URBAN FIRE FORUM
NATIONAL FIRE PROTECTION ASSOCIATION

FIRE SERVICE DEPLOYMENT:

Assessing Community Vulnerability

(2nd Edition-High-Rise Implementation Guide)

METROPOLITAN FIRE CHIEFS
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INTRODUCTION

Effectively managing a fire department requires an understanding of and an ability to demonstrate how changes to resources will affect community outcomes. It is imperative that fire department leaders, as well as political decision makers, know how fire department resource deployment in their local community affects community outcomes in three important areas: civilian injury and death; firefighter injury and death; and property loss. ***If fire department resources (both responding apparatus and personnel) are deployed to match the risk levels inherent to hazards in the community, it has been scientifically demonstrated that the community will be far less vulnerable to negative outcomes in all three areas.***

Fire Department Core Values

Protect lives, property, and the environment through preparedness, prevention, public education, and emergency response with an emphasis on quality services, efficiency, effectiveness, and safety.

Regis Tower, at 750 Adams Avenue in Memphis, Tennessee, is an 11-story concrete-and-steel high-rise building constructed in 1964. At 02:05 am on April 11, 1994, the central station monitoring service for the Regis Tower called the Memphis Fire Department to report an alarm indicating a trouble alarm on the ninth floor. Upon arrival, firefighters encountered heavy smoke and fire on the ninth floor. Fire companies made several attempts to rescue occupants and extinguish the fire from the interior. Two firefighters and two civilian occupants were killed.

BACKGROUND

Throughout North America many communities are experiencing geographic expansion, annexation, and regionalization, while many others continue to struggle in a sustained economic decline. These situations, both positive and negative, are causing decision makers to alter fire department resources faster than fire service leaders can evaluate their impact. These whirlwind decisions can leave a community without sufficient resources to respond to emergency calls safely, efficiently, and effectively. Effectively managing these challenges requires a basic understanding of how changes in levels of fire department resources deployed affect outcomes from emergencies that occur daily. Failing to manage these challenges can leave individuals, a fire department and a community vulnerable to undesirable events.

Out of necessity, today's Fire Service has taken on the role of "all hazards responders". Service expectations include fire suppression, Emergency Medical Services (EMS), response to natural disasters, response to hazardous materials incidents, response for technical rescue, response to active shooter events, and response to acts of terrorism. The number of responses for fire departments has steadily increased over time. Yet, often fire chiefs are faced with policies created by municipal officials who are challenged to balance community service expectations with finite budgetary resources and who do so without a solid technical foundation for evaluating the impact of staffing and deployment decisions on the safety of the public and firefighters. This is often a situation of planning fire department resources to budget rather than budgeting to the proper service delivery and deployment plan.

UNDERSTANDING THE NEED FOR COMMUNITY RISK ASSESSMENT

Traditionally, the focus of risk assessment was the identification of fire hazards and planning an appropriate suppression response force to mitigate the emergency. Today, hazard or risk assessment goes well beyond the fire problem to medical and other emergencies.

In light of this change, fire chiefs must assess a wide array of hazards, the risk level associated with an adverse event involving those hazards and the necessary resources for response to such an event. The resources (personnel and equipment) needed for the response must consider the outcomes mentioned previously.

- Civilian injury and death
- Firefighter injury and death
- Property loss

Community risk assessment begins with identification of the hazards present in the community. Given that a particular hazard exists in a community, the consequences of an emergency event (e.g. fire) in such a hazard are ultimately determined by the mitigation efforts. In other words, the consequences are the results of the combination of the risk level of the hazard, the duration and nature of the event, property loss (e.g. building damage or collapse), personal injury or loss of life, economic losses, interruption of business and related operations, and damage to the environment. These consequences are often grouped into four categories.

CONTRIBUTING FACTORS TO CONSEQUENCES OF COMMUNITY HAZARDS			
Injury and Loss of Life	**Property Damage/Loss**	**Critical Infrastructure Damage /Loss**	**Environmental Damage/Loss**
Population demographics (e.g., age)	Construction Date (modern light weight construction)	Agriculture and Food	Water / Hazardous Materials runoff
Community socio-economic status- income by type of household (census data)	Building materials	Water Mains and Hydrants	Air Quality from smoke (products of combustion)
Population distribution	Sprinklers present	Public Health Resources	Threats to trees, foliage, etc....
Population density (pop/sq. mi.)	Building type (high-rise or two-story etc...)	Emergency Services	Threats to wildlife

- **Human impacts** (civilian and firefighter injuries and deaths)
- **Economic impacts** (property loss both direct and indirect effects)
- **Psychological impact** (public confidence)
- **Functional impact** (continuity of operations)

Prior to proceeding to identification of hazards and their associated risks, the community type and related parameters should be defined. For the purpose of this document, metropolitan and urban communities will be considered.

- Metropolitan- designation means an incorporated or unincorporated area with a population of over 200,000 people and/or a population density over 3,000 people per square mile.

- Urban- designation means an incorporated or unincorporated area with a population of over 30,000 people and/or a population density over 2,000 people per square mile.

IDENTIFYING AND CATEGORIZING COMMUNITY RISKS

Community risk level is typically established through an overall profile of the community based on the unique mixture of demographics, socioeconomic factors, occupancy risk, fire management zones, and the level of services currently provided.

Consequences of community hazards, associated risk events, and fire department mitigation efforts may be divided into 4 categories.

- Civilian and firefighter injury or loss of life
- Property damage or loss
- Critical infrastructure damage or loss
- Environmental damage or loss

Each of these categories contains hazards and therefore risks relevant to emergency responders.

Characteristics of properties can have significant impact on outcome and associated response requirements. Each property or structure in a community can be considered a hazard that carries inherent risks based on occupancy type and fire load. Occupancy risk is a sublevel of property risk and is established through an assessment of the relative risk to life and property resulting from a fire inherent in a specific building/structure or in generic occupancy classes (e.g. high rise residential).

The *NFPA Fire Protection Handbook* defines hazard levels of occupancies by types[1].

- **High-Hazard Occupancies** – High-rise buildings, hospitals, schools, nursing homes, explosive plants, refineries, public assembly structures, and other high life hazard or large fire potential occupancies.

- **Medium-Hazard Occupancies** – Apartments, offices, mercantile and industrial occupancies that may require extensive use of fire fighting forces.

- **Low-Hazard Occupancies** – One-, two- or three-family dwellings and scattered small business and industrial occupancies.

Fire service leaders assess the number and location of each type of occupancy and its associated hazard level and then plan resource deployment to assure that sufficient fire department resources are dispatched to adverse events that occur in the occupancies.

Matching Resources to Risk

Following a community hazard/risk assessment, fire service leaders prepare a plan for timely and sufficient coverage of all hazards and the adverse risk events that occur. This plan is often referred to as a ***Standard of Response Coverage***.

Standards of response coverage can be defined as those written policies and procedures that establish the *distribution* and *concentration* of fixed and mobile resources of an organization[2].

Resource distribution is associated with geography of the community and travel time to emergencies. Distribution is typically measured by the percent of the jurisdiction covered by the first-due units within a specified time frame[3].

1 Fire Protection Handbook, 20th Edition, Copyright © 2008 NFPA
2 Fire & Emergency Service Self-Assessment Manual, 7th Edition, Copyright © 2006, Commission on Fire Accreditation International, CPSE, Inc.
3 NFPA Standard 1710 requires that a fire department's fire suppression resources be deployed to provide for the arrival of an engine company within a 240-second travel time to 90 percent of the incidents (NFPA 1710 – 5.2.4.1.1). The Standard further requires that fire departments shall have the capability to deploy an initial full alarm assignment within a 480-second travel tiem to 90 percent of the incidents (NFPA 1710 – 5.1.4.2.1).

Concentration is also about geography and the arranging of multiple resources, spacing them so that an initial "effective response force" can arrive on scene within the time frames established by community expectation and fire service leadership.

Response time goals for first-due units (distribution) and for the total effective on-scene emergency response force (concentration) drives fire department objectives like fire station location, apparatus deployed and staffing levels. The service level objectives established in any community drives response time performance by all responding resources and the assembly of effective firefighting (or EMS) response force on scene. Both response time performance and assembly times subsequently drive resource distribution and concentration. If response times and force assembly times are low, it is more likely that sufficient resources have been deployed which is associated with more positive outcomes from risk events. Conversely, if response times and force assembly times are high, it is more likely that insufficient resources have been deployed which is associated with more negative outcomes.

There are several other considerations that fire service leaders must take into account when preparing a standards of response coverage. These considerations should include an assessment of the probability or likelihood that a particular event will occur.

> This paper focuses on structure fires. According to NFPA, structures are an assembly of materials forming a construction for occupancy or use in such a manner as to serve a specific purpose. A building is a form of structure. Open platforms, bridges, roof assemblies over open storage or process areas, tents, air-supported, and grandstands are other forms of structures.[4]
>
> The structure fire problem continues to account for the vast majority of civilian casualties. National Fire Protection Association (NFPA) estimates show that, while structure fires account for only 35 percent of fires nationwide, they account for a disproportionate share of losses: 88 percent (2,640) of fire deaths, 89 percent (15,635) of fire injuries, and 83 percent ($9.7 billion) of direct dollar losses.[5]

FIRE DEPARTMENT OPERATIONAL PERFORMANCE

Fire department operational performance is a function of three considerations; resource availability/reliability, department capability and overall operational effectiveness.

- Resource Availability/Reliability is the degree to which the resources are ready and available to respond.
- Department Capability is the ability of the resources deployed to manage an incident.
- Operational Effectiveness is the product of availability and capability. It is the outcome achieved by the deployed resources or a measure of the ability to match resources deployed to the risk level to which they are responding[6].

The probability of any given unit's availability (or unavailability) is one indicator of the fire department's response reliability. Response reliability is defined as the probability that the required number of competently prepared staff and properly equipped apparatus will be available when a fire or emergency call is received. As the number of emergency calls per day increases, the probability that a needed piece of apparatus will be busy when a call is received also increases. Consequently, if the proper level of redundancy is not built into the system so that timely and adequate response to emergency calls can be maintained, the department's response reliability decreases.

To measure response reliability, all types of calls for service must be taken into account including hazardous materials response, wildland urban interface response, and response to natural, technological and manmade disasters. Today, EMS calls have a significant impact on the availability of fire department resources and should also be considered in the overall evaluation of department reliability. Response reliability can be determined from historical run data and is typically expressed as a per/company statistic, as well as an agency-wide statistic.

Fire department capability, as a measure of the ability of firefighters to respond, mitigate and recover from each emergency call, often depends on the time of dispatch, arrival of first responders and the assembly of an effective response force in relation to the magnitude of the risk event when they arrive. For example, some fires will be at an early stage and others may already have spread throughout an entire building. Therefore, when determining fire station location, apparatus placement and staffing levels, fire service leaders target a particular point of a fire's growth that marks a significant shift in its threat to life and property. The goal of resource deployment is to save the lives of occupants, minimize risk to firefighters by engaging prior to substantial risk escalation, and to protect property and the environment.

ON SCENE RISK ESCALATION

During the growth stages of a residential fire, flashover is a significant event. Preventing this stage of fire behavior is a factor in establishing fire department resource needs. When flashover occurs, in that instant, everything in the room erupts into open flame. This eruption of flame generates a tremendous amount of heat, smoke and pressure with enough force to push the fire

4 National Fire Protection Association (NFPA) Estimates. Fire Estimates 2011. http://www.usfa.fema.gov/statistics/estimates/nfpa/, August 2013.
5 NFPA, Fires in the United States During 2011. One-Stop Data Shop, Fire Analysis and Research Division, NFPA 2013.
6 National Fire Service Data Summit Proceedings, U.S. Department of Commerce, NIST Tech Note 1698, May 2011

On October 17, 2003, a fire on the 12th floor of the 37-story of the Cook County Administration Building in Chicago, Illinois resulted in 6 civilian fatalities. The fire originated in a closet within a 2629 sq ft (244 m2) suite of offices on the east side of the 12th floor. Upon arrival, firefighters were faced with an intense fire that they were unable to extinguish from an interior hallway position. Elevated master streams were used to knock down the fire from the exterior. Interior hose streams were then redeployed to achieve final extinguishment.

through doors and windows and beyond the room of origin. Flashover is a significant stage of fire growth for several reasons. First, the likelihood of survival and the chance of saving any occupants trapped drops dramatically. Second, flashover creates an exponential increase in the rate of combustion as well as the risk to the health and safety of firefighters. Third, a considerably greater amount of water is needed to extinguish the burning material. Fourth, a greater number of firefighters are required to handle the fire spread to different locations in the structure and the larger hose streams now necessary to extinguish the fire.

Finally, science shows that post flashover, the fire is less survivable even for firefighters in their protective gear. Everything is more hazardous and more difficult for firefighters as risks increase… the bigger the fire, the higher the risk.[7] Post flashover, the fire burns hotter and grows faster as time progresses thus compounding the search and rescue task in the remainder of the structure, again requiring a greater number of firefighters to mitigate the incident. Regardless of whether a structure is conducive to flashover, fire growth is the primary factor that drives the need for sufficient resources available to intervene.

The dynamics of fire growth and the associated potential for risk escalation dictate various configurations of fire station locations and firefighter staffing patterns. Understanding fire behavior, particularly flashover, is key to designing an emergency response system so that a sufficient number of firefighters and equipment are strategically located throughout the community to assure that the minimum acceptable response force can be assembled to engage in a fire before flashover (or substantial risk escalation) occurs. Therefore, to save lives and limit property damage, firefighters must be properly trained and arrive at the right time with adequate resources to do the job.

In emergency medical response, there is a similar perspective. The same need to intervene early to stop the progression or escalation of a risk event can be noted in firefighter/EMT and Paramedic response to cardiac or traumatic emergencies. For example in a heart attack that progresses to a cardiac arrest where a victim becomes pulseless and stops breathing, there is a six minute window of opportunity to intervene. Without intervention from bystanders or first responders arriving in a timely manner, irreversible brain damage will ensue. The same is true for badly injured victims of trauma where blood loss is significant, without appropriate intervention, the emergency continues to escalate to a point of irreparable damage or death.

EFFECTIVE RESPONSE FORCE

An effective response force is defined as the minimum number of firefighters and equipment that must reach a specific emergency incident location within a maximum prescribed travel [driving] time[8]. The maximum prescribed travel time acts as one indicator of resource deployment efficiency.

There is a need to deploy adequate resources to each individual fire or emergency incident. A single incident still requires sufficient resources to extinguish the fire, conduct search and rescue, overhaul to assure that the fire has not spread, and salvage property. The total number of fires and other emergency incidents occurring annually in a community should not be the sole driver of crew size, overall staffing or on scene assembly needs.

Prior to an incident, appropriate resources should be made available to respond to emergency events. Cost effective resource decisions require detailed information on the cost/benefit profile of possible resource investments, including number and location of fire stations, number, type, and location of fire apparatus, firefighter staffing levels, and pre-planned alarm assignments. Resource allocation may also address community infrastructure such as fire hydrants and building inspections[9].

As discussed previously, fire department response capability and capacity is a function of the community's resource allocation and is a significant determinant in the degree of vulnerability of a community to unwanted fires and other emergencies. Naturally, a community with a sizeable and effective firefighting force, for example, would be less vulnerable to the large negative consequences of an unwanted fire than would a community with fewer resources allocated. Recognizing this phenomenon, the remainder of this paper will examine the tools available for minimizing the consequences of unwanted fires and other emergencies in a community by matching the allocation of fire department resources to the risk profile of a community.

MATCHING RESOURCES TO RISKS — TOOLS FOR DECISION MAKING

Once the details of risks/hazards are known for a community, the fire department can plan and deploy adequate resources to either manage the known risks or respond and mitigate the emergency when an adverse risk event like an unwanted fire, hazardous

7 Averill et.al., Report on High-Rise Fireground Field Experiments, U.S. Department of Commerce, NIST Tech Note 1797, April 2013.
8 Fire & Emergency Service Self-Assessment Manual, 8th Edition, Copyright © 2011, Commission on Fire Accreditation International, CPSE, Inc.
9 Hamins, A., et.al., Reducing the Risk of Fire in Buildings and Communities: A Strategic Roadmap to Guide and Prioritize Research. U.S. Department of Commerce, NIST Special Publication 1130. April 2012.

materials incident, natural or man-made disaster, wildland fire, or medical emergency occurs.

For example, when considering resource deployment decisions, regardless of the size of a burning structure, firefighting crews must engage in four priorities;

- Life safety of occupants and firefighters
- Confinement and extinguishment of the fire
- Property conservation
- Reduction of adverse environmental impact

Interdependent and coordinated activities of all fire fighting personnel deployed are required to meet these priority objectives. There are a number of tasks related to each of the priorities and these tasks (e.g., stretching a hose line to the fire, ventilation, search and rescue) can be conducted simultaneously, which is the most efficient manner, or consecutively (one after the other), which delays some task(s) thereby allowing risk escalation, explained earlier, to occur.

There are a number of resources available to assist political decision makers and fire service leaders in planning for adequate resource deployment in their community to assure that firefighter intervention in a risk event occurs in a timely and coordinated manner to limit risk escalation and negative outcomes. Each of these resources is explained below.

NFPA Standard 1710 specifies the number of on-duty fire suppression personnel sufficient to carry out the necessary fire fighting task operations given expected fire fighting conditions in various hazard level occupancies. Though 1710 specifically addresses low hazard environments, it also mentions medium and high hazard levels as well. Helpful excerpts from the 1710 Standard are below[10].

- **5.2.2* Staffing.** The number of on-duty fire suppression personnel shall be sufficient to perform the necessary fire-fighting operations given the expected fire-fighting conditions.

- **5.2.2.1** These numbers shall be determined through task analyses that take the following factors into consideration:
  (1) Life hazard to the populace protected
  (2) Provisions of safe and effective fire-fighting performance conditions for the fire fighters
  (3) Potential property loss
  (4) Nature, configuration, hazards, and internal protection of the properties involved
  (5) Types of fireground tactics and evolutions employed as standard procedure, type of apparatus used, and results expected to be obtained at the fire scene.

- **5.2.2.2.1*** The fire department shall identify minimum company staffing levels as necessary to meet the deployment criteria required in 5.2.4 to ensure that a sufficient number of members are assigned, on duty, and available to safely and effectively respond with each company.

- **5.2.3 Operating Units.** Fire company staffing requirements shall be based on minimum levels necessary for safe, effective, and efficient emergency operations.

- **5.2.3.1** Fire companies whose primary functions are to pump and deliver water and perform basic fire fighting at fires, including search and rescue, shall be known as engine companies.

- **5.2.3.1.1** These companies shall be staffed with a minimum of four on-duty personnel.

- **5.2.3.1.2** In jurisdictions with tactical hazards, high-hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors as identified by the AHJ, these companies shall be staffed with a minimum of five or six on duty members.

- **5.2.3.2** Fire 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 known as ladder or truck companies.

- **5.2.3.2.1** These companies shall be staffed with a minimum of four on-duty personnel.

- **5.2.3.2.2** In jurisdictions with tactical hazards, high-hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors as identified by the AHJ, these companies shall be staffed with a minimum of five or six on duty personnel.

- **5.2.4 Deployment.**

- **5.2.4.1 Initial Arriving Company.**

- **5.2.4.1.1** The fire department's fire suppression resources shall be deployed to provide for the arrival of an engine company within a 240-second travel time to 90 percent of the incidents as established in Chapter 4.

- **5.2.4.1.2*** Personnel assigned to the initial arriving company shall have the capability to implement an initial rapid intervention crew (IRIC).

- **5.2.4.2 Initial Full Alarm Assignment Capability.**

- **5.2.4.2.1** The fire department shall have the capability to deploy an initial full alarm assignment within a 480-second travel time to 90 percent of the incidents as established in Chapter 4.

- **5.2.4.2.3*** Fire departments that respond to fires in high-, medium-, or low-hazard occupancies that present hazards greater than those found in the low-hazard occupancy described in 5.2.4.2.2 shall deploy additional resources on the initial alarm.

10 NFPA 1710- 2010, Organizational and Deployment of Fire Suppression Operations, emergency Medical Operations, and Special Operations to the Public by Career Fire Departments, Copyright © 2010, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.

• **5.2.4.3 Additional Alarm Assignments.**

• **5.2.4.3.1*** The fire department shall have the capability to deploy additional alarm assignments that can provide for additional command staff, personnel, 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 for those situations that are beyond the capability of the initial full alarm assignment.

• **5.3.3 EMS System Functions.**

• **5.3.3.1** The AHJ shall determine which of the following components of an EMS system the fire department shall be responsible for providing:
(1) Initial response to provide medical treatment at the location of the emergency (first responder with AED capability or higher)
(2) BLS response
(3) ALS response
(4) Patient transport in an ambulance or alternative vehicle designed to provide for uninterrupted patient care at the ALS or BLS level while en route to a medical facility
(5) Assurance of response and medical care through a quality management program

• **5.3.3.2 Staffing.**

• **5.3.3.2.1** On-duty EMS units shall be staffed with the minimum personnel necessary for emergency medical care relative to the level of EMS provided by the fire department.

On September 24, 2010, a six-alarm fire at a downtown Toronto high-rise building resulted in 14 people being sent to hospital and left an estimated 1,200 people temporarily homeless. Eight adult civilians, three firefighters and three children required medical care, while an additional 10 firefighters were treated for heat exhaustion. The growth of the fire was attributed to extreme fuel loading in one apartment. Ontario Fire Marshal described the fire fuel load as one of the worst hoarding fires in Canada. Firefighters deemed the fire one of the hottest and most deep-seated fires they had ever fought and high winds made matters worse.

• **5.3.3.3.2** The fire department's EMS for providing a first responder with AED shall be deployed to provide for the arrival of a first responder with AED company within a 240-second travel time to 90 percent of the incidents as established in Chapter 4.

• **5.3.3.3.3*** When provided, the fire department's EMS for providing ALS shall be deployed to provide for the arrival of an ALS company within a 480-second travel time to 90 percent of the incidents provided a first responder with AED or BLS unit arrived in 240 seconds or less travel time as established in Chapter 4.

• **5.3.3.3.4** Personnel deployed to ALS emergency responses shall include a minimum of two members trained at the emergency medical technician–paramedic level and two members trained at the emergency medical technician–basic level arriving on scene within the established travel time.

The Fire Protection Handbook is a preeminent resource guide for the fire service. The *Handbook* identifies initial attack response capabilities for low, medium, and high hazard occupancies. [11]

- **High-Hazard Occupancies** – High-rise buildings, hospitals, schools, nursing homes, explosive plants, refineries, public assembly structures, and other high life hazard or large fire potential occupancies.
- **Operations response capability** - at least 4 pumpers, 2 ladder trucks (or combination apparatus with equivalent capabilities), 2 chief officers and other specialized apparatus as may be needed to cope with the combustible involved; not less than 24 firefighters and 2 chief officers plus a safety officer and a rapid intervention team.
- **Medium-Hazard Occupancies** – Apartments, offices, mercantile and industrial occupancies not normally requiring extensive use of fire fighting forces.
- **Operations response capability** - at least 3 pumpers, 1 ladder truck (or combination apparatus with equivalent capabilities) 1 chief officer and other specialized apparatus as may be needed or available; not less than 16 firefighters and 1 chief officer plus a safety officer and a rapid intervention team.
- **Low-Hazard Occupancies** – One-, two- or three-family dwellings and scattered small business and industrial occupancies.
- **Operations response capability** – at least 2 pumpers, 1 ladder truck (or combination apparatus with equivalent capabilities), 1 chief officer and other specialized apparatus as may be needed or available; not less than 12 firefighters and 1 chief officer plus a safety officer and a rapid intervention team.

11 Fire Protection Handbook, 20th Edition, Copyright ©2008 NFPA

NFPA Standard 1600 - Standard on Disaster/Emergency Management and Business Continuity Programs - Community preparedness programs should, at a minimum, incorporate all elements identified in NFPA 1600. The program should also consider day-to-day emergency operations. If a jurisdiction can't appropriately handle everyday incidents, they certainly won't be able to handle a large, catastrophic incident. The entity should develop and implement a strategy to eliminate identified hazards or mitigate the effects of those hazards. The mitigation strategy will be based on results of the hazard identification and risk assessment, impact analysis, programs assessment, operational experience, and cost-benefit analysis. The mitigation strategy should consider, at the least, redundancy or duplication of essential personnel, critical systems, equipment, information, operations, and material.[12]

United States Department of Labor - Occupational Safety and Health Administration – OSHA Regulation "2 in 2 out"- The "2 In/2 Out" policy is part of paragraph (g)(4) of OSHAs revised respiratory protection standard, 29 CFR 1910.134. This paragraph applies to private sector workers engaged in interior structural fire fighting and to Federal employees covered under Section 19 of the Occupational Safety and Health Act. States that have chosen to operate OSHA-approved occupational safety and health state plans are required to extend their jurisdiction to include employees of their state and local governments.

OSHAs interpretation on requirements for the number of workers required to be present when conducting operations in atmospheres that are immediately dangerous to life and health (IDLH) covers the number of persons who must be on the scene before fire fighting personnel may initiate an attack on a structural fire. 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 persons, in addition to the minimum of two persons inside needed to fight the fire, must be present before fire fighters may enter the building.[13] This regulation allows an exception for rescue operations conducted in the event of an imminent life-threatening situation where immediate action could prevent the loss of life or serious injury.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program was developed to provide a consensus standard for an occupational safety and health program for the fire service. The intent of this standard is to provide the framework for a safety and health program for a fire department or any type of organization providing similar services. This standard sets the minimum safety guidelines for personnel involved in rescue, fire suppression, emergency medical services, hazardous materials operations, and special operations (§ 1-2.1). The standard is designed to help prevent and reduce the severity of accidents, injuries and exposures (§ 1-2.2). Specifically, the standard addresses the following: the organization of a safety and health program, the training requirements of personnel, maintenance and operation requirements of vehicles and equipment, protective clothing requirements, emergency operations management, medical and physical requirements of fire fighters, and wellness programs[14].

- **8.5.17** Initial attack operations shall be organized to ensure that if, on arrival at the emergency scene, initial attack personnel find an imminent life-threatening situation where immediate action could prevent the loss of life or serious injury, such action shall be permitted with less than four personnel when conducted in accordance with 8.5.5.

- **8.5.17.1** No exception as permitted in 8.5.17 shall be allowed when there is no possibility to save lives.

- **8.5.17.2** Any such actions taken in accordance with 8.5.17 shall be thoroughly investigated by the fire department with a written report submitted to the fire chief.

- **8.5.5** Crew members operating in hazardous areas shall be in communication with each other through visual, audible, or physical means or safety guide rope, in order to coordinate their activities.

> On August 18, 2007 the 41-story Deutsche Bank was undergoing deconstruction and asbestos abatement due to the damage sustained after the collapse of the World Trade Center Buildings on September 11th, 2001. In the process of deconstruction, the building layout included maze-like partitions installed to prevent the spread of asbestos during abatement. The standpipe system was also being disassembled. A fire broke out at 3:30 pm on the 17th floor, with an initial first alarm being sent at 3:37 pm. After confirmation of the fire, a full alarm response was sent along with additional units plus an additional second alarm response. As a result of the high risk environment, 115 firefighters were injured and two firefighters were killed.

12 NFPA 1600 – 2013, Standard on Disaster/Emergency Management and Business Continuity Programs, Copyright ©2013, National Fire Protection Association, Quincy, MA. This material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.
13 Letter to Thomas N. Cooper, Purdue University, from Paula O. White, Director of Federal-State Operations, U.S. Department of Labor, Occupational Safety & Health Administration, November 1, 1995.
14 NFPA 1500- 2007, Fire Department Occupational Safety and Health Program, Copyright ©2007, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.

NIST Research on Fire Spread

As land prices continue to rise, homes are being built closer together, many without fire-resistant materials or built in fire suppression systems. Building officials and firefighters need information about the rate of fire spread in communities under various house spacing, construction methods and materials, and weather conditions. Fire service leaders also have to understand the time required for fire spread from one house to another in order to provide adequate response.

In a 2004 series of full-scale laboratory experiments at the National Institute of Standards and Technology (NIST)[15], it took less than 80 seconds for flames exiting from a simulated house with combustible exterior walls and a window to ignite a similar "house" just 6 feet (1.8 meters) away. The experiments were conducted at the NIST Large Fire Facility. The tests, along with additional tests conducted with more fire-resistant structures, are part of a program to develop computer models for predicting the spread of fire in residential communities.

Each experiment conducted at NIST involved two 16-foot structures clad in vinyl siding with windows that simulated neighboring houses. In the tests, typical home furnishings were ignited in one "home" and the fire spread was recorded, along with heat release rates and other data. In less than five minutes, flames shattered the window of the home with the original fire, spread across the gap, and ignited the exterior of the second structure.

NIST Research on Wind Driven Fires

Together with the Fire Department of New York City (FDNY), the Polytechnic Institute of New York University, and with funding from the Department of Homeland Security Federal Emergency Management Agency Assistance to Firefighters Research and Development Grant Program and the United States Fire Administration, researchers conducted a series of wind-driven fire experiments in a seven-story building on Governors Island, New York, in February 2008.[16]

The objective of these experiments was to improve the safety of firefighters and building occupants by developing a better understanding of wind-driven fires and wind-driven firefighting tactics, including structural ventilation and suppression. The results of the study showed that positive pressure ventilation (PPV) fans alone could not overcome the effects of a wind driven condition. However when used in conjunction with door control, wind control devices (WCDs), and floor below nozzles (FBN), the PPV fans were able to maintain tenable and clear conditions in the stairwell. Results also showed that the WCDs reduced the temperatures in the corridor and the stairwell by more than 50 % within 120 seconds of deployment. The WCDs also completely mitigated any velocity due to the external wind. The WCDs were exposed to a variety of extended thermal conditions without failure. Finally, the results showed that water flow suppressed the fires, thereby causing reductions in temperature in the corridor and the stairwell of at least 50 %. The water flow rates used in these experiments were between 160 gpm and 200 gpm, demonstrating that a relatively small amount of water applied directly to the burn fuels can have a significant impact.

These experimental results indicate that the post deployment thermal conditions for flow path control using a WCD, after the development of wind driven conditions, were still of a level which could pose a hazard to firefighters in full PPE. However, when used in combination with PPV fans to force cool air into the stairwell and out through the fire floor, and/or with the cooling effect from an externally applied water stream, the fire floor temperatures can be reduced to near ambient conditions in a matter of minutes.

The experiments also provided potential guidance for firefighters as a part of a fire size up and their approach to the room of fire origin noting that wind conditions in the area of the fire may cause "pulsing flames", or flames not exiting a window opening. Firefighters should examine smoke conditions around closed doors and maintain control of doors in the potential flow path. The study found that even if flames are being forced out of adjacent windows with a high amount of energy, there could still be sufficient energy flows on the fire floor to create a hazard for firefighters. The data from this research will also help to identify fire fighting strategies to improve standard operating guidelines (SOG) for the fire service to enhance firefighter safety, fire ground operations, and use of equipment.

NIST Studies: How Resource Allocation Can Change Community Fire Risk

Given the occurrence of a residential fire (low hazard) or high-rise fire (high hazard), deployment of firefighting resources is a primary line of defense. The effectiveness of the fire department response (or consequences of the fire) will be a function of the number of firefighters deployed and their arrival time.

NIST RESIDENTIAL FIREGROUND FIELD EXPERIMENTS

In 2010, a partnership of fire safety organizations[17] conducted studies to establish the relationship between resource allocation and fire risk for a range of residential fire scenarios and firefighter deployment configurations. The full "Report on Residential Fireground Field Experiments" (NIST Technical Note 1661) can be found at www.firereporting.org.[18]

As an example from the 2010 experiments, consider two different resource deployment configurations. Resource Allocation (A) is designed by community leaders to deploy to the residential fire three engines and one truck, Battalion Chief and aide, with first-due engine arriving 4 minutes after the call arrives at the dispatch, each with four-person companies onboard. The firefighters conduct standard fireground operations, including

15 Maranghides, A., et.al., NIST Lab Experiments Simulate House-to-House Fire Spread, NIST, November 2004 http://www2.bfrl.nist.gov/userpages/wmell/PUBLIC/WUI/House_to_House_Fire_NIST_Fact_Sheet.pdf. August 2013.

16 Madrzykowski, D., Kerber, S., Fire Fighting Tactics Under Wind Driven Fire Conditions: 7-Story Building Experiments. U.S. Department of Commerce, NIST Tech Note 1629, April 2009.

17 The partnership included the International Association of Fire Chiefs (IAFC), the International Association of Fire Fighters (IAFF), the National Institute of Standards and Technology (NIST), Worcester Polytechnic Institute (WPI), the Urban Institute (UI), and the Center for Public Safety Excellence (CPSE).

18 Averill et.al., Report on Residential Fireground Field Experiments, U.S. Department of Commerce, NIST Tech Note 1661, April 2010.

occupant search-and-rescue, ventilation, and suppression. For comparative purposes, consider an alternative resource allocation. Resource allocation (B) is designed by community leaders to deploy to the residential fire three engines and one truck, Battalion Chief and aide, with the first-due engine arriving six minutes after the call arrives at the dispatch, each with two-person companies onboard. The two-person crews conduct the same standard fireground operations as the four-person crews, including occupant search-and-rescue, ventilation, and suppression. As shown in Table 1, for a "typical" fire growth rate,[19] the resulting fire risk for the community is expected to be quite different based on the chosen deployment configurations.

Table 1 clearly shows the expected changes in the consequences resultant from the same fire hazard when the resource allocation provided by the community is changed. The fire department deploying with Resource Allocation (A) would likely rescue trapped occupants, including susceptible populations such as the young and elderly, prior to incapacitation or death. Additionally, the fire department would likely contain the fire to the room of origin since suppression activities commenced prior to the onset of room flashover. Resource Allocation (B), which deploys fewer firefighters who arrive later in the development of the fire, is likely to find an occupant who is incapacitated or dead as a result of exposure to toxic gases. Additionally, the fire at the time of suppression operations is at the threshold for room flashover, which significantly increases the likelihood of fire spread beyond the room of origin and the likelihood of thermal injuries to the suppression team.

NIST HIGH-RISE FIREGROUND FIELD EXPERIMENTS

In 2012, the same partnership of fire safety organizations[21] conducted experiments to establish the relationship between resource allocation and fire risk for a high-rise structure. The full "Report on High-Rise Fireground Field Experiments" (NIST Technical Note 1797) can also be found at www.firereporting.org.[22]

NIST HIGH-RISE FIELD EXPERIMENT REPORT EFFECTS ON FIRE DEVELOPMENT

Overall, the results of this study show that the number of fire service crew members in each company responding to a fire had a dramatic effect on the crew's ability to protect lives and property. When responding to a medium growth rate fire on an upper floor of a high-rise structure, 3-person crews ascending to the fire floor confronted an environment where the fire had released 60% more heat energy than the fire encountered by the 6-person crews. Larger fires expose firefighters and occupants to greater risks and are more challenging to extinguish.

Overall, the results of this study show that the number of fire service crew members in each company responding to a high-rise fire had a dramatic effect on the crew's ability to protect lives and property. When responding to a medium growth rate fire on an upper floor of a high-rise structure, 3-person crews ascending to the fire floor confronted an environment where the fire had released 60% more heat energy than the fire encountered by the 6-person crews. Larger fires expose firefighters and occupants to greater risks and are more challenging to extinguish.

Table 1: Consequences of a Residential fire as a function of fire resource allocation

Hazard	Resource Allocation		Consequences	
			Occupant	Fire Size
Medium t-square fire on first floor of a 2,000 sf, two-story, single family residence	A	4-person company Total Effective Force 18 First engine – 6.5 minutes* Full alarm – 9.5 minutes	FED[20] = 0.11	1.5 MW
	B	2-person company Total Effective Force – 10 First Engine: 8.5 minutes** Full alarm – 11.5 minutes	FED = 1.37	2.1 MW

* assumes 2.5 minutes from fire ignition until the first fire truck leaves the station and 4 minutes travel time.
** assumes 2.5 minutes from fire ignition until the first fire truck leaves the station and 6 minutes travel time.

19 For this example, the "medium t-square fire growth rate" is assumed. More information on standardized fire growth rates can be found in NIST Tech Note 1661 or the SFPE Handbook of Fire Protection Engineering.

20 In order to convert instantaneous measurements of local gas conditions, the fractional effective dose (FED) formulation published by the International Standards Organization (ISO) in document 13571 Life-threatening Components of Fire – Guidelines for the Estimation of Time Available for Escape Using Fire Data (ISO 2007) were used. FED is a probabilistic estimate of the effects of toxic gases on humans exposed to fire effluent. There are three FED thresholds generally representative of different exposure sensitivities of the general population. An FED value of 0.3 indicates the potential for certain sensitive populations to become incapacitated as a result of exposure to toxic combustion products. Sensitive populations may include elderly, young, or individuals with compromised immune systems. Incapacitation is the point at which occupants can no longer effect their own escape. An FED value of 1.0 represents the median incapacitating exposure.

21 The partnership included the International Association of Fire Chiefs (IAFC), the International Association of Fire Fighters (IAFF), the National Institute of Standards and Technology (NIST), Worcester Polytechnic Institute (WPI), the Urban Institute (UI), and the Center for Public Safety Excellence (CPSE).

22 Averill et.al., Report on High-Rise Fireground Field Experiments, U.S. Department of Commerce, NIST Tech Note 1797, April 2013.

Getting the fire out is critical to reducing risk to both firefighters entering the structure and to trapped occupants. Fire Out, in the study, was defined as having both the attack line and the second hose line in place. There was a 2 minutes 14 s difference (8.1 %) in the Fire Out time between the 3- and 4-person crews. There was an additional 1 minute 15 s difference (5.0 %) in the Fire Out time between the 4- and 5-person crews. (i.e., 5-person crews extinguished the fire 3 minutes 29 s faster than 3-person crews). Finally, there was a 7 minutes 2s difference (25.6 %) in the Fire Out time between the 3- and 6-person crews.

The fire floor in the study was an open floor plan and contained 96 cubicles. In the high hazard high-rise commercial building, the 4-person crew started the search 1 minute 23 s (7.8 %) faster and completed the search and rescue 11 minutes 21 s (18.4 %) faster than the 3-person crews. In the same structure, the 5-person crews started the search 1 minute 4 s (6.7 %) faster than the 4-person crews and 2 minutes 27 s (14.1%) faster than the 3-person crew. Additionally, 5-person crews completed the search faster than the 4- and 3-person crews by 13 minutes 34 s (29 %) and 24 minutes 55 s (42 %) respectively. Six-person crews had the best performance, starting the search 1 minute 19 s faster and completing the search 2 minutes 57 s (8.0%) faster than 5-person crews. The greatest difference in search times was between 6- and 3-person crews. Six-person crews started the search on the fire floor 3 minutes 46 s (22 %) faster and completed the search 27 minutes 51 s (47 %) faster than the 3-person crews.

There was a single victim located on the fire floor that was found and rescued by all crews. A 5-person crew located the victim on the fire floor 25 minutes 19 s (50.6 %) faster than a 3-person crew and 12 minutes 7 s (32.9 %) faster than a 4-person crew. Likewise, a 6-person crew located the victim on the fire floor 28 minutes 33 s (57.1 %) faster than the 3-person crew, 15 minutes 21 s (41.7 %) faster than the 4-person crew, and 3 minutes 14 s (13.2 %) faster than a 5-person crew.

Overall scene time is the time that firefighters are actually engaged in tasks on the scene of a structure fire. During the experiments, this time included all operational tasks with the exception of overhaul and salvage. The time to completion of all tasks decreases as crew size increases. On average, 3-person crews took nearly an hour to complete their fire response, while crews of 6 firefighters required a mean time of just under 40 minutes for completion. The performance of crews sized 4 and 5 were in-between, with crew size 5 taking about 2 minutes longer than crew size 6, and crew size 4 taking about 9 minutes longer than crew size 5 but 12 minutes less than crew size 3. Therefore, the time to complete all task times are substantially reduced for crew size of 6 compared to 5, 5 compared to 4, and 4 compared to 3.

To characterize the accumulated hazard associated with inhalation of gases typical of combustion products, a time-integrated value known as the fractional effective dose (FED) was used in the NIST experiments. FED is an international standard, maintained by the International Standards Organization (ISO) and documented in ISO document 13571. FED is a probabilistic quantity used to estimate the impact of toxic gases on humans[23]. For this study, FED included the impact of excess carbon monoxide and carbon dioxide inhalation and oxygen depletion. Additional gases such as cyanide, nitric oxide and irritants were not included in the calculation of the FED value as they tend to be of secondary importance compared to carbon monoxide, carbon dioxide, and oxygen.

There are three FED thresholds – 0.3, 1.0 and 3.0. The lowest FED threshold is 0.3, which typically relates to the most sensitive populations: elderly, young, or those with compromised immune systems. The lowest threshold group encompasses approximately 11 % of the population. The second threshold occurs at an FED value of 1.0, which represents the level at which the median or 50 % of the population is likely to become incapacitated. An FED value of 3.0 represents the upper threshold for tolerance to combustion gas inhalation. Only the most physically fit in society can survive 3.0 (the likelihood for incapacitation is greater than 89 %).

The high-rise study saw a significant reduction in the FED when crew size increased and response time decreased. For both 3-person and 4-person crews, a significant area on the fire floor was above an FED of 1.0. The 5-person and 6-person crews encounter FED levels above 0.3, but no regions increased above an FED of 1.0.

23 ISO 13571: Life-threatening Components of Fire — Guidelines for the Estimation of Time Available for Escape Using Fire Data. (2007). International Standards Organization, Geneva.
24 Commission on Fire Accreditation International (CFAI), http://www.publicsafetyexcellence.org/agency-accreditation/about-accreditation-cfai.aspx , October 2013.
25 ISO Community Fire Suppression, Fire Suppression Rating Schedule, http://www.isopropertyresources.com/Products/Community-Mitigation-Classifications/Community-Fire-Suppression.html, October 2013.

Figure 1: Visualization of HRR for a medium growth fire for a 3-person crew using the stairs (left) and a 6-person crew using the elevators (right) at the time firefighters make entry to the floor˜

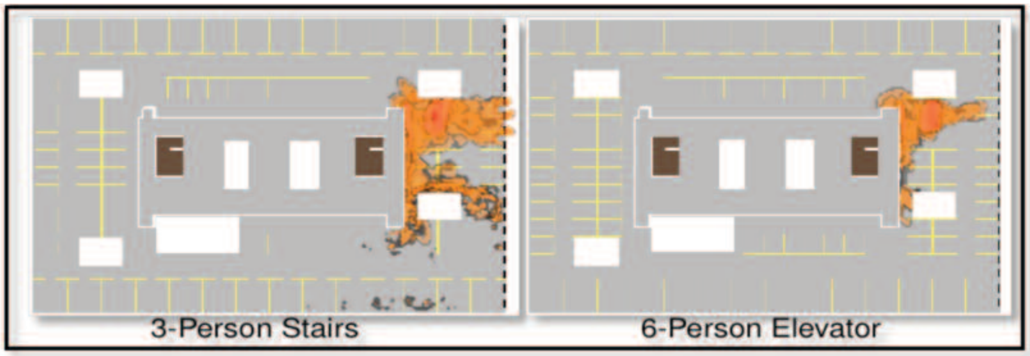


Table2: Relating FED values to percentage of population likely to be incapacitated and indicating coloring scheme for visualization.

FED Value Range	Estimated Population Range of Incapacitation	FDS-Smokeview Coloring
0.0 < FED ≤ 0.3	0.0 < % ≤ 11	(blue)
0.3 < FED ≤ 1.0	11 < % ≤ 50	(yellow)
1.0 < FED ≤ 3.0	50 < % ≤ 89	(orange)
FED > 3.0	% > 89	(red)

Table 3: (below) Relating FED values to fire growth and time of victim rescue by crew configuration.

Hazard	Resource: Crew Configuration and Ascent Mode	Consequences		
		Victim Rescue Time (MM:SS)	FED- Medium Growth Rate Fire	FED - Fast Growth Rate Fire
Fire on 10th Floor (30,000 sq ft) Of 13-Story High-Rise Building	3S*	51:34	1.22	4.29
	3E**	48:55	0.78	3.36
	4S	37:44	0.68	2.92
	4E	35:50	0.48	2.36
	5S	25:09	0.29	1.62
	5E	24:12	0.27	1.54
	6S	22:23	0.21	1.25
	6E	20:30	0.14	0.68

Figure 2: (below) FED at Button Press (reflect FED at the time firefighters on search crews reached each area)

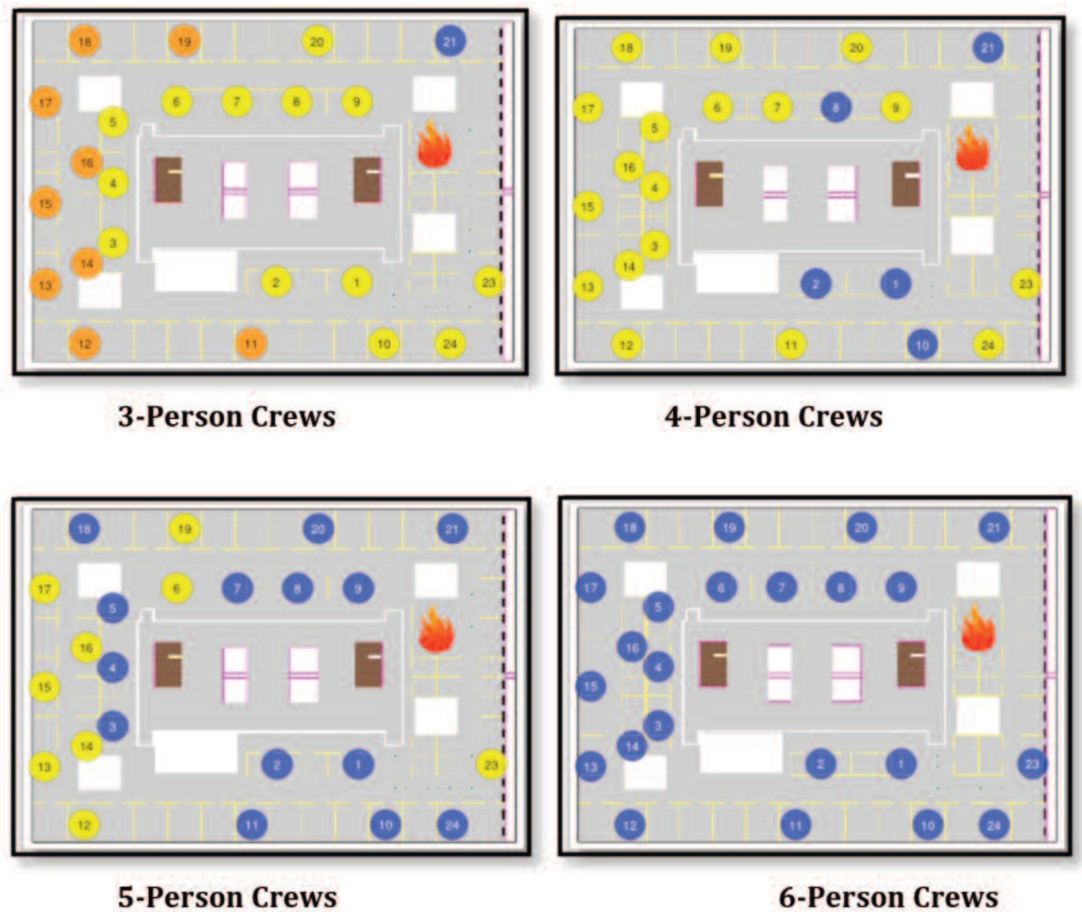
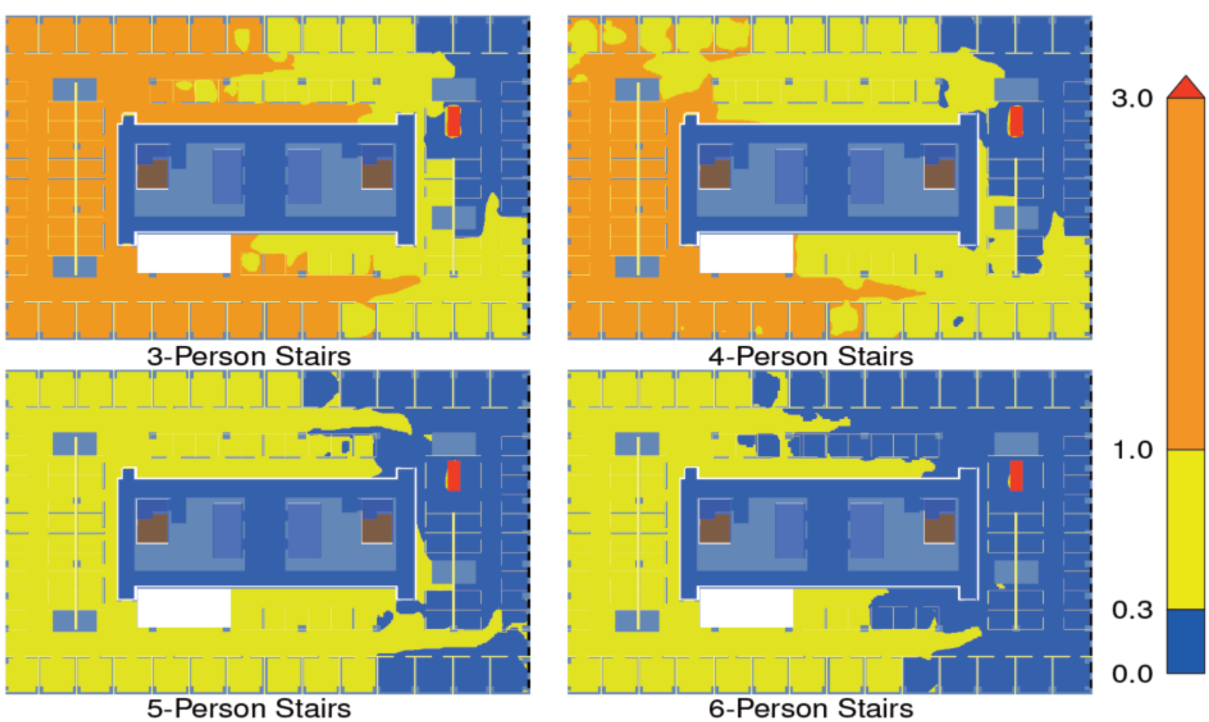


Figure 3: (below) FED contours at an elevation of 3 ft (0.9 m) on the fire floor for a medium growth non-sprinklered fire at the time the search is complete.



Fire Department Accreditation[24]- The accreditation program is a comprehensive self-assessment and evaluation model that enables fire and emergency service organizations to examine past, current, and future service levels and performance and compare them to industry best practices. This process leads to improved service delivery by helping fire departments:

- Determine community risk and safety needs
- Evaluate the performance of the department
- Establish a method for achieving continuous organizational improvement

Insurance Service Office (ISO)[25] - ISO is a leading source of information about property casualty insurance risk that provides risk information to many industries, including government. The ISO Public Protection Classification program is designed to help establish fire insurance premiums for residential and commercial properties based in part on community's fire protection services. By securing lower insurance premiums for communities with better public safety services, the Public Classification program provides incentives in the form of lower insurance rates for communities with appropriate fire fighting operations. By itself, ISO ratings do not provide comprehensive assessment of staffing, deployment and service delivery. Keep in mind that ISO is not an industry standard — it is only an index developed through a standardized data pool that is used by insurers to set rates. ISO visits more than 46,000 communities around the country to collect information about their fire departments through its Fire Suppression Rating Schedule (FSRS).

The FSRS measures the major elements of a community's fire suppression system and develops a numerical grading. ISO uses this information to assign a Public Protection Classification number from 1 to 10 based on the response capabilities of the fire department. Class 1 represents exemplary fire protection, and Class 10 indicates that the fire suppression program does not meet ISO's minimum criteria.

Once a fire department's capability is determined and classified, the information is communicated to and used by insurers to set rates for homeowners and commercial properties in local communities. For ISO classified departments that are threatened with resource reduction, it is important that an elected official or the fire chief request a re-evaluation of the ISO classification since a reduction in resources will likely affect the ISO classification and, in turn, possibly change the insurance rates for residential and commercial property in the community.

Decision makers need to understand the overall effect of resource reduction decisions *before* making them. Equally important is that the public understands that saving dollars by cutting fire department resources may well cost them in the form of higher insurance rates.

The Economic Impact of the Phoenix Fire Department: Case Study[26]
The Phoenix Fire Department responds to hundreds of fires every year, and has many methods of assessing its effectiveness as an organization. However, these methods overlook the impact of the Fire Department's operations on the local economy. This study used a REMI model—-A market-leading, dynamic forecasting and analysis tool developed by Regional Economic Models Inc. Through its dynamic modeling, REMI helps track the economic impact of a business at different moments in time. The model was used in Phoenix to estimate the economic impact of the City of Phoenix Fire Department's successful intervention at eight fires, June 1 to August 31, 2012, affecting thirteen commercial businesses or organizations.

Approximately 2,173 total private non farm jobs could have been lost in the State of Arizona over the course of one year if the City of Phoenix Fire Department had not successfully intervened at the eight commercial fires studied. If government and farm sector employment is included, the total impact could have increase to 2,322 jobs over the course of just one year in the State of Arizona. Maricopa County, as the host county, could have suffered most of the estimated job losses, including 495 full time direct jobs for at least one year. Gross state product could have been lower by approximately $196 million (2012 $) throughout the State of Arizona, and real disposable personal income lowered by $94.6 million (2012 $), without the City of Phoenix Fire Department's successful interventions at these eight commercial fires. State revenues could have also fallen by approximately $10.6 million (2012 $) throughout Arizona if the fires had not been extinguished. The City of Phoenix Fire Department is therefore estimated to exert a significant impact on the local economy at both a state and county level.

INFORMATION RESOURCES FOR DECISION MAKING

Resources available for decision makers include the following.

- *Fire Service Conferences* - numerous meetings around the country annually, including NFPA, IAFC or IAFF-sponsored events.
- *Workshops* - often organized to address a specific topic of interest by various groups including federal agencies (such as U.S. Fire Administration (USFA) and National Institute of Standards and Technology (NIST)) and non-profits (such as NFPA or Underwriters Laboratory (UL))
- *Professional Literature* – one of the primary objectives of the professional literature is to communicate best practices and research findings (including *Fire Chief Magazine*, *International Fire Fighter*, *International Journal of Fire Service Leadership and Management, and the NFPA Journal*)
- *Newsletters* – publications (such as www.fire.gov , *Fire Protection Research Foundation* at www.NFPA.org and *OnScene* at www.IAFC.org) communicate the latest research findings to the fire service.
- *Online Resources* – including discussion forums and stakeholder websites (such as www.NFPA.org, www.IAFC.org and www.IAFF.org) can communicate lessons learned, resource discussion, talking points and best practices. There are also numerous research materials available at www.firereporting.org and www.fire.nist.gov.

24 Commission on Fire Accreditation International (CFAI), http://www.publicsafetyexcellence.org/agency-accreditation/about-accreditation-cfai.aspx , October 2013.
25 ISO Community Fire Suppression, Fire Suppression Rating Schedule, http://www.isopropertyresources.com/Products/Community-Mitigation-Classifications/Community-Fire-Suppression.html, October 2013
26 Croucher, M., Evans, A., Seidman Research Institute, W.P. Carey School of Business. September 2012..

Fire Service Leaders Faced with Decisions

Whether being challenged by growth opportunities, budget crises, rising call volume, personnel and equipment shortages, security issues or the changing nature of hazards in the community, resources are required to respond to calls for help. Based on these circumstances, changes to precious resources are often made without the understanding of adverse impact on the community. So what is the pathway forward?

When evaluating current capability or measuring impact of a change in the level of resources deployed, department leaders (and community officials) must prioritize all hazards services and decide:

- What resources to commit to risk assessment and risk management (prevention/pre-planning/preparation);
- What resources to commit to response/mitigation/stabilization/growth; and
- What is the acceptable level of risk.

These decisions must be based on an understanding of the relationship between community hazards and associated risk, basic emergency response infrastructure, including fire department response capability and outcomes of emergency incidents. Considering these three elements and the tools available to decision makers, a basic community vulnerability formula can be developed and used for measurement regardless of the size of the community.

Based on the resources available to decision makers and fire service leaders, an example policy could state:

> "For 90 percent of all incidents, the first-due unit shall arrive on scene within a four minute travel time. The first-due unit shall be capable of advancing the first line for fire suppression, starting rescue or providing basic life support for medical incidents."

Risk	Resources Deployed	Outcome
Risk Level	**Too few resources (-)**	**= (-) Outcome**
Risk Level	**Appropriate Resources (+)**	**= (+) Outcome**
Hazards + Probability of Risk event (e.g. low hazard/high probability)	Example #1 : **Low Hazard / Residential** Dispatch = 3 engines , 1 truck, 1 BC @ 4 firefighters per/company Initial Response / Total number of Firefighters on scene for low hazard events = 18 First engine arrives = 4 minutes Full alarm arrives = 8 minutes	FF Injury /death = **likely positive outcome** Civilian injury / death = **likely positive outcome** Property loss = **likely positive outcome**
Hazards + Probability of Risk event (e.g. high hazard/low probability)	Example #2: **High Hazard/ High Rise Structure** Dispatch = 4 engines , 4 trucks, 3 ambulances, and 2 BC @5 or 6 firefighters per/company Initial Response/ Total number of Firefighters (initial alarm) for high-rise events = 50 - 58 First engine arrives = 4 minutes Full First alarm arrives = 8 minutes	FF Injury /death = **likely positive outcome** Civilian injury / death = **likely positive outcome** Property loss = **likely positive outcome**

QUALITY DECISION MAKING

Fire service leaders know the communities they serve best; therefore, fire service leaders must continue to collect, analyze and use real incident data when working with decision makers to assess the impact that resource deployment decisions have on community risk levels. Officers must quantify their local fire department experiences including type of emergency events to which they respond, staffing levels/crew size on each incident, mobile asset configurations, response time performance, frequency and manner of personnel training, and fire prevention programs. Fire department leaders should follow a rigorous and transparent process to prepare thoughtful and factual reports for decision makers as described in more detail below.

STEP 1 Assess Hazards and Associated Risks in the Community
Examine and analyze the relevant risk factors that characterize their community. The assessment should include an analysis of the probability of risk event scenarios that occur and their subsequent consequences.

STEP 2 Collect Response Data
Collect and summarize detailed deployment data, including individual apparatus and overall alarm staffing data from actual emergency response calls to reported (working) structure fires and EMS responses.

STEP 3 Analyze Response Data
The purpose of data analysis is to determine actual resource deployment capabilities and capacity and identify response deficiencies.

STEP 4 Summarize Emergency Response System Status The purpose of a status report is to provide detailed information about the current state of fire department capability, availability, capacity, and overall operations. The report should also include options for changes and recommendations that link resource allocations to the anticipated outcomes.

STEP 5 Report to Decision Makers
Prepare a report to decision makers identifying the current fire suppression capability and capacity as well as an assessment of vulnerability based on any proposed resource cuts.

CONCLUSIONS

Effectively managing a fire department requires an understanding of and an ability to demonstrate how changes to resources will affect community outcomes. It is imperative that fire department leaders, as well as political decision makers, know how fire department resource deployment in their local community affects community outcomes in three important areas: civilian injury and death; firefighter injury and death; property loss and environmental impact. If fire department resources (both responding apparatus and personnel) are deployed to match the risk levels inherent to hazards in the community, then it is expected that outcomes in all three areas will likely be positive. Likewise, failure to match fire department resources deployed to the level of the risk events to which firefighters respond will likely result in negative community outcomes.

Interdependent and coordinated activities of all fire fighting personnel deployed are required to meet these priority objectives. There are a number of tasks related to each of the priorities and these tasks (e.g., stretching a hose line to the fire, ventilation, search and rescue) can be conducted simultaneously, which is the most efficient manner, or concurrently which delays some tasks thereby allowing risk escalation, explained earlier, to occur.

> There are a number of resources available to assist political decision makers and fire service leaders in planning for adequate resource deployment in their community to assure that firefighter intervention in a risk event occurs in a timely and coordinated manner to limit risk escalation and negative outcomes.

When evaluating current capability or measuring impact of a change in the level of resources deployed, department leaders (and community officials) must prioritize all hazards services and decide:

- What resources to commit to risk assessment and risk management (prevention/pre-planning/preparation);
- What resources to commit to response/mitigation/stabilization/growth; and
- What is the acceptable level of risk.

These decisions must be based on an understanding of the relationship between community hazards and associated risk, basic emergency response infrastructure, including fire department response capability and outcomes of emergency incidents. Considering these three elements and the tools available to decision makers, a basic community vulnerability formula can be developed and used for measurement regardless of the size of the community.

Fire department response capability and capacity is a function of the community's resource allocation and is a significant determinant in the degree of vulnerability of a community to unwanted fires and other emergencies. A community with adequate and effective firefighting force will be less vulnerable to the large negative consequences of adverse risk events than will a community with fewer resources allocated. Recognizing this phenomenon, decision makers must minimize the consequences of structure fires and other emergencies in a community by matching the allocation of fire department resources to the fire risk profile of a community.