Fire Department Response Capability, Performance and System Resilience

URBAN FIRE FORUM

NFPA

Telling the Story: Fire Department Response Capability, Performance, and System Resilience

Background

Fire and Rescue Departments are “ALL-Hazards” Departments providing emergency medical response, fire suppression, technical rescue, hazardous materials response, response to active shooter/hostile events, fire inspections, public education, investigation, community training and more. Effectively managing a fire department requires an understanding of and an ability to demonstrate how changes to resources in any of these areas will affect the overall safety of the community. One of the greatest challenges to public safety is articulating its value in a quantifiable manner. The necessity of data collection, analysis and reporting cannot be overstated. Data are the sustaining lifeblood of the fire service. Data, and the information gleaned from it, show the need for prevention, public education, and emergency response services including the number of appropriately staffed and deployed apparatus necessary to mitigate the emergencies that occur, assure optimal performance of responders on scene, and best facilitate a positive outcome of the incident.

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 economic loss. To facilitate this, fire department leaders must have reliable statistical data useful for optimization of resources in every area of the fire department. However, even with recent technological advances and substantial fire department efforts in data collection, the fire service is often unable to quantify experiences to determine its relative effectiveness.

In 2015 NFPA reported that fire departments responded to 1,345,500 fires, more than 21.5 million EMS calls, 2.5 million false alarms, 1.5 million mutual aid responses, 442,000 hazardous materials responses and more than six million other responses. These data represent just over half of the fire departments in the United States. In 2016, NFPA reported that there were 1,342,000 fires reported in the United States. These fires caused 3,390 civilian deaths, 14,650 civilian injuries, and $10.6 billion in property damage. Of all the fires in the NFPA dataset, 475,500 were structure fires, causing 2,950 civilian deaths, 12,775 civilian injuries, and $7.9 billion in property damage. NFPA also reported that 173,000 of the fires were vehicle fires, causing 280 civilian fire deaths, 1,075 civilian fire injuries, and $933 million in property damage. Though these data are informative regarding the incidents that occur, they do not tell the story of the responders nor their actions upon arrival to intervene, mitigate the risk and positively affect the outcome.

Data use in many fire departments takes the form of annual reports. These reports produced primarily for decision makers, include many interesting facts like response statistics, division reports, specialty team reports, and highlights of other services provided by the Fire Department. Annual reports also provide an opportunity for leaders to demonstrate the department’s value and educate stakeholders. These reports are a powerful, effective and efficient way to connect with the community. However, traditional annual reports do not tell the complete story of the department’s capabilities, activities, performance and system resilience. Annual reports primarily focus on outputs achieved rather than the actual outcomes associated with a given level of fire department resources and the budgeted funding. Fire Chiefs and other department leaders must learn to leverage data available in their own system to tell their department’s story. They must not only communicate what the fire department did, but also the impact of those actions on the safety of the community.

This white paper is divided into 12 Sections. Section 1 discusses the historical use of fire department annual reports and their limitations. Section 2, provides guidelines for a detailed community risk assessment addressing hazards and their associated risks. Section 3 addresses how to gather data necessary to conduct a community risk assessment. Section 4 discusses fire department performance and the associated metrics found in industry standards and in the NFORS data system. Section 5 discusses workload analysis assessing sufficient resources positioned appropriately to address emergencies as they occur in an equitable manner. Section 6 addresses unit response data and assessing unit availability and capability. Section 7 addresses the emergency response system overall workload and discusses a department’s “busy-ness” by analyzing the number of companies/units that are engaged on assignment per hour. Section 8 discusses using data to assess overall department availability and capability to respond. Section 9 addresses system capacity as the maximum service output that the system of workers, equipment and vehicles is capable of producing as a whole. Section 10 discusses system resilience or the capacity to recover quickly from surges in call volume or major incidents. Section 11 provides guidance on reporting or telling a fire departments story to decision makers using data and graphic visualizations. Finally, section 12 provides guidance for reporting fire department performance and value to outside organizations.

Historical Data Preparation

Fire department reporting typically includes the following statistics.

1. Fires per capita (per 1000 population)
2. Fire Loss estimates vs assessed property value
3. Fire Loss per capita (per 1000 population)
4. Civilian injury/ death per year
5. Smoke detectors installed
6. Total number of incidents
7. Incidents number /percentage by category (fire, EMS, Hazmat)
8. Incident number/percentage by type (cardiac, trauma, vehicle fire, trash fire, etc…)
9. Response times overall and by specific service areas
10. Total fire inspections and public education sessions conducted

Today, fire service leaders must tell a more comprehensive story. There is an array of data elements and calculations that can help. The first rule is to anticipate the questions to be asked by decision makers, the press and the public. The next step is to not only answer those questions but also go beyond to educate them on your message. Leaders must communicate the reality of the fire department's capability, activity, performance, resilience and the actual impact the fire department had on the safety of the community.

Telling the Story: Community Risk Assessment

Risk Assessment

Fire service leaders must identify, categorize and prioritize hazards that exist within the community. These hazards bring with them inherent risks to the citizens and visitors of that community including their property and the environment itself. Hazards are the causes of danger and peril in the community and risk quantifies the degree of potential danger that the hazard presents. The process for assessing risk within the community requires a logical, systematic, and consistent methodology that can be utilized and replicated over the entire community from year-to-year. Leaders can use these methods to assess risks created by the identified hazards to determine potential adverse impact from fire, medical emergencies, hazardous materials incidents, technical rescue incidents or other incident types.

Any risk assessment methodology should include stable and known data from the U.S. Census, as well as dynamic information included in geospatially referenced parcel data. These elements provide a baseline from which to recognize an increase or decrease in the risk factors based on topographical inputs, socioeconomics, structure types, the presence of protection systems, and ongoing risk reduction efforts. While the risks are typically assessed using census tract perimeters, they may also be managed at the Service Demand Zone (fire station first due) level or smaller geographic areas for deployment and administration purposes.

Fire departments should use three factors when assessing risk.

- Probability (likelihood) of an incident occurring
- Consequence (magnitude) of an incident on the community
- Impact of an incident on the department's response system and its ability to provide ongoing services to the remaining areas for known service demand.

Probability

Probability is associated with the frequency of a particular incident type. For example, the probability of incidents occurring in a given census tract is related to the expected number of incidents in that census tract. By using the Computer-Aided Dispatch (CAD) data and the demographic, social, and physical characteristic of the census tracts where those incidents occurred, a statistical regression can be used to predict the future number of incidents. The predicted number of incidents is used to represent the probability of a particular incident type occurring in each census track because, statistically, incidents with high probability will occur more frequently. Once these predictions are made, the census tracts receive a ranking (low, moderate, high).

Regression Coefficients

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots$$

Number of Incidents

Demographic and physical data from US Census, GIS Parcels, etc.

Census tracts are then sorted by the number of predicted incidents in those tracts, from the lowest to the highest. The sum of the predicted incidents of all the census tracts defines the total number of incidents for the department. The cumulative sum of the predicted incidents of each census tract, starting from the census tract with the lowest number of predicted incidents and proceeding towards the highest, defines the risk ranking: low for census tracts whose sum of predicted incidents is lower than 33% of the total incidents, moderate for tracts whose sum of predicted incidents is greater than 33% and less than 67% of the total, and high for the remaining census tracts.

Consequence

Consequence is the measure of the outcome of a particular incident type occurrence. To assess consequence, fire department leaders must determine the variables to be used to assess the level of consequence on the community for each incident group type (fire, EMS, Hazmat, etc.…). Risk coefficients or weights are then created for these variables. The following variables may be used for the fire department incident types.

- EMS
  - ALS incident (as reported in CAD)
  - BLS incident (as reported in CAD)
- Fire
  - Risk of death and injuries based on the following
    - age
    - gender
    - race
    - socioeconomic status
    - structure type
    - Extent of damage to property (e.g. number of rooms affected[1])
- HazMat
  - State of the material
  - Stability of the material
  - Property value (based on parcel data)
- Rescue
  - Type
  - Situation found
  - Extrication and medical transport (reported in CAD)

Next, determine the risk rank for each incident type at the Census tract group level and/or at other geographic levels including census block, fire box or first due level. Once the variables are quantified (e.g. number of fires per census block), the risk is ranked following a procedure similar to the one for probability. Census tracts are sorted by magnitude

1. Presently based on structure type and property value

of the incidents in each tract, from the lowest to the highest. The cumulative sum of the magnitude of incidents in each census tract, starting from the census tract with the lowest number of predicted incidents and proceeding towards the highest, defines the consequence ranking: low for census tracts whose sum of predicted consequence is lower than 33% of the total magnitude for the community, moderate for tracts whose sum of predicted consequence is greater than 33% and less than 67% of the total, and high for the remaining census tracts. The total risk rank is calculated based on the probability and consequence score of each tract group and then evaluated at the census block, firebox and/or first due level. The probability and consequence risk rank should be evaluated at a 1 to 1 ratio. The outcome is the risk rank of the municipality overall.

Figure 1 Risk Probability

This figure contains actual fire department data and shows an example of risk probability categorization. The census blocks are sorted by the expected number of incidents predicted by the regression. The number of incidents is summed starting from the left and proceeding to the right. The partial totals equal to 33% and 67% of the total expected incidents define the boundaries between the low, moderate, and high-risk categories.

Impact

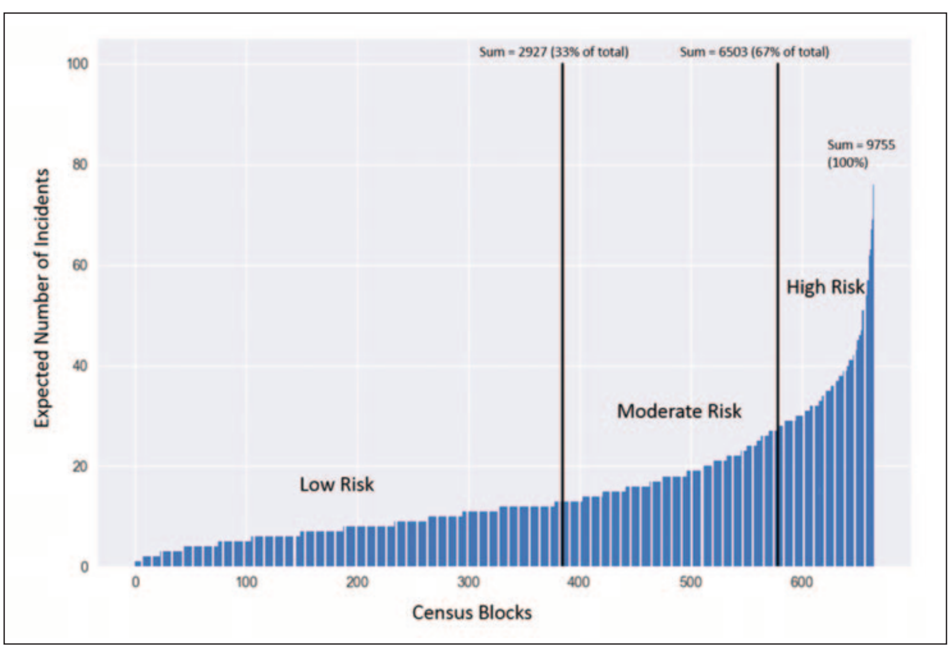
NFPA 1710 Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments establishes criteria by which fire departments should measure their performance. The metrics in the 1710 Standard lend themselves well to ongoing evaluation of fire department's emergency response availability, capability, and operational performance.

Using ESRI ArcGIS Network Analysis computer modeling, departments can assess their ability to meet several NFPA Standard 1710 response objectives. Findings can be assembled to show the percent of compliance for each objective by first due area. The measurable objectives in the NFPA Standard 1710 are listed below including the percent coverage for geographic related objectives:

NFPA 1710 Performance Objectives

- Alarm Answering Time
  - 15 sec 95% of calls
  - 40 sec 99% of call
- Alarm Processing Time
  - 64 sec 90% of calls
  - 106 sec 95% of calls
- Turnout Time =
  - 60 sec EMS responses
  - 80 sec Fire responses
- First Engine Arrive on Scene Time
  - 240 sec (4 min) 90 % of responses
- Initial Full Alarm (Low and Medium Hazard) Time
  - 480 sec (8 min) on 90% of responses
- Initial Full Alarm – High Hazard/ High-Rise Time
  - 610 sec (10 min 10 sec) on 90% of responses

Figure 1:



Steps for Community Risk Assessment

Step 1: The Probability and Consequence ranking obtained as described above for each census tract or other geographic area is associated with a numerical score: 1 for low, 2 for moderate, and 3 for high. The probability and consequence scores are averaged with a 1:1 weight to obtain a single score:

Probability and Consequence (*combined score*) = (*Probability Score+Consequence Score*) / 2.

Step 2: The Probability and Consequence combined score should then be ranked as low, moderate, and high, following the cumulative sum method already used separately for Probability and Consequence described previously. The combined score gives an immediate idea of the risk level in a particular census tract or defined area of measure. Decision makers should then look separately at the Probability and Consequences scores for that particular area in order to decide how and where to distribute resources, apparatus and staff. An example of the resulting rank, for a fire department using first due area as the unit of measure, is shown in figure 2 below.

Figure 2:

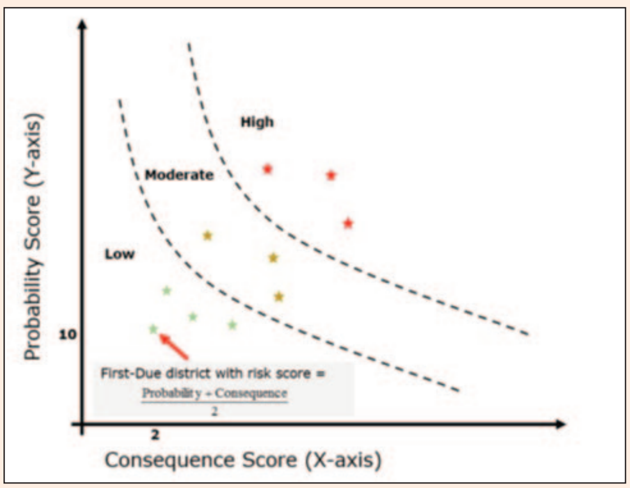


Figure 2 Probability and Consequence Ranking by First Due Area

Using GIS, these scores can then be displayed on a map by first-due area and/or response zones. An example of the resultant map(s) is shown in the figures 3 and 4 .

Step 3: The Impact variable is kept separated and ranked using the cumulative sum method.

The two final products of the risk assessment process are a combined probability-consequence score and an impact score for each first due district and for each risk category. Fire Departments can categorize the risk based on the combined probability-consequence score, place the risk in the low, moderate or high category, and use the information from the impact score to adjust the concentration and distribution of resources. In other words, geographic areas with higher risk probability and consequence scores, should have greater number of resources deployed in those areas.

FIGURE 3:

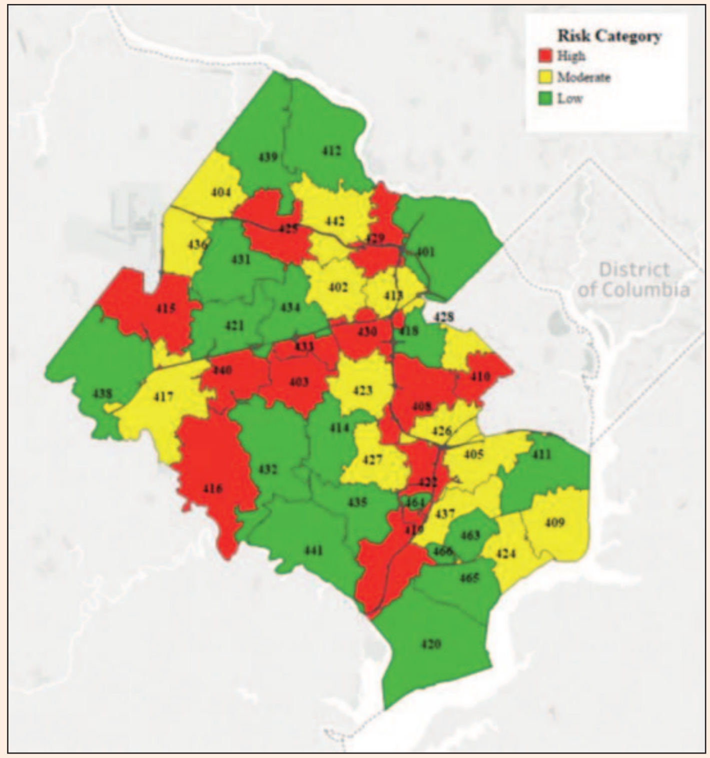


Figure 3 EMS Probability and Consequence Risk Rank by Fire Station First Due Areas

FIGURE 4:

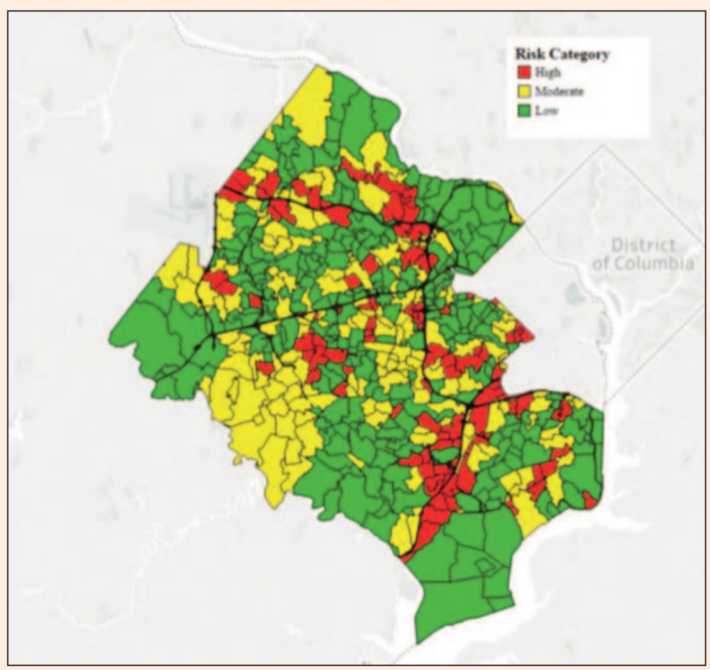


Figure 4 Fire Probability and Consequence Risk Rank (Injury) by Response Zones (Fire Box or Alarm Zone)

Gathering Risk Assessment Data

The following input factors and information layers are necessary when applying the risk assessment methodology described.

Data Acquisition[2]

- Computer-Aided Dispatch (CAD) Data (1-3 years preferred)
- Station First-due response zones (or fire box zones)
- Station First-due boundaries
- Building footprint and building type
- Parcel data (land/property value)
- Demographic data from the American Community Survey portion of the U.S. Census at the census block level preferred (Gender, Age, Race, Education, Income/Poverty, Housing Characteristics)
- Physical Data (e.g. transportation network, utility lines, river, and floodplains)

Example Data Reports

Working and Living	
Businesses	115,917
Unemployment Rate (age 20-64)	7.5%
Median Housing Value	$501,200
Median Home Size	1,589 Sq. Ft.
Average Monthly Rent	$1,687
Households	403,934

Housing by Type	Number of units
Total Housing Units	413,746
Single Family	195,273
Town House/Duplex/Triplex	100,354
Multi-Family 1-8 Stories	99,591
Multi-Family 9+ Stories (High-rise)	18,528

People		
Population:		1,125,385
Gender:	Male	49.5%
	Female	50.5%
Age:	20-Under	26.4%
	21-64	62.5%
	65-Over	11.1%
Race:	White, Not Hispanic	52.75%
	Black, Not Hispanic	9.01%
	Asian/PI, Not Hispanic	18.39%
	Hispanic/Latino	15.98%
	Other, Not Hispanic	3.86%
Persons with High School Education		92.0%
Persons speaking non-English at home		37.7%
Median Household		$112,552
Persons in Poverty Income		6.0%

2. These data elements have been compiled in the Community Assessment, Response Evaluation System (FireCARES) data system for U.S. Fire Departments. Every U.S. Fire Department has a designated page with data in FireCARES. www.firecares.org

Telling the Story: Fire Department Response Performance

There are three basic components of fire department response performance. These components are availability, capability and operational effectiveness.[3]

- **Availability —** The degree to which the resources are ready and available to respond.
- **Capability —** The abilities of deployed resources to manage an incident.
- **Operational Effectiveness —** A product of availability and capability. It is the outcome achieved by the deployed resources or the ability to match resources deployed to the risks to which they are responding.

To assess these aspects of a department, data are necessary, and most can originate in the Computer Aided Dispatch (CAD) system. The CAD provides a treasure trove of information including geocoded addresses for visualization of response data. CAD also records the type of call, times for crew dispatch, turnout, arrival on scene and termination of the response. These times are all significant in assessing performance and can be enriched by additional on scene operational task times. Together these data tell the story and portray the value of a fire department to the community.

Total Response Time Components

Fire departments measures baseline performance in terms of total response time, which is the time it takes from the call to be received at the Public Safety Answering Point (PSAP) until the first unit arrives on the scene of the emergency incident. Total response time should be measured and reported for all first due units and the effective response force (ERF) assembly. Total response time is composed of call-processing time, turnout time, and travel time.

Call processing time is the time the call being received at the PSAP to the dispatching of the first unit. This is measured for all emergency incidents.

Turnout Time is the elapsed time from when a unit is dispatched until that unit changes their status to 'responding'.

Travel time is the elapsed time from when a unit begins to respond until its arrival on the scene.

There are numerous other data elements necessary to show fire department performance. These elements are listed and defined below.

Resources responding includes all mobile resources dispatched to an incident. Frequency of response can also be determined for each unit.

Staffing/crew size is a measurable objective in NFPA 1710 and is an important determinant in assembling and effective response force on scene. Crew size also determines what tasks can be accomplished once a unit arrives on scene. For example, a first in engine with 3-person crew cannot engage in interior firefighting until a second unit arrives to assure the OSHA criteria two-in and two-out[4] is accomplished. Therefore, crew size affects the on-scene intervention time to stop risk escalation. 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. This concept is also reflected in NFPA Standard 1500 and must be communicated and understood by decision makers. NFPA 1500 section 8.8.2.10 states that 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 NFPA 1500 - 8.8.2[5].

First unit arrival denotes the first arriving fire department vehicle with the potential to intervene in the situation and curtail or stop the escalation of the incident. In the absence of on-scene task times, if crew size and structure type are known, this time can be used as a proxy for estimation of tasks like water on fire time[6].

Initial alarm arrival (Assembly of Effective Response Force) — Given expected on scene conditions, the number of on-duty members sent in an initial alarm should be determined through task analysis considering; 1) Life hazard protected population, 2) Safe and effective performance, 3) Potential property loss, 4) Hazard levels of properties, and 5) tactics employed. The timing of the complete assembly of these forces is significant in assuring that risk control tasks can be implemented in a timely and effective manner. For example, on the fireground, coordinating ventilation with water on the fire is an absolute and requires sufficient number of personnel to complete.

Intervention time is the time that responders arriving on scene engage to stop the emergency. For EMS this time is typically when the responders are at a patient's side. For fire response, this time is documented for water on fire. Intervention time is a critical indicator of operational performance.

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3. The data elements and proposed analytics in this section are the basis of the National Fire Operations Reporting System (NFORS). NFORS is available to fire departments worldwide. www.nfors.org

4. The "2 In/2 Out" policy is part of paragraph (g)(4) of OSHAs revised respiratory protection standard, 29 CFR 1910.134. 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 firefighting 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.

5. NFPA 1500- 2018, Fire Department Occupational Safety, Health, and Wellness Program, Copyright ©2018, 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.

6. Averill, J., Moore-Merrell, L., Barowy, A., Santos, R., Peacock, R.,Notarianni, K., Wissoker, D. NIST TN 1661: Report on Residential Fireground Field Experiments. National Institute of Standards and Technology, Gaithersburg, MD. 2010

These times can be captured and recorded in simple charts to show the effectiveness of fire department response and intervention. Table 1 and 2 shows many of the metrics discussed with performance results for a fire department.

Fire Department Response Capability Based on NFPA 1710	
4 – MIN FIRE COMPANY	29.60%
8 – MIN FIRE COMPANY	80.50%
4 – MIN ENGINE	29.30%
8 – MIN ENGINE	80.30%
4 –MIN LADDER TOWER	13.70%
8 – MIN LADDER TOWER	62.80%
4 –MIN TECH. RESCUE	1.00%
8 – MIN TECH. RESCUE	6.10%
4 –MIN “2 IN – 2 OUT”	29.60%
8 –MIN “2 IN – 2 OUT”	80.50%
4 –MIN MEDIC UNIT	11.70%
8 –MIN MEDIC UNIT	53.40%
4 –MIN AMBULANCE UNIT	18.50%
8 –MIN AMBULANCE UNIT	61.20%
4 – MIN SQUAD UNIT	4.50%
8 – MIN SQUAD UNIT	22.90%
4 – MIN DISTRICT CHIEF	9.20%
8 – MIN DISTRICT CHIEF	44.90%
4 –MIN EMS COMMAND	3.90%
8 –MIN EMS COMMAND	21.80%
8 – MIN 15 FF	49.40%
8 – MIN 27 FF	20.00%
610 – MIN 43 FF	24.90%

Table 1 Summary of Fire Department Response Capability Using Metrics in NFPA 1710

Structure Fire Incidents, 90th Percentile (minutes)		2014	2015	NFPA 1710 Standard Low-Hazard Alarm Response
Alarm Handling	Pick-up to Dispatch	1:21	1:44	1:04
Turnout Time	Turnout Time 1st Unit	2:00	1:33	1:20
Travel Time	Travel Time 1st Unit	7:00	7:11	4:00
	Travel Time ERF	22:00	16:29	8:00
Total Response Time	Total Response Time 1st Unit on Scene	8:00	7:48	6:20
	Total Response Time ERF	23:00	17:16	10:24

Table 2 Summary of Fire Department Response Capability to a Low-Hazard Structure Fire Using Metrics outlined in NFPA 1710

Using Geography is an effective way to visualize response capability based on the performance objectives in the NFPA 1710 Standard. Figures 5 and 6 below show a department's coverage capability for the arrival of an engine in 4 minutes and the arrival of an initial alarm assignment for low hazard (minimum 15 firefighters in 8 minutes).

Figure 5 Fire Department's Coverage Capability
Arrival of First Due Engine in 4 Minutes

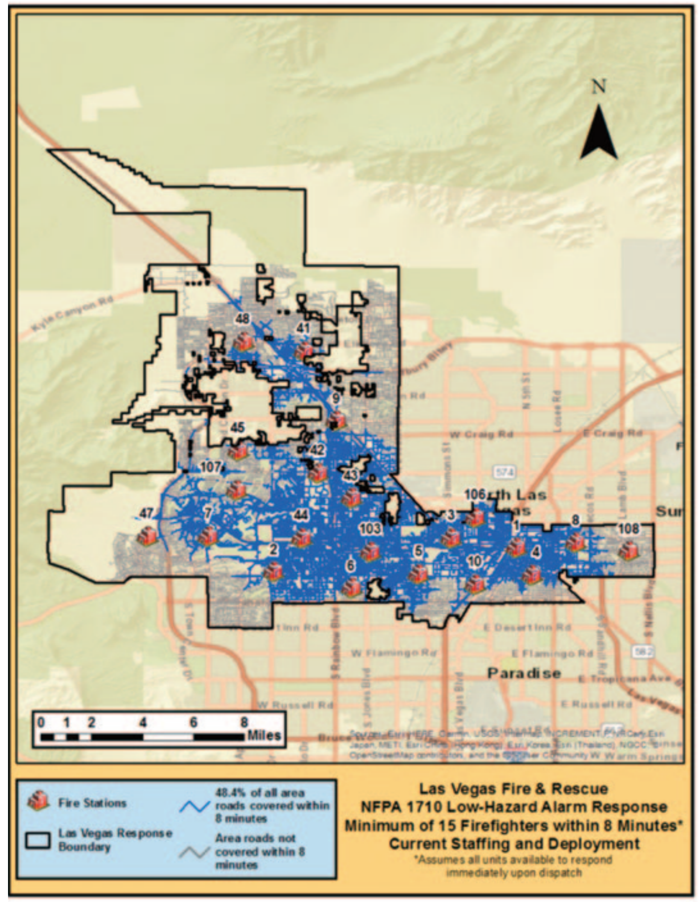

Figure 6 Fire Department's Coverage Capability
Arrival of Initial Alarm (Low Hazard) in 8 Minutes

Challenges to Response Capability

Traffic — Traffic may have a significant effect on response capability. Fire service leaders should evaluate and report major arteries, interstates and access roads, waterways, rail and other transportation systems and monitor effects.

Road Infrastructure — larger emergency vehicles are generally more cumbersome and may be negatively affected by their weight, size, and inability to travel narrow surface streets. Fire service leaders should identified areas in their community where travel may be restricted and ensure the necessary resources are positioned.

Terrorism — Metropolitan cities and suburban areas in close proximity may experience ongoing alerts of extremist groups both domestic and foreign. Fire service leaders must be cognizant of the ongoing threats and the security measures often implemented by law enforcement and other agencies. These measures at times can hinder normal operations.

Fire Department Emergency Response System Workload Analysis

The provision of fire protection and EMS response and care are vital services that local governments provide usually through the fire service. In order for these services to be effective, they must have sufficient resources positioned appropriately to address emergencies as they occur in an equitable manner. A Department's workload or "busy-ness" can be revealed by analyzing the number of companies/units that are engaged on assignment per hour. This method of analysis will identify the percentage of times Department resources are depleted over a given time period.

On Assignment Time refers to the total time spent on an incident by calculating the time from when the assigned apparatus and personnel are dispatch to the incident until the assigned apparatus and personnel complete all tasks and are cleared from the scene of the incident.

Units engaged per hour refers to the total number of emergency events to which apparatus are assigned within any one-hour time interval. Units engaged per hour is measured in one-hour intervals though the total time assigned for a particular unit may be shorter or longer than a single hour. For example, A department could have ambulance units assigned to the point of having 100% of units engaged on assignment 25.0% of total hours in a month (or any given time period).

A Department may experience numerous hours where a significant percentage of resources are engaged on assignment. These incidents can also be geographically located in the same neighborhood, or directly adjoining neighborhoods, causing resources throughout the department to be displaced due to continuously responding outside their first due area. The high volume of incidents and frequency of overlapping incidents experienced may lead to the conclusion that the Department requires additional resources in specific areas of the community in order to continue to provide effective and efficient emergency response.

Using Response Data to Assess Department Availability and Capability

Data necessary to assess availability and capability include response hours by unit and station. Figure 7 shows the hours for each apparatus and the overall station totals. This visualization clearly shows the immense volume of station 7, 8, and 9. This figure tells the story of busy-ness in these first due areas. Coupling this information with actual response time data will identify whether these units are meeting response goals of the department. Further, coupling this data with response time data from other units responding INTO these station first due areas will likely show longer response times since they are traveling longer distances to assist in covering the call volume for these neighborhoods.

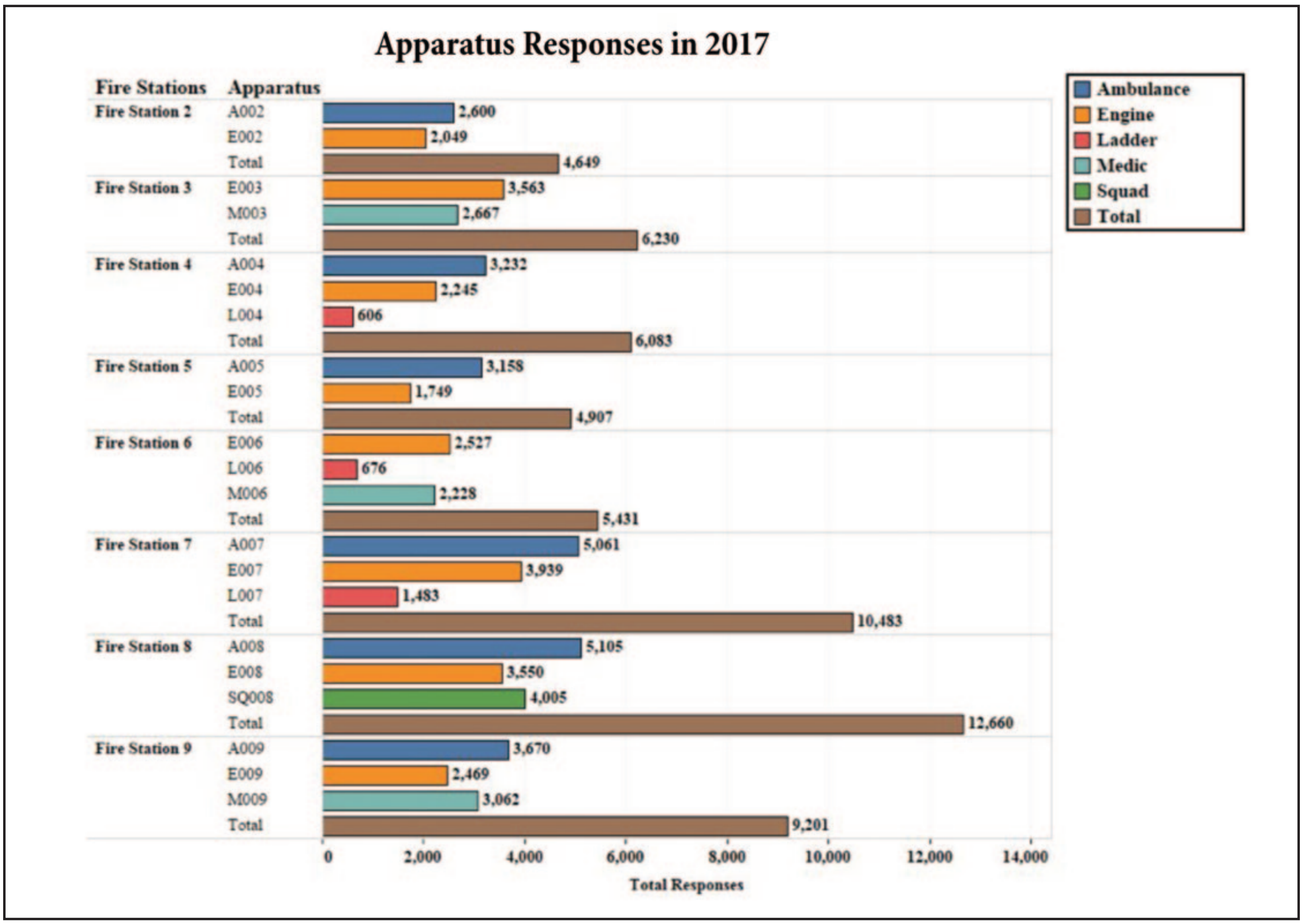

Figure 7 The number of responses for each apparatus and the station overall.

Another means of evaluating a Department's emergency services related workload is to analyze the number of companies/units that are engaged on assignment per hour. The analysis focuses on all responses by engines, ladders, ambulances, and other companies. "Dispatch time" and "clear time" for each apparatus should be assembled and examined to identify the total number of apparatus that were engaged on assignment within an hour. The results can then be used to identify a yearly average of the number of times that the units engaged on assignment (in any hour) fall into three categories a) greater than 75% of all apparatus, b) between 25% and 75% of all apparatus, and c) less than 25% of all apparatus. When resources are depleted, the department may not be capable of immediate response to emergency incidents. Additionally, when resources are depleted, there is a higher probability that units will be responding from further away leading to longer response times overall. Table 3 shows an example of apparatus (unit) hours and the percentage of time during the year a resource depletion threshold was reached.

Ambulance Hours on Assignment 2017

Percent of Ambulances on Assignment	Total Hours	Percentage of Time Reached
Greater than 75% Ambulances on assignment	5,223	59.6%
25% - 75% Ambulances on assignment	3,503	40.0%
Less than 25% Ambulances on assignment	34	0.4%

Table 3 Ambulance hours and the Percentage of Time During the Year a Resource Depletion Threshold Reached

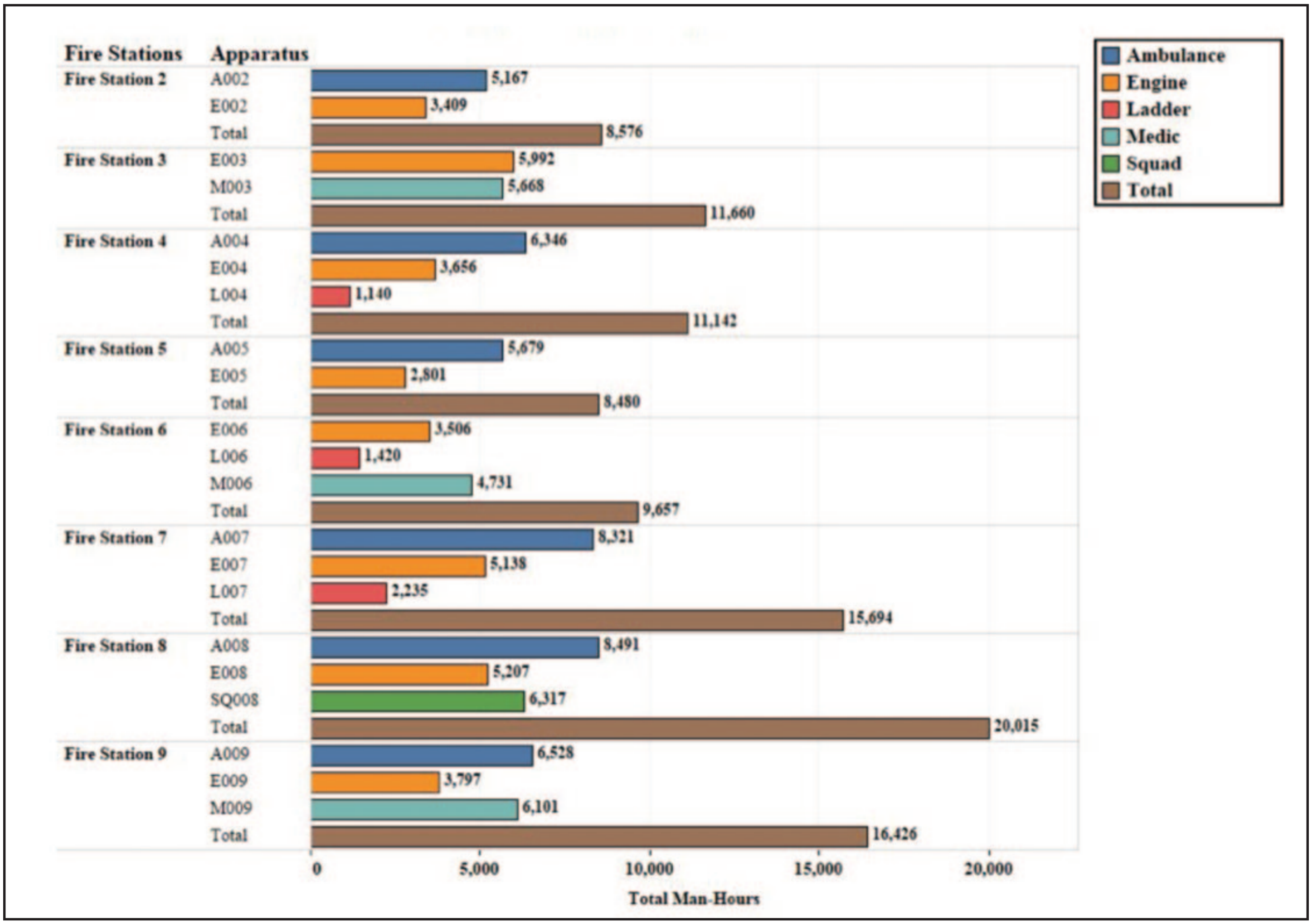

Figure 8 Apparatus Human-Hours by Apparatus and Station Overall

One other way to assess department busy-ness is to assess Individual hours (person hours) of responding personnel. Person-hours are evaluated by multiplying the number of personnel on each apparatus by the company's total on assignment time. Evaluating the Department's person-hours assists in understanding the distribution of workload throughout the Department as in figure 8 above.

System Capacity

System capacity may be defined as the maximum service output that the system of workers, equipment and vehicles is capable of producing as a whole. In addition to personnel, examples of items included in the capacity analysis consist of the following.

- A notification / dispatch system for incidents
- The number and location of stations, equipment and personnel, training
- The number/type of units responding
- Crew size per responding unit
- Water supply characteristics – hose, tank size
- EMS equipment (defibrillators, tourniquets, bandages)

It is important to note that system capacity can reach a maximum and at that point become fragile (See System Resilience below). To assess one aspect of System Capacity, individual unit responses can be examined over time and visualized as a whole. This visualization will provide insights that cannot be seen by looking at time indicators alone. Figure 9 shows a distribution of ambulance response by time of day. Note that the length of each response bar indicates the time committed to the individual response. The number of units available for response in this department on this day between 1100 and 1500 hours is extremely limited. This type visualization can assist in telling the response capacity story for fire departments.

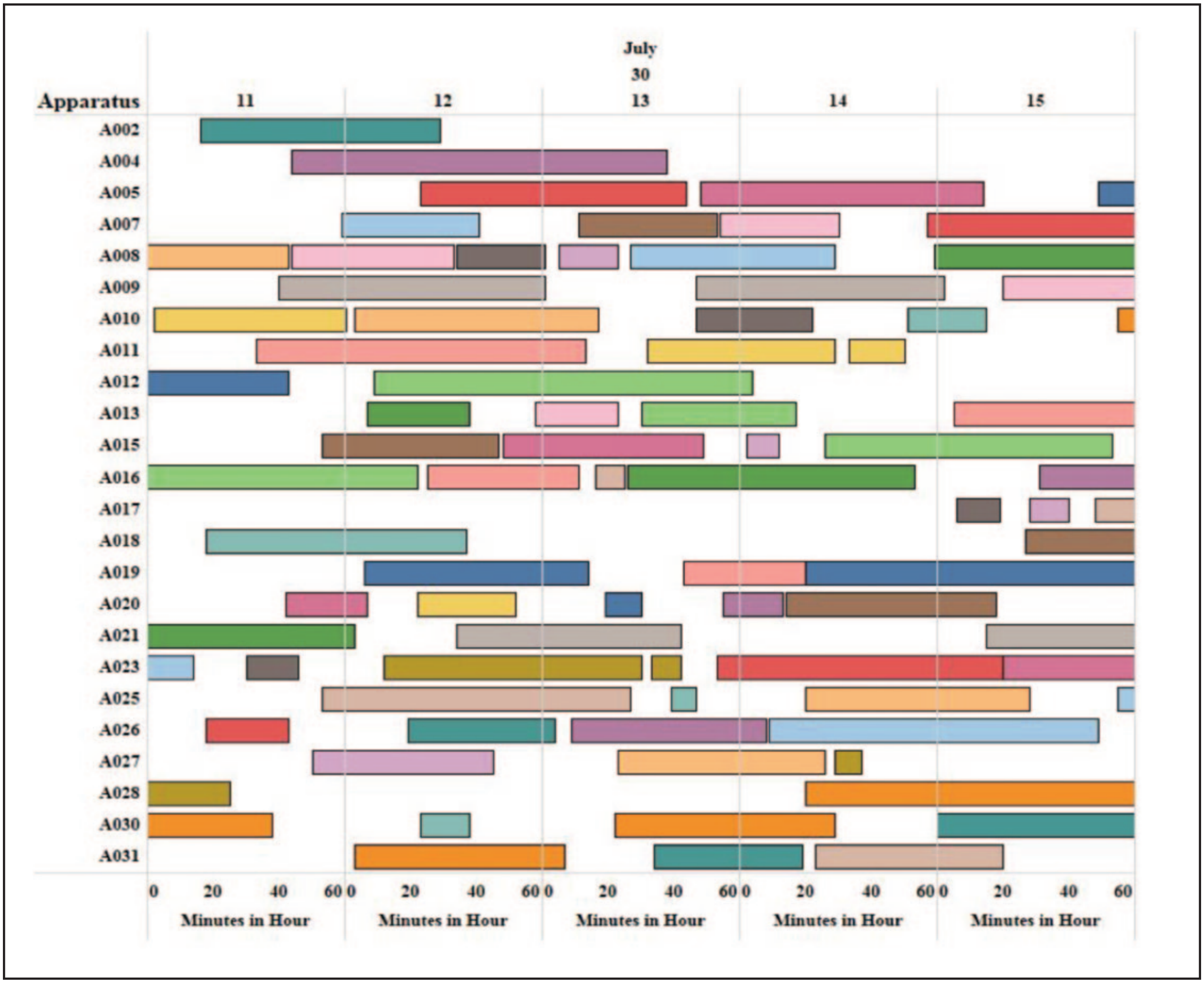

Figure 9 Shows a distribution of ambulance response for a single fire department by time of day.

Another helpful visualization is to view department responses by time of day and by year. Figure 10 shows responses by hour and by year. This figure provides insight into the overall pattern of responses and any increase in volume by year. This example clearly shows the call volume increase between 2014 and 2016.

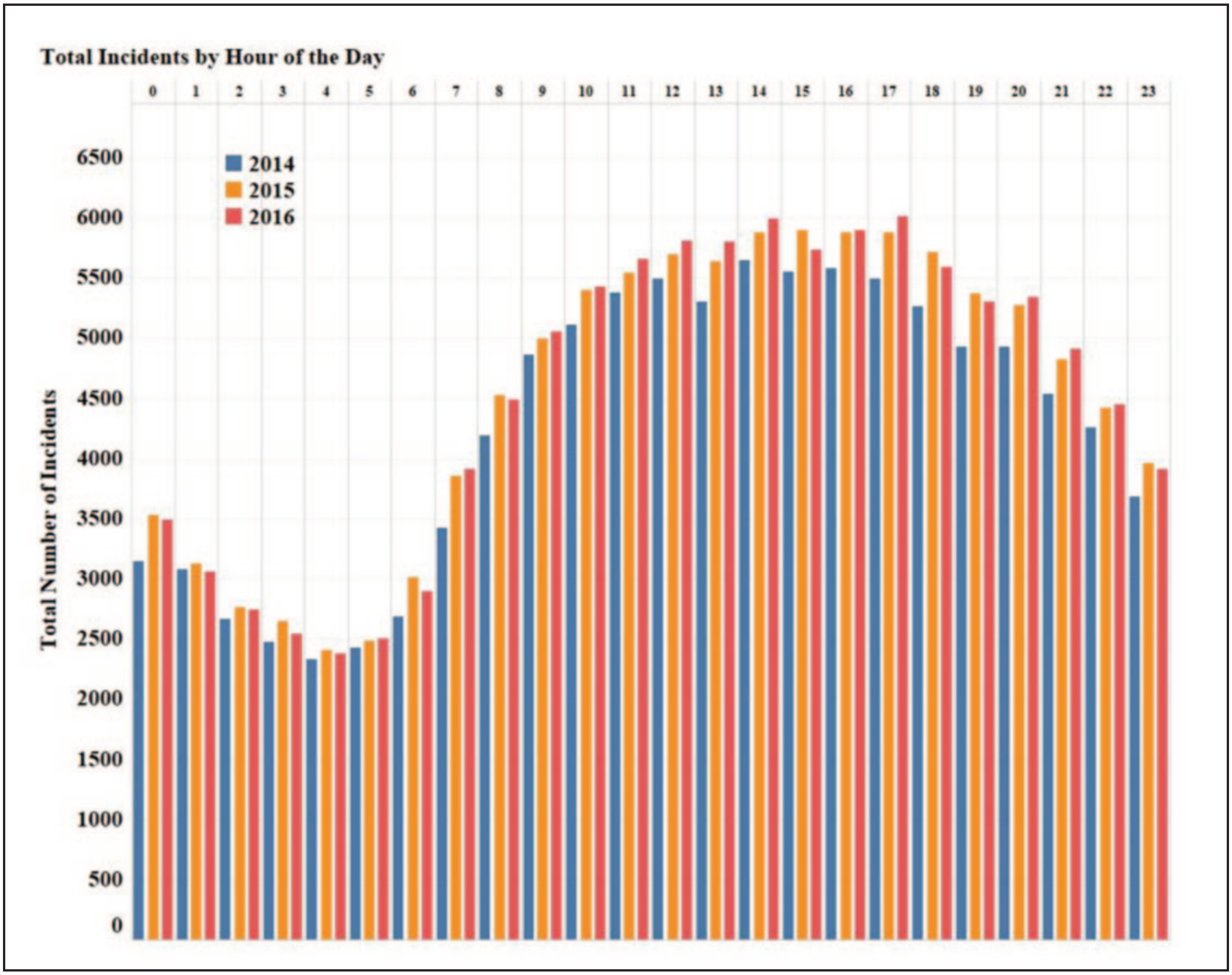

Figure 10 Total Incidents by Hour of Day and Year.

The number of incidents alone does not tell the story of fire department response availability, capability, or service delivery. Another way to tell the story of system capacity is to assess the number of incidents along with the number of overall responses to those incidents. Fire departments rarely send a single unit to an incident. For fire multiple units are deployed to assure timely assembly and intervention. For EMS, multiple units are sent for early first response intervention along with advanced care and transport. Therefore, to tell the story, the number of responses must be reported. Figure 11 shows the number of incidents vs. the number of responses for a fire department. The difference is clear and provides greater insight to decision makers.

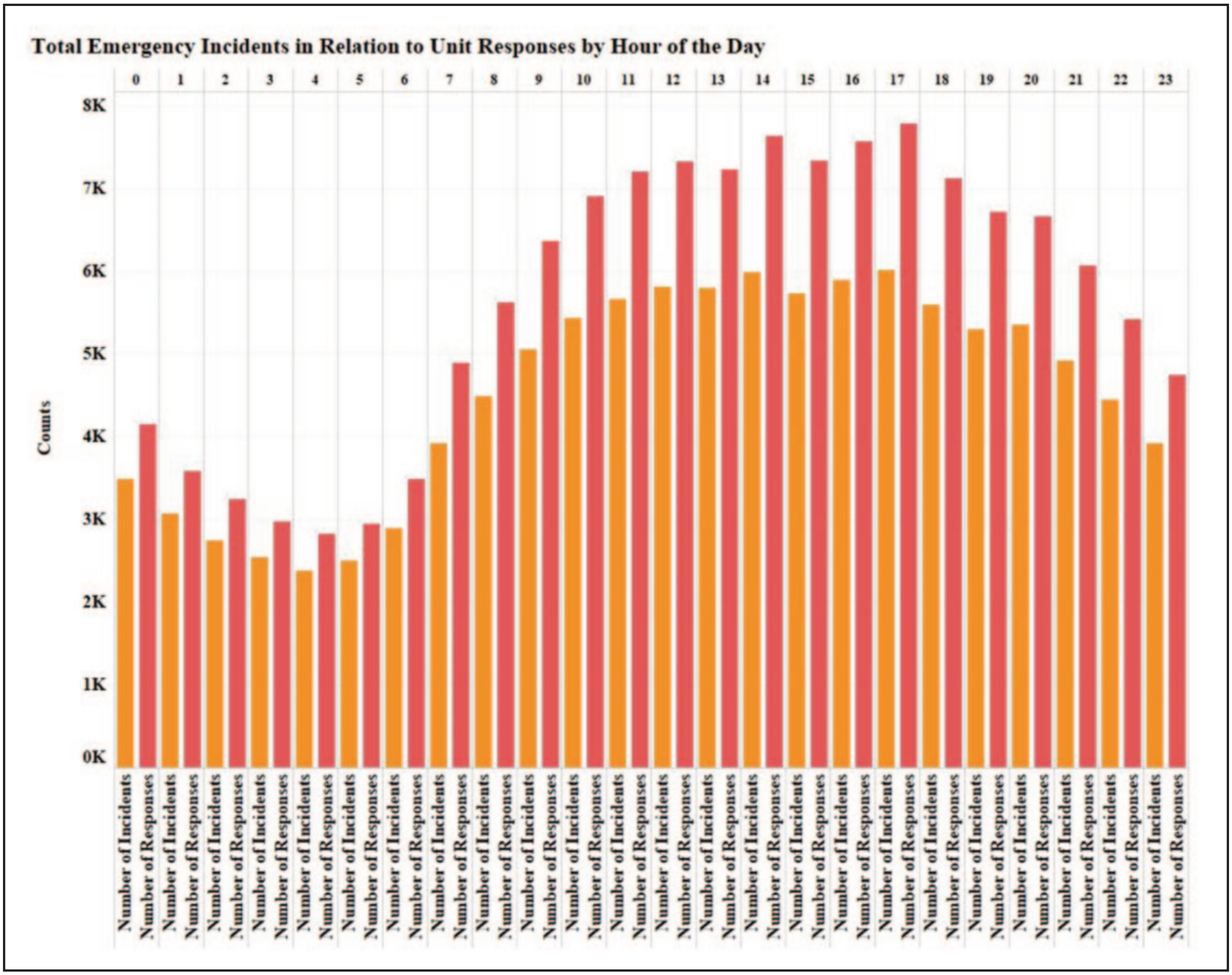

Figure 11 Total Emergency Incidents in Relation to Unit Response by Hour of Day

Assessing System Resilience

Resilience is the capacity to recover quickly from difficulties or stresses. This concept certainly applies to emergency response systems under stress. It is important that emergency response systems have built in redundancy. Excess capacity or built-in surge capacity is necessary to assure that systems are resilient in the face of excess demand. Many departments have elaborated systems of move-ups and mutual aid agreements to accommodate this need. Departments with maximum use of apparatus on a daily basis without such built-in redundancy are destined to experience failure in the form of negative outcomes. Using much of the data previously mentioned, departments can assess overall time commitments by station. Table 4 shows the percentage of 24 hour shifts that units are deployed. These percentages represent responses alone and do not factor in other workload for training, inspections, apparatus preparation, gear cleaning, and station chores.

Fire departments are often faced with challenges that multiply after natural or human-caused events or disasters. Surge planning for immediate response resource availability should be critical components of every fire departments emergency plan for these type events. Surge capacity is a measurable representation of ability to manage a sudden influx of call volume. The surge may affect all response units in the jurisdiction or it may only affect one type of response unit like EMS transport units. A fire departments capability to assure surge capacity within the response system is dependent on a well-functioning communications and incident management system and other variables like geography, supplies, staff and any special considerations. (Saylors 2016)

Fire departments are response models, not production models meant to maximize efficiencies (Saylors, 2016). Efficiency is defined as the ability to accomplish something with the least waste of time and effort including competency in performance. Therefore, efficiency is intended to maximize output of a system with minimal input. Efficient systems are not designed to be resilient or redundant, but rather to be profitable, optimized, and low cost. These systems, when stretched to the max become fragile. By eliminating redundancy or built in surge capacity that allows a system to deal with any overload, systems will evolve into fragile, error-prone systems. According to Saylors (2016) departments may reap the benefits of short-term efficiency but will eventually suffer from it. Efficient systems fail from unanticipated shocks. Resilient systems can survive shocks with sufficient built-in redundancy. Response models need to be resilient to survive the impact that overturns efficient systems. (Saylors, 2016)

Fire Stations	Total Station Responses	Total Engine Responses	Percent of 24 Hour Shift Engine on Assignment
Fire Station 2	4,649	3,436	39%
Fire Station 3	6,230	4,332	49%
Fire Station 4	6,083	4,087	47%
Fire Station 5	4,907	3,540	40%
Fire Station 6	5,431	3,242	37%
Fire Station 7	10,483	5,445	62%

Table 4 The Percentage of 24 Hour Shifts that Units Are Deployed.

Reporting: Telling the Story

Geographic Distribution of Responses

An effective way to visualize data is by census tract or other geographic areas. The United States, like other nations, is divided into tracts by which a census survey is deployed. The survey captures how many people live in an area and acquires many details about those people including age, gender, ethnicity, and employment status. All these variables are relevant to the fire service and should be used in reporting. Figure 12 shows population by census tracts.

Equally beneficial is a map with census tracts combined with call volume. This visualization provides greater insight at a smaller neighborhood level. These more granular insights are helpful in assessing risks and making resource deployment decisions. Figure 13 shows the call volume by census tract.

Though elected officials are interested in the good and welfare of the entire community, they are particularly interested in the welfare of those who directly elected them to office. Therefore, parsing data by council district is a particularly effective way to tell the story. Figure 14 shows a department call volume by council district. This graphic report may also be done by call type (e.g. EMS only). The analysis can be done easily using GIS and should become a staple for reporting.

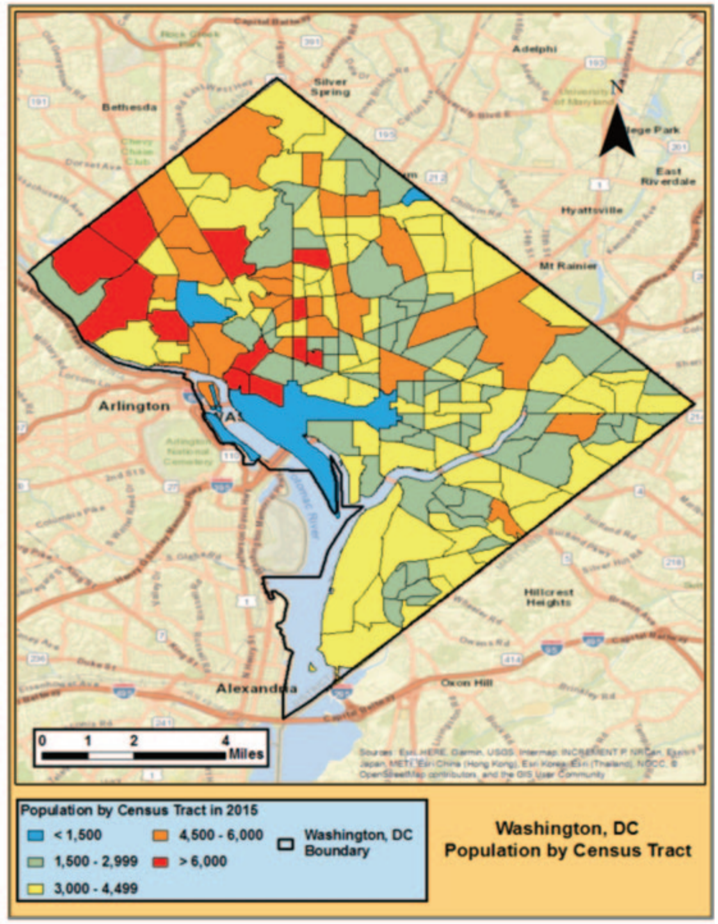

Figure 12 Population by Census Tract

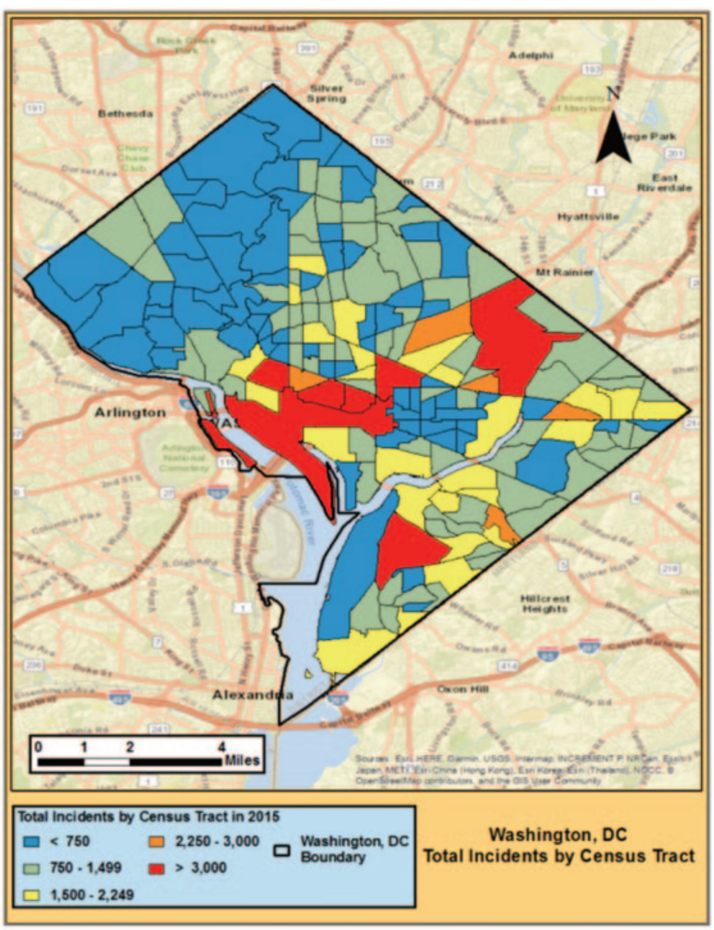

Figure 13 Call Volume by Census Tract

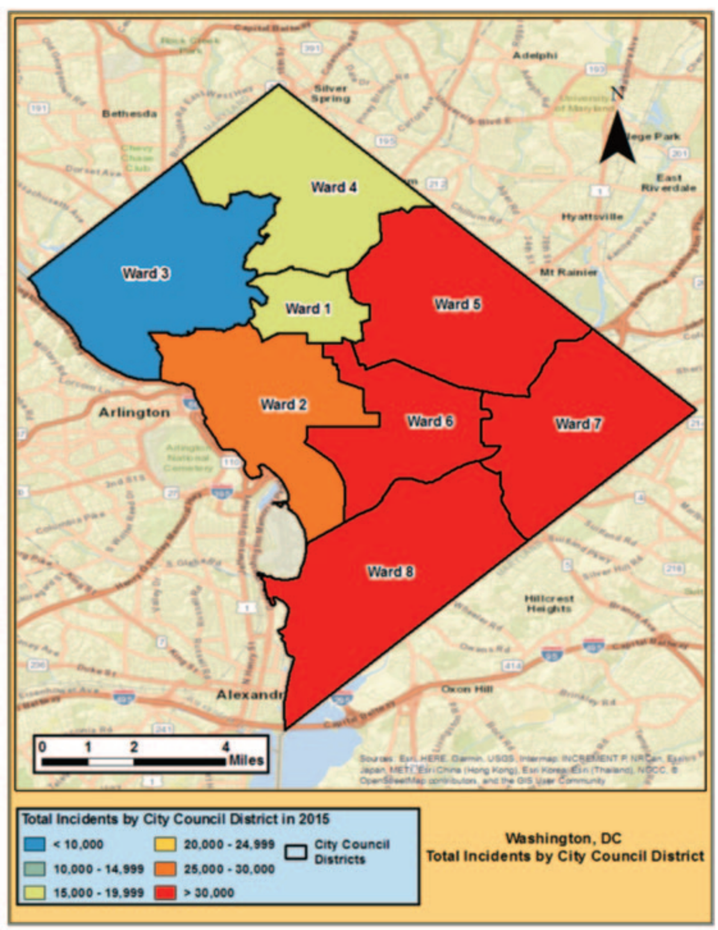

Figure 14 Fire Department Total number of Incidents by City Council Districts

EMS Reporting

Cardiac emergencies are one of the most resource intensive incidents to which firefighters and paramedics respond. Though these calls are typically less than 3% of most responses, they serve as a measure of system capability and operational performance. Table 5 is an example of reporting successes from cardiac responses. The method used is to divide resuscitations with the return of a spontaneous circulation (ROSC) prior to hospital arrival by all cardiac resuscitations. This information is of particular interest to decision makers and the public.

Year	% ROSC at ED Arrival	Method
FY2015	23%	ROSC @ ED/all resuscitations
FY2016	21%	ROSC @ ED/all resuscitations

Table 5 Return of Spontaneous Circulation Prior to Hospital Arrival

Training

Many departments work hard to stay in the forefront of firefighting and emergency medical techniques and technology. Therefore, training is a vital part of everyday activities. These activities occur in addition to all response activity and should be tracked, recorded, and reported.

Dedicated training hours for each company at the fire academy are typically limited particularly in busy response systems. For example, a goal may be to assure that each company is out of service to be onsite at the training academy twice annually. Additionally, all ALS and BLS providers must get specific EMS related training to assure compliance with state regulation and to maintain licensure/certification. In addition to training at the academy, in-station drills are conducted periodically if not daily. Some departments also deploy battalion training officers to conduct multi-unit drills on complex response functions to assure preparedness for low frequency/high consequence incidents. Finally, many departments also have mandatory officer training that should be recorded and reported.

Other Activities

Normal daily activities comprise many hours in a shift. Activities other than response and training include completing incident reports, station supply requisitions, maintenance reports, training records, preplan inspections, hydrant testing, street map books upkeep, daily inspection of all equipment and PPE, apparatus maintenance, daily staffing scheduling, time and attendance records, leave scheduling, employee orientation, rookie task book completion and review, and employee evaluations. Many departments also spend hours interacting with the public during station blood pressure checks, school fire and other emergency drills, and infant seat installation. All activities should be tracked, recorded and reported.

Community Risk Reduction Activity(CRR)

Community risk reduction activity is necessary in every community and it is a fire service role. CRR coordinates emergency operations with prevention and mitigation efforts throughout both the community and at the fire-station level. CRR reporting to decision makers should include the presence of new and emerging hazards to which the fire department will be called upon to respond. New and emerging hazards may include;

- New mass gathering venues
- Residential development
- Commercial development
- Population influx with demographic changes
- High risk populations that are underserved by other public social services

Fire Prevention Divisions typically conduct Investigations and Fire Prevention activities. Personnel are often trained and certified to enforce a variety of fire prevention regulations. Often fire inspectors investigate reports of life-threatening or dangerous fire code violations and respond to structures with out-of-service fire protection systems to ensure that the systems are repaired, and fire protection is maintained. The cumulative efforts of the Fire Marshal and investigators help to ensure lower property insurance costs, foster economic development, lower the number and severity of firefighter injuries, and increase the quality of life in the community. Table 6 shows the cumulative activities in fire prevention services.

FIRE PREVENTION SERVICES	
Fire Systems Tests	11,936
Fire Inspections	20,520
Plans Reviewed	10,788

Table 6 Fire Prevention Activities

Public Education (Community Safety and Education)

In addition to responding to emergencies that occur, a goal of a fire department is preventing the 911 call. Departments employ various tactics to reach the public, educate and protect them from preventable emergencies. Recording these contacts is vital to telling the story of the reach of the fire department in the community. This reach goes far beyond emergency response.

In many departments, firefighters go door-to-door within the communities they serve to check homes for working smoke alarms, provide home inspections, and important seasonal fire and life safety information to residents. When residents are not at home, a door hanger with safety tips and contact information is left behind.

LIFE SAFETY EDUCATION — Direct Contacts	
Preschool Children	23,745
School-Aged Children	9,028
Older Adults 50+	19,837
Juvenile Fire-setters	48

Table 7 Life Safety Education Contacts

Community wellness programs are also designed to prevent the 911 emergency medical call. Community-based programs typically address lifesaving subjects such as carbon monoxide poisoning, automated external defibrillator (AED) training, bleeding control training, and community CPR training. Table 8 below shows and example of the total contacts for these type activities.

Number of Homes Visited- CO Testing	35,125
Number persons trained in CPR	2,700
Smoke Alarms Installed3,908	

Table 8 Community Wellness Activities

Reporting Department Evaluation by Outside Agencies

CFAI Accreditation — The Commission on Fire Accreditation International (CFAI) defines a process known as "deployment analysis" as a written procedure which determines the distribution and concentration of fixed and mobile resources of an organization. Earning CFAI accreditation is a significant accomplishment and provides numerous opportunity for reporting. Departments that go through the accreditation process should include decision makers in the efforts and be sure to include them in the accolades.

ISO Classification — Insurance Services Office is a source of information about property casualty insurance risk. The ISO Public Protection Classification program is designed to help establish fire insurance premiums for residential and commercial properties based in part on a community's fire department capacity and capability. 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. The PPC program is an ISO analysis of data collected through its Fire Suppression Rating Schedule (FSRS) and is not, in and of itself, a comprehensive assessment of staffing, mobile resources deployment or service delivery. According to ISO, by securing lower fire insurance premiums for communities with better public protection, the PPC program provides incentives and rewards for communities that choose to improve their firefighting services. The ISO FSRS is not an industry standard. It is only an index calculated through a standardized data collection tool. The purpose of the FSRS is to review available fire suppression resources and develop a PPC for fire insurance rating purposes. The delivery of emergency medical services (EMS) at any level is not currently a component of the ratings schedule — even while fire department EMS call volume in North America is as high as 70-80 percent of the total number of calls. The scope of the FSRS is limited to the development of a PPC number on a scale of one to 10 and is not recommended for purposes other than insurance rating (ISO, 2014).

Conclusion

The 2015 National Fire Service Research Agenda identified several major deficiencies with respect to the need for fire service data. One of the highest priority recommendations from the Research Agenda was to identify and make use of traditional and non-traditional data to supplement, update and enhance fire service programs, including fire suppression and emergency operations, public education, fire prevention and community risk reduction efforts. Fire Chiefs and other department leaders must learn to leverage data available in their emergency response system to tell the fire department's story. Data, and the knowledge gleaned from it, show clearly that lives and property are protected or saved every day through the encounters fire departments have in the areas of prevention, public education, and emergency response services.

In today's fast changing economy, local government decision makers often alter emergency response resources faster than fire service leaders can evaluate the potential impact. These whirlwind decisions can leave a community without sufficient resources to respond to emergency calls safely, efficiently, & effectively. The effects of uninformed decision making can have even greater impact on vulnerable populations including the elderly, young children, & people with disabilities. It is imperative that fire department leaders, as well as political decision makers, understand how fire department response and other vital activities affect their local community.

Using near real-time data analyzed and reported appropriately to tell the true story of risks, response capability, and outcome can not only ensure efficient expenditure of public resources, but also identify the location of vulnerable populations in local communities and raise the bar for the technical discussion of community impact of changes to fire department resource levels. ■

Resources

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Acknowledgements

Authors

- Lori Moore-Merrell, DrPH, MPH
  International Association of Fire Fighters
- Thomas Breyer, MSHS, NRP
  International Association of Fire Fighters
- John Celmer, MS/GIS Analyst
  International Association of Fire Fighters
- Francesco De Bernardis, PhD, Data Science/GIS Analyst
  International Association of Fire Fighters

Editors

- Dennis Compton
  International Fire Service Training Association
- Russ Sanders
  National Fire Protection Association
  Metropolitan Fire Chiefs

IPSDI
International Public Safety Data Institute

URBAN FIRE FORUM
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September 2018