



Career Lieutenant and Fire Fighter Die in a Flashover During a Live-Fire Training Evolution - Florida

SUMMARY

On July 30, 2002, a 32-year-old male career Lieutenant (Victim #1) and a 20-year-old male career fire fighter (Victim #2) died while participating in a live-fire training evolution. A flashover occurred several minutes after the fire had been lit in the acquired vacant structure while both of the victims were performing a simulated search and rescue. The Lieutenant and the fire fighter were both transported by ambulances to a local hospital where they were pronounced dead. NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should

- *ensure that the fuels used in live-fire training have known burning characteristics and the structure is inspected for possible hazards prior to the training*
- *ensure that ventilation is closely coordinated with interior operations*

- *ensure that fires are not located in designated exit paths*
- *ensure that a method of fireground communication is established to enable coordination among the Incident Commander and fire fighters*
- *ensure that Standard Operating Guidelines (SOGs) specific to live-fire training are developed and followed*
- *consider using a thermal imaging camera during live-fire training*

Additionally, States should consider

- *developing a permitting procedure for live-fire training to be conducted at acquired structures. States should ensure that all the requirements of NFPA 1403 have been met before issuing the permit*



Incident Scene

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

www.cdc.gov/niosh/firehome.html
or call toll free 1-800-35-NIOSH



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INTRODUCTION

On July 30, 2002, a 32-year-old male career Lieutenant (Victim #1) and a 20-year-old male career fire fighter (Victim #2) died while participating in a live-fire training evolution. On July 31, 2002, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of these fatalities. On September 9-12, 2002, three safety and occupational health specialists from the NIOSH Fire Fighter Fatality Investigation and Prevention Program investigated the incident. NIOSH investigators interviewed the officers and fire fighters involved in this incident, and they met with representatives from the International Association of Fire Fighters and the Office of the State Fire Marshal. The NIOSH investigators reviewed the fire department's standard operating guidelines (SOGs), photographs of the incident scene, training records of the victims, reports completed by the State Fire Marshal's Office, and the death certificates.

This combination department is comprised of 135 career and 93 volunteer fire fighters, has 12 fire stations, and serves a population of approximately 100,000 in an area of about 1,450 square miles.

Training. The department requires all personnel to meet the State fire fighter requirements and have a minimum of National Fire Protection Association (NFPA) Firefighter Level I and II (480 hours) certification, and Emergency Medical Technician (EMT) I certification. The department also requires 40 hours of refresher training annually. Victim #1 had 9 years of fire-fighting experience, including 5 years as a Lieutenant. Victim #1 met the State and department requirements and had approximately 1,000 hours of fire-fighter training. Victim #2 met

the State and department requirements, which he had completed on April 24, 2002. He began serving as a career fire fighter with the department on July 22, 2002, and had completed two tours^a of duty with the department before the incident.

Personal Protective Equipment. At the time of the incident, both of the victims were wearing their full array of personal protective clothing and equipment, consisting of turnout gear (coat and pants), helmet, Nomex[®] hood, gloves, boots, and a Self-Contained Breathing Apparatus (SCBA) with a Personal Alerting Safety System (PASS) integrated into the air pack. During the NIOSH interviews, the participants reported not hearing the PASS devices sounding when the victims were found. The SCBA with integrated PASS devices were significantly damaged during the incident and were not examined by the investigators.

Structure. The structure was a vacant single-family, single-story, ordinary concrete block dwelling (approximately 1,600 square feet) with a pitched-style roof with asphalt shingles (Photo 1). Several years earlier a garage or carport had been converted into a bedroom. The structure contained three bedrooms, two bathrooms, a living room, and a kitchen (Figure 1). The structure had a total of 10 windows, 4 on the A-Side and 3 each on the B-Side and C-Side.

The converted bedroom, used as the burn room (approximately 24 by 15 square feet) during the live-fire training, was where the live-fire was ignited and where both victims were found (Photo 2). The floor in the burn room was covered with an indoor/outdoor-type carpeting with a urethane foam padding, and a scuttle hole^b in the ceiling had been

^a Each tour consists of working a 24-hour shift

^b Opening in the ceiling of the structure, fitted with removable cover for the purpose of providing access and ventilation to the cockloft or roof.



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covered to prevent fire extension. According to the Office of the State Fire Marshal, several of the rooms in the structure had some furnishings (e.g., a television set, an easy chair, a set of twin beds), and the floor was carpeted throughout the structure.

Fuel. The fuel used to generate the live-fire for the training consisted of approximately five wooden pallets, a bale of straw, and a twin-size urethane foam mattress. Other fuels in the burn room included carpeting, foam urethane padding, hollow core closet doors, wood molding, wall-mounted headboards, and painted gypsum board on the walls and ceiling.

Weather. The air temperature was 84 to 88 degrees Fahrenheit and the wind was calm. Weather conditions did not appear to be a factor in this incident.

Fire Analysis. Upon a request from NIOSH, the National Institute of Standards and Technology (NIST) developed a fire analysis of the incident. The purpose of the fire analysis is to help demonstrate the growth and the fire's reaction when different variables are introduced. The complete fire analysis will be available for viewing on-line in the near future at <http://www.fire.nist.gov>.

INVESTIGATION

On July 30, 2002, a 32-year-old male career Lieutenant (Victim #1) and a 20-year-old male career fire fighter (Victim #2) died while participating in live-fire training. The victims' combination department was leading the training with a career department participating. At approximately 0900 hours, personnel arrived at the training site, and the Instructor-in-Charge/Incident Commander (IC) gave them their assignments. The following personnel, listed according to their assignments, participated in the live-fire training exercise:

- Instructor-in-Charge/Incident Commander (IC) (Officer)
- Search and Rescue Team (Lieutenant/Victim #1

- and Fire Fighter/Victim #2)
- Ignition Officer/Interior Safety (1 Fire Fighter)
- Interior Safety (3 Fire Fighters)
- Rapid Intervention Team (RIT) (2 Fire Fighters)
- Attack Line 1 (Officer and 2 Fire Fighters)
- Attack Line 2 (Officer and 1 Fire Fighter)
- Exterior Ventilation (Fire Fighter)
- Pump Operator (Fire Fighter)

Before the start of the training, the IC and the participants walked through the structure so that the IC could give them a preburn briefing (Photo 1 and Figure 1). The IC pointed out the ingress and egress routes, and he told them that a mannequin dressed in fire fighter bunker gear would serve as a simulated rescue victim in the training exercise. He did not tell the participants that the mannequin would be located in the kitchen area. The IC told the participants that the live-fire would be built inside a closet on the northwest corner of the burn room. The participants helped put the fuel—wooden pallets and straw—inside and outside of the closet.

At approximately 1010 hours, the Ignition Officer/Interior Safety used a road flare to ignite the items in the closet and radioed the IC that the fire had been lit. When the Ignition Officer/Interior Safety left the burn room, the live-fire was producing some flames, and the smoke had diminished visibility in the room (Photo 2). To produce a larger fire, some of the fire fighters retrieved a twin-size mattress from another bedroom and put it on the live-fire in the burn room.

The Ignition Officer/Interior Safety and one of the participants who was acting as Interior Safety assumed their position in the hallway outside the burn room while the other two Interior Safety fire fighters staged in the living room. At approximately 1011 hours, the Ignition Officer/Interior Safety radioed the IC that they were ready to begin the first training evolution. The IC ordered the search and rescue team (Victim #1 and Victim #2) to enter the structure.



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Victim #1 and Victim #2 crawled through the front door (A-side) and performed a right-hand search to look for the simulated victim. A very brief time later, after receiving orders from the IC, the crew on Attack Line #1 entered the structure through the front door (A-side) with a charged 1 3/4-inch hoseline.

While Victim #1 and Victim #2 were conducting a search of the living room where two of the interior safety fire fighters were positioned, Victim #1 was overheard giving instructions on searching techniques to Victim #2. After both of the victims performed their search in the living room, they crawled down the hallway to the burn room, followed by one of the interior safety fire fighters from the living room. *Note: Conditions in the structure at this time were heavy smoke with very little visibility.*

As both victims were conducting their search, one of the victims collided with one of the interior safety fire fighters in the hallway outside the burn room. The interior safety fire fighter in the hallway identified himself to the victims as one of the interior safety personnel and instructed them to continue their search. The interior safety fire fighter that had followed both of the victims from the living room into the hallway told one of the other interior safety fire fighters in the hallway outside the burn room that he was going to look for the crew with the first attack line. Victim #1 was overheard in the burn room asking Victim #2 if the entire room had been searched and receiving an affirmative response.

As the interior safety fire fighter went back down the hallway to look for the first attack line crew, he encountered them entering the hallway, and he told them to put some water on the fire. He then headed back toward the burn room followed by the crew

from Attack Line #1. Once he reached the section of hallway outside the burn room, he asked one of the interior safety fire fighters in that area for the location of both victims. Receiving a reply that they were out, he then asked a second time if both victims were out of the burn room and received an affirmative response. He left to search for both the victims in the bedrooms on the B-Side and the kitchen on the C-Side.

At approximately 1013 hours, the IC radioed Attack Line #1 that the window in the burn room was going to be vented, and the exterior ventilation person broke out the window. When the window (56 inches in height by 42 1/2 inches in width and made of 1/4-inch-thick plate glass) was vented, it emitted very heavy black smoke followed a few seconds later by intense flames. According to the Office of the State Fire Marshal, and the fire analysis performed by NIST, a flashover^c is believed to have occurred in the burn room after the window was broken. *Note: According to NIST, the fire analysis of the incident indicates that the gases were so fuel rich in the burn room that it took the fire seconds to mix with the oxygen and flashover.* Attack Line #1, positioned at the doorway of the burn room, began applying water in short-flow increments into the room. At approximately 1014 hours, the IC ordered the crew of Attack Line #2 to enter the structure with the second 1 3/4-inch hoseline. He then attempted to make radio contact with the victims. At approximately 1015 hours, Attack Line #1 radioed the IC that water was being applied to the fire. One of the interior safety fire fighters that was positioned in the hallway outside the burn room began to feel like he was getting steamed as a result of the water being applied to the fire. As he crawled down the hallway, he told the Ignition Officer/Interior safety in

^c A flashover is defined by the International Fire Service Training Association (IFSTA) as a stage of fire at which all surfaces and objects within a space have been heated to their ignition temperature, and flame breaks out almost at once over the surface of all objects in the space.



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that area that he needed to leave. When he entered the living room, visibility improved, and he was able to stand and walk out of the structure. As he exited on the A-Side, he told the IC that he had gotten hot and steamed. At approximately 1016 hours, the IC radioed the crews inside and told them to let him know if the roof needed to be vented. Meanwhile, the exterior ventilation person went to remove a gable vent on the D-Side.

After completing his search for both victims in the bedrooms on the B-side and kitchen on the C-Side, the interior safety fire fighter discovered the simulated rescue mannequin in the kitchen. Realizing that the victims had not performed a search in that area, he left the structure and asked the IC if the victims had come out. Receiving a negative response, he reentered the structure to perform another search for both victims. At approximately 1017 hours, the IC radioed the victims to report in for accountability, with no response. At approximately 1018 hours, the IC attempted to contact the victims again on the radio.

Returning from ventilating the gable on the D-Side, the exterior ventilation fire fighter looked into the burn room window and saw a white helmet lying on the floor. The conditions in the burn room were reported as heavy fire and smoke. He reached into the window and retrieved the helmet, which was within arm's reach, and gave it to the IC. *Note: The white helmet caused some confusion because all the participants were wearing yellow helmets. The helmet was yellow, but exposure to the heat had turned it white.* After experiencing a lot of heat and getting steamed, the Ignition Officer/Interior Safety assigned to the hallway outside the burn room exited the structure. He informed the IC of the intense heat, told the IC that he did not know the location of the victims, and advised that a personnel accountability report (PAR) needed to be done.

At approximately 1019 hours, the IC called on the radio to ask who was missing a helmet. An interior safety fire fighter assigned to the living room radioed a request to the IC for D-Side to be ventilated. The IC directed ventilation to be performed by the exterior ventilation fire fighter, who interpreted the request as C-Side and ventilated that side. The IC radioed a request for status reports from Attack Lines #1 and #2 and the victims. At approximately 1020 hours, Attack Line #2 entered the burn room and radioed that they were applying water on the fire. The IC called by radio for a PAR and sent in the RIT to search for both victims. The RIT entered the structure with the third 1 3/4-inch hoseline and went to the hallway outside the burn room. At approximately 1021 hours, the IC received a PAR from Attack Lines #1 and #2, but he did not receive any response from the victims. Attack Line #2 radioed the IC that they had knocked down the fire in the burn room and that they did not find any fire extension in the ceiling. The IC radioed Attack Line #2 to ask if they had seen the victims, and they said no. In the hallway the RIT met some fire fighters who informed them that the fire was under control and that the burn room was clear. The number of fire fighters in the hallway made it difficult to move, so one of the RIT members went to the bedrooms on the B-Side and the kitchen area on the C-Side to search for the victims.

At approximately 1023 hours, the IC radioed orders to evacuate the structure and commanded the air-horn blasts to be sounded. After hearing the evacuation air horns, the Attack Line #2 crew began to leave the burn room when they saw what they thought was the simulated mannequin lying facedown on the floor next to the closet where the fire had been ignited. As they attempted to move the mannequin, they realized that it was actually Victim #1. The Ignition Officer/Interior Safety walked over to the A-Side and climbed through the window into



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the burn room. *Note: Conditions in the burn room were reported as white smoke or steam emitting from the floor area.*

At approximately 1024 hours, a call was radioed from the burn room to report that a fire fighter was down. The Ignition Officer /Interior Safety, a fire fighter from the RIT, and the crew from Attack Line #2 removed Victim #1 through the window in the burn room. The IC radioed a request for two ambulances to respond to the scene. After inquiring about the location of the other victim, one of the interior safety fire fighters reentered to perform a search. After searching the kitchen and bathroom areas (C-Side), he entered the burn room and shone his flashlight around the room. Observing a helmet lying in the middle of the floor, he went to it and discovered Victim #2 lying on the floor next to the window on A-Side. To get the attention of fire fighters outside, he threw his helmet out the window. Fire fighters outside the structure helped remove Victim #2 through the window. At approximately 1027 hours, the IC radioed to dispatch that they had one fire fighter with burns and another fire fighter being removed from the building. Both of the victims were transported via ambulances to a local hospital where they were pronounced dead.

CAUSE OF DEATH

The death certificates listed the cause of death for both victims as smoke inhalation and thermal injuries.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Fire departments should ensure that the fuels used in live-fire training have known burning characteristics.¹

Discussion: Fuels for training fires should have known burning characteristics, and the quantities used should be the minimum necessary that are controllable and able to create the desired fire conditions. The NFPA

notes that fuel materials shall be used only in the amounts necessary to create the desired fire size. Pressure-treated wood, rubber, plastic, and straw or hay treated with pesticides or harmful chemicals should not be used. According to the NFPA, the fuel load shall be limited to avoid conditions that could cause an uncontrolled flashover or backdraft. According to NIST, the fire analysis of the incident indicates that the carpet, the foam padding, the hollow core wood doors and the mattress added to the fuel load and the speed of the fire development. The structure should be inspected to identify and remove materials that could contribute to rapidly spreading fires and create an environmental or health hazard.

Recommendation #2: Fire departments should ensure that ventilation is closely coordinated with interior operations.²⁻⁵

Discussion: Chapter 10 of *Essentials of Fire Fighting*, 4th edition, states that “ventilation must be closely coordinated with fire attack.” Fire can quickly spread in a structure, causing problems such as flashover, a backdraft, or an explosion. Ventilation timing is extremely important and must be carefully coordinated between interior operating crews and ventilation crews. Ventilation is necessary to improve a fire environment so that fire fighters can perform such duties as search and rescue and approach a fire with a hoseline for extinguishment. Incident command should determine if ventilation is needed and where ventilation is needed. The type of ventilation should be determined, based on evaluation of the structure and the location of any interior crews. Proper venting of heat, smoke, and combustible gas/air mixtures from buildings can reduce the possibility of dangerous situations that confront fire fighters.

Recommendation #3: Fire departments should ensure that fires are not located in designated exit paths.¹



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Discussion: During a training exercise, every effort must be made to ensure the exit paths are free from obstructions. To provide a protected area of travel, fires should not be located in the vicinity of exit paths. Once the closet area in the burn room was ignited, the fire continued to increase in size, which produced fire, heat and smoke in the exit path of the only doorway in the room.

Recommendation #4: Fire departments should ensure that a method of fireground communication is established to enable coordination among the Incident Commander and fire fighters.¹

Discussion: The NFPA Standard 1403, 2-4.9, notes that communication shall be established between the Incident Commander and fire fighters performing any interior operations, sector leaders, and the safety officer. Proper communication is a must at any incident site. Portable radios should be used to keep all personnel on the scene in communication with the Incident Commander. The use of a portable radio that is located in a radio coat or pants pocket impairs the performance of the unit. Portable radios should be held or used with a microphone and speaker attached to the lapel of the coat, which allows the fire fighter to monitor and transmit a clear message. In this incident, Victim #1 had a portable radio; however, it was kept in the pocket of his bunker coat. Victim #2 did not have a portable radio. During the NIOSH interviews, several of the interior safety fire fighters acknowledged that they were unable to hear their radios during the incident because their radios were in their pants or bunker coat pockets.

Recommendation #5: Fire departments should ensure that Standard Operating Guidelines (SOGs) specific to live-fire training are developed and followed.⁶

Discussion: Standard operating guidelines (SOGs) should be developed specifically for training fires and include areas such as facility inspection, fuel materials, RIT operations, SCBA, water supply, and hoseline operations. These SOGs will then form the foundation as to how the training will be conducted. The SOG should be in written form and be included in the overall risk-management plan for the fire department. If these procedures are changed, appropriate training should be provided to all affected members.

Recommendation #6: Fire departments should consider using a thermal imaging camera during live-fire training situations.⁷⁻⁹

Discussion: Thermal imaging cameras may assist fire fighters by allowing them to see through blinding smoke and in zero visibility conditions. With the help of a thermal imaging camera, training instructors, interior safety officers, and fire fighters may observe and critique participants, ensuring that they develop good foundational skills in areas including accountability, conducting effective search patterns, and handling a hose. A thermal imaging camera may be an excellent tool to enhance training.

Advances in technology allow a thermal imaging camera to be equipped with a wireless video transmitter to provide an instructor, Incident Commander, or other training participants who are outside the structure with the opportunity to observe training activities. Thermal imaging technology allows the instructor and interior safety officers to monitor heat and fire conditions inside the structure, which could help to keep the participants safe. Of course, fire departments must always remember that thermal imaging cameras have limitations and that technology does not replace or alter basic safety procedures and fire-fighting tactics.



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Additionally, States should consider the following:

Recommendation #7: Develop a permitting procedure for live-fire training to be conducted at acquired structures. States should ensure that all the requirements of NFPA 1403 have been met before issuing the permit.^{1,10}

Discussion: NFPA 1403, *Standard on Live Fire Training Evolutions*, is the guideline for conducting live-fire training evolutions at approved training centers, and in this case, acquired structures. Approved training centers have burn buildings that are specifically designed for repeated live-fire training evolutions. The structures that are acquired for live-fire training are usually in disrepair and were never designed for live-fire training. Any building that is acquired for live-fire training must go through an inspection process to identify and eliminate any hazards or potential hazards that may be present to the participants, the public, and the environment. An application for permit procedure that is overseen by the State through local officials or a State fire marshal would help ensure safety. If training facilities with approved burn buildings are available, then live-fire training exercises should not be conducted in acquired structures.

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INVESTIGATOR INFORMATION

This incident was investigated by Nancy T. Romano, Jay Tarley, and Stephen Berardinelli Jr., Safety and Occupational Health Specialists, NIOSH, Division of Safety Research, Surveillance and Field Investigation Branch.

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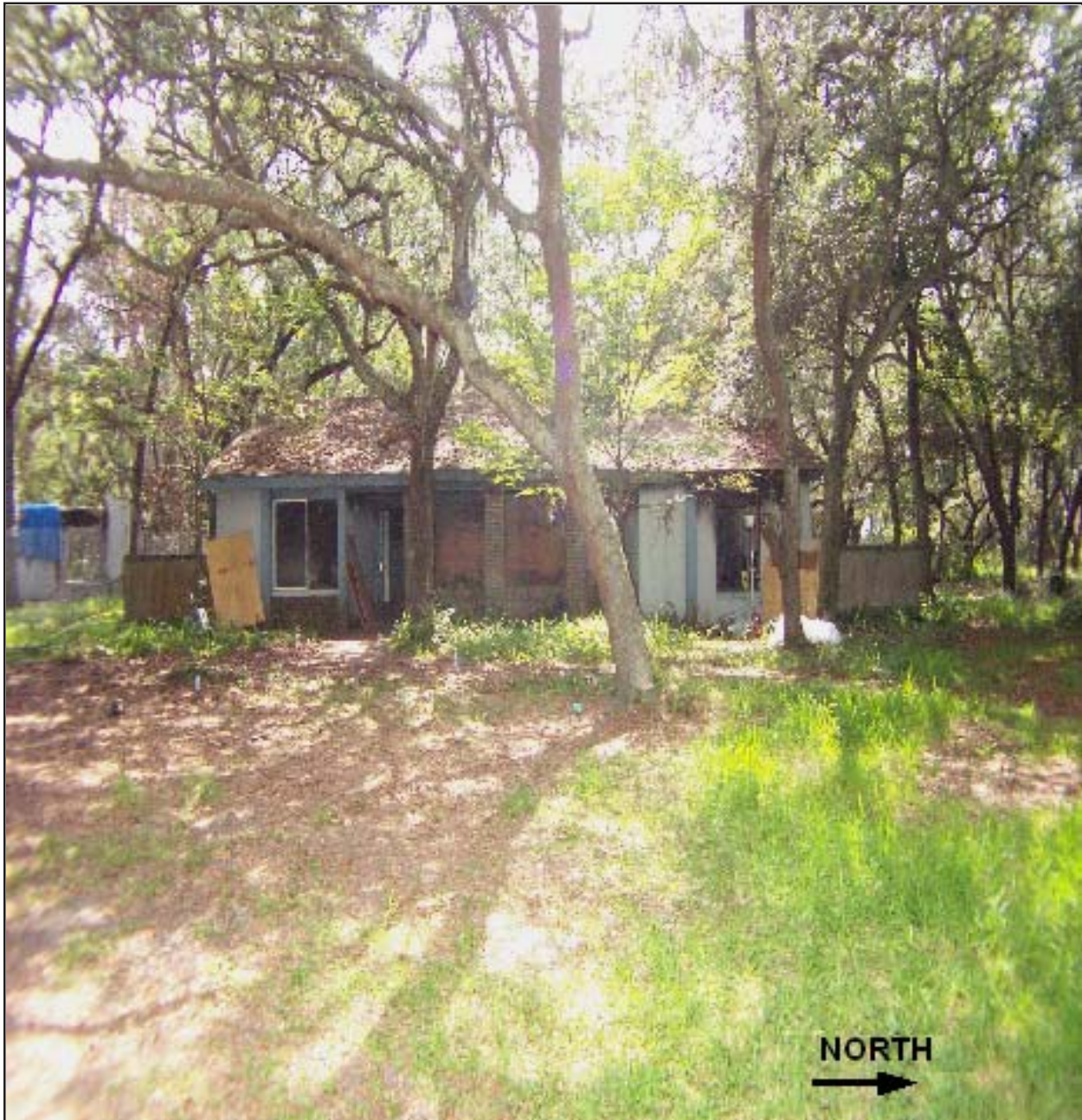


Photo 1. Front of structure used for live-fire training

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Photo 2. Burn room in the structure



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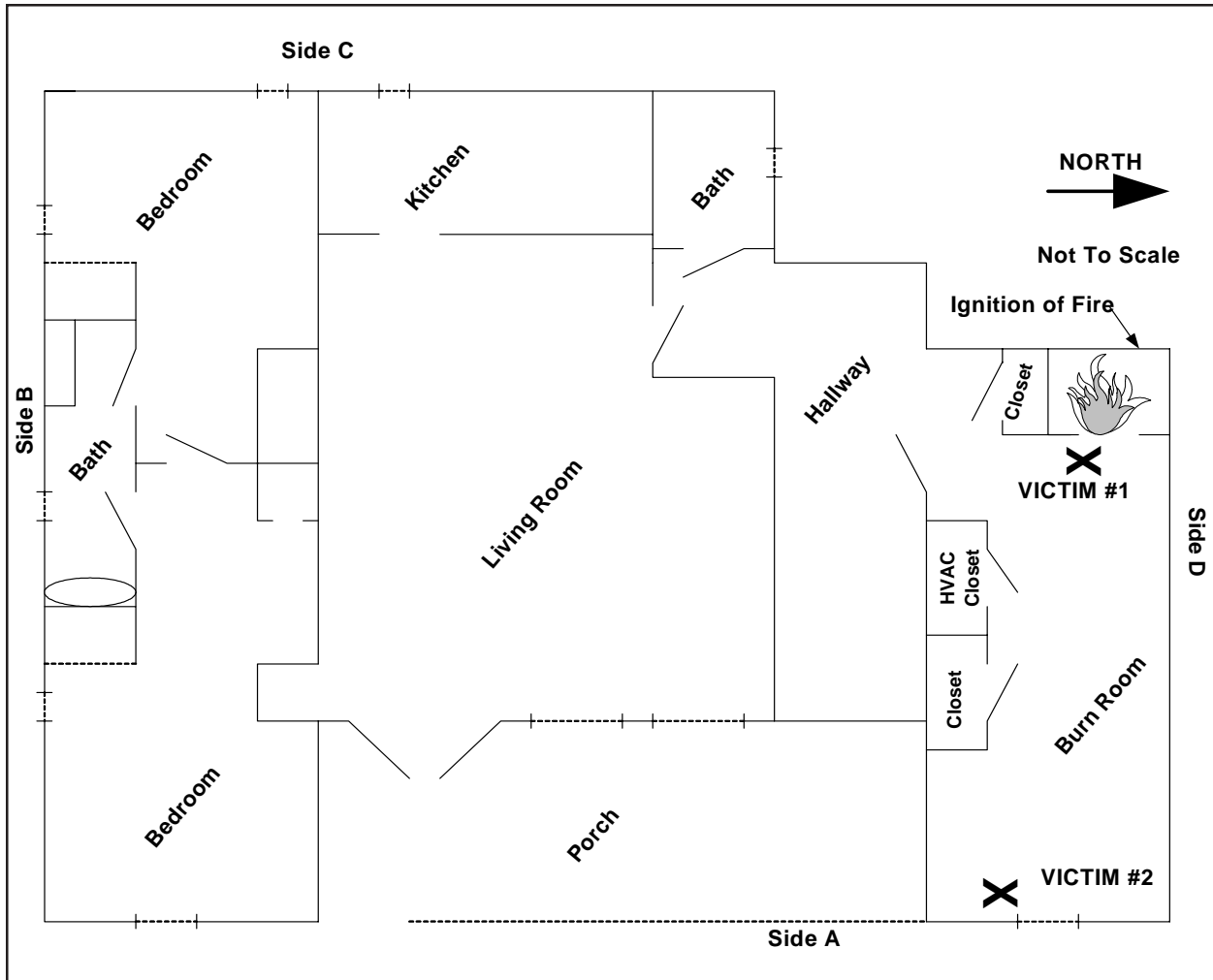


Figure 1. Floor plan; overhead view of structure

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