].*

At this time during this incident, fire was observed to be self-venting through the roof at the rear of the structure. The wind was blowing from the Southeast in excess of 10 miles per hour. Opening the rear

door with the front door already open created a flow path for fresh air to feed the fire. At some point in this approximate time-frame, positive pressure ventilation fans were placed in service on Side Alpha, introducing additional air (more oxygen) to the fire. As fire fighters pulled ceiling tiles to search for the fire, an additional flow path for the fire to travel from rear storage area and the concealed void spaces above the drop ceiling into the smoke-filled exercise area was created, causing the conditions in the exercise area to rapidly deteriorate, trapping the Ladder 35 fire fighters. *Note: See the UL report - Study of the effectiveness of fire service positive pressure ventilation during fire attack in single family homes incorporating modern construction practices [Zevotek and Kerber 2016]*.

Recommendation #6: Fire departments should ensure that Rapid Intervention Crew (RIC) or Rapid Intervention Team (RIT) resources are dedicated, assigned and in-place before interior firefighting operations begin and throughout an incident so that they can immediately respond to emergency situations.

Discussion: The Occupational Safety and Health Administration (OSHA) Respirator Standard Title 29, Code of Federal Regulation 1910.134 [OSHA 1998] requires four persons (two in and two out); each with protective clothing and respiratory protection as the minimum number essential for the safety of those performing work inside a structure [OSHA 1998].

NFPA 1500 Standard on Fire Department Occupational Safety, Health and Wellness Program, Chapter 8.6.7 states that "at least two members shall be present outside the hazardous area available for assistance or rescue at emergency operations where members are operating inside a hazardous area [NFPA 2018]." Chapter 8.8.4 of NFPA 1500 states "An RIC (rapid intervention crew) shall consistent of at least two members and be available for immediate rescue of a member or a crew." *NFPA 1500, Chapter 8.8 Rapid Intervention for Rescue of Members*, provides overall guidance for fire fighters assigned for the rescue of members operating at emergency incidents [NFPA 2018].

The fire department involved in this incident had a "***Rapid Intervention Standard Operating Procedure***" in place dated 06/18/2010 and revised 04/10/2015. The stated objective was "…intended to provide an outline for the formation and operation of a Rapid Intervention Team or teams at the scene of emergency incidents. In addition, this SOP will clarify the "Procedures for Interior Structural Fire Fighting (2-In/2-Out Rule)" mandated by Texas Commission on Fire Protection's rule 435.17." The "***Objective***" section of this SOP stated "The objective of a RIT is to have a fully equipped and dedicated rescue team onsite, in a ready state, to immediately respond to the rescue of firefighters. This SOP is intended to provide a means for the Incident Commander to initiate an immediate rescue effort for firefighters in distress."

The fire department's SOP defined a Rapid Intervention Team as:

> "Rapid Intervention Team (RIT): A designated crew of at least three or more firefighters standing by at an incident that may be called upon to rescue other firefighters who become trapped, lost, injured, or are unaccounted for. At the discretion of the Incident Commander (IC), RIT members can be composed of a three or four person engine crew, a Ladder company or the Technical Rescue Team (TRT). During Heat Stress Policy months, consider relieving the RIT frequently so that no team is standing-by in full protective clothing for an extended period

of time."

During this incident, the initial dispatch consisted of four engine companies and two ladder companies. All companies were assigned fireground tasks as they arrived on-scene. Engine 27 initially attempted to respond to Side Charlie but a fence stopped their progress so they responded to Side Alpha and were assigned to supply water to Engine 35. A dedicated RIT was not assigned until Engine 27 was assigned to be RIT approximately 2 minutes after the Engine 35 Fire Fighter 2 declared a Mayday over the radio.

Recommendation #7: Fire departments should train fire fighters on the principles of situational awareness.

Discussion: All 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. Fire fighters need to understand the importance of situational awareness and personal safety on the fireground. *Essentials of Fire Fighting and Fire Department Operations* defines situational awareness as an awareness of the immediate surroundings. On the fireground, every fire fighter should be trained to be constantly alert for changing and unsafe conditions. This applies not only to the conditions found within a burning structure, but to exposure buildings and the exterior fireground as well. Even though a safety officer may have been designated for an incident, all personnel are obligated to remain alert to their immediate surroundings.

The ability to maintain situational awareness is reliant on a fire fighter's training, judgment, and personal condition. These factors must come together every time a fire fighter goes to an emergency incident, especially those involving a low-frequency, high-risk event, such as structural fire-fighting, wildland fire-fighting, trench rescue, high-angle rescue, or any of the wide arrays of emergencies fire fighters are called upon to mitigate. A lack of competency, or even a temporary lack of focus, can lead to a chain of events that may be catastrophic or even fatal [Brennan 2009, Gasaway 2013].

To properly train personnel to maintain situational awareness on the fireground or at any emergency incident, a fire department has to develop and utilize effective scenario-based training. Training fire fighters to maintain situational awareness on the fireground needs to include building construction, fire behavior, fireground tactics and strategy, ventilation, and other fireground operations. This is a continuous process that is initiated in recruit school and continues throughout a fire fighter's entire fire service career.

Fire fighters need to understand the importance of situational awareness, personal safety, and company/crew accountability on the fireground. The fireground dangers and hazards can and do change as an incident evolves and the event duration increases. Situational awareness is defined as recognition of the immediate surroundings. On the fireground, every fire fighter should be trained to be constantly alert for changing and unsafe conditions related to their immediate surroundings. Each and every fire fighter needs to be responsible and accountable for their own safety, as well as team members and others working in the immediate area. This applies not only to the conditions found within a burning structure, but to the exterior fireground as well.

Career Fire Fighter Dies and Another is Seriously Burned Fighting an Arson Fire at a Commercial Strip Mall — Texas

The United States Coast Guard says that "situational awareness is the ability to identify, process, and comprehend the critical elements of information about what is happening to the team with regards to the mission." In other words, in order to have “situational awareness” you must constantly know what is happening around you and where you are in relation to threats.

The need for fire fighters to maintain situational awareness is paramount. A loss of situational awareness can lead directly to disorientation. Disorientation far too often leads to a fire fighter line-of-duty death. In addition, a perceived lack of a threat can lead directly to complacency or an unrealistic feeling of comfort in one’s environment. Situational awareness is a cognitive skill; it can be taught. In order to have situational awareness, you must be able to perceive the threat, comprehend the threat, and predict what effect that threat may have on you. These elements—Perceive, Comprehend, and Predict—form the cornerstone of maintaining complete situational awareness [Brennan 2009, Gasaway 2013].

In this incident, the Ladder 35 fire fighters were assigned to enter the structure to search for possible victims as the Engine 35 crew deployed a 1 ¾-inch preconnected hose line. The Ladder 35 crew began pulling ceiling tiles to search for the fire, and they advanced beyond the protection of the Engine 35 hose line. When the conditions inside the fitness center rapidly deteriorated, the Ladder 35 crew became disoriented.

Recommendation #8: Fire departments should ensure that crew integrity is properly maintained by visual (eye-to-eye), direct (touch), or verbal (voice or radio) contact at all times when operating in an immediately dangerous to life and health (IDLH) atmosphere.

Discussion: When a crew enters a structure, the members should remain in contact by visual (eye-to-eye), verbal (radio or person-to-person), or direct (by touch) contact. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program* states in Paragraph 8.5.5, "Crew members operating in a hazardous area shall be in communication with each other through visual, audible, or physical means or safety guide rope, in order to coordinate their activities." Additionally, NFPA 1500 Paragraph 8.5.6 states, "Crew members shall be in proximity to each other to provide assistance in case of an emergency" [NFPA 2013b].

The International Association of Fire Chiefs, Safety, Health, and Survival Section has redefined the *Rules of Engagement for Structural Fire Fighting*. One of the objectives is to ensure that fire fighters always enter a burning building as a team of two or more members and no fire fighter is allowed to be alone at any time while entering, operating in, or exiting a building. A critical element for fire fighter survival is crew integrity. Crew integrity means fire fighters stay together as a team of two or more. They must enter a structure together and remain together at all times while in the interior, and all members come out together. Crew integrity starts with the company officer ensuring that all members of the company understand their riding assignment, have the proper personal protective equipment, and have the proper tools and equipment. Upon arrival at the incident, the company is given a task to perform by the incident commander. The company officer communicates to the members of the company what their assignment is and how they will accomplish their assignment. As the members of

a company enter a hazardous environment together, they should leave together to ensure that crew integrity is maintained. If one member has to leave, the whole company leaves together [IAFC 2012].

It is the responsibility of every fire fighter to stay in communication with crew members at all times. All fire fighters should maintain the unity of command by operating under the direction of the incident commander, division/group supervisor, or their company officer at all times. The ultimate responsibility for crew integrity and ensuring no members get separated or lost rests with the company officer. They should maintain constant contact with their assigned members by visual observation, voice, or touch while operating in a hazard zone. They should stay together as a company or crew. If any of these elements are not adhered to, crew integrity is lost and fire fighters are placed at increased risk. If a fire fighter becomes separated and cannot re-connect with his/her crew immediately, the fire fighter should attempt to communicate via portable radio with the company officer. If reconnection is not accomplished after three radio attempts or reconnection does not take place within 1 minute, a Mayday should be declared. If conditions are rapidly deteriorating, the Mayday should be declared immediately. As part of a Mayday declaration, the fire fighter should next activate the radio's emergency alert button (where provided), followed by manually turning on the PASS alarm. Similarly, if the company officer or the fire fighter's partner recognizes they have a separated member, they should immediately attempt to locate the member by using their radio or by voice. If contact is not established after three attempts or within 1 minute, a Mayday should be declared immediately [IAFC 2012].

In this incident, The Ladder 35 and Engine 35 crews entered the structure at approximately the same time. Per fire department SOPs, the initial ladder company's assignment is to search for possible victims. Soon after entering the exercise facility, the Ladder 35 crew began searching for the seat of the fire. As the conditions inside the structure deteriorated, the two Ladder 35 fire fighters became separated and were trapped by the deteriorating conditions. Neither was able to exit the structure. The Ladder 35 Fire Fighter 2 radioed for assistance and RIT crews were quickly sent inside. The Ladder 35 Fire Fighter 2 was located and RIT crew members assisted him outside. New RIT crews were sent back inside to look for the missing Ladder 35 Fire Fighter 1. While searching inside the structure as a member of the RIT crew, the Aerial Ladder 11 Fire Fighter 1 became separated from his crew and also had to be rescued just before deteriorating conditions forced an end to interior operations. When the Aerial Ladder 11 Fire Fighter was brought outside, it was assumed that he was the missing Ladder 35 Fire Fighter 1. Several minutes passed before it was realized that the Ladder 35 fire fighter was still missing. Unfortunately, the Ladder 35 Fire Fighter 1 was not located until approximately 2333 hours.

Recommendation #9: Fire departments should ensure that an initial risk assessment is performed and continuous risk assessment is accomplished throughout the incident and the strategy and tactics match the conditions encountered.

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

- Activities that present a significant risk to the safety of fire fighters should be limited to situations that have the potential to save endangered lives.

- Activities that are routinely employed to protect property should be recognized as inherent risks to the safety of fire fighters, and the actions should be taken to reduce or avoid these risks.

- No risk to the safety of fire fighters should be acceptable where there is no possibility to save lives or property [Brunacini 2002].

The strategy and tactics of an incident are dictated by the size-up, initial risk assessment, and initial report by the first arriving officer. As in this case, and at every structure fire, it is a priority that a 360-degree size-up is included in the risk assessment. Life hazard, fire extent and location, and building conditions are factors that need to be a part of the size-up and help to match the strategy and tactics with the conditions encountered and this information must be continual. If a 360 degree walk around cannot be completed, then a size-up of the areas can be accomplished through the assignment of personnel and apparatus to divisions starting with a priority of Division C or the rear of the building.

Incident commanders are responsible for evaluating conditions at a structure fire and determining the strategy and tactics for fighting the fire. In many cases the first arriving officer is the initial incident commander and sets in motion the strategy and tactics. Command is later passed to a higher-level officer and a formal command is established. Incident commanders need to ensure that the strategy and tactics are appropriate with all of the size-up factors. To accomplish this, the incident commander should use a standardized strategic decision-making model.

First, the incident commander should size up the critical fireground factors [PFD 2009]. Before ordering an offensive attack, the incident commander 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 the offensive attack if the risk evaluation changes during the fire-fighting operation. A full range of factors must be considered in making the risk evaluation, including the following:

- Presence of occupants in the building
- A realistic evaluation of occupant survivability and rescue potential
- Size, construction, and use of the building
- Age and condition of the building
- Nature and value of building contents
- Location and extent of the fire within the building
- Adjacent exposures (structures)
- Fire involvement or compromise of the building’s structural components
- Residential or commercial structure
- Delayed discovery/reporting and its effect on burn time and structural stability
- Considerations of fire loading and fire behavior

- A realistic evaluation of the ability to execute a successful offensive fire attack with the resources that are available [PFD 2009; NIOSH 2010].

These fireground factors should 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 incident commander 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 2010]. Risks to fire fighters versus gains in saving lives and property should always be considered when deciding whether to use an offensive or defensive attack.

The incident commander should continually match the actions against the conditions based upon continuous reports from all operating companies. This gives the incident commander the ability to control the situation by forecasting and staying ahead, rather than the fire dictating the actions taken. The incident commander 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 incident commander 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 2013b; PFD 2009].

The risk assessment of a building during fire-fighting operations should be continuous with building intelligence and reconnaissance communicated on degrading conditions, fire extension and compromise, building integrity considerations, the effects of fire spread and suppression on the interior compartment(s), and the structural system and building envelope.

It is important that fire officers and fire fighters understand risk management principles and apply that knowledge to modern fire conditions, especially in commercial structures. Never under-estimate a working fire in a commercial structure. Prior to implementing operations, the Incident Commander must perform a risk assessment considering life safety and the safety of fire fighters and forecast these factors against expected conditions. At large and/or advanced fires in vacant commercial buildings, the incident commander must not only recognize the present fireground factors for his/her size up; they must quickly forecast the factors and apply the forecast as well to the incident action plan. In most circumstances, in a large or advanced fire in a vacant commercial building a defensive operation should be a primary tactical consideration. The Incident Commander may vary certainly from the current strategy and the incident action plan should a life hazard or extreme exposure protection issues arise. [NIOSH 2013b]

In this incident, the captain of the first arriving apparatus took incident command and initiated a fast attack. The first arriving crews pulled a pre-connected 1 ¾-inch hose line to the front door of the commercial strip mall. Fires in large structures often require large volumes of water for extinguishment. It was late evening (approximately 2117 hours) and few cars were in the parking lot. The first arriving battalion chief drove completely around the strip mall to perform a 360-degree size-up before he assumed Command. Soon after the Engine 35 and Ladder 35 crews entered the structure, conditions deteriorated. Wind was blowing from the Southeast and smoke conditions increased at Side

Alpha throughout the incident. Engine 35 advanced their charged 1 ¾-inch hose line to the right but the zero visibility made advancing the hose line through the exercise equipment and furnishings difficult. The Engine 35 lieutenant requested ventilation and a double door was opened at Side Charlie and positive pressure ventilation (PPV) fans were set up at Side Alpha in an effort to remove smoke and improve visibility. Unknown to the responders, the intentionally set arson fire continued to rapidly accelerate causing the interior conditions to rapidly deteriorate. Due to the limited visibility and the exercise equipment and furnishings restricting the advancement of the hose line, an effective interior water stream was never applied to the fire prior to the Ladder 35 fire fighters being trapped by the fire conditions. After the Engine 35 lieutenant reported that the roof support structures were exposed to the fire, the Incident Commander ordered all interior crews to come outside. The Ladder 35 fire fighters had advanced beyond the protection of the hose line and were caught in the rapidly deteriorating conditions and were not able to exit.

Recommendation #10: Fire Departments should ensure critical benchmarks are communicated to the Incident Commander on a regular basis.

Discussion: The Incident Commander monitors exterior conditions while company officers and crew leaders monitor the interior conditions while they are effecting their tactical assignment, communicating to the Incident Commander as soon as possible. Knowing the location and the size of the fire inside the building lays the foundation for all subsequent operations. Reports on interior conditions could change the Incident Commander's initial strategy. This is especially true when operating in marginal or changing conditions in a high risk/low frequency event such as a structural fire in a commercial occupancy. Residential tactics such as quick searches with crews operating above the fire or beyond the charged hose line should be discouraged. Commercial occupancies dictate different tactics than room and content residential structural fires, including maintaining crew integrity, hose line size, water supply (not off of tank water) and searching for the fire without the protection of a changed hose line.

It is important that company officers when operating inside the structure, communicate to the Incident Commander or division supervisor when making initial entry, while searching and clearing areas, during fire attack, and when exiting the structure. They need to relay important benchmarks such as water on the fire, primary and secondary search as well as crew status benchmarks. **It is equally important to communicate to the Incident Commander when crews can't complete a benchmark or are having trouble completing a search, finding the fire and especially deteriorating conditions.**

Proper size-up and risk-versus-gain analysis require that the Incident Commander gather a number of key pieces of information and be kept informed of the constantly changing conditions on the fire ground **[**NIOSH 2013b].

The Incident Commander must develop and utilize a system that captures pertinent incident information to allow continuous situational evaluation, effective decision making, and development of an incident management structure. Decisions can be no better than the information on which they are based. The Incident Commander must use an evaluation system that considers and accounts for

changing fire ground conditions in order to stay ahead of the fire. If this is not done, the incident action plan will be out of sequence with the phase of the fire, and the Incident Commander will be constantly surprised by changing conditions [Brunacini 2002, Smith 2002, NIOSH 2010].

Interior size-up is just as important as exterior size-up. Since the Incident Commander is located at the command post (outside), the interior conditions should be communicated by interior crews as soon as possible to the Incident Commander. Interior conditions could change the Incident Commander's strategy.

Interior crews can aid the Incident Commander in this process by providing reports of the interior conditions as soon as they enter the fire building and by providing regular updates, especially when benchmarks are met (e.g., "primary search complete is all clear" and "the fire has been knocked down").

The Incident Commander can never assume the action-oriented responders engaged in operational activities will stop what they are doing so they can feed the Incident Commander with a continuous supply of objective information. It is the Incident Commander's responsibility to do whatever is required to stay effectively informed [Brunacini 2002].

In this incident, the Engine 35 lieutenant made two radio transmissions reporting the fire was in the void space and lightweight trusses were exposed. The Ladder 35 Fire Fighter 2 made one radio transmission reporting that they had found the fire. Other critical benchmarks such as water flowing, water on the fire, and ventilation were not communicated on a regular basis to the Incident Commander.

Recommendation # 11: Fire departments should consider periodic training on the transfer of Command.

Discussion: The need to effectively communicate and manage resources on the fireground is of vital importance. A single individual or a collective team must be in charge to prioritize tasks, give direction and be in control. Otherwise, span of control and overall incident command can break down and chaos may result.

The Incident Command System (ICS) uses a common terminology in order to control personnel, resources, and communications at the scene of a critical incident. ICS is a well-organized team approach for managing critical incidents. It has a modular organization that can be used for all types of incidents regardless of size. It is essential that all emergency responders understand their specific roles when using ICS. One such role involves transferring Command. ICS 300 training covers Incident Management and the reasons for and steps involved to transfer Command.

Transfer of Command should be regulated by:
The ranking officer assuming Command will communicate with the person being relieved by radio or face-to-face (face-to-face is the preferred method). Then the person being relieved will brief the ranking officer assuming Command by indicating:

- Current situation status, incident action plan (IAP), completed objectives, safety considerations
- Current assignments of companies and personnel.
- Resource needs

The officer assuming Command should broadcast over the radio confirmation of the transfer of Command and provide an updated condition report.

In this incident, Ladder 35 was the first apparatus to arrive on scene and the Ladder 35 captain assumed Command per established fire department procedures. When Battalion 3 arrived on scene, he radioed to the Ladder 35 captain that he would assume Command after completing a 360-degree size up by driving around the strip mall complex. After completing his size up, Battalion 3 radioed that he was assuming Command but the Ladder 35 captain did not hear the radio transmission. Battalion 3 and the Ladder 35 captain did not meet face-to-face or discuss the locations of crews working inside the structure or what their assignments were. This resulted in both officers directing fireground operations for a few minutes until Battalion 3 directed the Ladder 35 captain to join up with his company.

Recommendation #12: Fire departments should conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics.

Discussion: National Fire Protection Association (NFPA) 1620 *Standard for Pre-Incident Planning, 2015 Edition, A.4.1.1* states, "a pre-incident plan is one of the most valuable tools available for aiding responding personnel in effectively controlling an emergency." The pre-incident plan is defined as "a document developed by gathering general and detailed data that is used by responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment [NFPA 2015]. A pre-incident plan identifies deviations from normal operations and can be complex and formal, or simply a notation about a particular problem, such as the presence of flammable liquids, explosive hazards, modifications to structural building components, or structural damage from a previous fire [Dunn 2007, NFPA 2015, NIOSH 1999].

In addition, NFPA 1620 outlines the steps involved in developing, maintaining, and using a pre-incident plan by breaking the incident down into pre-, during- and post-incident phases. In the pre-incident phase, for example, it covers factors such as physical elements and site considerations, occupant considerations, protection systems and water supplies, hydrant locations, and special hazard considerations. Building characteristics including type of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics should be recorded, shared with other departments who provide mutual aid, and if possible, entered into the dispatcher's computer so that the information is readily available if an incident is reported at the noted address.

Since many fire departments have tens and hundreds of thousands of structures within their jurisdiction, making it impossible to pre-plan them all, priority should be given to those having elevated or unusual fire hazards and life safety considerations. Additionally, it is important to note that strategies and tactics employed at the emergency incident need to match the structure. The pre-plan information can be used to help ensure that residential fire tactics are not applied at commercial structures.

In this incident, the fire department had a program to conduct pre-incident inspections but had not conducted a formal pre-plan inspection at the structure involved in this incident.

Recommendation #13: Fire departments should ensure that Mayday training programs are developed and implemented so that fire fighters are adequately prepared to call a Mayday.

Discussion: The highest priority in fire fighter safety is avoiding situations that render responders unable to perform their duties effectively. The fire fighter must maintain situational awareness at all times while operating on the fireground. Fire fighters must understand that when they are faced with a life-threatening emergency, there is a very narrow window of survivability, and any delay in egress and/or transmission of a Mayday message reduces the chance for a successful rescue. Knowledge and skill training on how to prevent a Mayday situation and how to call a Mayday should begin and be mastered before a fire fighter engages in fireground activities or other immediately-dangerous-to-life-or-health environments. Mayday training should include utilizing a standard pneumonic that is practiced regularly. One example is **L-U-N-A-R** (**L**ocation, **U**nit, **N**ame, **A**ssignment and Air, **R**esources). Calling a Mayday is not intuitive. Fire fighters must, from a very early point in their basic training, understand the circumstances under which they should call a Mayday. This can and should be accomplished through non-IDLH scenario-based training that mimics circumstances a fire fighter is expected to encounter [Clark 2005, 2008].

Beginner fire fighter training programs should include training on such topics as air management; familiarity with an SCBA, a radio, and personal protective equipment; crew integrity; reading smoke, fire dynamics, and fire behavior; entanglement hazards; building construction; and signs of pending structural collapse. Fire fighters must be able to recognize when they find themselves in a questionable position (whether immediately dangerous or not) and be trained on procedures for when and how a Mayday should be called. A fire fighter's knowledge, skill, and ability to declare a Mayday must be at the mastery level of performance. This performance level should be maintained throughout their career through training offered more frequently than annually [IAFF 2012].

Fire departments must understand that each fire fighter may have a different interpretation of what is life-threatening. The ability of a fire fighter to call a Mayday is a complicated behavior that includes the affective, cognitive, and psychomotor domains of learning and performance [Clark 2005; Grossman and Christensen 2008]. Any delay in calling a Mayday reduces the chance of survival and increases the risk to other fire fighters trying to rescue the downed fire fighter. This incident illustrates the need for fire fighters to be given specific training on determining when a Mayday must be called.

No rules are established for determining when a Mayday must be called, and Mayday training is not included in the job performance requirements in NFPA Fire Fighter I or II standards. It is up to the authority having jurisdiction to train members for emergency operations [NFPA 2013a, b] and to develop rules and performance standards for a fire fighter to call a Mayday. The National Fire Academy (NFA) has an on-line course addressing the fire fighter Mayday doctrine: Q133 Firefighter Safety, Calling the Mayday, a 2-hour program covering the cognitive and affective learning domain of the fire fighter Mayday doctrine [Clark 2005]. The NFA course H0134 Calling the Mayday: Hands-on

Training, an 8-hour course covering the psychomotor learning domain of the fire fighter Mayday doctrine, was handed off to state fire training academies and metro fire departments [Clark 2008]. These courses are based on the military methodology used to develop and teach ejection doctrine to fighter pilots. The NFA Mayday courses present specific Mayday parameters or rules for determining when a fire fighter must call a Mayday. The courses may help fire departments in developing and teaching Mayday procedures for fire fighters. Also, NFPA 1001 *Standard for Fire Fighter Professional Qualifications* includes job performance requirements related to the fire fighter calling for assistance (such as a Mayday situation) [NFPA 2013a].

The International Association of Fire Fighters (IAFF) Fire Ground Survival program is another resource for fire departments and was developed to ensure that training for Mayday prevention and Mayday operations is consistent among all fire fighters, company officers, and chief officers [IAFF 2012].

Any Mayday communication must contain the location of the fire fighter in as much detail as possible and, at a minimum, should include the division (floor) and quadrant. It is imperative that fire fighters always know their location when in IDLH environments to effectively be able to give their location in the event of a Mayday. Once in distress, fire fighters must immediately declare a Mayday. The following example uses LUNAR (Location, Unit, Name, Assignment/Air, Resources needed) as a prompt: "Mayday, Mayday, Mayday, Division 1 Quadrant C, Engine 71, Smith, search/out of air/vomited, can't find exit." When in trouble, a fire fighter's first action must be to declare the Mayday as accurately as possible. Once the incident commander and rapid intervention team (RIT) know the fire fighter's location, the fire fighter can then try to fix the problem, such as clearing the nose cup, while the RIT is en route for rescue [USFA 2006].

A fire fighter who is breathing carbon monoxide (CO) quickly loses cognitive ability to communicate correctly and can unknowingly move away from an exit, other fire fighters, or safety before becoming unconscious. Without the accurate location of a downed fire fighter, the speed at which the RIT can find them is diminished, and the window of survivability closes quickly because of lack of oxygen and high CO concentrations in an IDLH environment [Clark 2005, 2008; USFA 2006].

In this incident, the Ladder 35 fire fighter 2 radioed Mayday but did not state his name, company or location. The Ladder 35 fire fighter 1 had a radio but radio transcripts do not show any indication that he attempted to use his radio. During the RIT operations, the fire fighter from Aerial Platform 11 became disoriented and was separated from his crew. He ultimately had to be rescued but never radioed for assistance.

Recommendation #14: Fire departments should provide all fire fighters with radios and train them on their proper use.

Discussion: In September 2003, NIOSH released the document, *Current Status, Knowledge Gaps, and Research Needs Pertaining to Firefighter Radio Communication Systems* [TriData 2003]. Page 13 states: “It is critical for firefighters to communicate with one another within a structure and with units

operating outside the structure, regardless of the building construction." The best way this can be done when crews are separated or in trouble is through the use of a personal portable radio.

National Fire Protection Association (NFPA) 1561, *Standard on Emergency Services Incident Management System and Command Safety*, Section 6.3 Emergency Traffic, states in section 6.3.1: "To enable responders to be notified of an emergency condition or situation when they are assigned to an area designated as immediately dangerous to life or health (IDLH), at least one responder on each crew or company shall be equipped with a portable radio and each responder on the crew or company shall be equipped with either a portable radio or another means of electronic communication" [NFPA 2014]. The joint U.S. Fire administration (USFA) and International Association of Fire Fighters (IAFF) report, *Voice Radio Communications Guide for the Fire Service* [USFA/IAFF 2008, 2016], provides an overview of radio communication issues involving the fire service. Effective fireground radio communication is an important tool to ensure fireground command and control as well as helping to enhance fire fighter safety and health. Every fire fighter on the fireground should be provided with their own radio in case they become lost or separated from their crew. It is every fire fighter's and company officer's responsibility to ensure radios are properly used. Ensuring appropriate radio use involves both taking personal responsibility (to have your radio, having it on, and on the correct channel) and a crew-based responsibility to ensure that the other members of your crew are doing so as well. Radios should be designed and positioned to allow the fire fighter to monitor and transmit a clear message. These radios should be well maintained and inspected by qualified personnel on a regular basis.

The fire department involved in this incident issues a radio to every fire fighter and has a policy requiring weekly radio function checks. In this incident, the Ladder 35 Fire Fighter 1 had a working radio but there was no evidence that the radio was used. The Aerial Platform 11 Fire Fighter 1 who was injured also had a working radio but never used it when he became separated from the rest of the RIT while searching inside the structure. The only Mayday transmissions were made by Ladder 35 Fire Fighter 2.

Both the International Association of Fire Chiefs (IAFC) [IAFC 2009] and the International Association of Fire Fighters (IAFF) [USFA/IAFF 2008] recommend that all fire fighters be assigned a radio. In 1999, the U.S. Fire Administration technical report *Improving Firefighter Communications* identified a number of radio communication issues, including the need for all fire fighters to have portable radios. The report stated "Ideally, every firefighter working in a hostile environment should have a portable radio with emergency distress feature [USFA 1999]." The IAFF Fireground Survival Program contains training on radio communication procedures in emergency operations including how to call a Mayday [IAFF 2012].

Issuing a radio to every fire fighter is not enough. **Training must accompany any effort to improve fireground communication.** First and foremost, the fireground radio frequency can become congested, especially during the early stages when the incident is not yet under control. As such, radio discipline is important and messages should be limited to those of an important tactical nature (Conditions-Actions-Needs or CAN report), accountability (PAR) report, and fireground emergencies (Mayday). Second, training must also encompass circumstances when an incident commander opts to

change radio frequencies. This is a potentially dangerous action and should only be undertaken in the most extreme circumstances given the possibility of "losing" personnel in the movement from one channel to another. After switching frequencies, command should conduct a PAR to confirm that the appropriate units are operating on the correct channel. Often times, fire fighters who encounter hazardous situations do not radio for assistance. In this incident, the fire department later analyzed dispatch radio logs and confirmed that the radios carried by the victim and injured fire fighters had pinged nearby radio towers, indicating the radios were working properly at the time of dispatch.

Recommendation # 15: Fire departments should ensure that fire fighters are trained to understand the influence of building design and construction on fire behavior and growth and the needed tactics for safe firefighting operations.

Discussion: It is important that fire officers and fire fighters understand risk management and apply that knowledge to modern fire conditions, especially in commercial structures.

Chief Christopher Naum, (Command Institute) notes:

> "Firefighting in commercial buildings and occupancies demands alternate tactical engagement and management that differentiate from residential deployment and operations. Building features and systems and complexities create very distinct and defined incident action parameters that required commanders, officers and firefighters to implement discrete strategies, tactics and awareness that are commonly resource driven, complex, concurrent and high risk.
>
> Commercial building fires and incidents require specific training, skill sets, and experience and risk management protocols. Today's fireground demands, challenges and risks are less forgiving than in the past, leave little to no margin for error and when those errors and omissions manifest themselves-may be very unforgiving in their resulting severity and magnitude. This then requires significant adaptability in the identification, selection of strategic, tactical and task level actions that demand critical thinking skills, based on fluid incident and building assessment and evaluation for conditions.
>
> The importance of implementing Tactical Discipline, Tactical Patience and Adaptive Fireground Management [Clark 2008] is formative on today's fireground and built upon an established platform of building knowledge, an understanding of the predictability of the building's performance under fire conditions and the integration of critical thinking skills that aligns with the unique given conditions of an incident scene and structural fire in a building.
>
> Firefighting continues to be driven by long established practices and protocols that have a basis on expected building or fire performance and behaviors. These long held beliefs and methodologies have had new perspectives applied based on on-going research, development and emerging practices that suggest adaptive and alternatives methods, practices and protocols that are changing the rules of engagement [NIOSH 2016, Naum 2013]"

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The risk assessment of a building during fire-fighting operations should be continuous with building intelligence and reconnaissance communicated on degrading conditions, fire extension and compromise, building integrity considerations, the effects of fire spread and suppression on the interior compartment(s), and the structural system and building envelope. The "Fire Risk Matrix" listed below can be used to conduct the continuous risk assessment during fire-fighting operations in which the potential for structural collapse exists (see Figure 2).

The inherent building materials in the form of the light-frame structural steel system, the presence of a contiguous metal gage roof diaphragm, unrestrained steel beams and a moderate to high interior fuel load package (common to retail shopping occupancies) that would contribute toward fire growth in both intensity and magnitude support the premise of a higher probability of expected fire development in a compartment, rapid fire extension in the event of a fire incident and building component and assembly compromise, deterioration, failure, and collapse.

If we use the buildings-on-fire-risk-assessment-matrix below we can see that the identified severity of risk level would be considered marginal-critical. The occupancy's severity of risk would be considered marginal-critical with the operational probability of an adverse event to be High (H) to Extreme (E), resulting in a likely event to occur during operational times. The large open span floor area, concealed plenum, and structural support system increase that occupancy risk [NIOSH 2016, Naum 2013].

In this incident applying the identified Severity of Risk Level from Figure 2 for the predictable incident conditions in the tenant spaces involved (fitness center, computer store, thrift store storage area, etc.) and the overall shopping complex suggests a defined level of:

> **Critical;** May cause severe personnel injury, possible death; major property loss or significant degraded conditions.

This is based on two primary factors; the lack of a commercial sprinkler system, and construction features such as the presence of the unprotected steel truss assembly and roof system and a large open span compartment in the gym occupancy and the unprotected tenant spaces and associated fire load packages (assumed) present in the thrift store storage area (Side Bravo exposure) and the computer store (Side Delta exposure).

The probability for an escalating multiple alarm fire occurring in this strip mall shopping center complex creating limiting conditions of operations, high resource demands, operational severity, urgency and escalating incident growth issues were highly probable and could be expected based on fire location, the occupancy use of that tenant space, the time of day of the incident, and the operational readiness and availability of the fire department to respond, deploy, and intervene [NIOSH 2016, Naum 2013]

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 consistent 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 2. Buildings on Fire Risk Assessment Matrix.
(Courtesy of Buildingsonfire.com and the Command Institute, additional information can be accessed at the Buildingsonfire.com website.)

Recommendation #16: Fire departments should ensure that fire fighters are trained and proficient on following hose lines outside as a means for egress and self-rescue.

Discussion: Fire fighters should always work and remain in teams whenever they are operating in a hazardous environment. Team integrity depends on team members knowing who is on their team and who is the team leader; staying within visual contact at all times (if visibility is low, teams must stay within touch or voice distance of each other); communicating needs and observations to the team leader; and rotating together for team rehab, team staging, and watching out for each other (e.g., practicing a strong buddy system). Following these basic rules helps prevent serious injury or even death by providing personnel with the added safety net of fellow team members. Teams that enter a hazardous environment together should leave together to ensure that team continuity is maintained.

Hose lines can be the last line of defense and the last chance for a lost fire fighter to find egress from a burning building. According to the USFA Special Report, *Rapid Intervention Teams and How to Avoid Needing Them*, the basic techniques taught during entry-level fire-fighting programs describe how to escape a zero-visibility environment using only a hose line [USFA 2003]. However, as years elapse

from the time of basic training, fire fighters may overlook this technique. Exiting a structure in zero visibility should be simple, fast, and easy for a fire fighter with a hose line based on training and experience to build muscle-memory. A fire fighter operating on a hose line should search along the hose until a coupling is found. Once found, the fire fighter can "read" the coupling and determine the male and female ends. The IFSTA manual *Essentials of Fire Fighting* teaches that the female coupling is on the nozzle side of the set and the male is on the water side of the set. In most cases, the male coupling has lugs on its shank while the female does not. Once oriented on the hose, fire fighters can follow the hose line in the direction away from the male coupling (away from the nozzle and toward the exit) which will take them toward the exit (see Figure 3)[IFSTA 1998, NIOSH 2009]. A fire hose can also be marked in a number of ways that will indicate the direction to the exit, including the use of raised arrows and chevrons that provide both visual and tactile indicators. Fire departments may use a variety of techniques to train fire fighters on how to identify hose line couplings and the direction to the exit, based on the model of the hose used by the department. The key point is that this training needs to be conducted and repeated often so that fire fighters are proficient in identifying the direction to the exit in zero-visibility conditions while wearing gloves, when the hose is entangled, and with various obstructions present. This procedure should be incorporated into standard operating procedures, trained upon, and enforced on the fireground.

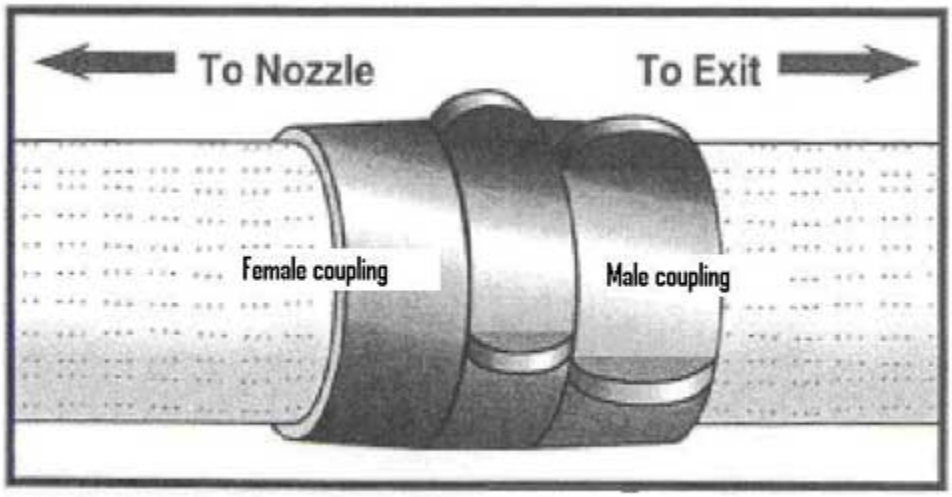

Figure 3. Hose couplings will indicate the direction toward the exit.
(Adapted from IFSTA Essentials of Fire Fighting, 4th Edition.)

In this incident, the Ladder 35 fire fighters advanced beyond the protection of the Engine 35 hose line. They also did not deploy a search rope. Once the fire conditions inside the fitness center rapidly deteriorated, they were unable to find their way outside. A hose line or a deployed search rope could have aided the fire fighters in finding their way to the front entrance.

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Recommendation # 17: Fire departments should ensure that fire fighters are trained to report search findings as soon as the search is completed, and if the search team does not have the protection of a hose line, immediately exit to a safe area.

Discussion: While searching for victims in a fire, rescuers must always consider their own safety. Incident commanders must also consider the hazards to which fire fighters may be exposed while conducting search and rescue operations [IFSTA 2008]. The same applies to the initial arriving crews searching for the seat of a fire. Some of the key search safety guidelines recommended by the International Fire Service Training Association (IFSTA) include:

- Do not enter a building in which the fire has progressed to the point where viable victims are not likely to be found. Report to your supervisor any conditions that would appear to preclude viable victims.
- Work according to the Incident Action Plan (IAP). Do not freelance.
- Maintain radio contact with your supervisor (Command, Division, or Group Supervisor, etc.) and monitor radio traffic for important information.
- Continuously monitor fire conditions that might affect the safety of your search team and other fire fighters.
- Work in teams of two or more and stay in constant contact with each other. Rescuers are responsible for themselves and each other.
- Search systematically to increase efficiency and to reduce the possibility of becoming disoriented.
- Stay alert. Maintain situational awareness.
- Continuously monitor the structure's integrity and communicate any significant change.
- Maintain contact with a wall, a hose line, or tagline when visibility is obscured. Working together, search team members can extend their reach by using ropes or straps.
- Have a charged hose line at hand whenever possible when working on the fire floor (or the floor immediately above or below the fire) because it may be used as a guide for egress as well as for firefighting.
- Report promptly to the supervisor once the search is complete. Besides giving an "all clear" (primary or secondary search complete also report the progress of the fire and the condition of the building [IFSTA 2008].

In this incident the fire department had a written guideline: "***SEARCH AND RESCUE STANDARD OPERATING GUIDELINE"*** dated 06/1/10 and reviewed 9/18/14. Page two of this guideline stated "All initial attack efforts must be directed toward supporting rescue efforts and hose lines must be placed in a manner to control interior access, confine the fire, and protect avenues of escape."

During this incident the initial Incident Commander (Ladder 35 captain) directed the Engine 35 lieutenant to take their charged 150 foot preconnected 1 ¾" hose line inside and directed the two Ladder 35 fire fighters to conduct a quick and shallow search for possible victims. The Ladder 35 captain instructed the Engine 35 hose line crew and the Ladder 35 search crew to perform a quick and shallow search into the fitness center. Due to the limited visibility and exercise equipment and furnishing inside the structure, the Engine 35 crew was only able to advance the hose line a short

distance inside the structure and an effective interior hose stream could not be adequately applied. When fire fighters began pulling ceiling tiles at the rear of the fitness center, the interior conditions rapidly deteriorated, and the Ladder 35 fire fighters were not able to exit the structure.

Recommendation #18: Fire departments should train and empower all fire fighters to report unsafe conditions to Incident Command.

Discussion: *Although there is no evidence that the following recommendation would have prevented this fatality, it is being provided as a reminder of good safety practice*. The International Association of Fire Chiefs (IAFC), Safety, Health and Survival section developed the *Rules of Engagement for Structural Fire Fighting*. The rules of engagement have been developed to assist both the fire fighter and the incident commander (as well as command team officers) in risk assessment and "Go or No-Go" decisions. The fireground creates a significant risk to fire fighters, and it is the responsibility of the incident commander and command organization officers to minimize fire fighter exposure to unsafe conditions and stop unsafe practices [IAFC 2012].

The IAFC Rules of Engagement can assist the incident commander, company officers, and fire fighters (who are at the highest level of risk) in assessing their situational awareness. One principle applied in the rules of engagement is that 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 makers 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.

One of the IAFC Rules of Engagement for Firefighter Survival states: "**You Are Required to Report Unsafe Practices or Conditions That Can Harm You. Stop, Evaluate, and Decide."** This Rule applies the principles of crew resource management by encouraging all fire fighters to apply situational awareness and be responsible for their own safety and that of other fire fighters. In a sense, all fire fighters become the additional eyes and ears of the incident commander and should alert him (or the immediate supervisor) to unacceptable situations. No fire attack or building is worth the life of a fire fighter or a preventable (sometimes career-ending) injury. The intent of this Rule is to allow any member to report a safety concern through a structured process without fear of penalty.

One of the key tenants of the National Fallen Firefighter Foundation is their 16 Life Safety Initiatives. The 16 Firefighter Life Safety Initiatives (FLSI) were jointly developed by representatives of the major fire service constituencies in 2004 at a Firefighter Safety Summit in Tampa, Florida. At that time, the National Fallen Firefighters Foundation was tasked with promulgating the Initiatives throughout the fire service and developing material to support their implementation [NFFF 2004a].

Life Safety Initiative number 4 is "Empowerment: All fire fighters must be empowered to stop unsafe practices." While this may appear to be a challenging or even controversial statement, it simply means that every organization should provide an environment that allows its members to speak up regarding personal and organizational safety, without negative consequences for doing so (within a prescribed

context) and without decentralizing the authority of the formal leader. The goal is to have every member fully engaged during an emergency incident with a focus on doing the work in a proficient manner and looking out for one another to avoid injuries and potential line-of-duty death [NFFF 2004b].

Every fire fighter is responsible for their individual safety and the safety of other fire fighters. Each fire fighter is responsible for identifying risks and hazards and reporting them. Supervisors are responsible for accepting reports regarding safety concerns without penalizing the fire fighter and properly acting on the report to ensure the safety of fire fighters.

In this incident, the Engine 35 lieutenant observed that the fire was burning in the void space above the drop ceiling and was in contact with the lightweight metal bar joists supporting the roof. He radioed this observation to Command. It is not clear whether the Ladder 35 fire fighters heard this transmission.

Recommendation #19: Fire departments should consider using search lines when conducting primary and secondary searches in large or smoke-filled areas.

Discussion: *Although there is no evidence that following this recommendation would have prevented this fatality, it is being provided as a reminder of a good safety practice*. Regardless of how large or small a building may be, fire fighters almost always search the building if it is safe and reasonable to do so. Search teams should carry a radio, thermal imager, flashlights, and forcible entry tools whenever they enter a burning building and throughout the search. Some departments also require search teams to take a search rope with them when they enter the hazard zone [IFSTA 2008].

There are many types and variations of search lines and many different variations on procedures to using the search line in large or smoke-filled areas. The search line is anchored to a fixed object about 10 feet outside the entry point. A company identifier, such as a flag, metal tag, or other identifier, should also be attached to the end of the search line. An example of a search line is one consisting of 200 feet of 3/8-inch rope with abrasion and heat resistant sheathing to protect the rope. A series of knots and rings are placed at equal intervals along the length of the search line, usually about every 20 feet. A 2-inch steel ring is attached into the rope 20 feet from the end in a manner so that the ring will not slip or come loose from the rope. Immediately after the ring, one or more knots are tied in the rope to indicate the distance from the beginning point. The knots are placed after the ring to indicate direction. In this example, the knots indicate direction to the fire and the rings indicate direction to the exit. The rings are used as anchor points for lateral tether lines that allow fire fighters to search away from the main search line while having the tether as an aid in returning to the main search line [IFSTA 2008]. Using this example, a team of two or three fire fighters can quickly search a large area while maintaining some level of safety in being able to locate the location where they entered.

The Ladder 35 fire fighters did not deploy a search line during this incident. The use of a search line can be especially critical in structures where obstructed floorspaces and limited visibility make ingress and egress difficult.

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Investigator Information

This incident was investigated by Timothy R. Merinar, Safety Engineer, Matt E. Bowyer, General Engineer, Karis Kline, Occupational Health and Safety Specialist, and Steve Miles, Occupational Health and Safety Specialist with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research (DSR), NIOSH, located in Morgantown West Virginia. An expert technical review was provided by Dan Madrzykowski, Underwriters Laboratories (U.L.), UL Firefighter Safety Research Institute and formerly with the National Institute of Standards and Technology (NIST). A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Information

Texas State Fire Marshal's Office / Texas Department of Insurance
The Texas State Fire Marshal's Office conducted a separate investigation of this incident. The Texas State FMO investigation report is available at the Texas State Fire Marshal Office website.

Additional investigation reports conducted by the Texas State FMO involving recent fire fighter line-of-duty deaths can also be found at the Texas State Fire Marshal Office website.

Modern Fire Behavior
This website is meant to serve as a clearinghouse of news and training information related to Modern Fire Behavior and Modern Building Construction Research, Tactics, and Practices, along with actual street experiences. **ModernFireBehavior.com** is a joint effort between FirefighterCloseCalls.com (home of the Secrets List) and the Underwriters Laboratories Fire Safety Research Institute.

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

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

National Institute for Standards and Technology (NIST)—Fire on the Web
Fire on the Web is a collection of resources from the Building and Fire Research Laboratory's Fire Research Division at NIST. These webpages provide links to fire-related software, experimental fire data, and mpeg/quick time movies of fire tests, which can be downloaded and/or viewed with a Web browser.

Underwriters Laboratories (UL) Firefighter Safety Research Institute
Information on completed studies and free on-line fire fighter training programs involving ventilation, suppression, structural collapse and below-grade fires intended to advance fire fighter safety and health

can be found at the UL Firefighter Safety and Research Institute website.

One example of an online course offered by the **UL Firefighter Safety Research Institute (FSRI)** highlights the tactical application of nearly two decades of research at the National Institute of Standards and Technology (NIST) and UL on how best to fight modern fires. In 2012, The New York City Fire Department (FDNY), NIST, and UL FSRI set fire to abandoned townhouses on Governors Island, New York, in a series of experiments to examine tactics for controlling fires and rescuing occupants inside burning homes.

Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date.

Career Fire Fighter Dies and Another is Seriously Burned Fighting an Arson Fire at a Commercial Strip Mall — Texas

Appendix One
Timeline of Events

The following timeline of events is a summary of events that occurred during this incident in which a 31-year-old male career fire fighter died after fire conditions rapidly deteriorated in a commercial strip mall fire. Not all incident events are included in this timeline. The times are approximate and were obtained by studying the dispatch records, audio recordings, witness statements, and information provided courtesy of the local fire and police departments and other available information. This timeline also lists the changing fire behavior indicators and conditions reported, as well as fire department response and fireground operations at key points in time. **All times are approximate and in some cases rounded to the closest minute**.

Dispatch Communications & Fire Department Response. ***Fireground conditions.***	TIME	**Fireground Communications & Fireground Operations**
Initial Call to 911 reporting fire.	2110:10	
Dispatch assigns first alarm.	2112:01	First alarm assignment for Engine 35, Engine 26, Engine 27, Engine 44, Ladder 35, Aerial Platform 32, Medic 27 and Battalion Chief 3 assigned on the Alert Channel.
Ladder 35 arrives first on scene. Smoke showing from roof.	2117:20	Captain reports smoke showing from a large strip mall roof. Reports offensive mode to investigate.
Engine 26 arrives on scene.	2118:22	Engine 26 officer requests assignment.
	2119:32	Ladder 35 captain assumes Incident Command and requests second alarm.

Dispatch assigns second alarm.	2119:44	Second alarm assignment for Engine 45, Engine 15, Engine 49, Engine 33, Aerial Platform 51, Ladder 41, Battalion Chief 8, Battalion Chief 4, Medic 35, Medic Officer 2, Engine 11, Heavy Rescue 11, Aerial Platform 11, Rehab 1, and FSC and AC41.
	2120:08	Command (Ladder 35 captain) requests company to go to Side C and check for access. Engine 44 officer acknowledges and states Engine 44 is going to the rear from the east.
Battalion Chief 3 arrives on scene.	2120:35	Battalion Chief 3 advises Command that he is going to do a full 360 degree size-up and will assume command when he is done. Command (Ladder 35 captain) acknowledges.
	2121:18	Engine 35 officer radios command that there is zero visibility with heavy smoke coming from front door. Requests ventilation be set up.
	2121:28	Command (Ladder 35 captain) advises Dispatch that Engine 26 is searching computer store on Side Delta exposure.
Dispatch advises Command – 10 minutes into event.	2121:59	
Dispatch relays from Command – "Working fire, heavy smoke, one crew on attack, one crew on search, checking for extension on Side Delta exposure. Engine 44 at Side Charlie."	2122:34	

	2122:47	Battalion Chief 3 assumes Command, reports heavy smoke at back of building, advises Engine 44 to stay where they are at Side Charlie.
	2123:08	Ladder 35 captain radios engine company coming in from east (Engine 27) to catch hydrant by restaurant.
Engine 27 dropped 5-inch supply line at hydrant east of strip mall near restaurant and supplied Engine 35.	2123:10	Engine 27 acknowledges and asks who to supply. Ladder 35 captain advises Engine 27 to supply Engine 35 and then protect Side Bravo exposure. (*NOTE: At this time, the Ladder 35 captain was not aware that Battalion Chief 3 had assumed Command*)
Dispatch advises that Battalion Chief 3 has assumed Command. Aerial Platform 32 radios to Command they are on scene.	2123:48	
	2123:49	Ladder 35 captain (as Command) tells Aerial Platform 32 to come in behind Engine 26 and set up aerial platform.
	2124:06	Engine 26 radios for Command. Engine 35 radios for Command to repeat orders. Ladder 35 captain repeats that Aerial Platform 32 is to set up behind Engine 26.

	2124:32	Ladder 35 Fire Fighter 2 (injured FF) radioed Command "**We have found the fire, the fire is in the attic, have the motor crew do a right hand search and bring the nozzle back here to us**." Ladder 35 captain acknowledges.
	2125:13	Battalion Chief 3 advises Ladder 35 captain that he has Command now and the captain can go meet up with his crew. Battalion Chief 3 advises Aerial Platform 32 to set up behind Engine 26.
Fire through roof at rear of structure.	2125:37	Engine 44 radios Command – "We're back here behind the building with fire through the roof. We can open a door and put a line on it." Command advises Engine 44 to open the door but don't put any water on fire because he doesn't want to push the fire back onto the crews inside.
Heavy smoke, zero visibility, high heat.	2126:13	Engine 35 Lieutenant advises Command that there are lightweight trusses in the roof, there is zero visibility inside, zero ventilation going on and lots of heat inside.
	2126:26	Engine 27 officer requests water, asks for the hydrant to be turned on and to flow water.
Pump pressure at 200 psi.	2126:31	Engine 27 engineer replies "water on the way."

Fire burning in concealed cockloft exposing roof support system.	2127:14	Engine 35 officer advises Command that there is zero visibility inside and the fire is in the roof where the trusses are.
	2127:27	Command radios Engine 35, Engine 26, Engine 27 and Ladder 35 and says – "If you are inside I want you to come out till they get ventilation started. Command radios Engine 44 to open up the back so they can see what they have.
	2128:16	Ladder 35 Fire Fighter 2 (injured FF) – "MAYDAY, MAYDAY."
	2128:21	Command asks "Who is calling a Mayday?" - No response.
	2128:29	Command orders all companies on the interior to get out now and give a PAR.
	2128:35	Ladder 35 Fire Fighter 2 (injured FF) keys up mic in severe distress.
	2128:35 – 2128:51	Ladder 35 Fire Fighter 2 (injured FF) keys up mic several times.
Dispatch sounds Evacuation Tone	2129:08	Crews begin to exit building.
	2129:29 – 2132:48	Ladder 35 Fire Fighter 2 (injured FF) keys up mic several times. Command asks several times where the missing fire fighter is located at. Command requests PAR. Companies begin giving PAR reports.

	2129:40	Ladder 35 Fire Fighter 2 (injured FF) radios "MAYDAY… somebody break windows. I can't get out of here."
	2130:38	Command asks Engine 27 if they can go inside for RIT.
	2130:49	Engine 27 officer radios they are RIT looking for missing Ladder 35 fire fighter.
Door at rear (Side Charlie) of fire building open, heavy smoke inside, zero visibility inside. Line is in place but not in operation.	2132:51	Engine 44 advises Command that they have opened door at Side Charlie, have heavy smoke and zero visibility inside, and have a line down and are waiting for orders.
	2133:03	Ladder 35 Fire Fighter 2 (injured FF) keys up mic on TAC 3 for 3.8 seconds (he has switched from TAC 2 to TAC 3). He later keys up mic at least two more times.
	2133:04	Command orders Engine 44 to open up every door on Side Charlie that they can. Engine 44 acknowledges.
	2134:14	Command radios Engine 26 and advises them he is sending in the 11's crew to assist with RIT.
	2135:10	Engine 26 officer radios Command that they are coming outside to change air cylinders. Command acknowledges.

	2135:20	Battalion Chief 8 radios Command that he is taking over RIT Division and he has the Engine 35 officer and Engine 27 officer and asks for another company to back them up.
	2135:33	Command advises Battalion Chief 8 that Aerial Platform 11 is coming to help with RIT.
	2135:38	Battalion Chief 8 advises Command that two fire fighters from Ladder 35 are trapped inside, location unknown, and it is getting very hot inside.
	2136:02	Battalion Chief 8 advises Command that the Ladder 35 captain is with the Engine 27 crew going inside for RIT. He is also working with the 11's crew who are preparing to go inside.
	2136:41	Engine 27 officer radios "EMERGENCY TRAFFIC, EMERGENCY TRAFFIC, get an ambulance to the front, we've got one man down, we need an ambulance out to the front."
	2137:06	Battalion Chief 8 radios Command that one fire fighter has been pulled out and has been exposed to a lot of heat (Ladder 35 Fire Fighter 2 - injured FF).
	2137:52	Battalion Chief 8 radios Command that one fire fighter is out and the 11's crew is going inside to get the other.

Heavy smoke at Side Charlie with doors open	2138:32	Engine 44 radios that they have 4 doors open at Side Charlie and smoke is getting heavier.
Flames self-vent through roof at front of building.	2138:41	Aerial Platform 32 radios that they have flames through the roof at this time.
	2138:52	Battalion Chief 8 radios that the Engine 26 crew is with him and the 11's crew is inside with a team of 4.
	2139:02	Command radios "Do not let anybody else inside the building until we get everybody else out." Command directs Aerial Platform 32 and Ladder 35 to put aerial master streams in operation on the fire. Command states "Don't give me a heavy stream."
Flames through roof at front	2139:27 to 2140:11	Battalion Chief 8 and Command discuss fire conditions. Battalion Chief 8 asks to hold off on the master stream water due to RIT crews inside. Command orders Aerial Platform 32 and Ladder 35 to hold off on water. Both crews acknowledge.
	2140:32	Command orders Aerial Platform 32 and Ladder 35 to put fans in doors (at front) and push smoke out the back.
Dispatch advises Command – 30 minutes into event.	2142:27	Command radios "30 minutes in, one fire fighter has been removed, We've got accountability on everybody except for one."

	2144:13	Aerial Platform 11 officer radios Command and asks about breaking out glass windows at Side Alpha to ventilate smoke inside fire structure.
	2144:26	Command acknowledges and states he will send a crew to front to open windows.
	2144:39	Engine 44 radios Command that he needs a saw and assistance to open the rest of the doors at Side Charlie.
	2145:11	Command assigns Battalion Chief 4 to Charlie Division and assigns Ladder 41 to assist Engine 44 in opening doors at Side Charlie.
	2145:42	RIT (Aerial Platform 11 captain) radios that they have advanced about 60 feet inside structure and are doing a right hand search. He reports lots of smoke, not much fire, with all the heat concentrated near Side Alpha opening.
	2146:51	Battalion Chief 8 radios Command to report that Aerial Platform 11, Engine 11 and Heavy Rescue 11 are inside doing search with additional resources staged outside.
	2149:18	Injured Ladder 35 Fire Fighter 2 transported to hospital by Medic 27.

	2153:01	Battalion Chief 8 (RIT Command) radios Command and discusses 11's crew is inside doing right hand search. He wants to send another crew (Engine 32) inside to do left hand search with Engine 27 staged outside for backup RIT. Command gives ok to proceed.
Heavy smoke coming out door openings at Side Charlie. Some fire visible through roof.	2153:32	Battalion Chief 4 (Charlie Division) reports all doors at Side Charlie are open and lots of smoke is coming out. Also some fire visible thru roof and heavy equipment on the roof.
	2154:43	Battalion Chief 8 (RIT Division) reports Engine 11 has exited building after right hand search and finding heavy fire at rear of building. They need another hose line to reach the fire. Engine 32 is taking hose line inside now. Engine 27 will do a left hand search. Requests another company for RIT assignment. Command acknowledges.
	2156:10	Battalion Chief 8 advises Command that Aerial Platform 11 and Engine 11 have exited building and is checking for PAR.
	2158:52	Engine 32 radios Command that they have found the downed fire fighter. *NOTE: This was the missing Aerial Platform 11 Fire Fighter 1 who did not exit with his crew and not the missing Ladder 35 Fire Fighter 1.*

	2159 - 2204	Crews work to evacuate downed Aerial Platform 11 Fire Fighter 1. Command requests PAR on all crews. Battalion Chief 8 radios Command and requests to cease operations at Side Alpha as soon as the fire fighter is brought outside due to the fire and heavy smoke at the front of the structure. He advises attacking fire from Sides Bravo and Charlie and get aerial master streams in operation. Command acknowledged that as soon as everyone was outside they would open the aerial streams.
	2204:26	Safety radios Command and reports the missing fire fighter is outside. Safety requests an Evacuation Tone to make sure everybody is out. Safety reports rapid fire progression at front of fire building.
Dispatch sounds Evacuation Tone	2204:51	
	2205:00 to 2206:41	Command directs Aerial Platform 32 and Ladder 35 to open master streams. PARs requested.

	2207:57	Battalion Chief 8 (RIT Division) radios Command and advises that the second fire fighter brought out was from Aerial Platform 11 and not the missing Ladder 35 Fire Fighter 1. He reports a fire fighter is still missing inside. He also advises Command that conditions inside are not viable and some fire apparatus are in danger from the fire rolling out the front of the building.
Defensive operations with elevated master streams. Dispatch sounds Evacuation Tone.	2208:22	Command and Battalion Chief 8 discuss defensive operations. Command states he does not want to give up on the missing fire fighter. Command requests another evacuation tone from Dispatch.
Roof collapse in fire building.	2211:58	Aerial Platform 32 Fire Fighter 1 radios that the roof has collapsed near the Alpha-Bravo corner.
	2213:47	Injured Aerial Platform 11 Fire Fighter 1 transported to a different hospital
	2218:04	Interior operations initiated thru double doors between the thrift store and the Side Bravo exposure to hold the fire to the fire building. Engine 10, Engine 41, Engine 15 and Ladder 41 crews and Battalion Chief 1 deployed.
	2227:30	Battalion Chief 1 radios that crews have stopped the spread of the fire into the thrift store.

	2227:30 – 2311:45	Continue defensive operations with crews deployed on all 4 sides of fire building.
Companies begin shutting down operations for silence on fireground.	2311:45	Command to all companies on fireground. – "We're going to shut down all apparatus, all water, all fans…. To see if we can hear the PASS device."
Resume defensive operations	2315:25	Command informs all companies to resume defensive operations where they shut down.
	2333:54	Missing Ladder 35 Fire Fighter 1 is located. *NOTE: Observers at front see reflective trim on turnout gear near Side Bravo*
	0030:25	Ladder 35 Fire Fighter 1 is transported with escort to medical examiner's office.

Appendix Two
Self-Contained Breathing Apparatus Evaluation Report

Evaluation of Three Self-Contained Breathing Apparatuses for Potential Contribution to a Fatal Event in the Fire Service.

Career Fire Fighter Dies and Another is Seriously Burned Fighting an Arson Fire at a Commercial Strip Mall — Texas

As part of the **National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program (FFFIPP), investigation F2017-14 TX**, the National Personal Protective Technology Laboratory (NPPTL) agreed to examine and evaluate three SCBA units identified as Scott® Safety Air-Pak® model AP50 4.5, 4500 psi, 45 minute, self-contained breathing apparatus (SCBAs) under NIOSH Task Number 21618.

The SCBA units were delivered via FedEx to the NIOSH facility in Morgantown, West Virginia on June 8, 2017. The units were taken to the lower floor of the lab, room 1513, for secured storage. The SCBA units were then removed from storage for inspection on June 13, 2017 and placed back into secured storage until the testing on June 19, 2017.

The purpose of Respirator Status Investigations is to determine the conformance of each respirator to the NIOSH approval requirements found in Title 42, Code of Federal Regulations, Part 84. A number of performance tests are selected from the complete list of Part 84 requirements and each respirator is tested in its "**as received**" condition to determine its conformance to those performance requirements. Each respirator is also inspected to determine its conformance to the quality assurance documentation on file at NIOSH.

Summary:
Three Scott® Safety Air-Pak® model AP50 4.5, 4500 psi, 45 minute, self-contained breathing apparatus were submitted to NIOSH NPPTL by the San Antonio Fire Department for inspection and evaluation.

The SCBA units were delivered via FedEx in cardboard boxes to Lab H1513 at the NIOSH facility in Morgantown, West Virginia on June 8, 2017. The units were identified as having NIOSH Approval Number TC-13F-0715CBRN.
An extensive visual inspection of the units was conducted on June 13, 2017 and it was determined that two of the units were in good condition while one had extensive heat damage and could not be tested.

A corresponding facepiece was provided for each unit. Unit #1 had excessive heat damage, and could not be inspected or tested. The cylinders in Units #2 and #3 were delivered empty and closed. The mask mounted regulator (MMR) on Unit #2 was loose while the MMR on Unit #3 was attached to the waist belt. Overall, units #2 and #3 were in good condition. The NFPA approval labels were present and readable. The Personal Alert Safety System (PASS), Heads-up Display HUD, and alarm systems functioned on both unit #2 and #3.

SCBA units #2 and #3 met the requirements of the NIOSH Positive Pressure Test, since they maintained a positive pressure for the 45 minute minimum duration of the test. These units passed all of the other NIOSH tests. The complete evaluation report can be found on the NPPTL PPE website.

In light of the information obtained during this investigation, NIOSH NPPTL has proposed no further action on its part at this time.

Career Fire Fighter Dies and Another is Seriously Burned Fighting an Arson Fire at a Commercial Strip Mall — Texas

The following photograph is provided as a teaching-aid to highlight the fact that NIOSH and National Fire Protection Association (NFPA) certified self-contained breathing apparatus and personal protective equipment can only protect fire fighters for a limited amount of time. Extreme fire events often result in thermal conditions that will compromise a fire fighter's protective clothing and gear which can lead to injury and death (see Photo 5).

Photo 5. Photo shows thermal damage to the facepiece, helmet and hood worn by the injured Ladder 35 fire fighter. Similar damage has been observed on numerous NIOSH investigations. *(NIOSH Photo.)*