Risk Based Dispatching

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Abstract

The problem was the San Ramon Valley Fire District (District) does not consider a buildings size or use when dispatching resources to a structure fire. The purpose of this research was to identify how the District could incorporate a buildings' size or use into its' assignment of resources. Descriptive research methodology was used. Research questions investigated: (1) How peer agencies consider a buildings size or use when dispatching resources. (2) What building use and size classifications must be identified and the resources required by each. (3) What changes need to be made to SRVFD's computer aided dispatch system (CAD) to dispatch based on risk. (4) What advantages or disadvantages are in matching resources dispatched to the buildings size or use. A questionnaire and four interviews were used to answer these questions. A literature review identified previous research in peer review, resource allocation by risk level, CAD, advantages, or disadvantages of risk based dispatching. The results showed the Districts resource commitment to higher risk incidents is below both industry standards and those of its peers, most peers have multiple levels of dispatch, and the advantages of risk based dispatching are greater than the disadvantages. The research made a case to implement risk based dispatching using a standard and high-risk level.

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Risk Based Dispatching

The San Ramon Valley Fire Protection District (District) protects 155 square miles of urban, sub-urban, and rural areas. These areas are defined by the size and use of the buildings predominant in each as well as their population densities. A buildings size and use are the two broad factors that define its risk or potential demand for fire protection services. Not all response areas are equal. A high-risk occupancy with a high occupant load requires more resources to rescue people and control fires than a low-risk occupancy (Commission on Fire Accreditation International [CFAI], 2008, p. 7). The CFAI also states that many agencies serve a mixture of areas and a "one-size-fits-all" response with only one service level expectation would not be realistic (CFAI, 2008, p. 21).

The District does not consider a buildings size or use when dispatching resources to a structure fire. The problem is any given fire might be receiving an improper amount of resources. The importance of this problem was highlighted in the District's accreditation process. In its report recommending the District for accreditation, the CFAI stated:

> The District strives to meet its baseline response objectives utilizing eighteen personnel for all fires, which has not optimized agency improvements. This has led this team to recommend a "risk based response" approach utilizing industry standards and best practices from NFPA 1710 for appropriate fire risk responses (CFAI, 2010, pp. 20).

The purpose of this research was to identify how the District can incorporate a buildings size or use into its assignment of resources. Matching the resources committed to the risk posed by the incident potentially increases safety and effectiveness of those resources. Descriptive research was conducted to answer the following questions: (1) How do other fire agencies with similar resources to the District consider a buildings size or use when dispatching resources?

(2) What building size and use classifications must be identified and what is the proper amount of resources to dispatch to each? (3) What changes need to be made to the District's computer aided dispatch system (CAD) to allow consideration of building size and use when recommending resources? (4) What advantages or disadvantages would the District realize by matching resources dispatched to the building's size and use?

Background and Significance

The San Ramon Valley is located in the eastern part of California's San Francisco Bay Area. It encompasses approximately one third of Contra Costa County. The District includes the communities of Alamo, Blackhawk, Danville, Diablo, and San Ramon as well as some unincorporated parts of Contra Costa County. The total population served exceeds 169,900 with 71% of the District's population residing in its' urban areas, 26% in its' suburban areas, and 3% in its' rural areas. On weekdays, employees of various businesses add 30,000 to the Valley's population (San Ramon Valley Fire Protection District Administrative Services Division [SRVFPD Administrative Services Division], 2011, p. XX). In the past 25 years, much of the San Ramon Valley has transformed from a collection of rural communities surrounded by cattle ranches and orchards to its current collection of thriving urban and suburban areas. The valleys largest city is San Ramon, which is home to the headquarters of Chevron Corporation, 24-Hour Fitness, and the San Ramon Medical Center as well as the West Coast headquarters of AT&T.

The District first existed as the Danville Farm Defense Fire District, a volunteer organization established in 1912 (SRVFPD Administrative Services Division, 2011, p. X). In 1921, a state law empowered fire districts with the authority to levy taxes thus the Danville Farm Defense Fire District became the Danville Fire Protection District, an autonomous professional fire district (SRVFPD Administrative Services Division, 2011, p. x). In 1980 the San Ramon

Fire District and Danville Fire Protection District were merged to become the San Ramon Valley Fire Protection District. A five member Board of Directors, elected by their constituents and each serving a four-year term, governs the District (SRVFPD Administrative Services Division, 2011,p. xi).

The District employs 190 personnel, in addition to approximately 50 volunteers. Nine stations house paid firefighters and 15 volunteers staff one remote station (SRVFPD Administrative Services Division, 2011, p. xviii). The District staffs 15 suppression companies including 12 engine companies and 3 trucks companies. In addition five ALS ambulances are staffed: two as a part of a two-piece company and three are cross-staffed. Cross staffing is the practice of one fire company staffing more than one type of apparatus. When a call is received a cross staffing company will respond in whichever apparatus type is appropriate for the call. The District also cross staffs a California Office of Emergency Services (OES) Type II certified Hazardous Materials unit, and an OES certified medium rescue unit and one breathing support unit. In addition, the District operates its own Communications Center staffed daily with three dispatchers.

The District has always had an initial fire response of one set number and type of apparatus. A buildings size or use has never been a factor (J. Barton, personal communication, August 16, 2012). This practice is worthy of research because different buildings pose different levels of risk and one level of response to all may be limiting the organizations effectiveness. This point is supported by the Metropolitan Fire Chiefs (a section of the NFPA) who wrote if resources are deployed to match risk levels inherent in the community, it has been scientifically demonstrated that the community will be far less vulnerable to death, injury, and property loss (Metropolitan Fire Chief's, 2011, p. 3). The District traditionally sent two engines, one truck, an

ambulance, and a battalion chief to all structure fires (J. Barton, personal communication, August 16, 2012). In 1998 the Occupational Safety and Health Administration published the two-in/two-out rule mandating a minimum of two firefighters outside an immediately dangerous to life and health atmosphere (exception for known rescues) (Carter, 2002, p. 70). As a result the District added one more engine to its initial structure response. The next change in the initial structure fire response resulted from the Districts' chief officers belief that second alarms were too often called when only one more company was needed. (At that time, a second alarm was two engines and one truck). Therefore, to reduce needlessly committing resources, a second truck was added to the standard first alarm. Thus the background of the problem being studied is a critical task analysis has never been done to establish that a single level response of 18 firefighters is appropriate for all buildings within the District. Instead the resource assignments are based on: a traditional practice that two engines and one truck are a structural first alarm, adding in one more engine to provide a two out crew, then adding one more truck to reduce second alarms. Structural alarm assignments were not tailored to any risk assessment or recognized standard (J. Barton, personal communication, August 16, 2012).

In 2010 the District earned accredited agency status from the Commission on Fire Accreditation International (CFAI). The CFAI is an 11-member commission consisting of representatives from within the International Association of Fire Chiefs, the International City/County Management Association, National Fire Protection Association (NFPA), the insurance industry, and the International Association of Fire Fighters (Center for Public Safety Excellence [CPSE], 2006). After a four-day site inspection the assessment team consisting of a fire chief, two battalion chiefs and a captain concluded: "…there are opportunities to improve their ability to provide an effective response force (ERF) to building fires" (Commission on Fire

Accreditation International [CFAI], 2010, p. 11). To realize these opportunities the team recommended that the District evaluate its' total ERF requirements and determine whether they match the task requirements for each parcel based upon its' hazard and risk analysis. In other words is an ERF of 18 appropriate for all buildings the District responds to? The team also recommended that the District evaluate what effect alarm upgrades or downgrades on alarm outcomes (CFAI, 2010, p. 11). The implication was different levels of resource commitment may improve organizational effectiveness. These recommendations make it clear, in the opinion of the peer assessors; there is room for improvement regarding how the District dispatches resources to structure fires. A required step in the accreditation process is a Standards of Cover (SOC) study. This study reviews the adequacy of the District's existing deployment system and proposes enhancements the District could consider (Citygate Associates, LLC, 2009, p. 4). Finding 9 in the Districts' SOC report provides further evidence that there is room for improvement through this recommendation: "Given the population density diversity in the District a single district-wide deployment goal is not appropriate. The District needs to adopt deployment measures based on population density, risk assessment and desired outcomes for each population density area" (Citygate Associates, LLC, 2009, p. 7).

The National Fire Protection Administrations Standard 1710 (NFPA 1710) addresses the organization and deployment of fire suppression operations as well as other types of emergencies. In deployment section 5.2.4.2.2 the standard speaks of the minimum requirements for an initial alarm to a fire in a 2,000 square foot, two story, single-family home without a basement and posing no threat to exposures (a low-hazard occupancy by NFPA definition). NFPA 1710 lists eight objectives that shall be met with a minimum commitment of personnel for each (critical task analysis). Adding the required personnel from each objective produces a total

of 14 personnel required (15 if an aerial ladder is raised). The next paragraph in the standard says: “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” (National Fire Protection Association [NFPA], 2010, para. 5.2.4.2.3). The Districts current initial alarm exceeds the NFPA’s recommendation for low risk occupancies. However, NFPA 1710 provides further justification for the study since the District fails to tailor that initial alarm to the different levels of hazard presented by a buildings size or use as mandated in the standard. The NFPA is a proponent of utilizing task analysis to determine how many firefighters are necessary at a fire based on level of risk (NFPA, 2010, para. 5.2.2.1). As explained earlier the District has never done a formal critical task analysis. This practice has worked in the past but it has two probable future impacts on organizational effectiveness. The first is the District’s urban areas are developing to include high rise structures (exceeding five stories or 75 feet) as well as other larger buildings that present a higher level of risk and a response designed to meet the average need may be overwhelmed. The other is as future call volume increases, sending unneeded resources to low risk events may deprive the system of resources needed elsewhere.

This applied research project proposed that a single level of response to building fires (which pose all levels of risk) varies from industry mandates, recommendations, and standards. Background analysis provided the needed data for the District to decide if this is a practice they want to continue or if risk based dispatching would better meet their needs. The project led to a solution to the problem by identifying the practices of other similar agencies, what building classes the District could consider when assigning resources, the effect this will have on the Districts computer aided dispatch system (CAD) and what advantages or disadvantages are

associated with a risk based dispatching system. A major goal of the Executive Development Course at the National Fire Academy is change management. This project started with the identification of a problem involving a major functional element of the District. Because of the significance of the changes this project suggested, it was critical that lessons learned from the change management unit of the Executive Development Course be incorporated in the research projects report. This research also met the United States Fire Administration's goal to improve fire and emergency services' capability for response to and recovery from all hazards.

Literature Review

The District is not the only fire organization to consider incorporating a buildings size or use into its allocation of fire suppression resources. The objective of this stage of the project was to research what others have learned about the subjects presented by each of the projects four-research questions.

The first research question considered was: How do other fire agencies with similar resources to the District consider a buildings size or use when dispatching resources? Comparing organizations practices to those of its peers is a valued decision making tool in business, academia, and government. Many organizations use this practice to analyze both their current and proposed operations. The Center for Public Safety excellence (CPSE) recommends that the number, type, and spacing of resources should be commensurate with the agencies risk analysis and similar to agencies sharing the same type of risk profile (CPSE, 2006, p. 48). This comparison is a form of benchmarking. Spendolini writes that benchmarking is a systematic process for evaluating the services and work processes of organizations recognized as representing best practices and is done for organizational improvement (1992, p. 2). Bennett agreed when he wrote: external comparisons enable an organization to see how it compares to

some of its high performing peers and identify best practices to enhance its own performance (2004, p. 2). However, Chief Moeller of the Sunrise Florida Fire Department cautions of two dangers associated with benchmarking; first the results may shine a less than favorable light on one or more of the participants and second when seeking additional resources to get the job done if your performance is good then your request will face an uphill battle (2002 p. 1). Moeller's point was similar to that of the saying "be careful what you wish for" since information gained from comparisons may show a peer agency in a poor light and thus damage a cooperative relationship. He also explained that the information might make your job harder if it shows you to be ahead of your peers. If you are out performing your peers, then the authorities with the power to grant what you need may decline further support, even if you are not meeting your own expectations. Stewart wrote that there are no mandatory federal or state (in California) regulations dictating a specific level of fire protection (2007 para. 1). Thus although some industry suggestions exist, to understand how a fire agencies resource allocation practices measure up, benchmarking is often the tool of choice.

Many authors suggested that benchmarking is most accurate when done among similar organizations. Flynn discussed what makes another organization similar; it is not just size. Geography, types of hazards protected, demographics, climate, or even budget constraints are all characteristics that contribute to the similarities of like departments (Flynn, 2009 p. 101). Another opinion that benchmarking among similar agencies is valuable comes from the Oklahoma City Fire Department Fire Station Location Study. Its authors stated there are no perfect deployment models (in the fire industry) and that deciding how many emergency response resources to deploy was not an exact science (Tri Data, 2006, p. 31). They concluded to put a department's performance in perspective; it is helpful to compare the department with

other departments that share similar characteristics thereby finding benchmarks to measure its own performance (Tri Data, 2006, p. 61). Oklahoma City's experience is only one example but an excellent one illustrating that, although some standards exist, it is wise to study deployment models of your peers to see what is and is not working.

Question two was: What building use and size classifications must be identified and what is the proper amount of resources for each? In a technical report assessing resource levels at structure fires, the National Institute of Standards and Technology (NIST) weighed in on this. They stated this is a difficult question to answer since there is no scientifically based tools available to fire service leaders to asses the effects of deployment or staffing decisions at fires (Averill et al., 2010, p. 13). To begin to develop these scientific tools, in 2010 NIST conducted field trials testing the relationship between resource allocation and expected outcomes at residential structure fires. One field trial involved timing identical tasks performed by a response force of 18 firefighters versus one of 10 firefighters. The tasks involved a simulated fire with a rescue scenario on the first floor of a 2,000 square foot two-story single-family residence. The data collected showed that the response force of 18 would likely rescue trapped occupants prior to incapacitation or death and likely contain the fire to the room of origin since suppression activities commenced prior to flashover. The response force of 10 performing the same tasks in the same circumstances was likely to find an occupant incapacitated or dead as a result of exposure to toxic gases (Metropolitan Fire Chief's, 2011, p. 9). Since the described incident involves a low risk structure (per most industry classifications) NIST's study suggests that 18 is a minimal amount of resources to commit to any structure fire. TriData, a fire service management consulting business, writes that deciding how many resources to deploy and where is not an exact science. The ultimate decision is based on a combination of risk analysis,

professional judgment, and willingness of the authority having jurisdiction to accept more or less risk (Tri Data, 2006, p. 31). The literature reviewed agreed on two points: There is no legal mandate governing the number of personnel that must respond to a given structure fire and that the number will vary by organization due to factors unique to each jurisdiction.

The CPSE is a nonprofit organization dedicated to assisting fire and emergency service agencies in achieving quality improvement and the enhancement of service delivery through self assessment and accreditation (CPSE, 2006, p. 14). The Commission on Fire Accreditation International (CFAI) is the branch of CPSE that focuses on supporting and encouraging public safety agencies to meet international performance standards. To guide fire agencies through a process of assessing the distribution and concentration of their resources the CFAI produced a manual called the Standards of Cover. This Standards of Cover document stated that allocated resources must be matched to the risk level of the event (Commission on Fire Accreditation International [CFAI], 2008, p. 27). CFAI uses the term differential response system to describe the different dispatch levels resulting from matching the response to the risk associated. They make the case that a risk based dispatch system can and should be used to insure firefighter safety, system efficiency, and effectiveness (CFAI, 2008, p. 27). The CFAI also produced a Fire and Emergency Service Self-Assessment Manual. This manual guides a fire agency through the larger process of seeking accreditation (assessing an agencies standards of cover is one step in the accreditation process). The Self-Assessment Manual recommends an agency analyze its community risk using the factors of the probability of an event occurring and the consequences of that event. The Self-Assessment Manual discusses six building risk categories all of which consider a buildings (or collection of buildings) size, risk of life loss, economic value to the community, construction features, built in fire protection systems and the ability to protect

occupants in place who cannot self extricate (CPSE, 2006, p. 53). Keeping information regarding each buildings risk factor up to date often falls to an agencies fire prevention staff. How often the inspections are done to provide this information is usually a balance of fire prevention staff hours and the number of commercial buildings within a community (Hall, Flynn, & Grant, 2008, p. 7). Although the CFAI manual defines six different risk classes, it states that not all communities will have buildings that meet the definition for every class. The Self Assessment Manual also cautions against creating more than four to six risk classes. However, it states that it is a requirement of accreditation that every agency identify risks in their community and define how many categories of risk must be dealt with (CPSE, 2006, p. 56). Since the District is a CFAI accredited agency, their suggested risk groupings for buildings are worthy of consideration for the answer to the first half of research question two.

Another take on establishing building use and size classifications comes from the NFPA. The NFPA recommends establishing different building classes for the purpose of assigning resources and that the pertinent factors should be population density of a response area (i.e., suburban, rural, or wilderness) as well as occupancy hazards (NFPA, 2010, para. A.4.1.2). NFPA uses the term occupancy to refer to a buildings' use. The NFPA states that their 1710 standard is a benchmark for a low risk occupancy response and a platform for developing a resource deployment plan to higher hazard occupancies based on task analysis (NFPA, 2010, para. 1.3.2). 1710 specifies that agencies who respond to fires in high, medium, or low hazard occupancies, presenting risks greater than that presented by the low hazard occupancy example, shall deploy additional resources on the initial alarm (NFPA, 2010, para. 5.2.4.2.3). In 1710's low hazard example they used task analysis to demonstrate a need for 14 personnel (15 if an aerial is raised) (NFPA, 2010, para. 5.2.4.2.2). 1710 also states, when a fire agency responds to

an occupancy presenting greater risk than the example used, the initial dispatch must contain greater than 15 personnel. These points are supported by research conducted by the Columbus Fire Division. The research found the proportion of incidents in which property loss exceeded $5,000 and horizontal fire spread exceeded 25 sq. ft. was significantly greater for response forces less than 15 at residential fires and 23 at large-risk fires. This same research also found that firefighter injuries occurred more often when the response force was less than 15 at residential and 23 at large-risk fires (Averill et al., 2010, p. 14). NFPA however does allow the agency having jurisdiction to use its own task analysis to determine what an effective response force number is. 1710 specifies that task analysis should consider the following factors: life hazard; safety and efficacy of firefighters; potential property loss; the properties themselves, configuration, hazards and built in fire protection; standard operating procedures, types of apparatus used, and desired outcome (NFPA, 2010, para. 5.2.2.1). The desired outcome factor refers to goals established by fire agencies based on resource capacities or response times. These goals may be to hold the fire to the room of origin or the building of origin etc. Although the standard mentions low, medium and high risk building classes it does not recommend that three is the proper number of classes. NFPA 1710 says risk classes shall be identified and a number of personnel assigned to each but leaves to the fire agency discretion to deploy the appropriate numbers and types of fire apparatus. Similar to their 1710 standard, NFPA in their 20th edition of the Fire Protection Handbook, recommends the use of high, medium, and low building use and size classifications (Cote, 2008, p. 2:12). For a high hazard occupancy the handbook recommends not fewer than 24 firefighters and two chief officers, for a medium hazard occupancy not fewer than 16 firefighters and one chief officer and for a low hazard occupancy not fewer than 12 firefighters and one chief officer (Cote, 2008, table 10-2A).

The US Fire Administration developed RHAVE software to help communities assess risk in a measurable and objective way. The software was developed to provide a source for risk-based criteria in order to promote commonality among risk based deployment models (CFAI, 2003, p. 2:3). The software was intended to create a standardized typing of risks across the country and a more common understanding of how communities response to risk types. RHAVE advocates no more than four risk categories plus one for special risks and states any more than this would be an unrealistic amount of response levels. The RHAVE categories are: maximum, significant, moderate, and low (CFAI, 2003, p. 2:5)

The Insurance Services Office (ISO) is a for-profit organization providing statistical, actuarial and underwriting information to the insurance industry (Freeman, 2003, p. 180). The ISO's Insurance Grading Schedule has traditionally been used by fire agencies to evaluate their resource allocation. A part of ISO's review establishes the number of needed engine companies for a given response area based on basic fire flow, distribution and operations. Basic fire flow is an average needed fire flow computed by ISO. Distribution means an additional engine company is needed in areas where an engine required by basic fire flow is more than 1 ½ miles from 50 percent of its first due area. Operations mean that ISO requires two engine companies, except when basic fire flow only requires one (Freeman, 2003, p. 191). In regards to ladder companies, ISO says every protected area must have one respond and if one of those areas is beyond 2 ½ miles of an existing ladder company, then an additional one is required (Freeman, 2003, p. 193). In the Oklahoma City Station Deployment Study the System Planning Corporation evaluated ISO's Fire Suppression Rating Schedule. Their conclusion was that the ISO standards are useful but only as a supplement to a more comprehensive assessment of resources (Tri Data, 2006, p. 32). The ISO does address resources needed based on required fire

flow but that is the only element of building risk it considers; it fails to evaluate life safety (firefighter or civilian), property value or any other forms of risk. ISO ratings alone fail to provide a complete assessment of staffing, deployment, or service delivery (Metropolitan Fire Chief's, 2011, p. 10).

Research question three was: What changes need to be made to the District's computer aided dispatch system to allow consideration of building size or use? When a 911 call is received this address is entered or electronically transferred into a computer aided dispatch system (CAD). The CAD utilizes a master street address guide to identify a specific service area and then recommend the specific units to be dispatched (Cote, 2008, p. 12:228). CAD systems contain tables known as geofiles that can link an address to premise information such as a buildings risk class or the presence of hazardous materials (Furey, 2003, p. 464). Unique risk based dispatch assignments would not mean that every geofile would have to be reprogrammed. The districts' CAD has a generic response recommendation for a structure fires unless an override is programmed in (S. Call, personal communication, June 29, 2012).

Two different sources wrote how it may be difficult to program a CAD system to recognize and recommend automatic aid resources. Different companies make CAD systems and interoperability is still an issue that the Association of Public Safety Officials and others are addressing ("Computer-Aided Dispatch," n.d.). One of the most restrictive aspects of CAD systems can be they do not allow a dispatcher to add foreign (mutual or auto aid) units to their entries which can make them useless as a dispatching or recording tool (Bagley, 2012, para. 6). If risk based dispatches rely on automatic aid resources a lack of interoperability may necessitate some changes to standardize the Districts CAD system with those of our partners. Another author wrote when a dispatcher enters an incident the CAD would provide a recommendation of

which units should respond based on actual unit location determined by global positioning data ("Computer-Aided Dispatch," n.d.). The programing concern is the District's CAD must be configured to look for a given number of designated resources rather than a named resource. For example, for a moderate risk structure fire look for the closest three engines, two trucks, ambulance and Battalion Chief rather than Engine 1, 2, 3; Truck 1, 2; PM1; and BC1.

Research question four was: What advantages and disadvantages would the District realize by matching resources dispatched to the buildings size and use? According to the NIST, in 2007 3,430 civilians and 118 Firefighters died in fires that caused 14.6 billion dollars in property damage. After a 2010 study of fire ground resource deployment and its affects on life safety, NIST concluded that community planners and decision makers need tools to align resources committed with the demands of the incident (Averill et al., 2010, p. 12). NIST states that there is a consistent relationship between the number of engine and ladder resources deployed and a decrease in the incidence of injury among fire service personnel. They also found an increase in the occurrence of positive performance outcomes when sufficient resources were deployed. NIST cited statistics showing that property damage was significantly greater as were firefighter injuries when the number of personnel on the fire ground was less than 15 at residential fires and 23 at large risk fires (Averill et al., 2010, p. 14). NIST concluded based on these findings that when resources are properly matched to the risk, fire-ground safety and effectiveness increases (Averill et al., 2010, p. 52). Therefore, a risk based dispatching system that accurately matches resources to risk would improve safety and incident outcomes.

Since the late '70's states have been renouncing the doctrine of sovereign immunity and courts have used NFPA standards (whether adopted or not) as reasonable person standards. Because of these two trends, staffing must be considered a liability issue. Therefore, basing

dispatch levels on objective standards considering risk can protect a department from liability (Reeves, 2006, p. 106). Reeves opinion that it is advantageous to base dispatch levels on standards considering risk is reinforced by the NFPA: “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” (NFPA, 2010, para. 5.2.4.2.3). Rukavina agreed it is legally advantageous for a fire department to follow (not necessarily adopt) NFPA standards. He explains that significant in a negligence lawsuit is establishing what a reasonable fire officer would have done. NFPA standards are among those that are cited as the standard of reasonable fire service behavior and they are the “benchmark” against which the act or omission is judged (Rukavina, 2001, p. 78). The reviewed literature showed that matching resources to risk based on a standard has the advantage of putting the agency on more defensible legal ground.

Not putting more resources on the road than are necessary based on incident risk improves firefighter safety: each year since 1984, 20 to 35 percent of firefighter deaths have resulted from vehicle accidents (Jenaway, 2006, p. 165). In 2009 (most recent data available), 17 people (civilians and firefighters) were killed in crashes involving fire apparatus (National Highway Traffic Safety Administration [NHTSA], 2009, p. 142). After the 2011 meeting of the Urban Fire Forum a white paper was released by the Metropolitan Fire Chiefs (a section of the NFPA) that began by stating “ If fire department resources …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”. The three areas referred to are: Firefighter injury and death, civilian injury and death, and property loss

(Metropolitan Fire Chief's, 2011, p. 3). In this case the literature showed that limiting resources to what the risk requires improves safety of both civilians and firefighters.

Accreditation is another reason risk based dispatching is advantageous for the District. Although CFAI's assessor team recommended the District be accredited, they also stated that the one-size fits all dispatch practice has degraded the benefit of some of the District's other improvements. This led the accreditation team to specifically recommend a "risk based response" in order to meet industry standards and best practices from NFPA 1710 (CFAI, 2010, p.20).

A possible negative to risk based dispatching is liability resulting from desperate levels of protection. If the high-risk response zone gets 24 firefighters on the initial dispatch but the moderate-risk zone only gets 18, could this put the authority having jurisdiction in a bad position? Rukavina says no. He states that with few exceptions, the courts have declined to intervene in "legislative decisions" made by elected officials. In these cases Judges defer to the expertise of the authority having jurisdiction. However, he cautions, although this is true for the autonomy to make or adopt operational or budgetary policy, in cases where an adopted policy is not followed the courts will intervene and impose liability (2001 p.76).

The literature on benchmarking reinforced the value of the practice and helped define the data and the agencies this study used for comparison. The CFAI and the NFPA both provided expert opinions that risk based dispatching is the standard for current industry practice. NIST's study further validated this point with their findings. NIST's field experiments proved that matching resources to the risk present reduced firefighter and civilian injuries as well as property loss. Statistics revealed in this section indicated that reducing responding apparatus to only those required increased firefighter safety and decreased liability for the District. This research also

revealed that NFPA standards are often used to establish a reasonable care standard and therefore, following them decreases liability.

Procedures

Research for this project was conducted using the descriptive method. This Applied Research Project was inspired by the District's accreditation through the CFAI. Although the District was granted accreditation in 2010, the Accreditation Report contained strategic recommendations for improvement. The intent of this project was to help the District focus on and address the CFAI assessment team's recommendation to create a "…risk based response utilizing industry standards and best practices from NFPA 1710 for appropriate fire risk responses" (CFAI, 2010, p. 20). A thorough literature review shined some light on all four-research questions but none of them were completely answered by the previous work of others. The researcher decided research question one and some of research question two would most appropriately be answered by a survey of similar fire agencies. Research question one asked how the Districts peers considered a buildings size or use when dispatching resources. Research question two asked what building size or use classifications must be identified and what is the proper amount of resources for each.

The survey conducted to answer research questions one and part of two was titled the Staffing and Dispatch Questionnaire (questionnaire) (Appendix A). With assistance from the District's technology systems manager the questionnaire was developed into a Wufoo on-line survey. Wufoo is a web application specializing in on line form construction for people without code writing knowledge (http://www.wufoo.com/). An explanatory letter (Appendix B) introduced the questionnaire and contained a hyperlink to the Wufoo survey site. This letter was e-mailed to fifty peer fire agencies inviting them to participate. The fifty agencies were targeted

based on their similarity to the District. To judge who was similar, criterion was developed based on recommendations found in the NFPA report *Fire Service Performance Measures* (Flynn, 2009, p. 7). Flynn suggests not just considering the size of the agency to be compared to but to also consider its proximity. Flynn wrote that proximity is important because it accounts for similar climate and geographic challenges. For this reason the highest preference was given to agencies within the San Francisco Bay Area, then the State of California and finally, the Western States. Size also was a factor in judging similar. An Internet search was used to match agencies as much as possible based on their number of staffed companies. Flynn suggests as well comparing to areas with similar demographics. Therefore, the survey focused on agencies serving a similar ratio of population densities (urban, suburban and rural). A primary goal of this project was to help the District conform to the CPSE accreditation standards. For this reason, accredited agencies were given preference. When this criterion was considered as a whole, there were fifty agencies that fit within it. See Appendix C for a list of the fifty agencies solicited and those who completed the process.

To solicit participation in the survey, Internet or phone research was done to identify an appropriate contact person for each target agency. Although more time consuming than mass mailing, direct communication with each agencies person in charge of deployment was done to increase the chances of participation. Between May 14, 2012 and June 16, 2012 the contacts were then sent a concise e-mail introducing the researcher as an executive fire officer student and fire captain. The e-mail also explained the subject and purpose of the survey. To further encourage participation, the contact was assured that completing the questionnaire would take no more than ten minutes. A full letter of introduction was sent as an attachment along with a document titled Occupancy Risk Assessment Definitions Form. This form was designed to

insure the accuracy of answers by establishing what building classes were to be used and defining each. This process continued until fifty similar agencies were contacted. Of those fifty, thirty completed the survey.

The questionnaire content was created by carefully analyzing research questions one and two then formulating survey questions to solicit pertinent and objective responses. Although most surveys do not ask the participants to identify themselves question one of this survey did. Knowing the identity of the respondent maintained an ability to contact them if follow up questions occurred; this option was not exercised. Research question one was: How do other fire agencies with similar resources to the District consider a buildings size or use when dispatching resources? Although potential respondents were prescreened to insure they were peers, survey questions two through five introduced into the results the number and types of companies at the respondents disposal. These four questions were designed to show how similar peers were in terms of resources as well as how having slightly more or less resources effects the agencies commitment to different levels of risk. Research question two was: What building size and use classifications must be identified and what is the proper amount of resources for each? Survey questions six through nine identified the respondent's commitment to each of four CPSE levels of building risk thus identifying the peer's opinion regarding the proper amount of resources for each. Survey question 10 established the number of personnel on each type of apparatus and when multiplied by the apparatus commitment identified the total number of personnel committed. Survey questions 11 through 13 solicited how peers identify building size and use classes and how they determine the proper amount of resources for each. Survey question fourteen identified how peers keep their building size and use classes up to date.

The questionnaire identified how peers answered research question two but to completely answer the research question the Districts' operations assistant chief (operations chief) as well as one of its battalion chiefs (BC) were interviewed. These same interviews were used to answer research question four: What advantages or disadvantages would the District realize by matching resources dispatched to the buildings size or occupancy? The operations chief is in charge of the Districts' service delivery and therefore the agency's authority on its allocation of its fire suppression resources. A BC was interviewed because this position allocates resources at structure fires. This job duty makes them experts regarding the adequacy of the District's current dispatch levels as well as potential impacts of changes. For an industry experts perspective on research questions two and four Stewart Gary was interviewed. Stewart Gary is the fire and emergency services principal for Citygate Associated LLC. Citygate Associates LLC is a management and public safety consultancy firm for government agencies. He is also the author of the District's Standards of Cover (SOC) Study, a teacher of standards of cover evaluation, and a retired fire chief. The opinions of these three people will provide insight regarding building classifications necessary, the proper amount of resources to allocate to each as well as the advantages and disadvantages of risk based dispatching.

Jack Barton, the operations chief for the District was interviewed in his office (J. Barton, personal communication, August 16, 2012). Please see Appendix D for a list of the seven questions asked of Operations Chief Barton. Interview question one was designed to elicit the operations chief's opinion regarding the need for risk based dispatching. Question two asked for an inside experts opinion on how many building classes were necessary. NFPA 1710 is a standard regarding the allocation of resources to structure fires. Interview question three looked for the operations chief's opinion regarding NFPA 1710. Question four asked his opinion of

how many building size and use classes are necessary. Interview question five asked the operations chief's opinion of risk based dispatching's advantages or disadvantages: This was done to help answer this projects research question four. Interview question six was designed to establish if the District had the capacity to send more than its' current dispatch of personnel on a structure fire. Because risk based dispatching was specifically recommended in the CFAI's accreditation review, question seven asked if the District was risking reaccreditation if it did not adopt risk based dispatching. The interview with the BC was conducted by phone (J. Viera, personal communication, August 2, 2012). Please see Appendix E for a list questions asked of BC Viera . Interview questions one and three both were designed to determine the BC's opinion of the District's current single level dispatch: Is the current number adequate and/or are multiple levels of dispatch needed? If multiple levels are needed, question two was designed to elicit how many levels and the personnel necessary for each level. Interview question four asked the BC's opinion of NFPA 1710 and its' possible effect on District operations. Interview question five was designed to answer research question four by asking the BC's opinion regarding the advantages and disadvantages of risk based dispatching. In the BC interview there was also discussion about necessary building classes and how to define them.

To gain the perspective of an outside expert, Stewart Gary was interviewed by phone (S. W. Gary, personal communication, September 1, 2012). Please see Appendix G for a list of questions asked of Chief Gary. The first three interview questions were designed to answer parts of research question two: Interview question one asked how many risk based dispatch levels would serve the District best. Question two solicited his opinion of the best criteria to assign risk levels to buildings. Question three asked for his perspective on how to determine the proper amount of resources to match each risk level. Interview question four was designed to answer

research question four by asking Chief Gary's opinion of the advantages or disadvantages of risk based dispatching.

Research question three was: What changes need to be made to the Districts computer aided dispatch system to allow consideration of a buildings size or use classifications? To answer this question the researcher interviewed the Districts technology systems manager in his office (S. Call, personal communication, June 29, 2012). The technology systems manager is the District's expert on its CAD system as well as other computer programs associated with CAD. The interview consisted of eight questions (one question had three parts). Please see Appendix F for the questions asked. Interview question one asked if CAD was currently programmed to collect and use data necessary for a risk based dispatching system: Question two established if CAD had the capability to collect this data. Questions three and four asked what programming changes CAD would require to perform risk based dispatching. Interview question five established how complex it may be to have CAD consider each address in the District. Question six was designed to see if the Districts existing pre-planning program (which has already rated buildings for risk) could serve a double purpose by providing datum necessary for risk based dispatching. All parts of interview question seven (a, b, and c) inquired if there was an existing CAD system of the same manufacturer and version currently doing risk based dispatching. Question eight asked for the technology systems manager's expert opinion of the challenges of risk based dispatching with the Districts brand and version of CAD.

Research question four was: What advantages or disadvantages would the District realize by matching resources dispatched to the buildings size or use? The researcher incorporated this question into the interviews with operations chief Barton (J. Barton, personal communication, August 16, 2012), BC Viera (J. Viera, personal communication, August 2, 2012) and Stewart

Gary (S. W. Gary, personal communication, September 1, 2012) as previously noted. The findings of all interviews are presented in the Results Section of this report.

A limitation of the research was that not all solicited agencies choose to complete the survey: 30 agencies responded to the questionnaire out of the 50 that were solicited. This potentially creates a small sample size but the researcher is satisfied it is a sample providing meaningful insight into industry norms and best practices of similar agencies. The questionnaires purpose was to create a benchmark by which the District's practices could be compared and contrasted with those of its peers. Since great care was taken to follow NFPA's recommendations on selecting peer agencies for benchmarking, all 30 agencies represent valid examples of peers for comparison (See tables one through four in the Results Section). If the surveys questionnaire had asked peer agencies what they felt the advantages or disadvantages of risk based dispatching were; research question four would have been answered from an industry as well as an organizational perspective.

The subject of research question one was a limitation: How do other fire agencies with similar resources to the District consider a buildings size or use when dispatching resources? Due to its specialized nature there is no existing literature covering the subject of this question. However the researcher was able to locate and use literature that dealt with the purpose of the question. The purpose was to analyze the District's dispatch practices by benchmarking them to the District's peers. Research question three posed a similar challenge for literature revue. Research question three was: What changes need to be made to the District's CAD system to allow consideration of building size or use? There has been no written research concerning the District's CAD system or its specific brand and version. The available literature deals with limitations of CAD in general and its ability to recommend specific units in certain situations.

Results

The first research question asked how do other fire agencies with similar resources to the District consider a buildings size or use when dispatching resources. This question begins the research by benchmarking the dispatch practices of the District to its peers. It was designed to discover the frequency and methods of risk based dispatching among peers. It is reasoned that what works well for the District's peers is indicative of what will work well for the District. NFPA and CPSE recommend risk based dispatching but do other agencies really use it? Research question one was also designed to discover how peer agencies consider the building on fire and how this affects the resources assigned. To answer all aspects of research question one a questionnaire was developed. The questionnaires first four questions were designed to establish the amount of resources each respondent had at their disposal. This creates a context that adds meaning to the peers responses about: do they utilize risk based dispatching or one size fits all dispatching, how many building risk classes do they use and what criteria are they based on, what amount of resources are felt to be necessary at each, do they use critical task analysis to establish the required number of firefighters, and how do they insure their risk classes do not become outdated?

The first four tables present data showing resources available to each of the respondents. This data was a significant criterion in which agencies were judged to be or not to be peers of the District. The researcher avoided agencies with too few resources since their practices would not reveal their opinions or experiences regarding risk based dispatching. For example, an agency who only had three or four companies staffed would likely send them all and nothing more to every structure fire whether they believed in risk based dispatching or not. Agencies who had significantly more resources staffed than the District would likely have less need to maintain

resources for consecutive calls or station coverage and therefore commit more resources on a first alarm. Although the District was not counted in the data total presented in the next four tables, where the Districts resource level falls in the spectrum is indicated on each table by the word “District.”

Table 1

Number of Engines Staffed Daily

Answer Options	Count	Percent
1-5	4	13.3
6 -10 District	8	26.7
11-15	5	16.7
16-20	4	13.3
21-25	3	10.0
26 or more	6	20.0

Table 2

Number of Truck or Quintuple Companies Staffed

Answer Options	Count	Percent
0	1	3
1-2	13	43.3
3-4 District	7	23.3
5-6	2	6.7
7-8	3	10
9 or more	4	13.3

Table 3

Number of Ambulance or Rescue Squads

Answer Options	Count	Percent
0	9	30
1	5	16.7
2 District	5	16.7
3	3	10
4	2	6.7
5 or more	6	20

Table 4

Number of Incident Command Vehicles

Answer Options	Count	Percent
1 District	7	23.3
2	9	30
3	3	10
4	5	16.7
5	2	6.7
6 or more	4	13.3

The results of Tables 1 through 3 show the respondents represented a valid peer group: About half the respondents had more resources and half had less. Table 4 was the exception: the District was on the low end of the spectrum for incident command vehicles sent to a structure fire.

Survey questions five through eight asked how many of each type of resource the peer agency sends on an initial dispatch for a fire in a specified risk category. Since the District is an accredited agency and accredited agencies were targeted for this survey, the risk category definitions from the CPSE were adopted for this purpose (Please see Appendix B). Table 5 represents where the Districts initial alarm resource commitment fits into the average commitment of its peers. Along the bottom row the resources dispatched by the District are shown.

Table 5

Mean Average Initial Alarm Resources Dispatched by Risk Category

Building Risk	Engines	Trucks/Quintuples	Ambulances	IC Vehicles	Total FFs
Special	3.72	1.7	.80	1.90	23.67
High	3.00	2.33	.80	1.70	22.17
Moderate	3.17	1.13	.70	1.60	18.83
Low	3.07	1.10	.70	1.53	18.17
District	3.00	2.00	1.00	1.00	18.00

The District's initial alarm response for structure fires is three engines, two trucks, one ambulance, and one incident command (IC) vehicle. Three engines on an initial response matches the average shown in table 5 for all but the special risk category where it is one engine short. The District's response of two truck companies exceeds the average of its peers in all categories except the high-risk response where it matches its peers. Sending one ambulance on an initial response is approximately the average for peer agencies. Regardless of risk category the District sends a total of 18 firefighters on its initial response to a structure fire. Compared to its peers, the District's response is on par with a low risk response but almost six firefighters below its peers special risk response.

Survey question 10 asked each respondent what their minimum staffing was by apparatus type. Table six shows how the District compares to the mean average staffing among its peers for each apparatus type.

Table 6

Mean Average Staffing by Apparatus Type

	Peers	District
Engine	3.33	3.00
Truck	3.43	3.00
Ambulance	1.33	2.00
IC Vehicle	1.07	1.00

Although how many total personnel arrive in the initial alarm is the more important number, it is also worth looking at how many arrive on each piece of apparatus. In regards to staffing by apparatus type the District is generally on par with its peers. However when the criteria of .5 or higher is applied as the gauge for rounding up, the District is close to being one person under average staffing on both engines and trucks. The data collected by question ten was also used to calculate each peers initial response force: The minimum staffing per apparatus type multiplied by the number of each apparatus type equals the initial response force.

Survey question 11 asked if the peers initial dispatch to a structure fire is based on the building, then please list the factors influencing the resources sent. The questionnaire provided the following examples: building size, building code class (A, B, R1, etc.), construction class (fire resistive, non-combustible, wood frame, etc.), and hazards of contents or processes. If their initial dispatch was based on factors other than the building then they were asked to describe those factors. Choices here were: ISO fire flow, population density, or probability/consequence calculations. If the peer agency did not practice risk based dispatching they were asked to indicate that here. Ten respondents or 33 % indicated that they did not practice risk based

dispatching. The other 20 respondents or 66% indicated that they practiced some form of risk based dispatching. Out of the 20, 15 or 75% had two tiers of response and 5 or 25% had three. The most common factor for judging risk (6 out of 20 or 30%) was building code class. The next largest consideration for judging risk was the building's size (5 out of 20 or 25%). Some indicated they judged risk based on number of stories: this was tallied as a building size response. Some peers indicated that they used a combination of the choices provided. The most common here was a combination of building size and code class (3 out of 20 or 15%). The following responses all occurred once: population density; hazards of contents or processes; judgment; combination of life hazard, building size, building construction and hazardous materials; building code class, construction type, hazards of processes, and population. One peer indicated that they use RHAVE software. RHAVE is a tool available from the U. S. Fire Administration that assists in collecting a comprehensive set of risk factors for a building. It then assists with calculating a fire risk score for the building (Jenaway, 2006, p. 91).

Table 7 expresses the popularity among peer agencies of each building risk evaluation factor. Only factors that occurred more than once are included. For comparison the choice of no factors used is included in Table 7.

Table 7

Percent of Respondents Utilizing Each Risk Evaluation Factor

	Percent
No Factors Used	33
Building Code Class	20
Building Size	17
Size/Code Class Combination	10

Question 12 asked those peers who practiced risk based dispatching if their method used to place a building in a risk class was adopted from an outside organization such as NFPA, CPSE, etc. and if so, which one. Of the 20 respondents who practice risk based dispatching, 6 (30%) indicated they had adopted a system of risk classification from an outside source. The most common occurrence was the CPSE system, which was used by 3 of the 20 agencies (15%). The U.S. Fire Administration (USFA), Insurance Services Office (ISO), and National Fire Protection Administration (NFPA) were each used by one peer agency.

Survey question 13 asked if the peer agency used critical task analysis to determine how many firefighters should respond on the initial alarm. In this case, critical task analysis involves listing each task that needs to be accomplished by the first alarm. Next to each task the number of personnel needed to accomplish it is written down. The sum of these numbers becomes the personnel required to respond on the initial alarm. Of the 20 respondents who use critical task analysis 11 (55 %) indicated that they did use some form of critical task analysis. The following is a list compiled from the peer agencies indicating what critical tasks personnel were allocated to. A number indicating the amount of respondents who reported considering it follows the task.

Attack/Attack Line (7)

Back Up Line (6)

IC/Command (6)

Search and Rescue (5)

Safety (4)

Initial Rapid Intervention Crew (2)

2nd BC for Safety then Operational Support (2)

Support for Hose Lines (1)

EMS/Rehabilitation (1)

Designated Fire Investigator (1)

Water Supply (7)

Ventilation (6)

Rapid Intervention Crew (6)

Pump Operator (4)

Utilities (2)

Exposure Line (2)

Ladder Operations (1)

Forcible Entry/Search (1)

Primary Search (1)

Status (1)

Survey question 14 asked how the peer agency insures building risk classes are up to date. As tenants change in commercial buildings the buildings contents and processes may change. This event could create a significant change in the risk level posed by a building. Of the 20 peer agencies practicing risk based dispatching, 15 indicated their method to insure building risk classes are up to date. Of the 15 there were 4 (20%) who indicated that they have no system to update risk profiles and 1 peer (7%) simply stated that they have a five-year review. The most common method to update risk profiles (practiced by 5 peers or 33%) was to rely on data obtained from fire prevention inspections. The next most common method was a tie between annual company inspections and a combination of fire prevention and company inspections (3 responses for each or 20%). Relying on their target hazard program were 2 peer agencies (13%). There was 1 peer (7%) who used a combination of fire prevention inspections, building department inspections, and company pre plan inspections.

Research question two was: what building use and size classifications must be identified and what is the proper amount of resources for each? The literature review uncovered some industry standards and pertinent information. The Staffing and Dispatch Questionnaire added more information by identifying how the District's peers have answered this question. However, it is the District's own technical experts that can answer how industry standards and the practices of peer agencies are best applied to the District's practices. For this reason the Districts operations chief and its most senior shift BC were interviewed.

The purpose of the interview (J. Barton, personal communication, August 16, 2012) (Appendix D) was to get his opinion regarding how many firefighters are needed on a first alarm structure assignment. The operations chief was asked how many firefighters were needed on the initial alarm to efficiently address the critical tasks and are there types or sizes of structures in which 18 firefighters (the District's standard initial alarm response) was too few or too many. The operations chief stated he could see as few as 13 as a minimum to get going. He clarified that this would be true only for a simple single-family residence and if it were really on fire we would need 18. The fact that NFPA 1710 recommends 15 firefighters on a low risk structure fire was discussed. NFPA's example of a low risk structure fire is a 2,000 square foot single -family residence. The operations chief said if it were known that the structure was limited to this description, he would be comfortable with 15 firefighters on scene. However, he doubted that a low risk response of 15 personnel could work in the District for two reasons. One was that in his experience as a BC and as the operations chief if a rescue were involved even the low risk structure would require more than 15 people. The other concern he had was that the District has very few residential neighborhoods with homes of a consistent size. For many years the areas we serve have had the prime lots built out and land has remained in high demand. These two

factors have led to the older smaller homes being bought up, torn down, and significantly larger homes built. The result is neighborhoods with large and small homes thoroughly mixed in. Therefore, in the operations chief's opinion the only way to class a residential dispatch as low or anything else would be to evaluate and log each individual home throughout the 155 square miles covered by the District. The operations chief also mentioned the on deck concept. This is the practice of having replacements for functions such as fire attack or search ready to go. When the operating team runs out of air the on deck team steps in and maintains consistent operations. He stated he has seen fires almost under control but then grow while the initial wave of firefighters is out replacing their air bottles. For this reason, it was his opinion that even if 13 or 15 firefighters could fill the current needs at least 18 would be needed to provide that on deck resource.

The operations chief was asked if a risk based dispatching system was used, how many building risk classes it would take to address the mix of risks found in the District. Because small and large buildings are so consistently mixed in together he felt a low risk class would not work but a system with a standard and higher-level dispatch would. He was in favor of identifying high-risk buildings for the enhanced dispatch level. We discussed that the District already has a Target Hazard Program. This program preplans target hazards and classifies them as low, medium, or high-risk. It was mentioned that the technology systems manager believed the District's CAD could easily be programmed to recognize target hazard buildings based on 911 data. The operations chief agreed this would be a viable way to identify high hazard buildings.

To gain a second perspective on research question two the District's senior BC was interviewed (J. Viera, personal communication, August 2, 2012) (Appendix E). The BC was

asked if his experience had shown 18 firefighters on an initial alarm to be the right number. He was also asked if he typically had critical tasks without personnel to assign to them or if he typically had unassigned people waiting. He stated it was his experience that he always found jobs for all 18. When asked if this was because they were there and if they were not could the critical tasks be effectively handled, he indicated that with certain structures yes but with most no. He did indicate that some fires happen in low hazard buildings and are basic in nature (cited examples included no rescue and the fires location on the first floor) so they could be handled with less than 18. However, he expressed a reservation that these situations are not known until after arrival. When asked how often he encountered fires that required more than 18 on the initial alarm, he indicated that this happens but in these cases a second alarm arrives in time to get critical needs addressed. The BC questioned what a good reason would be for sending less than 18 on the initial alarm and expressed his opinion that in the absence of a good reason, why make a change. He added that if operational reasons suggested change than change was a valid course to him. However, to change for the sake of meeting accreditation goals was not (risk based dispatching was an accreditation team recommendation).

The BC was also asked about NFPA 1710 and its recommended response of 15 firefighters to a low hazard building. He said he would agree 15 are an adequate number but only for a one story single-family residence of a small size. He then said our fire district serves a collection of affluent communities containing very few neighborhoods with structures of this description.

Although the District's own experts know it best, the opinion of outside industry experts provides valuable insight. Such an expert provides an industry perspective regarding the building classes necessary, how to allocate the right amount of resources to each, and advantages

or disadvantages of risk based dispatching. Stewart Gary was interviewed for this project as an expert on fire resource allocation (S. W. Gary, personal communication, September 1, 2012) Please see Appendix G for a list of interview questions. In the SOC document, Chief Gary recommended the District adopt a risk based dispatch system (Citygate Associates, LLC, 2009, p. 7). Because of his recommendation he was asked how many levels of risk would work well for an agency the size of the District. Chief Gary felt in an agency like the District with largely homogenous structures, a standard alarm could work, but it could be done better. Even for bigger agencies he stated he is not sure if more than two to three dispatch levels are necessary. He added many agencies, even big ones, use a "light or still alarm" which is a moderate level dispatch until the first unit reports smoke, and then if it is a high-risk structure, a "full alarm" is struck. Chief Gary stressed the CFAI accreditation process leaves the number of risk classes up to the individual agency: Agencies are encouraged to match staffing numbers to a desired outcome for each type of risk. Regarding how to best determine the number or resources to assign to each risk level; Chief Gary said the key is for an agency to look at their high and special risk buildings, do critical task analysis, and ask them selves if the standard dispatch will meet the need. If not, then a higher dispatch level delivering more personnel is needed to address that risk group. It is the critical task analysis that will document whether a particular risk group is different enough to require greater numbers of personnel; if the current dispatch level does not fill the critical task necessary to achieve the desired outcome then a unique dispatch level is justified. Chief Gary cautioned that critical task analysis should be limited to the number of personnel needed to stop the escalation of the problem. Personnel required for needs like crew rotation or overhaul can arrive in subsequent alarms. When questioned about the best criterion to assign a risk level to a particular building he said that population density should be

considered as well as the building itself. It is perfectly appropriate to establish a goal of confining the fire to the room of origin in an urban or suburban area but in that same agency's rural area have the goal of confinement to the building of origin. This recognizes the fact that in rural areas the tax base is not present to support the level of dispatch necessary to confine a fire to the room of origin. Rural areas by their nature present longer response times thus would require more resources in the initial dispatch to achieve confinement to the room of origin. Rural areas create a unique response category as well because they contain structures that typically do not require ladder trucks but do require water tenders.

In Stewart Gary's opinion the District could start by evaluating two risk levels for dispatch. A standard level for residential and one to two story commercial buildings and a "commercial dispatch" for higher risks. He cautioned to be aware of the residential class in affluent communities like the District. Some upscale single-family residential buildings can require a commercial response; this is done in some cities like Beverly Hills. Agencies who have a predictable class of building predominant in a geographic area will some times establish risk classes based on emergency response zones rather than specific buildings. He said: "Remember the fire problem is more important than the building type." Stewart Gary finished by mentioning another system of establishing dispatch levels based on risk is to evaluate only target hazard buildings. This is commonly done by larger agencies when the volume of individual buildings makes it impractical to evaluate each one.

Research question three was: What changes need to be made to the District's computer aided dispatch system to allow consideration of building size or use classifications? To answer this question the researcher interviewed the District's technology systems manager (S. Call, personal communication, June 29, 2012) (Appendix F). The technology systems manager is the

person ultimately responsible for all information technology and communication systems. Specifically, he is the District's expert on its CAD System. The District has a target hazard program that has identified 271 buildings posing significant levels of risk. Each of the 271 buildings has been assigned a vulnerability rating from low to high by a risk assessment team (Citygate Associates, LLC, 2009, p. 28). This data has been used for pre fire and disaster planning purposes. The technology systems manager was asked if our CAD system had the ability to use target hazards to identify buildings requiring unique levels of initial alarm dispatch. He said this was not currently the case but it could easily be done and there are two ways the CAD system could do it. The CAD could be programmed to recognize individual target hazard buildings based on 911 data then send a custom initial alarm or it could be programmed to know that certain emergency service zones are low, moderate or high dispatch zones. An emergency service zone (ESZ) is a small geographically defined part of the District recognized by the CAD system as unique. The District is divided into 103 ESZs and CAD could easily be programmed to know how many target hazards from each risk level are in each zone. He was asked if the District went to a risk based dispatching system would the risk level of every building in the District have to be programmed into CAD. The technology systems manager said CAD could recommend a standard response for everything not programmed as an exception. If we used our target hazards as the exceptions it would take one technician about a week to program all of them into CAD.

One limitation of using target hazard buildings to identify risk level is the criterion that was used to assign these levels. To reduce the cost of its preplan program, the District partnered with police agencies serving our communities as well as the school district. To meet the needs of all stakeholders the risk levels assigned to the target hazards do not just reflect fire related risks

they consider law enforcement factors as well. For this reason and the fact that CPSE recommends building construction class as the risk assessment criteria, the technology systems manager was asked if CAD could use building construction classes to determine an initial response level. He said CAD could just as easily be programmed to recognize these criteria. This information is not currently in CAD but it does exist in the fire prevention division's global information system database. He explained the prevention division has utilized this data to track due dates for inspections of buildings. One limitation would be that residential class buildings are not included since they are not subject to inspection by our fire prevention division.

The technology systems manager was then asked what challenges he saw to utilizing CAD for the purpose of risk based dispatching. He recommended utilizing data already in our CAD system such as pre plan hazard ratings. His concern was that each hazard class in risk based dispatching creates an additional layer of consideration for CAD to consider. Cited examples were ESZs with no hydrants, required automatic aid dispatches, etc. Every layer of consideration in CAD requires hours of programming time. The technology systems manager estimated that given the known layers of consideration, each risk level would require two to three programmers about two weeks of staff time. Despite his opinion that CPSEs construction class criteria would be an improvement over the generic target hazard risk and vulnerability ratings recommendation, he said it would save a lot of expense to utilize the existing target hazard risk levels. Not only are they already in the system but target hazards risk ratings would only create three layers of consideration where as construction classes would create up to 15 (California Building Code contains 15 separate construction classes).

Research question four was: What advantages or disadvantages would the District realize by matching resources dispatched to a buildings size or use? For insight from the District's

perspective its operations chief and its senior BC were interviewed. For an industry perspective Stewart Gary of Citygate, LLC was interviewed.

In the interview with the operations chief (J. Barton, personal communication, August 16, 2012) the fact was discussed that NFPA and CPSE as well as other authorities recommend risk based dispatching. He stated it is an advantage to be in compliance with recognized standards but to change a practice that works well for the District, just for the sake of meeting a standard, may not be wise. The operations chief expressed the opinion that sending the District's standard response has worked well for many years. He expressed concern about sending any less than the current 18 personnel to a structure fire. Mostly due to the problem of knowing what is low risk before units arrive. It is quit possible, the operations chief said, to arrive at a low risk structure only to learn that a rescue is involved making the low risk complement of personnel inadequate. Although he felt sending fewer than 18 personnel in a low risk dispatch was a disadvantage of the system, the operations chief did find merit in the possibility of a high-risk dispatch. He mentioned that San Ramon and Danville both are communities with a significant number or high-risk structures. Thus using risk based dispatch practices to deliver a larger first alarm response would be advantageous. This led to discussion of CPSE, NFPA, and others recommending 24 people on a high-risk first alarm. The operations chief agreed that a high-risk structure fire would often require all 24 firefighters but he mentioned that many high-risk buildings have sprinklers. He said this typically leads to a situation where the sprinklers contain the fire and the work to be done is the less urgent work of removing cold smoke or containing water damage. Another risk based dispatching disadvantage discussed was that a high-risk dispatch would mean committing eight of the Districts 13 on duty companies. The operations chief was concerned that the District often runs multiple calls and committing eight companies to

a fire would leave too many ambulances unavailable. This is backed up by the call statistics in the 2011 Comprehensive Annual Financial Report showing 50.25% of the time the District is running at least two calls (p. 72). This concern is complicated by the fact that the District is the provider of emergency ambulance service in its area. As such it staffs five ambulances. Two of the five ambulances have dedicated crews and it is one of these that are dispatch on structure fire alarms. The other three ambulances are staffed by crews that respond with a truck or ambulance depending on the nature of the call. Thus sending more companies to initial fire dispatches takes either ambulances or trucks out of service. An additional disadvantage of risk based dispatching mentioned was the large financial and time investment to design then implement a risk based dispatching system. Research would have to be done to obtain the facts necessary to identify critical tasks involved for each risk level and determine how many personnel to assign to each. CFAI and NFPA both recommend risk based dispatching but leave identifying the critical tasks and determining adequate resources up to individual agencies.

BC Viera was asked what advantages or disadvantages he saw in risk based dispatching (personal communication, August 2, 2012). He felt a standard response was less complex and therefore more predictable for dispatchers and firefighters. In his experience 18 personnel handle the majority of responses and the high risk ones can be handled by additional alarms. “A chiefs job is to make the complex simple. If the benefits do not outweigh the time and energy to implement change then change may not be warranted.” The BC also expressed his opinion that determining what constitutes a given risk level could be extremely time consuming. Within this district, he said, we have types of buildings that can range from moderate to special risk but are of the same construction type. His point was the District couldn’t just look at a construction type and say a building is of a certain risk level.

For an outside expert's perspective on the advantages or disadvantages of risk based dispatching, the question was included in the Stewart Gary interview (personal communication, September 1, 2012). Chief Gary felt the principle advantage of risk based dispatching was, if done right, it manages an agencies resources thus insuring too many resources are not committed to any one fire and leaving the system equipped to handle simultaneous calls. He said if the system is not set up to manage resources efficiently, an initial alarm to one or two high-risk structures could deplete the agencies resources. This can happen even without a fires presence being confirmed. At the same time, an agency still has its normal service demands for medical calls, other fires, etc. As an example of an efficient system he cited Los Angeles City who practices risk based dispatching but also evaluates the time of day and day of the week. They use statistics to predict call demand levels for a given period and modify the dispatch based on this as well as the risk of the building involved. Chief Gary said an efficient system uses a systems approach that balances the need to protect a given risk against the need to maintain resources for predictable concurrent service demands.

Chief Gary stated a disadvantage of risk based dispatching is that it takes risk analysis, critical task time drills, and agency policy to develop risk based outcomes from which to drive staffing needed for tasks on-scene in certain timeframes. There is a chance a homogenous risk agency – say all homes, after doing all the work may end up where they started, with 98 % of the fires needing the same staffing amount. Another disadvantage comes from the way some risk-based systems manage their resources. Phoenix, for example, initially sends a light dispatch then if a fire is confirmed, either by bona fide 911 reports or a condition report from the first due, the dispatch is upgraded. The downside is this system requires a significant level of dispatcher

training. They must learn to understand exactly what in the follow up information should trigger the full response.

Discussion

This research project began with the following problem statement: The San Ramon Valley Fire Protection District does not consider a building's size or use when dispatching resources to a structure fire. The problem is any given fire may be receiving an improper amount of resources. Literature and research supports the premise of this statement and indicates that risk based dispatching is an industry best practice which can help the District match resources to the fire problem. The NFPA mandates risk based dispatching in their standard 1710 (NFPA, 2010, para. 5.2.4.2.3). CFAI not only endorses it they claim it should be used to insure firefighter safety (CFAI, 2008, p. 27). The consulting firm hired by the District to evaluate its standards of cover stated a single district-wide deployment goal is not appropriate (Citygate Associates, LLC, 2009, p. 7). Of the 30 peer agencies that elected to participate in this projects survey, two thirds of them use some form of risk based dispatching.

Research question one asked how do other fire agencies with similar resources to the District consider a building's size or use when dispatching resources? Peer agencies were selected to participate in a survey that produced several results. The first result was that the District's resources compare closely with the responding peer group. This is significant since the literature review authors recommended benchmarking with agencies having similar resources (CPSE, 2006, p. 48). The implication for the District is the surveyed group does indeed represent the practices of relevant agencies. Another survey result was that two thirds of the District's peers utilize some form of risk based dispatching. Since Spendolini writes that organizational improvement comes from benchmarking with ones peers, the preference of such a

majority is important (1992, p. 2). This result establishes that more than just a simple majority of organizations, with similar resources and protecting similar communities, feel matching resources to the incidents risk level is the way to go. The survey result is supported in the literature by the NFPA who mandate that the resources dispatched shall match identified levels of risk (NFPA, 2010, para. 5.2.4.2.3). These results, when interpreted as a whole, mean if the District chooses to remain with a single dispatch it would be choosing a practice that varies from industry recommendations, common practice of peer agencies, the recommendation of its accrediting agency and an NFPA mandate.

Another significant result from the survey was how the District's single response compares with the average risk based response of its peers. Table 5 from the results section shows the District's standard dispatch of 18 compares well with its peers in the low and moderate risk categories. In the high and special risk categories, however, the District falls significantly behind. NFPA 1710 only calculates a standard number of responders for low hazard buildings. For moderate hazards and above, 1710 simply says more personnel must respond and each agency shall use task analysis to determine what their appropriate number of responders is (NFPA, 2010, para. 1.3.2). The CFAI however specifies a minimum number of responders by risk group. Their Standards of Cover Document specifies a 29 personnel response to a high hazard, 15 to a moderate, and six to a low hazard incident (CFAI, 2008, p. 88). The implication for the District is that compared to its peers and standards found in the literature it falls significantly behind on personnel responding to higher hazard incidents. If the number of personnel dispatched does not match the risk posed by the building on fire, this could jeopardize safety and lead to larger fire losses.

The survey also looked at what criteria the District's peers base risk classes on. The results from the 20 peers who risk base dispatch was that 6 use building code class, 5 use the buildings size, and 3 use a combination of code class and size. The other six agencies used criteria unique to them. The survey showed the criteria used by most peer agencies to be in alignment with industry recommendations as found in the literature review. CFAI recommends considering both the buildings size and construction features (CPSE, 2006, p. 53). NFPA 1710 recommends considering adopted building codes, complexity of facilities and a building's hazards (NFPA, 2010, para. A.4.1.2). The significance of these results is that utilizing some combination of a building's construction class and size to define its risk level is in alignment with peer practices and industry recommendations thus suggesting how the District could answer this part of the research question.

Survey question 12 asked peer agencies practicing risk based dispatching if the criteria defining their risk classes were adopted from an outside source. Peers using criteria from outside sources were asked to name their source. The purpose of this question was to further define how the District's peers established their risk classes. Of the 20 peers who practice risk based dispatching, only 6 indicated they had adopted their risk class criteria from an outside source. The only repeated response was CPSE criteria that were used by 3 respondents: of the other 3 respondents USFA, ISO, and NFPA criteria was each used by one of them. Basing risk categories on a recognized standard is significant because it is a recommended practice by CFAI and was a major goal of the USFA as expressed in its Risk Hazard and Value Evaluation Program (CFAI, 2003, p. 2:3). Since the District is accredited by a subdivision of CPSE (CFAI) it therefore makes sense that it adopt CPSE's criteria to define risk classes.

Survey question 13 asked agencies that use critical task analysis to list their critical tasks. The results showed no pattern of tasks that were thought to be critical among multiple respondents. This agrees with the literature review which revealed NFPA recommends factors to consider in critical tasking but leaves the actual tasks and number of personnel to assign up to each agency (NFPA, 2010, para. 5.2.2.1). What works for its peers would be meaningful as a solid starting point for the District to define its critical tasks. Unfortunately the survey results failed to provide guidance in this respect. The literature and practices of peer agencies both lead to the interpretation that assigning critical tasks is an individual decision.

Survey question 14 asked how the responding agency insured their building risk classes were kept up to date. Of the 20 agencies who practice risk based dispatching, 4 indicated they have no system to update their buildings risk assessments and 1 stated it is done every 5 years but did not specify how. Of the other fifteen, 33% use information provided by fire prevention inspections. Although this indicates a method the District could use it does not indicate the frequency of these updates. A study done by the Fire Protection Research Foundation found that although annual inspections are a suggested goal, most agencies inspection frequencies of commercial buildings are dictated by the ratio of staff hours available to the number of buildings in the community (Hall et al., 2008, p. 7). Annual suppression company inspections were the source of verification for 20 % of respondents. Another 20% indicated that they use a combination of fire prevention and suppression company inspections. The implication for the District is that virtually all of its peers have found utilizing data obtained from prevention related inspections is the most effective method. The researcher found it significant that only 13% of respondents utilize pre-planning visits by suppression companies as a way of obtaining this information.

Research question two was: What building use and size classifications must be identified and what is the proper amount of resources for each? A significant study result was the opinion of the District's operations chief that although the District does have small buildings (both commercial and residential), they are consistently mixed in with larger ones. For this reason, he believed a low risk response would be impractical since it would require every building within the District's 155 square miles to be individually classified for risk (J. Barton, personal communication, August 16, 2012). This result agreed with the experiences of other agencies that found using hazard or fire planning zones impractical; they also had risk levels thoroughly mixed together. Instead they found they had to look at individual buildings (S. W. Gary, personal communication, September 1, 2012). The operations chief also felt the current standard response (18 personnel) met the needs of moderate and some high-risk buildings. Where he felt there was room for a new response level was in the District' mid-rise and soon to be built hi-rise buildings. A hi-rise building is a building code definition for a structure over 75 feet or 6 stories in height (National Incident Management System Consortium Model Procedures Committee [NIMSMPC], 2007, p. 179). Although CFAI defines six different building risk categories in their Self-Assessment Manual it states that not all communities will have this many. The Self-Assessment manual professes that what is really important is that every agency identifies risks in their community and defines how many categories of risk there are to be addressed (CPSE, 2006, p. 56). This is in alignment with the operations chief's intuitive belief that the District may only need two levels of risk-based response. Stewart Gary of Citygate LLC, the researcher and author of the District's Standards of Cover document, recognized this possibility when discussing the disadvantages of risk based dispatching (personal communication, September 1, 2012). He stated that some agencies invest the time and resources in a risk analysis only to discover that

their buildings are homogenous enough that only one dispatch level is called for. NFPA in their 1710 Standard states that each risk level of building should have an appropriate number of responders dispatched. What an appropriate number is should be based on a critical task analysis performed by each agency (NFPA, 2010, para. 5.2.2.1). Therefore, in the opinion of risk based dispatching experts the operations chief's intuition could be the right course for the District. However, CFAI, NFPA, and Citygate LLC all agree that a community risk analysis be done to objectively identify the number of unique risk levels in the community.

Another significant result from research question two was the operations chief's opinion that a low risk response of 15 personnel would be impractical for the District (J. Barton, personal communication, August 16, 2012). He felt 18 was a minimal initial alarm response for a structure fire and mentioned two reasons for this. One was that the District has very few neighborhoods consisting of only buildings that do not exceed NFPA's low risk structure description. In other words small low risk buildings requiring 15 personnel are mixed in with larger moderate or higher risk buildings. This result was in agreement with one interview result from the District's senior BC; he also said that low risk buildings are too intermixed with other risk groups (J. Viera, personal communication, August 2, 2012). Both chiefs were expressing the concern that a lack of building risk consistency would prevent the creation of risk response zones and necessitate a unique risk assessment for each building in the District. This would be impractical given the number of buildings involved. The operations chief's other concern with a response of only 15 personnel was, based on his experience, if a rescue is involved in even a low risk structure, 15 is not a sufficient number to address fire attack and rescue simultaneously. This opinion was supported by very similar comments from the District's senior BC (J. Viera, personal communication, August 2, 2012). The chiefs opinions however are not in agreement

with NFPA 1710 which does make an allowance for a two-person rescue team when calculating personnel for a low risk structure (2010, para. 5.2.4.2.2). The operations chief's opinion that the District should consider a heavier response than the standard 18 for some buildings however is supported by the literature. In the Standards of Cover Deployment Analysis, Citygate stated an effective response force of even 18 would be seriously slowed if a fire were above the first floor in a low-rise apartment building or commercial/industrial building (2009, p. 45). CFAI supports this view by recommending a minimum of 29 personnel in a high- risk structure fire (CFAI, 2008, p. 88). NIST's fire ground field experiments found that 23 personnel was the minimum effective response force for large risk fires (Averill et al., 2010, p. 14). Although the literature does contradict the operations chief's view regarding the effectiveness of less than 18 personnel in some building fires, it does support his view that a stronger initial response should be considered for the more significant risks. Although the chiefs interviewed were content with the Districts standard response of 18 personnel, the literature and the practices of the Districts peers provide evidence that this practice needs to at least be evaluated. The implication is that critical task analysis should be used to evaluate the District's level of response to high and special risk structures. If the District chooses to remain with its 18 person response the decision should at least be based on analytical results.

One other result of the research is that the operations chief does favor the on deck concept. This is the concept of maintaining a replacement crew of firefighters just outside of the hazard zone. Their purpose is to step in and maintain a seamless firefighting effort when the interior crew runs out of air. The operations chief stated he could agree with the NFPA's recommendation of 15 on a low risk structure if he had an on deck team in addition. In this light

the operations chief's opinion and NFPA 1710 (as well as many other sources recommending 15) are in agreement.

Research question three asked: What changes need to be made to the District's computer aided dispatch (CAD) system to allow consideration of a buildings' size or use? The District's technology systems manager was interviewed to answer this question. The District has identified 271 target hazard buildings for pre planning purposes and rated them as low, medium, or high hazards (Citygate Associates, LLC, 2009, p. 28). The technology systems manager was asked what changes would have to be made to CAD so it could recognize an incident at one of these target hazards and recommend an appropriate response. He stated that CAD does not currently recognize this data but it could with minimal changes to the system (S. Call, personal communication, June 29, 2012). The implication is the District already has risk data regarding its most significant hazards (as preplans) and CAD to designate risk-based responses could readily utilize this data. A possible limitation of CAD using this data is the risk level assigned to some preplanned target hazards may not be accurate for fire purposes. This is because the District's target hazard program was a joint venture between a police department, two city emergency services departments and the District. Therefore, the risk levels are a compromise of law enforcement and natural hazard as well as fire concerns. In the opinion of the technology systems manager the ease with which CAD could use existing target hazard data was still a significant result. He felt the target hazards incorrectly rated from a fire perspective would be the exception and their risk ratings (for fire purposes) could be changed with minimal staff time (S. Call, personal communication, June 29, 2012).

Another result of the interview was that CAD already recognizes 103 emergency service zones (ESZs). An ESZ is a geographically unique area within CAD software. Currently the

District's CAD utilizes ESZs to identify aspects of particular areas such as: the response location is a freeway, there are no hydrants, and the type of call (structure fire, vehicle accident, etc.). Other agencies however are using this same CAD software to identify the buildings use based on 911 address data (S. Call, personal communication, June 29, 2012). This is significant because the District could use the existing capability of its CAD system to recommend an appropriate risk based response for each ESZ. 103 ESZs is not a set number. The only limitation to creating more ESZs would be the staff hours required to program them into CAD (S. Call, personal communication, June 29, 2012). Although there is no literature to review concerning the usefulness of the District's CAD recommending risk based responses based on its ESZ data, there are the opinions of two chief officers of the District for comparison. The District's chief officers contradict the technology systems manager's opinion that using ESZ data would be easy and valuable. In their respective interviews both the operations chief and BC expressed the opinion that the sizes of buildings in the District and their uses are so thoroughly mixed that establishing a meaningful ESZ risk level would be impossible (J. Barton, personal communication, August 16, 2012) (J. Viera, personal communication, August 2, 2012). The point was that an ESZ would end up only including one or maybe two buildings due to the inconsistency of risk in a typical area.

The technology systems manager was asked if CAD had building code class information within its database. For example, based on building code definitions is a building used for business, education, etc. He said no but this data could be merged in from the Fire Prevention Division's inspection database. Based on results from the survey of peer agencies, construction class is the most common factor used to determine a buildings risk level. The District's fire marshal however questioned the usefulness of this data. The District does not have enough

inspectors to inspect residential occupancies thus risk data concerning the most common building use (residential) would be missing (C. Jaimison, personal communication, September 10, 2012).

The result of the interview with the technology systems manager is that using CADs existing ability to recognize target hazards and match a response level to them is the most practical choice. Some target hazards may be inaccurately rated for fire purposes but they will be the exception. Inaccurately rated target hazards could be adjusted by the District's Operations Team, which consists of the operations chief, and the BCs. Although there was no literature to compare results obtained in this interview to, there were the opinions of three experts (operations chief, BC, and fire marshal). The other options discussed in this interview all had more significant flaws when compared to the opinions of the subject experts.

Research question four investigated the advantages and disadvantages of risk based dispatching. In the operations chief's interview he made it clear that the District's initial response of 18 firefighters worked well for the majority of structure fires. However he also said the District has high-risk structures where a response force of more would be an advantage. Examples cited were four and five story mid-rise office buildings, a hospital, and "big box" stores such as Costco and the Home Depot (J. Barton, personal communication, August 16, 2012). The opinion that risk based dispatching could be advantageous is shared by NFPA's Metropolitan Fire Chiefs. The Metropolitan Fire Chiefs state; if resources are deployed to match the risk levels inherent to an incidents hazards, it has been scientifically demonstrated that the community will be less vulnerable to negative outcomes in the areas of firefighter and civilian injury, death, and property loss (2011, p. 3). More specifically the NFPA expresses the opinion that high risk buildings should receive a response of more than 18. In their Fire Protection Handbook NFPA writes that not fewer than 24 firefighters and two chief officers should respond

to high-risk structures (Cote, 2008, p. 2:12). The implication of this finding is in the opinion of the operations chief and the literature, the District would be well served by a risk-based dispatch with at least two levels. The conclusion based on the literature and interview results is that the District should investigate the possibility of utilizing risk based dispatching to provide a heavier dispatch than its current standard of 18.

In his interview Chief Gary stated an advantage of risk based dispatching is its a management tool for agency resources (personal communication, September 1, 2012). According to the chief, all agencies of any size have simultaneous requests for emergency response at least some of the time. This finding is supported by the District's Standards of Cover Document which states the District responds to two calls 50.34% of the time, three calls 18.72% of the time, and four calls 4.01% of the time (Citygate Associates, LLC, 2009, p. 75). Chief Gary explained a properly designed risk based dispatching system manages the available resources in that it allocates what is needed but also assists with maintaining operational readiness. A "one size fits all" response is typically designed for the high frequency but moderate risk hazard. When the fire occurs in a high or special risk building this practice leads to an inefficient use of resources (S. W. Gary, personal communication, September 1, 2012). The literature supports this point of view. The CFAI writes "if resources arrive too late or lack sufficient capabilities, the emergency will continue to escalate, drawing more of the agencies resources into a losing battle." "What emergency response companies must do, if they are to save lives and limit property damage, is to arrive within a short period of time with sufficient resources to do the job" (CFAI, 2008, p. 7).

NIST in their Report on Residential Fire-ground Field Experiments states that their research, as well as that of others, documents a consistent relationship between resources

deployed and firefighter and civilian safety as well as the response forces effectiveness (Averill et al., 2010, p. 14). This opinion was substantiated by study results showing that although 15 firefighters were effective at residential fires, 23 were required to be effective at large-risk fires. The Metropolitan Fire Chiefs support this position and write that resources deployed based on the risk level of the event leads to more effective efforts as well as increased safety for firefighters and civilians (Metropolitan Fire Chief's, 2011, p. 3). The implication for the District is that matching a response force to the risk level posed, rather than a one size fits all response, increases effectiveness and safety. This implication is substantiated by scientific study and the opinion of industry leaders.

A risk based dispatching system that allocates personnel based on scientific study and industry standards is advantageous because it provides a defense against claims of malpractice. The literature supports this contention. Reeves writes that an agency can be held liable if it is shown inadequate staffing lead to an accident. He states the courts have used NFPA standards as the benchmark of what is adequate staffing (2006, p. 106). Rukavina writes that a big part of a negligence lawsuit is defining what a "reasonable" fire service leader would have done. Lawyers look to the fire service at large and specifically the NFPA's standards to define what the "reasonable" fire service leader would have done (2001, p. 78). Risk based dispatching is required by NFPA 1710 (para. 5.2.4.2.3) and recommended by CFAI (2008, p. 27). The implication of the literature is that risk based dispatching would be advantageous for the District since it could help keep the District in a legally defensible position.

This project's research questionnaire determined the District's peer agencies have used critical task analysis to set their effective response force numbers at an average of 22 personnel for a high risk and almost 24 for a special risk response. The District has never done a critical

task analysis but it is likely based on the findings of its peers and a review of the literature that, if one were done, it would show very similar requirements. The District's operations chief believes this would be a disadvantage of risk based dispatching because a high risk fire call would demand too many of the on duty resources (J. Barton, personal communication, August 16, 2012). Specifically his concern was about committing half of the District's 43 on duty personnel to one fire call while also having to staff ambulances and respond to other calls. The District comprises the southern third of Contra Costa County and has a contract to provide five ambulances within that zone. This concern was supported Chief Gary in his interview for this project (personal communication, September 1, 2012). He stated that numbers of personnel could be a risk based dispatching problem. However the problem can be managed by training incident commanders to cancel units early when they are not needed and/or utilizing established mutual aid agreements. As an expert source, Chief Gary said that additional training required for incident commanders is a risk based dispatching disadvantage. Stuart Gary stated agencies using risk based dispatching have an increased need for training to help dispatchers and firefighters work within the system (personal communication, September 1, 2012).

BC Viera proposed that the time necessary to establish a risk based dispatching system would be a significant negative consequence. He believed a risk-based system would require each building to be evaluated and judged as to the risk level it posed (personal communication, August 2, 2012). Operations chief Barton expressed a similar concern regarding set up time. He believed each risk level would require a defined set of outcomes, then a listing of critical tasks to achieve those outcomes, and identifying the number of personnel to complete those tasks (personal communication, August 16, 2012). The literature and the opinions of others both support and refute these concerns. The CFAI has already defined risk levels and what building

types (single family residence, apartments, warehouses, etc.) fit into them (CFAI, 2008, p. 33). The easiest way to risk base dispatch with the Districts CAD would be to send a standard dispatch to all but the 271 target hazards programmed into the system (S. Call, personal communication, June 29, 2012). Stuart Gary indicated that identifying outcomes and critical tasks for each risk level is not were the time is spent. This is because even relatively large agencies find they only need two or three risk levels. The time commitment and thus disadvantage of risk based dispatching is analyzing and identifying what risk level each of an agencies buildings fall in (personal communication, September 1, 2012). If the District chose to use a standard dispatch to all but its target hazards and utilize the CFAI risk assessment definitions for target hazards then much of the concerns would be assuaged. However, if the agency is not satisfied that most of their buildings can be handled by its' current 18 person dispatch then there will be a large time investment in assigning risk levels.

Recommendations

This project began with the problem statement: The District does not consider a buildings size or use when dispatching resources to a structure fire. The problem is any given fire may be receiving an improper amount of resources. The conclusion of this project is that the District should adopt risk based dispatching. The findings of all four-research questions lead to the conclusion that this process will insure the proper amount of resources are sent to each fire based on the risk posed by the incident.

This projects first research question analyzed how the Districts peers consider a buildings size or use when dispatching resources. The District dispatches 18 firefighters to fires in buildings posing all levels of risk. In low to moderate risk incidents this matches what its peers are doing as well as industry standards. However, in high and special risk situations, the District

falls four and six personnel respectively behind its peers. In a high risk event the District is six personnel below what is recommended by NFPA in their 20th edition of the Fire Protection Handbook. Based on results from research question one and the recommendation of industry experts, it is recommended that the District allocate resources based on a critical task analysis for each class of building size or use.

Research question two asked: What building use and size classifications must be identified and what is the proper amount of resources for each? To address the resource aspect, it is recommended that the District adopt at least a two tier risk based dispatching system consisting of a standard (18 personnel) and high risk (24 personnel) response. This recommendation is substantiated by the practices of peer agencies, the mandate in NFPA 1710, and the recommendations of the CFAI as well as other industry experts. Significant in this recommendation is the findings of the Peer Agency Questionnaire: 50% of the District's peers found that a two tiered response best fit the risks posed by the buildings they protect. The other part of research question two concerns how to classify a buildings use and size into a risk level. It is recommended to have CAD use the existing preplan data to create response risk levels. Using this data is the least work intensive of the credible options. The District is accredited by CPSE and they recommend the use of building construction classes to define risk levels. This option however would require the CAD system to be programmed for 15 different layers of consideration (analysis of factors affecting its dispatch recommendation) but the recommended use of existing target hazards only requires three layers of consideration.

Research question three asked what changes are necessary to the District's CAD for implementation of a risk based dispatching system. It is recommended that the technology systems manager's advice be followed and the District's CAD be programmed to recognize

target hazard buildings based on 911 data. There are several advantages to this recommendation. For preplanning purposes, the work of identifying which buildings pose an elevated level of risk has already been done by the District's target hazard program. During the interview with the technology systems manager, the researcher discovered that CAD could easily be programmed to recognize these target hazards. Although the criterion for assigning the target hazard levels of risk was not exactly matched to risk based dispatching for fires, it was very close. These target hazards have already been prioritized as low, moderate, or high hazard. It would be inefficient for the District to establish a parallel program assigning levels of risk for the buildings in its 155 square mile jurisdiction. To decide which target hazard levels warrant an enhanced response, it is recommended that the operations team (BCs and operations chief) select a representative number from each level and complete a critical task analysis. This process will determine at what target hazard risk level (low, medium, or high) a building requires more than the standard response of 18 personnel. The advantage here is that using critical task analysis to identify how many personnel are required for each level of building risk is the process recommended by CFAI and mandated by NFPA.

Research question four looked at the advantages and disadvantages of risk based dispatching: The results showed there are many advantages and few disadvantages. Based on the survey results, it is a practice that is meeting the needs of many agencies facing similar challenges with similar resources. The survey questionnaire revealed that 66 % of peer agencies dispatch based on the risk posed by the building on fire so most peers feel the advantages outweigh the disadvantages as well. The literature review also showed risk based dispatching to be industry best practice. An example is the fact that NFPA 1710 mandates it. NIST proved through field experiments along with their own literature review that the proper allocation of

personnel to the events risk level increased firefighter safety and effectiveness. The CFAI in its Accreditation Report to the District strongly suggested the District adopt it. Although the preceding points are strong and the advantages are numerous evaluation is still recommended. Risk based dispatching can cause problems. The CFAI cautions agencies not to create needless complexity through establishing more risk based dispatch levels than are necessary. Stuart Gary (fire and emergency services principal for Citygate Associates LLC) stated that risk based dispatching is an advantage but only if it is properly designed to allocate resources actually required by the incident. If not, the process can waste resources and compromise an agencies ability to respond to other demands for service.

Appendix A

Staffing and Dispatch Questionnaire

1. What is the name of your agency?

2. How many engine companies does your agency staff on a daily basis?

Answer Options

1-5	16-20
6-10	21-25
11-15	26 or more

3. How many truck/quint companies does your agency staff on a daily basis?

Answer Options

0	5-6
1-2	7-8
3-4	9 or more

4. How many ambulance or rescue squads does your agency staff on a daily basis?

Answer Options

0	3
1	4
2	5 or more

5. How many incident command vehicles does your agency staff on a daily basis?

Answer Options

1	4
2	5
3	6 or more

6. Your initial dispatch to a Special Risk structure fire includes how many of each listed resource?

Engines_____	Incident Command Vehicles_____
Trucks/quints_____	Other (please specify)_____
Ambulance/Rescue Squad_____	_____

7. Your initial dispatch to a High Risk structure fire includes how many of each listed resource?

Engines_____	Incident Command Vehicles_____
Trucks/quints_____	Other (please specify)_____
Ambulance/Rescue Squad_____	_____

8. Your initial dispatch to a Moderate Risk structure fire includes how many of each listed resource?

Engines_____	Incident Command Vehicles_____
Trucks/quints_____	Other (please specify)_____
Ambulance/rescue squad_____	_____

9. Your initial dispatch to a Low Risk structure fire includes how many of each listed resource?

Engines_____	Incident Command Vehicles_____
Trucks/quints_____	Other (please specify)_____
Ambulance/rescue squad_____	_____

10. What is your agency's minimum staffing on each of the following types of resources?

Engines_____	Incident Command Vehicles_____
Trucks/quints_____	Other (please specify)_____
Ambulance/rescue squad_____	_____

Note: for questions 11 through 14 the Wufoo on line survey allowed the respondent whatever room was needed to write in their answer.

11. If your initial dispatch to a structure fire is based on the building please list the factors influencing the resources sent. Examples may include the building size, building code class (A, B, R1, etc.) construction class (fire resistive, non-combustible, wood frame), hazards of contents or processes. If the initial dispatch is based on factors other than the building (ISO fire flow, population density of a zone, probability/consequence calculations, etc.) then please describe those factors:

12. Does your agency utilize building risk classes established by another organization to assign resources? Examples may include NFPA, Center for Public Safety Excellence, etc. If yes, please list the organization and standard below:

13. If your agency utilizes critical task analysis to determine what the first alarm must be able to accomplish, please list the critical tasks and the staff to complete each.

14. How does your agency insure building risk classes are kept up to date? For example, if tenants change new contents or processes may change the building's risk level.

Appendix B

Letter of Explanation

Dear fire service leader,

My name is Scott Bradley I am a captain with the San Ramon Valley Fire Protection District in the San Francisco Bay Area and an executive fire officer student at the National Fire Academy. As part of my studies I am conducting an applied research project and I am asking for your help. My project will gather data to identify how the San Ramon Valley Fire Protection District could incorporate a buildings use or size into the dispatch of resources to structure fires.

Would you please fill out a brief survey by clicking on this link: https://firedepartment.wufoo.com/forms/staffing-and-dispatch-questionnaire/. The data collected from your responses, as well as those of other agencies, will help answer two of this projects research questions: 1) How do other agencies with similar resources to the San Ramon Valley Fire Protection District consider a buildings use or size when dispatching resources? 2) What building use or size classifications must be identified and what is the proper amount of resources for a fire in each?

It is likely that each agency surveyed will have its' own building classes for dispatch purposes. Therefore, this study will standardize the data it collects by defining a generic system of building classification. That system will be the Occupancy Risk Assessment and its' categories as developed by the Commission on Fire Accreditation International. This survey will use four of the commission's six risk categories: Special, High Hazard, Moderate, and Low Risk. Please refer to the attached definitions of the risk categories when responding to the questionnaire, please fill in how many resources your agency would send on its initial dispatch.

Thank you for your help in providing this data. Please respond by June 22, 2012.

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Appendix B (Cont.)

Occupancy Risk Assessment Definitions

Special Risks

A building or complex requiring a response over and above that appropriate to the risk predominate in the surrounding area. Typical examples might include:
A) **Hospitals** or **detention facilities** where individuals are under 24 hour care or restricted mobility.
B) Isolated **high-rise structures** when they are in other risk areas.
C) Major **chemical, hazardous materials facilities** or other high risk **industrial plants.**

High Hazard Risks

Contains built up areas of substantial size with a high concentration of property presenting a substantial risk of life loss, a severe financial impact on the community or unusual potential damage to property. Examples of such areas might include:
A) **Strip shopping** and **business areas** offering some degree of a major fire problem.

B) A concentration of **medical facilities** (excluding hospitals).

C) Concentrations of **older multistory properties** offering substantial amounts of exposure to life loss potential. **Apartment buildings** more than two stories in height with areas beyond the reach of pre-connected hose lines, buildings of low occupant load but, which store high fire load materials or high fire hazard materials.

D) Infrastructure facilities, such as **schools, city, state or federal facilities, fire stations.**

E) **Industrial building** containing some high-risk occupancies.

Moderate Risk
Contains built up areas of average size, where the risk of life loss or damage to property in a single occupancy is usually limited to the occupants, although in certain areas, such as small apartment complexes the risk of death or injury may be relatively high.
Examples of such areas might include:
A) **Single family** generally detached housing, including **smaller multi-story dwellings**.

B) Areas of older, attached, **Multifamily two story dwellings** with the predominance of property accessible to pre-connected attack lines.

Appendix B (Cont.)

C) Areas of suburban terraced, **semi-detached multi-occupancy residential** properties.

D) Mixed **low risk industrial** and residential areas.

E) **Industrial** or **commercial** areas **under 10,000 square feet** without high-hazard or high fire load contents.

Low Risk
Small structures remote from other buildings. Such as:
A) **Commercial structures** under **1,500 square feet.**

B) **Detached residential garages**

C) **Out buildings.**

Critical Tasking
Establishing tasks that must be accomplished by an alarm assignment at a fire as well as the number of staff necessary to accomplish them in a safe efficient manner.

Appendix C

Fire Agencies Polled

Note: The names of those who responded appear in bold.

Akron Fire Department – Ohio

Alameda County Fire Department – California

Albuquerque Fire Department – New Mexico

Anaheim Fire Department – California

Bakersfield Fire Department – California

Beaumont Fire/Rescue - Texas

Boise Fire Department - Idaho

Cedar Rapids Fire Department - Iowa

Chandler Fire Department - Arizona

City of Hayward Fire Department – California

City of Riverside Fire Department - California

City of Tucson Fire Department – Arizona

Clackamas Fire District Number 1 - Oregon

Colorado Springs Fire Department - Colorado

Contra Costa County Fire Protection District – California

Denver Fire Department - Colorado

Freemont Fire Department – California

Fresno Fire Department – California

Fort Wayne Fire Department - Indiana

Fullerton/Brea Fire Department - California

Appendix C (Cont.)

Fire Agencies Polled

Las Vegas Fire Department – Nevada

Long Beach Fire Department - California

Merced Fire Department – California

Modesto Regional Fire Authority - California

Novato Fire District – California

North Las Vegas Fire Department - Nevada

North Tahoe Fire Protection District - California

Oakland Fire Department – California

Pasadena Fire Department – California

Phoenix Fire Department - Arizona

Portland Fire Department – Oregon

Pueblo Fire Department - Colorado

Richmond Fire Department – California

Reno Fire Department - Nevada

Roseville Fire Department – California

Sacramento City Fire Department – California

San Francisco Fire Department - California

San Jose Fire Department – California

Santa Clara City Fire Department - California

Santa Clara County Fire Department – California

Appendix C (Cont.)

Fire Agencies Polled

Santa Fe Fire Department – New Mexico

Santa Rosa Fire Department - California

Sioux Falls Fire – Rescue – South Dakota

Scottsdale Fire Department – Arizona

Spokane Fire Department - Washington

Stockton Fire Department – California

Tacoma Fire Department – Washington

Topeka Fire Department - Kansas

West Pierce Fire and Rescue – Washington

Witchita Fire Department - Kansas

Appendix D

Operations Assistant Chief Interview Questions

1. Based on your experience, what number of personnel on a structural first alarm allows the critical tasks to get done efficiently? This includes not having to wait on an occupied crew to become available before assigning a pending critical task.

2. Are there certain types or sizes of structures in which you have found 18 to be too many or too few personnel?

3 NFPA 1710 recommends an initial alarm of 15 firefighters to a 2,000 square foot single-family residence. In cases were the residences' size is limited to 2,000 square feet or less, how do you feel about this amount of resources?

4. If the District utilized a risk based dispatching system, how many classes of buildings do you feel would address the spectrum of risks but still be efficient?

5. Do you have opinions regarding advantages or disadvantages of risk based dispatching ?

6. Some industry standards recommend eight companies (24 personnel) be dispatched to a first alarm in a high-risk building. Considering the average availability of the Districts' 13 companies, what are your thoughts regarding the Districts ability to do this?

7. In the Commission on Fire Accreditation International's Accreditation Report the assessment team stated: "The District strives to meet it's baseline response objectives utilizing 18 personnel for all fires…This has led this team to recommend a 'risk based response'". Do you know if this recommendation is a condition of reaccreditation?

Appendix E

Battalion Chief Interview Questions

1. In your experience have you found 18 to be the right number of firefighters on an initial structure fire alarm?

2. Do you find that you have critical tasks at structure fires without people to assign to them or has your experience been that you have people waiting for an assignment?

3. How often have you found 18 personnel to be too many or too few at a structure fire?

4. What are your thoughts regarding NFPA 1710's calculation that 15 is the recommended number of firefighters for a low hazard structure fire?

5. What advantages or disadvantages do you believe risk based dispatching presents?

Appendix F

Technology Systems Manager Interview Questions

1 Is there currently any system programmed into the Computer Aided Dispatch System (CAD) whereby it knows the building's type or the building's hazards based on the address or phone number of the building?

2. Does the District's CAD system have the ability to look at a building's identifying information (e.g. address) and recommend a resource assignment unique to that building?

3. If the District went to a risk based dispatch system would every address have to have a dispatch level assigned to it or could CAD recommend a standard dispatch unless the building had previously been assigned a unique one?

4. If the District had to program its' CAD to recommend a building unique dispatch, how long would it take to program the building into the system?

5. How can the District determine the number of addresses in its response area?

6. The District's target hazards are already assigned a risk level (red, yellow, or green). Is this information already programmed into CAD?

7. A) Do you know of any other agencies using the same version of CAD who risk base dispatch?
   B) If not, are there any using the same brand of CAD to risk base dispatch?
   C) Would it be possible to contact the CAD vendor and determine this?

8. Are there any challenges to running a risk based dispatch system with the District's brand and version of CAD that we have not discussed?

Appendix G

Stewart Gary Interview Questions

1. You wrote in the District's Standards of Cover Document that it would benefit from risk based dispatching. How many risk based dispatch levels would you recommend for the District?

2. What method works best to determine how many resources should be assigned to each risk level?

3. What criterion works best to assign a risk level to a particular building?

4. What advantages and/or disadvantages do you see in risk based dispatching?

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