URBAN FIRE FORUM
NATIONAL FIRE PROTECTION ASSOCIATION

FIRE SERVICE DEPLOYMENT:
Assessing Community Vulnerability

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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: firefighter injury and death; civilian injury and death; and property loss. ***If fire department resources (both mobile 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.***

Background

Many fire departments across the nation are being challenged by budget crises, rising call volume, personnel and equipment shortages, security issues and the overall expectation to do more with less. 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.

In many communities, the sustained economic recession is forcing decisions to cut fire department resources faster than fire service leaders can evaluate their impact. These whirlwind cuts can leave a community without sufficient resources to respond to emergency calls safely and effectively.

Service expectations placed on the fire service, including Emergency Medical Services (EMS), response to natural disasters, hazardous materials incidents, technical rescue and acts of terrorism, have steadily increased. However, fire chiefs are often 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 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.

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.

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.

- Firefighter injury and death
- Civilian 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, any interrupted operations, and damage to the environment. These consequences are generally grouped into four categories.

- **Human impacts** (firefighter and civilian 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.

Community hazards and associated risks may be divided into 3 categories.

- Property
- Life
- Critical infrastructure

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

Community Hazards/Risks Examples

Property	Life	Critical Infrastructure
Construction Date (e.g., pre 1930)	Population demographics (e.g., age)	Agriculture and Food
Building materials	Community socio-economic status- income by type of household (census data)	Water
Sprinklers present	Population distribution	Public Health Resources
Building type (high-rise or two-story etc…)	Population density (pop/sq. mi.)	Emergency Services

The property category is of particular interest to the fire service. 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. Each hazard level carries inherent risks[1].

- **High-Hazard Occupancies** — Schools, hospitals, nursing homes, explosive plants, refineries, high-rise buildings and other high life hazard or large fire potential occupancies.
- **Medium-Hazard Occupancies** — Apartments, offices, mercantile and industrial occupancies not normally requiring extensive rescue by 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.

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 an indicator that sufficient resources have been deployed and outcomes from risk events are more likely to be positive. Conversely, if response times and force assembly times are high, it is an indicator of insufficient resources and outcomes from risk events are more likely to be negative.

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.

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[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.

You're going to have longer response times and less quality of care and it's going to be more dangerous to the public in general. While it might sound like a scare tactic, what it says only reinforces what the fire chief told city leaders when he warned them about the potential for big problems to emergency services if jobs were lost, saying, "Fewer personnel and EMS units responding increases EMS response time, which directly impacts survivability of individuals experiencing medical emergencies."

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[3].

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 right amount 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. Today, EMS calls have an impact on the availability of fire department resources and should 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. This point is known as "flashover".

On Scene Risk Escalation

During the growth stages of a 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 breaks into open flame. This eruption of flame generates a tremendous amount of heat, smoke and pressure with enough force to push the fire 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 in the room of origin 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 a post flashover 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.

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 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

[3] National Fire Service Data Summit Proceedings, U.S. Department of Commerce, NIST Tech Note 1698, May 2011

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.

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[4]. The maximum prescribed travel time acts as one indicator of resource deployment efficiency.

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 best practices 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 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 concurrently, 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[5].

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,

Since the Fire Department implemented the brownouts in February, up to eight engines have been placed out of service on a rolling basis to save $11.5 million annually. Ten stations rotate having one engine out of service. Three others have one of their two available engines always out of service.

[4] Fire & Emergency Service Self-Assessment Manual, 7th Edition, Copyright © 2006, Commission on Fire Accreditation International, CPSE, Inc.
[5] 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.

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.

5.2.4 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.

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

In an attempt to close a $19 million budget deficit, the Fire Department temporarily shut down Truck 11, which serves the city's Far West Side. The move was adopted to prevent having to lay off fire fighters and is expected to save the City $1 million in overtime pay.

(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.

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. [6]

- **High-Hazard Occupancies** — Schools, hospitals, nursing homes, explosive plants, refineries, high-rise buildings 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

[6] Fire Protection Handbook, 20th Edition, Copyright ©2008 NFPA

less than 24 firefighters and 2 chief officers plus a safety officer and a rapid intervention team. Extra staffing of high hazard occupancies is advised.

- **Medium-Hazard Occupancies** — Apartments, offices, mercantile and industrial occupancies not normally requiring extensive rescue by 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.

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, or material.

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. These states are required to adopt a standard at least as effective as the Federal standard within six months.

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.[7]

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[8].

> **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.

NIST Studies (Research) How Resource Allocation Can Change Community Fire Risk

Given the occurrence of a specific fire (essentially failure of prevention efforts), deployment of firefighting resources is a primary line of defense. The effectiveness of the fire department

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[7] 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.

[8] 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.

Ten firefighters got calls from Fire Chief telling them they are losing their jobs as the result of state budget cuts. Even more firefighters might have gotten laid off, but Mayor and City Council President said they're urging the council to dip into the city's reserves for $1.75 million to save 31 additional firefighter jobs and avoid any police layoffs.

response (or consequences of the fire) will be a function of the number of firefighters and their arrival time. In 2010, a partnership of fire safety organizations[9] conducted basic research 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.[10]

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 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,[11] the resulting fire risk for the community is expected to be quite different based on the chosen deployment configurations.

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

Hazard		Resource Allocation	Consequences: Occupant	Consequences: Fire Size
Medium t-square fire on first floor of a 2,000 sf, two-story, single family residence[11]	A	4-person company Total Effective Force 18 First engine — 6.5 minutes* Full alarm — 9.5 minutes	FED[12] = 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.

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

[9] 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).

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

[11] 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.

[12] 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.

Fire District announced two brownouts beginning Aug. 1 due to a $5.4 million deficit. The brownouts are due to a 3.3 percent decrease in property tax revenues. "We have comprehensively studied the impacts of reductions in service and made the difficult choices. Public safety and the safety of our firefighters continue to be our top priorities."

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.

Fire Department Accreditation[13]— 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)[14] - 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.

What is a Chief to Do When Forced to Make Decisions?

Despite the significance of recent research supporting the ability of local community leaders to make science-based deployment decisions, a fire chief must often act in the absence of complete information which establishes the complex links between resource allocation and the array of risks found in their communities. Every chief would likely agree that service delivery and the health and safety of the men and women of the fire service are the primary considerations when evaluating the impact of deployment changes. In such cases, experience and intuition are critical and necessary elements of the decision process. However, to help complement the limited experience of even the most veteran decision maker, the fire service can harness the power of community to identify and share best practices. Every fire chief has success stories about specific programs or resource deployments which have proven successful in their community over the years. Just as importantly, the same communities have observed their share of less successful policies and programs. Sharing these best practices with colleagues in communities that face similar risk profiles can improve service delivery by ensuring that failed strategies and programs are not replicated elsewhere and that best practices are more widely adopted.
Opportunities to identify or share best practices include the following.

- *Fire Service Conferences* - numerous meetings around the country annually, including 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

[13] Commission on Fire Accreditation International (CFAI), http://www.publicsafetyexcellence.org/agency-accreditation/about-accreditation-cfai.aspx , October 2011.

[14] ISO Community Fire Suppression, Fire Suppression Rating Schedule, http://www.isopropertyresources.com/Products/Community-Mitigation-Classifications/Community-Fire-Suppression.html, October 2011.

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 (such as www.NFPA.org, www.IAFC.org and www.IAFF.org) can communicate lessons learned, resource discussion, talking points and best practices.

Fire Service Leaders Faced with Decisions

As noted in the introduction, many fire departments across North America are being challenged by budget crises, rising call volume, personnel and equipment shortages, security issues and the overall expectation to do more with less. Based on these circumstances, cuts to precious resources are made without the understanding of adverse impact on the community. When evaluating current capability or measuring impact of a change in the level of resources deployed, department leaders (and community officials) must decide:

- What resources to commit to risk management (prevention/pre-planning/preparation);
- What resources to commit to response/mitigation; and
- 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.

Risk	Resources Deployed	Outcome
Hazards + Probability of Risk event (e.g. low hazard/high probability or high hazard/low probability)	Example : 4 firefighters per/company Total Effective Force on scene for low hazard events = 15-17 First engine arrives = 4 minutes Full alarm arrives = 8 minutes	FF Injury /death = Minimal Civilian injury/ death = Minimal Property loss =Minimal
Risk Level	Too Few Resources (-)	= (-) Outcome
Risk Level	Appropriate Resources (+)	= (+) Outcome

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

> "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."

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 rigorous and transparent process to prepare thoughtful and factual reports for decision makers as described in more detail below.

STEP 1 **Assess Fire 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.

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STEP 3 **Analyze Response Data**
The purpose of this 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: firefighter injury and death; civilian injury and death; property loss and environmental impact. If fire department resources (both mobile 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.

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 concurrently which delays some task 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 decide:

- What resources to commit to risk management (prevention/pre-planning/preparation);
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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 has been developed and can be 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 a sizeable and effective firefighting force will be less vulnerable to the large negative consequences of an unwanted fire than will a community with fewer resources allocated. Recognizing this phenomenon, decision makers must minimize the consequences of unwanted fires and other emergencies in a community by matching the allocation of fire department resources to the fire risk profile of a community. ■