The following section is excerpted from a June, 2016 report commissioned by the Branford Professional Firefighters Local 2533 entitled "GEOGRAPHIC INFORMATION SYSTEM EMERGENCY SERVICES RESPONSE CAPABILITIES ANALYSIS" prepared by the International Association of Firefighters. While this administration does not agree with all of the conclusions or recommendations contained within, we do agree with the excerpted section below. The information that follows is provided to help you understand fire growth and the importance of a rapid fire department response with the appropriate number of resources. The entire report is provided here *(weblink)* for reference.

"The business of providing emergency services has always been labor intensive, and remains so today. Although new technology has improved firefighting equipment and protective gear, as well as advances in modem prehospital medicine, it is the firefighters who still perform the time critical tasks necessary to contain and extinguish fires, rescue trapped occupants from a burning structure, and provide emergency medical and rescue services. In less than 30 seconds a small flame can bum out of control and become a major fire. During fire growth, the temperature of a fire rises to above 1,000° and Fahrenheit (F). It is generally accepted in the fire service that for a medium growth rate fire,[1]flashover - the very rapid spreading of the fire due to super heating of room contents and other combustibles - can occur. It is also worth noting that a flashover may occur more quickly depending on building construction materials and room contents that act as fuel. As fires grow, the odds of survival for unprotected individuals inside the affected area decrease to a virtually non-existent level. The rapid response and arrival of an appropriate number of firefighters is therefore essential to initiating effective fire suppression and rescue operations that seek to minimize fire spread and maximize the odds of preserving both life and property. Current minimum on-duty staffing does not allow for the assembly of 15 personnel within 8 minutes for a response to what is considered a low-hazard structure fire. A low-hazard structure fire is a fire in a typical, 2,000 square foot, single-family residential home with no basement or exposures.[2] In Branford, the practice of cross-staffing fire apparatus and ambulances reduces the Department's ability to respond rapidly and efficiently to emergencies and increases the risk to the community. The current minimum on-duty staffing is below industry standards and can impede fireground tactics and increase property loss as result of fire and smoke damage. Additionally, reducing the number of on-duty personnel increases the likelihood of fire related injuries and deaths for responders and citizens alike while also delaying the initiation of emergency medical treatment at EMS incidents. This section will explain fire growth and the importance of rapid fire department response with an appropriate number of resources.

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[1] As defined in the Handbook of the Society of Fire Protection Engineers, a fast fire grows exponentially to 1.0 MW in 150 seconds, a medium fire grows exponentially to 1 MW in 300 seconds. A slow fire grows exponentially to 1 MW in 600 seconds. A 1 MW fire can be thought-of as a typical upholstered chair burning at its peak. A large sofa might be 2 to 3 MWs. 11 NFPA 1710, 2016 ed. Pg. 1710-19 §A.4.1.2.5.)

[2] NFPA 1710, 2016 ed. Pg. 1710-19 §A.4.1.2.5.1

Fire Growth

The Incipient Phase

The first stage of any fire is the incipient stage. In this stage a high heat source is applied to a combustible material. The heat source causes a chemical change to the material's surface which begins to convert from a solid and release combustible gases. If enough combustible gases are released the material will bum freely. The process is exothermic, which means that it produces heat. The heat being generated raises the temperature of surrounding materials, which in turn begin to release more combustible gases into the environment and begins a chemical chain reaction of heat release and burning. At this point the fire may go out if the first object bums before another begins or the fire can progress to the next stage, which is called the Free Burning Phase.

The Free Burnings Phase

The second stage of fire growth is the "free" or "open burning" stage. When an object in a room starts to bum, (such as the armchair in Figure 1, following page) it bums in much the same way as it could in an open area. In this phase of the fire, oxygen in the air is drawn into the flame and combustible gases rise to the ceiling and spread out laterally. Simultaneously, the materials that are burning continue to release more heat, which heats nearby objects and materials to their ignition temperature, and they begin burning as well. Inside a room, unlike in an open area, after a short period of time confinement begins to influence fire development. The combustible gases that have collected in the ceiling will eventually begin to support fire and will begin to bum. Thermal radiation from this hot layer begins to heat the ceiling, the upper walls, and all the objects in the lower part of the room which will augment both the rate of burning of the original object and the rate of flame spread over its surface.

When this occurs, the structure fire reaches a critical point: either it has sufficient oxygen available to move on to the next stage or the fire has insufficient oxygen available to bum and it progresses back to the incipient stage. However, since structures are not airtight there is a low likelihood of the fire depleting the available oxygen. During this stage of fire growth, toxic chemicals released by the fire and high heat are enough to bum people in the immediate area and disorient and/or incapacitate people in the structure. Without rapid response and aggressive intervention by an adequately staffed fire department the fire will likely spread to the rest of the structure.

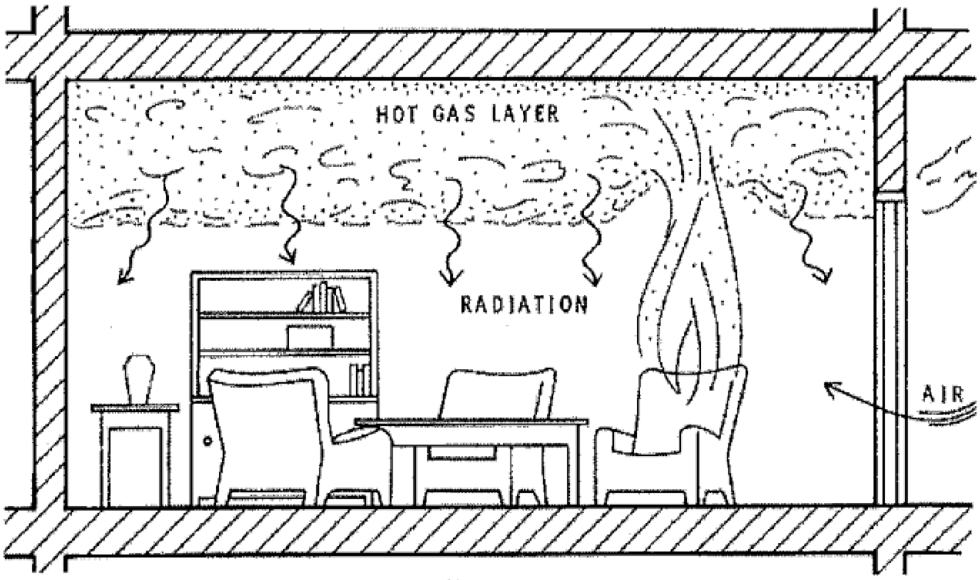

Figure 1: Fire Growth in a Compartment.[12] The above figure depicts the growth of fire in a compartment, which is an enclosed space or room in a building. In a compartment the walls, ceiling, floors, and objects absorb radiant heat produced by the fire. Unabsorbed heat is reflected back to the initial fuel source, which is depicted by the armchair above. This reflected heat continues to increase the temperature of the fuel source and therefore the rate of combustion. Hot smoke, combustible gases, and super-heated air will then rise to the ceiling and spread at first laterally across the ceiling, but later downward towards other fuel sources and the floor of the compartment. As this toxic, super-heated cloud touches cooler materials, the heat is conducted to them, increasing their temperature and eventually leading to pyrolysis, which is the process where a fuel source begins to release flammable vapor. This release of flammable vapor leads to further fire growth and eventually flashover. Flashover is the point at which all exposed fuel sources in a compartment ignite.

If there is sufficient oxygen then the fire will continue to grow and the heating of the other combustibles in the room continues to the point where they reach their ignition temperatures more or less simultaneously. If this occurs, all combustible materials in the room will spontaneously ignite. This transition from the burning of one or two objects to full room involvement is referred to as "flashover." [3]

Flashover

Flashover, when it occurs, is the most significant event during a structure fire. As combustible gases are produced by the two previous stages they are not entirely consumed and are therefore "available fuels." These "available fuels" rise and form a superheated gas layer at the ceiling that continues to increase, until it begins to bank down to the floor, heating all combustible objects regardless of their proximity to the burning object. In a typical structure fire, the gas layer at the ceiling can quickly reach

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12 Image courtesy of University of California at Davis Fire Department

3 J.R. Mehaffey, Ph.D., Flammability of Building Materials and Fire Growth. Institute for Research in Construction (1987)

temperatures of 1,200 degrees F or greater. With enough existing oxygen at the floor level, flashover occurs, burning everything in the room at once.

The instantaneous eruption into flame generates a tremendous amount of heat, smoke, and pressure. The pressure has enough force to push beyond the room of origin and through doors and windows. Usually at the time of flashover, windows in the room will break, allowing for the entry of fresh air. The introduction of fresh air serves to further drive the growth of the fire by increasing the fire's temperature and spreading the fire beyond the room of origin.

Based on the dynamics of fire behavior in an unprotected structure fire, any decrease in emergency unit response capabilities will correlate directly with an increase in expected life, property, and economic loss.

The Importance of Adequate Staffing: Concentration

Staffing deficiencies on primary fire suppression apparatus negatively affect the ability of the fire department to safely and effectively mitigate emergencies and therefore correlate directly with higher risks and increased losses. Continued fire growth beyond the time of firefighter arrival on scene is directly linked to the time it takes to initiate fire suppression operations. As indicated in Table 1, below, responding companies staffed with four firefighters are capable of initiating critical fireground operational tasks more efficiently than those with crew sizes below industry standards.

Engine Company Duties					Ladder Company Duties			
Fireground Tasks	**Advance Attack Line**	**% Change**	**Water on Fire**	**% Change**	**Primary Search**	**% Change**	**Venting Time**	**% Change**
4 Firefighters	0:03:27		0:08:41		0:08:47		0:04:42	
3 Firefighters	0:03:56	12% Less Efficient	0:09:15	6% Less Efficient	0:09:10	4% Less Efficient	0:07:01	32% Less Efficient
2 Firefighters	0:04:53	29% Less Efficient	0:10:16	15% Less Efficient	0:12:16	28% Less Efficient	0:07:36	38% Less Efficient

Table 1: Impact of Crew Size on a Low-Hazard Residential Fire.[14] The above table compares and contrasts the efficiencies of suppression companies in the completion of critical tasks for fire control and extinguishment. The smaller the crew size, the more tasks an individual must complete as a team member, which contributes to the delay in initiating fire attack and contributes to diminished efficiency in stopping fire loss. Because of insufficient suppression company staffing (the Department staffs as few as three firefighters on Engine 3 and two firefighters on the Ladder, assuming the Ladder can be staffed) first arriving companies must wait for additional companies before beginning interior operations.

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[4] Averill, J.D. et al. (2010). Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.

First-arriving companies staffed with four firefighters are more efficient in all aspects of initial fire suppression and search and rescue operations when compared to two- or three-person companies. There is a significant increase in time to task completion for all the tasks if a company arrives on scene staffed with only three firefighters compared to four firefighters. According to the National Institute of Standards and Technology (NIST) Report on Residential Fireground Field Experiments, four-person crews are able to complete time critical fireground tasks 5.1 minutes (nearly 25%) faster than three-person crews. The increase in time to task completion corresponds with an increase in risk to both firefighters and trapped occupants as well as the increased risk of property damage and economic loss.

With four-person crews, the effectiveness of first-arriving engine company interior attack operations increases by 12% to 29% efficiency compared to three- and two-person crews respectively. The efficacy of search and rescue operations also increases by 4% to 28% with four person crews compared to three- and two-person crews. Moreover, with a four-person company, because the first-in unit is staffed with a sufficient number of personnel to accomplish its assigned duties, the second-in company does not need to support first-in company operations and is therefore capable of performing critical second-in company duties.

Insufficient numbers of emergency response units or inadequate staffing levels on those units expose citizens and firefighters to increased risk, further drain already limited fire department resources, and stress the emergency response system by requiring additional apparatus to respond from further distances. Failing to assemble sufficient resources on the scene of a fire in time to stop the spread and extinguish the fire, conduct a search, and rescue any trapped occupants puts responding firefighters and occupants in a dangerous environment with exponential risk escalation such that it is difficult to catch up and mitigate the event to a positive outcome.

A prime objective of fire service agencies is to maintain enough strategically located personnel and equipment so that the minimum acceptable response force can reach a fire scene before flashover is likely.[5] *Two of the most important elements in limiting fire spread are the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire as close to the point of origin as possible, as well as rescue any trapped occupants and care for the injured. Rapid and aggressive interior attack of structure fires, as close as possible to the point of origin, can reduce human and property losses. Sub-optimal staffing of arriving units may delay such an attack, thus allowing the fire to progress to more dangerous conditions for firefighters and citizens. "If the arriving units have adequate resources to handle the situation, then they will fight the fire aggressively and offensively. They will attack the problem head-on and, following department standards, will accomplish their objectives efficiently, effectively, and safely. If they do not have adequate resources to aggressively handle the situation, then they will have to fight the fire in a defensive mode of attack. This mode will continue until enough resources can be massed to then change to an aggressive, offensive attack."*[6]

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[5] University of California at Davis Fire Department website; site visited June 7, 2004.
< http://fire.ucdavis.eduyucdfireAJCDFDoperations.htm >

[6] National Institute for Occupational Safety and Health, High-Rise Apartment Fire Claims the Life of One Career Fire Fighter (Captain) and Injures Another Career Fire Fighter (Captain)- Texas. October 21, 2002.

NFPA 1500 and 1710 both recommend that a minimum acceptable fire company staffing level should be four members responding on, or arriving, with each engine and ladder company. Recall that at the scene of an emergency, the driver/operator of the engine must remain with the apparatus to operate the pump. Likewise, the driver/operator of the ladder truck must remain with the apparatus to safely operate the aerial device. Due to the demands of fireground activities, a fire attack initiated by three firefighters is not capable of affecting a safe and effective fire suppression and/or rescue operation until sufficient personnel arrive.

At the scene of a structure fire, the driver/operator of the first engine company on the scene must remain with the apparatus to operate the pump. This leaves one firefighter to assist the operator in securing a water source from a hydrant and two firefighters to deploy a hoseline and stretch it to the fire. After assisting the operator, the third firefighter should begin to assist the other two firefighters with advancing the hoseline into the building and to the location of the fire. Before initiating fire suppression, the supervising officer of the first arriving engine company is also responsible for walking around the building to assess the situation, determine the extent of the emergency, and request any additional resources necessary to mitigate the fire.

Similarly, the driver/operator of the first arriving ladder company must remain with the apparatus to safely position and operate the aerial device while the other three firefighters also perform critical fireground tasks such as ventilation and search and rescue. Due to the demands of fireground activities, a fire attack initiated by companies with only three or fewer firefighters is not capable of affecting a safe and effective fire suppression and/or rescue operation until additional personnel arrive. By that time, the fire may be beyond control and property and lives lost.

The Importance of Crew Size to Overall Scene Time

Studies have shown that the more personnel that arrive on engine and ladder truck companies to the scene of a fire, the less time it takes to complete tasks associated with fire suppression and search and rescue. As units arriving with more firefighters increases, the overall time on the scene of the emergency decreases. In other words, the more firefighters available to respond and arrive early to a structure fire, the less time it takes to extinguish the fire and perform search and rescue activities, thus reducing the risk of injury and death to both firefighters and trapped occupants and reducing the economic loss.

Overall Scene Time Breakdown by Crew Size		
Scenario	**Total Time**	**Efficiency**
2-Person Close Stagger	0:22:16	29% Less Efficient
3-Person Close Stagger	0:20:30	25% Less Efficient
4-Person Close Stagger	0:15:14	N/A
2-Person Far Stagger	0:22:52	31% Less Efficient
3-Person Far Stagger	0:21:17	26% Less Efficient
4-Person Far Stagger	0:15:48	N/A

Table 2: The Relationship between Crew Size and Scene Time.[17] The above table displays how companies staffed with larger sized crews will be on the scene of an emergency for a shorter time than smaller sized companies. This lag on scene could be translated to mean that emergency resources will be unavailable longer to address other emergencies that may arise. Stagger is the difference between the arrival of each responding company. In the above table, a "close" stagger was 1 minute apart and a "far" stagger was 2 minutes. In Branford, the practice of cross-staffing fire and EMS apparatus can leave apparatus unavailable to respond and result in longer stagger times between arriving fire apparatus.

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As Table 2 shows, units that arrive with only two firefighters on an engine or ladder truck are on the scene of a fire almost 7 minutes longer than units that arrive with four firefighters on each crew. Responding units arriving with only three firefighters on an apparatus are on the scene of a fire 5 to 6 minutes longer than units that arrive with four firefighters on each apparatus. In addition to crew size, the time between the arriving crews matters to overall effectiveness and total on scene time.

In the NIST study on the low-hazard residential fire, close stagger was defined as a 1-minute time difference in the arrival of each responding company. Far stagger was defined as a 2- minute time difference in the arrival of each responding company[8 9] The results show a consistent pattern of units arriving with four firefighters in a close stagger or far stagger will decrease the overall time at the scene of the emergency compared to units that arrive with two or three firefighters, and are more efficient in fire suppression tasks as well. The results show a

Fire modeling was also used by researchers to mark the degree of the toxicity of the environment for a range of growth fires (slow, medium, and fast). Occupant exposures were calculated both when firefighters arrive earlier to the scene, and when arriving later. The modeling provided that the longer

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[7] Averill, J.D. et al. (2010). Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010

[8] Ibid.

[9] One minute and two minute arrival stagger times were determined from analysis of deployment data from more
than 300 U.S. fire departments responding to a survey on fire department operations conducted by the International
Association of Fire Chiefs and the International Association of Fire Fighters.

it takes for firefighters to rescue trapped occupants, the greater the risk posed to both the firefighters and occupants by increasing atmospheric toxicity in the structure.

Physiological Strain on Smaller Crew Sizes

The same NIST study also examined the relationship between crew size and physiological strain. Two important conclusions were drawn from this part of the experiments.

- *Average heart rates were higher for members of small crews.*
- *These higher heart rates were maintained for longer durations.*[10]

In 2014 alone, 57% of all firefighter fatalities were related to overexertion.[11] *There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.*[12] *Smaller crews are responsible for performing a number of task that are designed to be performed by multiple people and frequently in teams of two. This means that firefighters on smaller crews are required to work harder than larger crews to accomplish multiple tasks. Additionally, as discussed earlier, firefighters on smaller crews will also be working longer than larger-sized crews. Working harder and longer in high heat and dangerous stressful environments increases the likelihood of firefighters suffering an injury, or worse dying, as a result of overexertion.*

Charts 1 and 2, on the following pages, highlight the cardiovascular impact on firefighters based on crew size for the first arriving engine and Truck Company. The heart rates of firefighters of crew sizes ranging from 2 to 5 firefighters were measured as they participated in the NIST study. The study was able to conclude that not only do smaller crews work harder and longer than larger crews, their heart rates are also more elevated for longer periods of time. This increases the risk of firefighters suffering an injury or death from overexertion. A firefighter suffering a medical emergency on the scene of a working fire, EMS, or rescue incident negatively impacts outcomes and increases the risk to the community, the citizen requiring assistance, and the firefighter.

In Branford, fire suppression apparatus are staffed with a minimum of three on the engine and two on the ladder if personnel are available. Because of this, firefighters operating on the scene of a fire or labor intensive rescue situation will be potentially overexerting for a prolonged period of time.

[10] Averill, J.D. et al. (2010). Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.

[11] Fahy, R.F., LeBlanc, P.R., Molis, J.L. (June, 2015) Firefighter Fatalities in the United States-2014. NFPA.

[12] Albert, C.A., Mittleman, M.A., Chae C.U., Lee, I.M., Hennekens, C.H., Manson, J.E. (2000) Triggering Sudden Death from Cardiac Causes by Vigorous Exertion. N Engl J Med 343(19):1355-1361

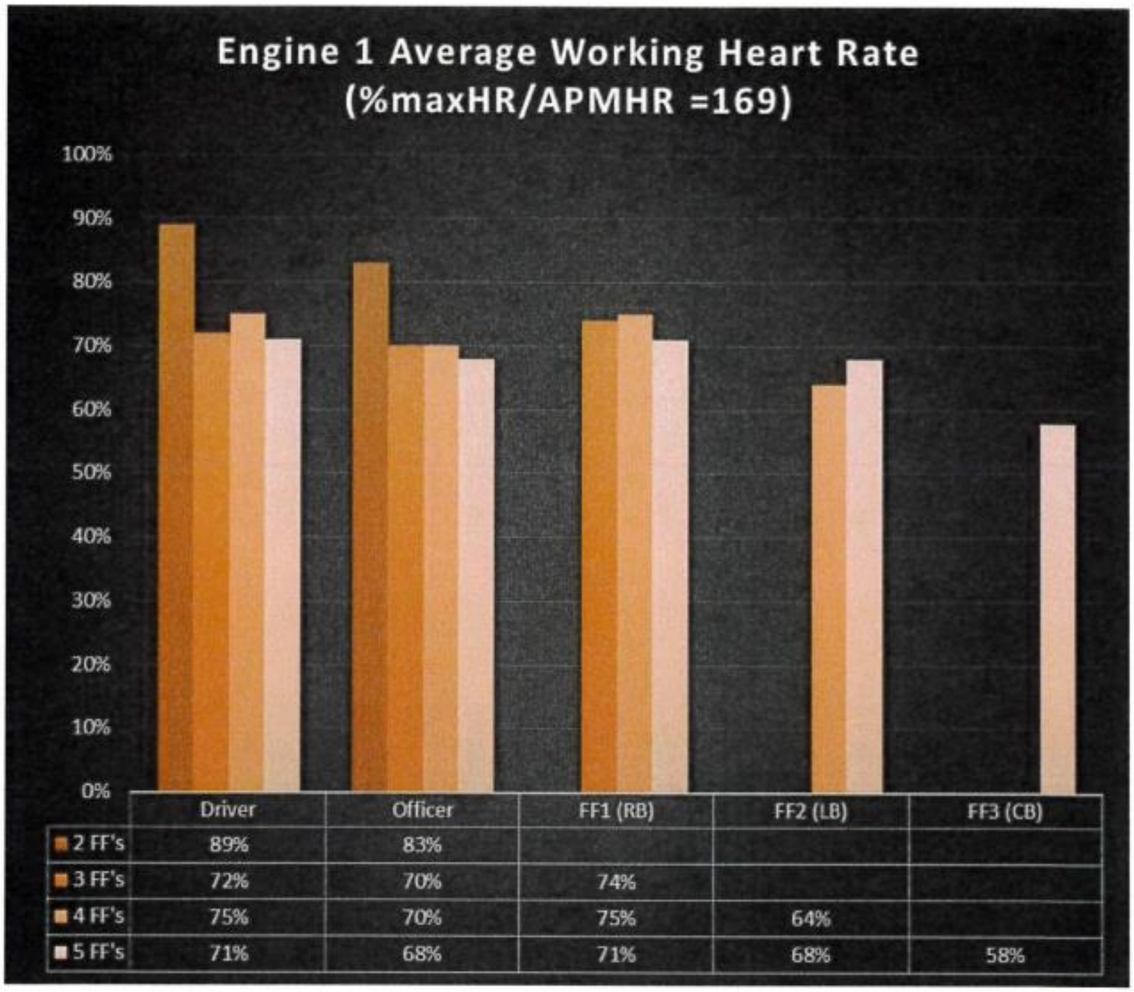

Chart 1: Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position.[23] *In Chart 1, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first engine company were above 80% of age-predicted maximum values when only 2 firefighters were working. When staffing was at 2 firefighters, the driver of the apparatus had an average peak heart rate of nearly 90% of the age-predicted maximum. This is largely due to the number of additional tasks the driver must perform to prepare the engine to pump water to the fire and then join the officer to stretch hose to the fire. As can be seen, the larger the crew size, the lower the heart rate.[24] Decision makers could potentially reduce their liability for firefighter injury and death by ensuring staffing is compliant with the minimum recommended industry standards of four firefighters per apparatus.

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[13] Riding position for Chart 1 are as follows: Driver, Officer, Firefighter 1-Right Bucket (RB) seat, Firefighter 2-Left Bucket (LB) seat, Firefighter 3- Center Bucket (CB) seat. A fire company that is staffed with 2 will consist of a Driver and an "Officer."

[14] Smith, D.L., Benedict, R. Effect of Deployment of Resources on Cardiovascular Strain of Firefighters. April, 2010. Pp 5-7

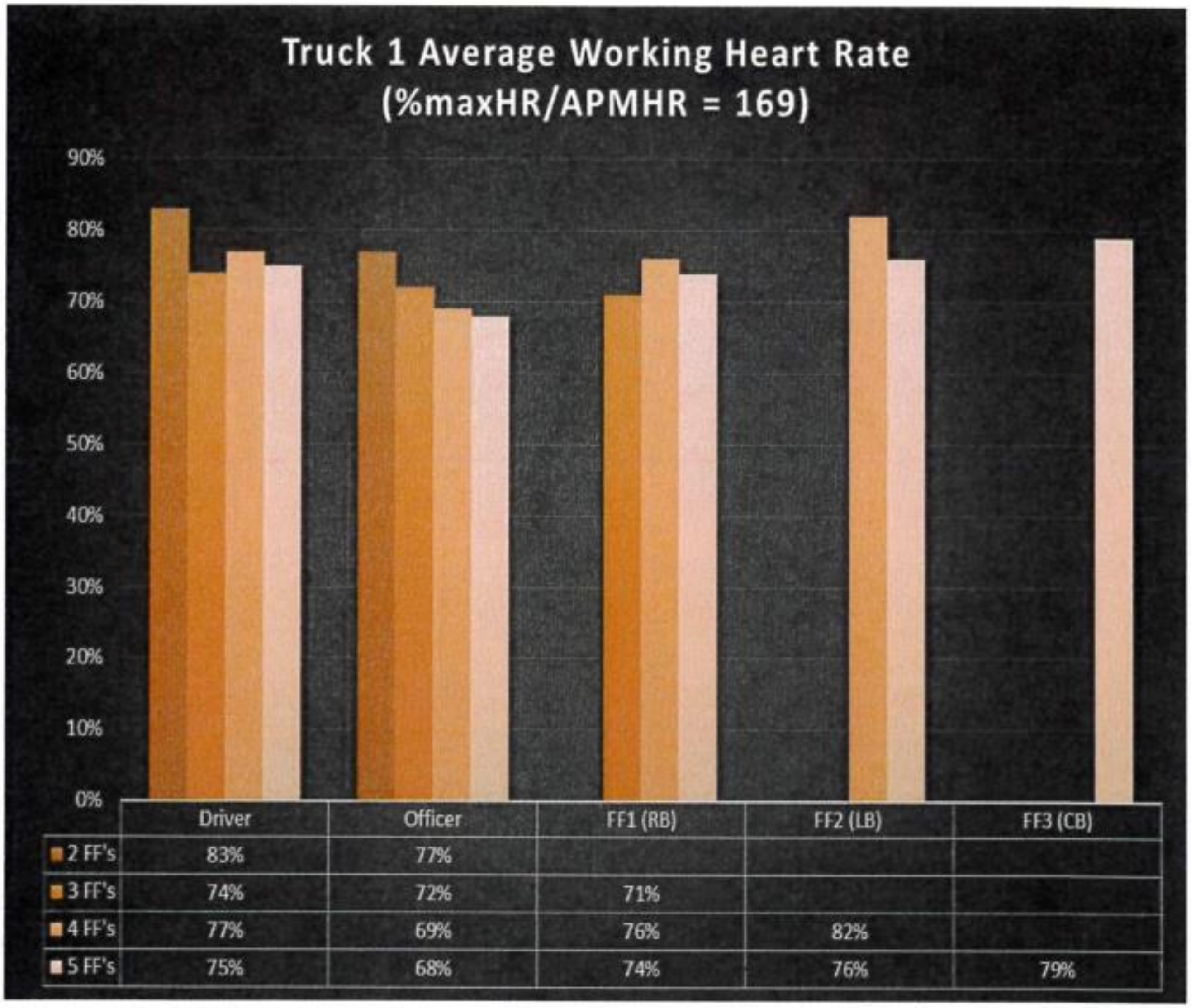

Chart 2: Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position.[25] *In Chart 2, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first truck company were above 80% of age-predicted maximum values when only 2 firefighters were working.[26] Decision makers could potentially reduce their liability for firefighter injury and death by ensuring staffing is compliant with the minimum recommended industry standards of four firefighters per apparatus.

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[15] Riding position for Chart 2 are as follows: Driver, Officer, Firefighter 1-Right Bucket (RB) seat, Firefighter 2-Left Bucket (LB) seat, Firefighter 3- Center Bucket (CB) seat. A fire company that is staffed with 2 will consist of a Driver and an "Officer."

[16] Smith, D.L., Benedict, R. Effect of Deployment of Resources on Cardiovascular Strain of Firefighters. April, 2010. Pp 5-7

The Importance of a Rapid Response

Uncontained fire in a structure grows exponentially with every passing minute. Any delay in the initiation of fire suppression and rescue operations, such as the 5- to 7-minute delay that results from smaller sized crews of firefighters, translates directly into a proportional increase in expected property, life, and economic losses as is shown in Table 3, below. It warrants emphasizing that if a structure has no automatic suppression or detection system, a more advanced fire may exist by the time the fire department is notified of the emergency and is able to respond. Fires of an extended duration weaken structural support members, compromising the structural integrity of a building and forcing operations to shift from an offensive to defensive mode.[17] *As with inadequate staffing, this type of operation will continue until enough resources can be amassed to then change to an aggressive, offensive attack.*

Fire modeling was also used by researchers to mark the degree of the toxicity of the environment for a range of growth fires (slow, medium, and fast). Occupant exposures were calculated both when firefighters arrive earlier to the scene, and when arriving later. The modeling provided that the longer it takes for firefighters to rescue trapped occupants, the greater the risk posed to both the firefighters and occupants by increasing atmospheric toxicity in the structure.

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[17] According to the NFPA, “it’s important to realize that every 250 GPM stream applied to the building can add up to one ton per minute to the load the weakened structure is carrying.”

Rate Per 1,000 Fires			
Flame Spread:	**Civilian Deaths**	**Civilian Injuries**	**Average Dollar Loss per Fire**
Confined fires (identified by incident type)	0.00	10.29	$212.00
Confined to object of origin	0.65	13.53	$1,565.00
Confined to room of origin, including confined fires by incident type[28]	1.91	25.32	$2,993.00
Beyond the room, but confined to floor of origin	22.73	64.13	$7,445.00
Beyond floor of origin	24.63	60.41	$58,431.00

Table 3: The Relationship between Fire Extension and Fire Loss.[29] The above table displays the rates of civilian injuries and deaths per 1,000 fires, as well as the average property damage. Following the far left column from top to bottom, each row represents a more advanced level of fire involvement in a residence. Typically, the more advanced the fire, the larger the delay in suppression. Assuming an early discovery of a fire, companies staffed with larger crew sizes help to minimize deaths, injuries, and property loss. This highlights why a 5- to 7- minute delay in suppression activities by smaller sized crews results in higher economic losses to a residence.

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[18] NFIRS 5.0 has six categories of confined structure fires, including cooking fires confined to the cooking vessel, confined chimney or flue fire, confined incinerator fire, confined fuel burner or boiler fire or delayed ignition, confined commercial compactor fire, and trash or rubbish fire in a structure with no flame damage to the structure or
its contents. Homes include one- and two-family homes (including manufactured housing) and apartments or other
multifamily housing. These statistics are national estimates based on fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire.
Property damage has not been adjusted for inflation.
29 National Fire Protection Association, NFPA 1710 (2016), Table A.5.2.2.2.1(b) Fire Extension Home Structure Fires, 2006-2010.
[19]National Fire Protection Association, NFPA 1710 (2016), Table A.5.2.2.2.1(b) Fire Extension Home Structure Fires, 2006-2010.

Initial Full Alarm Assignment

Initial Full Alarm Assignment Capability, as outlined in NFPA Standard 1710, states that the fire department shall, on incidents that are not in a high-rise structure, have the capability to deploy an initial full alarm assignment within a 480-second travel time to 90 percent of the incidents and that the initial full alarm assignment to a typical 2,000 ft^2 structure fire shall provide for the following:

Minimum Personnel for NFPA 1710 Full Alarm Assignment	
Assignment	**Required Personnel**
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator	1 Firefighters
Initial Rapid Intervention Crew (IRIC)	2 Firefighters
Required Minimum Personnel for Full Alarm	**14 Firefighters & 1 Scene Commander**

Table 4: NFPA 1710 Full Alarm Assignment Personnel Requirements. The expected capabilities of a full alarm assignment that complies with NFPA 1710 requires a minimum contingent of 15 fire suppression personnel. NFPA 1710 also requires that supervisory chief officers be assisted by an aide[30] which will increase on-scene staffing to 16 personnel. If an engine company is used to support water supply operations and the Chief is provided with an aide, the minimum number increases to 17 personnel.

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[20] NFPA 1710, § 5.2.2.2.5

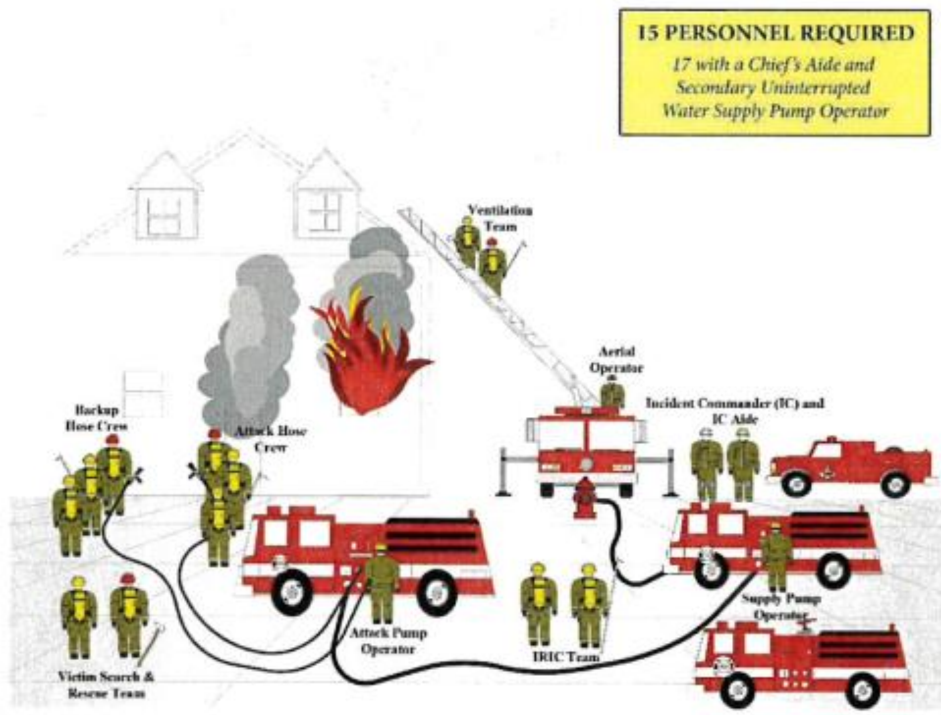

Figure 2: Initial Full Alarm Assignment Deployed Within 8 Minutes. The above figure depicts the full alarm assignment discussed in NFPA 1710, with an additional firefighter to act as an incident commander aide, and another additional firefighter to act as a pump operator for a supply apparatus. When personnel from fire apparatus must transition to ambulances to respond to EMS emergencies, available fire suppression resources are reduced.

In addition, NFPA 1710, §5.2.4.3.2 states, "The Fire Department shall have the capability for additional alarm assignments that can provide for additional command staff, members, and additional services, including the application of water to the fire; engagement in search and rescue, forcible entry, ventilation, and preservation of property; safety and accountability for personnel; and provision of support activities..."

The ability of adequate fire suppression forces to greatly influence the outcome of a structural fire is undeniable and predictable. Data generated by the NFPA provides empirical proof that a rapid and aggressive interior attack can substantially reduce loss of life and the loss of property associated with structural fires. Each stage of fire extension beyond the room of origin directly increases the rate of civilian deaths, injuries, and property damage.

Fire growth is exponential, growing in a non-linear manner over time. Extending the time for crew assembly by waiting for additional crews to arrive causes on-scene risk to escalate. The higher the risks at the time firefighters engage in fire suppression, the greater the chance of poor outcomes including civilian injury or death, firefighter injury or death, and increased property loss.

OSHA's "2 In/2 Out" Regulation

The "2 In/2 Out" regulation is part of paragraph (g) (4) of the United States Occupational Safety and Health Administration's revised respiratory protection standard, 29 CFR 1910.134. The focus of this section of the regulation is the safety of firefighters engaged in interior structural firefighting. OSHA's requirements for the number of firefighters required to be present when conducting operations in atmospheres that are immediately dangerous to life and health also covers the number of persons who must be on the scene before firefighting personnel may initiate an interior attack on a structural fire.[21] *An interior structural fire (an advanced fire that has spread inside of the building where high temperatures, heat and dense smoke are normally occurring) would present an IDLH atmosphere and, therefore, require the use of respirators. In those cases, at least two standby firefighters outside the structure, in addition to the minimum of two inside needed to fight the fire, must be present before firefighters may enter the building.*[22] *This requirement is mirrored in NFPA 1500, which states that "a rapid intervention team shall consist of at least two members and shall be available for rescue of a member or a team if the need arises. Once a second team is assigned or operating in the hazardous area, the incident shall no longer be considered in the 'initial stage,' and at least one rapid intervention crew shall be required."*

One of the most important elements in limiting fire spread is the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire as close to the point of origin as possible, as well as rescue any trapped occupants and care for the injured. Several existing National Fire Protection Association standards address this time-critical issue. NFPA Standard 1710 recommends that "fire companies whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue... shall be staffed with ***a minimum of four on-duty members****,"*[23] *except when, "In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members," or "In jurisdictions with tactical hazards, high hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members."*[24] *Suppression companies "... whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work... shall be staffed with a* ***minimum of four on-duty members****."*[25] *NFPA 1710 further states that ladder or truck companies "In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these fire companies shall be staffed with a minimum of five on-duty members," and "In jurisdictions with*

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[21] Paula O. White, letter to Thomas N. Cooper, 1 November 1995 (OSHA)
[22] According to NFPA standards relating to firefighter safety and health, the incident commander may make exceptions
to these rules if necessary to save lives. The Standard does not prohibit firefighters from entering a burning structure
to perform rescue operations when there is a "reasonable" belief that victims may be inside.
[23] NFPA 1710, § 5.2.3.1 and § 5.2.3.1.1
[24] NFPA 1710, § 5.2.3.1.2 and § 5.2.3.2.1
[25] NFPA 1710, § 5.2.3.2 and § 5.2.3.2.1

tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of six on-duty members."[26]

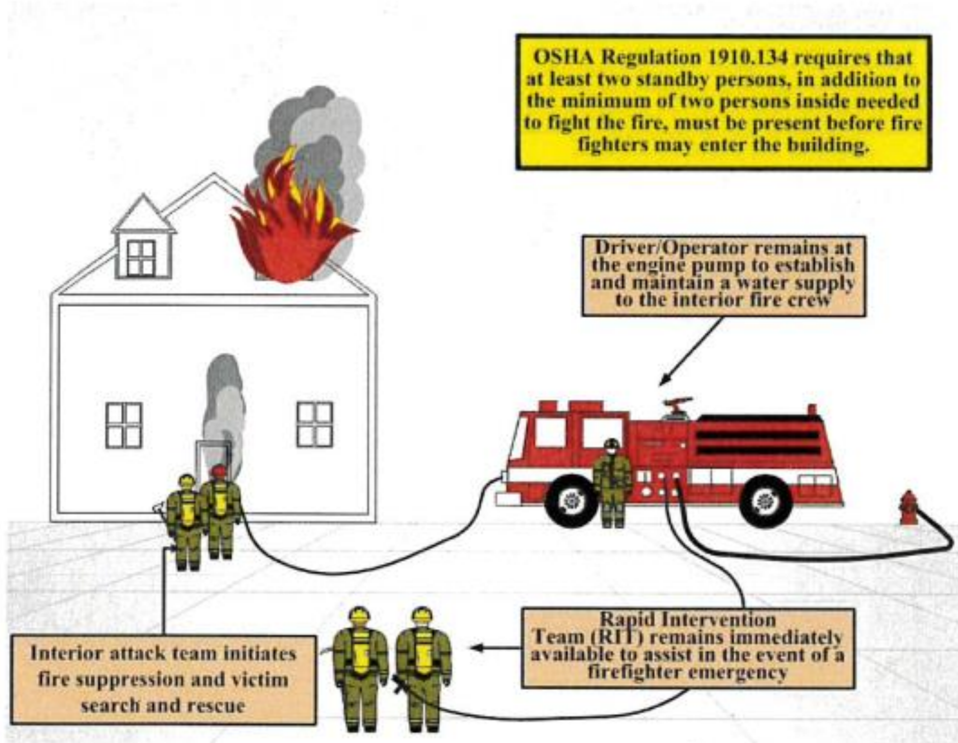

Figure 3: The OSHA "2 In/2 Out" Rule. The above figure depicts the number of firefighters required to meet OSHA regulation 1910.134, which demands one firefighter outside for every firefighter inside. In this sense the firefighters outside can support a secondary attack line and facilitate the rescue of trapped or disabled firefighters should the need arise. In this scenario the driver/operator of the apparatus is not counted towards the total number of firefighters.

A number of incidents exist in which the failure to follow the "2 In/2 Out" regulation have contributed to firefighter casualties. For example, in Bridgeport, Connecticut in July 2010, two firefighters died following a fire where NIOSH later found that although a "Mayday" was called by the firefighters, it wasn't responded to promptly as there was no Incident Safety Officer or Rapid Intervention Team (RIT) readily available on scene. In a second case, two firefighters were killed in a fire in San Francisco, California in June 2011. The initial RIT was re-assigned to firefighting duties, and the back-up RIT did not arrive on scene until after the victims were removed.

[26] NFPA 1710, § 5.2.3.2.2 and § 5.2.3.2.2.1

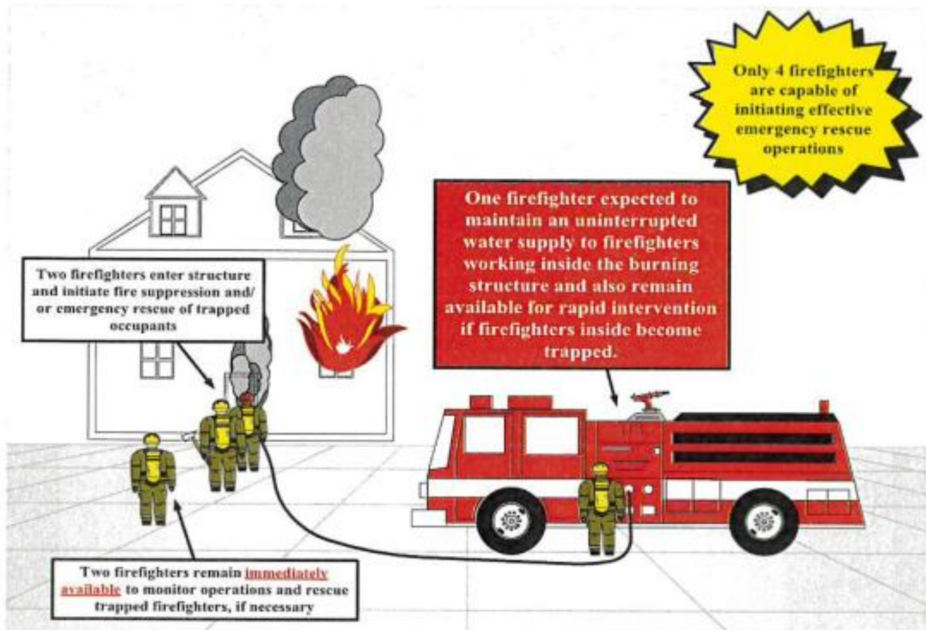

Figure 4: Emergency "2 In/2 Out" Operations. In the emergency model depicted above, the arriving fire apparatus is staffed with a crew of 4 personnel and operates under emergency conditions. In this case the driver/operator of the fire apparatus is also counted as a firefighter, which means he/she must be dressed in personal protective equipment (PPE) to be ready to participate in rescue if the need should arise. Analysis of BFD response capabilities found that Department resources (Engine 1 and at least one other company such as Medic 1) responding together from Headquarters could meet OSHA's "2 In/2 Out" requirements on 32.3%, assuming the Medic is available for response, of all roads in the total response area within 4 minutes travel. Because all career personnel respond from Headquarters this is the same as the total 4-minute response coverage time.

When confronted with occupants trapped in a burning structure and a single fire company is on scene, only a company staffed with four firefighters is able to initiate emergency search and rescue operations in compliance with the "2 In/2 Out" regulation. As indicated in the previous graphic, this requires the complete engagement of every firefighter from the first-in fire company, staffed with four, to participate in the effort, and means that the driver-operator of the apparatus must tend to the pump to ensure the delivery of water to the firefighters performing the initial attack and search and rescue operations and be prepared to make entry with the remaining firefighter should the crew operating inside become trapped.

Regardless, when there exists an immediate threat to life, only a company of four firefighters can initiate fire suppression and rescue operations in compliance with the "2 In/2 Out" regulation, and in a manner that minimizes the threat of personal injury. In crews with fewer than 4 firefighters, the first-in company must wait until the arrival of the second-in unit to initiate safe and effective fire suppression and rescue operations. This condition underlines the importance and desirability of fire companies to be staffed with four firefighters, and stresses the benefit of four-person companies and their ability to save lives without having to wait for the second-in company to arrive.

The Importance of Adequate Resources: Distribution

Distribution involves locating geographically distributed first-due resources for all-risk initial intervention. Stations should be located to assure rapid deployment for optimal response to routine emergencies within the response jurisdiction. Distribution can be evaluated by the percentage of the jurisdiction covered by the first-due units within adopted public policy service level objectives.[27] In this analysis, distribution is measured by the percentage of roads that are covered from each fire station within 4- and 8-minute travel times to adhere to NFPA 1710 standards.

A distribution study requires geographical analysis of first due resources. Distribution measures may include:[28]

- *Population per first due company*
- *Area served per first-due company (square miles)*
- *Number of total road miles per first-due company (miles)*
- *Dwelling unit square footage per first due company*
- *Maximum travel time in each first-due company's protection area*
- *Catchment areas (4-minute road response from all fire stations) to determine gap areas and overlaps of first-due resources*
- *Areas outside of actual performance*
    1. *Population not served*
    2. *Area not served (square miles)*
    3. *Road miles not served (miles)*
    4. *Dwelling unit square footage not served*
- *First-due unit arrival times (Engine, Truck, ALS unit, etc.)*

A major item to be considered in the distribution of resources is travel time. It should be a matter of public policy that the distribution of fire stations in the community is based on the element of travel time and the response goal. Travel time should be periodically sampled and analyzed to determine whether or not the fire department is achieving a reasonable response performance to handle emergencies.[29]

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[27] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.
[28] Ibid.
[29] Commission on Fire Accreditation International, 5th Edition. 2008. Page 53

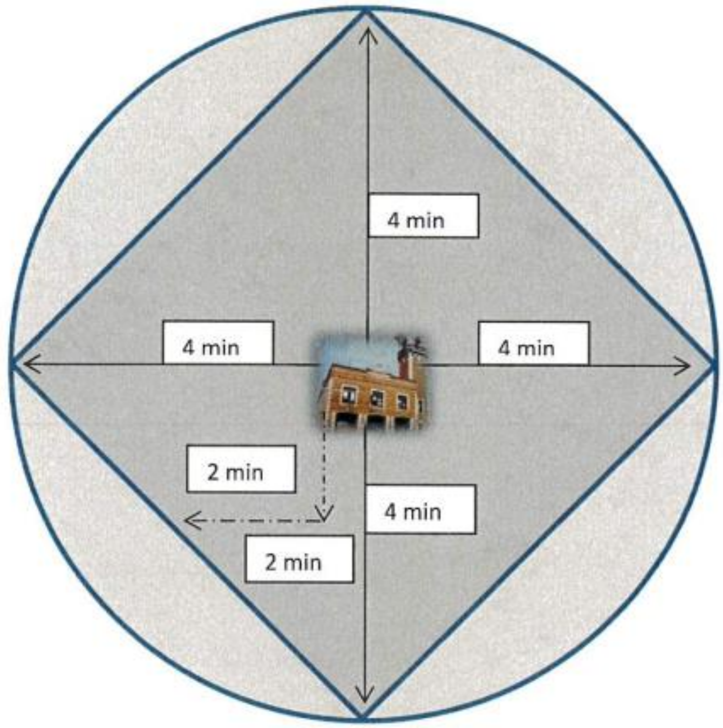

Figure 5: Normal distribution model for an initial 4-minute response area.[40] As depicted in the above figure, fire stations and emergency resources should be distributed throughout a community so that citizens receive equitable coverage and protection. However, there are additional points of concern when modeling a response district such as road network, traffic patterns, and building occupancies.

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Distribution strives for an equitable level of outcome: Everyone in the community is within the same distance from a fire station. Distribution is based on probabilities that all areas experience equal service demands, but not necessarily the same risk or consequences as those demands for service in other areas. For example suburban communities in the Town have the same service demand as an industrial factory area, but the level of risk is very different. This can have an impact on fire station locations as placement would probably put the stations near high risk areas with shorter travel times. But, would citizens in lower risk areas accept longer travel times? Additionally, EMS response times based on medical emergencies will drive equal distribution in the community and negate distribution based on risk, as the risk is equal.

First unit arrival times are the best measure of distribution. It should be noted that if an area experiences fire unit arrival times outside the adopted performance measure, in this case 4- minute travel time per NFPA 1710, it does not necessarily mean it has a distribution issue.[31] *Other issues occur*

[30] Derived from Commission on Fire Accreditation International, 5th Edition. 2008. Page 54
[31] Commission on Fire Accreditation International, 5th Edition. 2008. Page 55

such as reliability, call processing times and turnout times, and traffic which can affect the overall performance of response times.

An effective response force for a fire department is impacted not only by the spacing of fire stations but also by the type and amount of apparatus and personnel staffing the stations. To assemble the necessary apparatus, personnel, and equipment within the prescribed timeframe, all must be close enough to travel to the incident, if available upon dispatch. The placement and spacing of specialty equipment is always challenging.[32] Specialty units tend to be trucks, rescue units, hazmat, or command personnel. Most often there are less of these types of equipment and personnel compared to the first-line response of engines and medic units. Selecting where to put specialty units requires extensive examination of current and future operations within the fire department and a set goal of response time objectives for all-hazards emergencies within the Town.

Distribution vs. Concentration

Major fires have a significant impact on the resource allocation of any fire department. The dilemma for any fire department is staffing for routine emergencies and also being prepared for the fire or emergency of maximum effort. This balancing of distribution and concentration staffing needs is one that almost all fire agencies face on an ongoing basis. The art in concentration spacing is to strike a balance with respect as to how much overlap there should be between station areas. Some overlap is necessary to maintain good response times and to provide back-up for distribution when the first-due unit is unavailable for service or deployed on a prior emergency. Concentration pushes and pulls distribution. Each agency, after risk assessment and critical task analysis, must be able to quantify and articulate why its resource allocation methodology meets the governing body's adopted policies for initial effective intervention on both a first-due and multiple-unit basis.[33]

[32] Commission on Fire Accreditation International, 5Ul Edition. 2008. Page 62

[33] Commission on Fire Accreditation International, 5th Edition. 2008. Pages 62-63