Determining Workload Efficiency for San Bernardino County Fire Protection District Suppression Crews

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Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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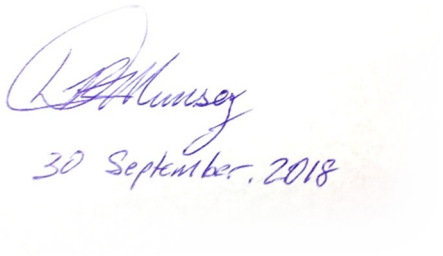

Abstract

The problem was that several San Bernardino County Fire Protection District (District), Division Two fire engines exceed 6,000 calls for service per year. This amount of annual call-load was considered “too busy” by the fire department, but a study defining what too busy means had never been conducted. The purpose of the research was to determine what the maximum emergency and non-emergency workloads are for a District crew and to define at what percentage of unit hour utilization (UHU) a unit would be considered "too busy". The descriptive research method was used for this ARP to conduct a workload and non-work activity analysis to determine the non-emergency workload of a fire engine crew. From this analysis, a maximum emergency call-load was calculated (as expressed in UHU). The descriptive research method used in this ARP defined the emergency and non-emergency tasks and commitments that are formally and informally required in a normal workday. Then the amount of time each task takes to complete was determined. Finally, the UHU percentage at which point a District crew is overtasked was determined. An extensive literature review indicated that very little work has been conducted examining the non-emergency workload of fire apparatus crews. Interviews and surveys were created to determine workload tasks, time commitments, and unmet leadership expectations. Research results indicated that on average 1,249 minutes per day was required to complete the average daily non-emergency related workload and essential non-work-activity. This leaves 191 minutes available daily for emergency response during a typical workday. Recommendations from this research indicate a 13.26% UHU be considered by the District as the point at which a unit is overtasked with current workload tasks.

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Introduction

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To determine what it means to be too busy, this Applied Research Project (ARP) calculates the average time that non-emergency workload and non-work activity takes as part of the overall daily fire engine crew workload. Then this ARP will determine how much time (on average) is left in the shift for the crew to undertake an emergency call workload while still being able to complete the required daily non-emergency work and non-work activities. Finally, the current apparatus assigned to Division Two will have their UHU examined to determine which units exceed workload expectations.

The descriptive research method is used for this ARP to conduct a workload and non-work activity analysis that can be used by the District to determine the essential tasks and activities that a fire engine crew must undertake daily. From this analysis, a maximum emergency call-load can be calculated (as expressed in UHU). The descriptive research used in this ARP was guided by the following questions: a) Which tasks/commitments are formally and informally required (either by law, ordinance, policy, culture, etc.) that crews must undertake daily? b) How much time (on average) do these commitments take to complete daily? c) How

much time is left remaining after the required tasks are completed for emergency calls and discretionary tasks? d) At what utilization percentage is a unit overtasked to meet all the crew's daily and emergency-call commitments and do any San Bernardino County Fire Protection District, Division Two apparatus exceed this overtasked utilization percentage?

Background and Significance

The City of San Bernardino has had its share of difficulties over the past decade. A deadly terrorist attack, a school shooting, major flooding, multiple devastating wildland fires, and being named in the top ten most dangerous cities multiple times would be more than enough to prove its adversities. But moreover, San Bernardino City (City) had to claim bankruptcy, reduce firefighter staffing, and ultimately close two fire stations. In July of 2016, in a final attempt to reduce expenditures, the City annexed its fire powers into the San Bernardino County Fire Protection District.

The San Bernardino County Fire Protection District is an all-risk emergency services organization covering 19,278 square miles of the 20,160 square mile county (San Bernardino is the largest county in the United States) providing services to over 60 communities, cities, and all the unincorporated areas of the county (http://www.sbcfire.org/about/AboutSBCFire.aspx). The District provides fire emergency medical services (EMS), hazardous materials response, aircraft rescue and firefighting (ARFF), urban search and rescue (USAR), and a full range of community risk reduction services. In doing this, the District employs over 1,000 personnel and responds to over 240,000 emergency incidents per year. To manage a large operational area with a full-range of emergency services, the District is divided into six geographical divisions and one special-operations division each division is managed by an assistant fire chief who manages the budget, operations, and day-to-day activities of that division.

Division Two, known as the “East Valley Division” overlays two incorporated cities, Grand Terrace and the City of San Bernardino, as well as the nearby unincorporated areas of San Bernardino County including Devore, Rosena Ranch, Muscoy, and Mentone. This ARP specifically researches San Bernardino City, as these units respond to the greatest frequency of emergency calls within the San Bernardino City area of Division Two.

The City of San Bernardino has a population of over 216,995 residents in almost a 60-square mile area ("San Bernardino City Census," 2017). The City is protected by nine fire stations located within the city boundaries and receives automatic-aid from three additional District fire stations, each located within four to six minutes of the City boundaries. The fire stations located within the City host ten advanced life support (ALS) fire engines, two ALS ladder trucks, and one ALS squad; all apparatus are staffed with career firefighters. These units are deployed at fire stations 221, 222, 224, 226, 227, 228, 229, 231, and 232. Three fire stations adjacent to San Bernardino City’s borders are likewise staffed with three ALS fire engines, each staffed with career personnel. These three fire stations are 2 (located in the community of Devore), 23 (located in the City of Grand Terrace), and 75 (located in the community of Muscoy).

Fire apparatus assigned in San Bernardino City are busy by call-load standards. Firehouse Magazine, in the 2017 National Run survey, ranked ME224 (an advanced life support Type-1 fire engine assigned in San Bernardino) as the fifth busiest fire engine in the United States with a call-load of 6,923 responses for emergency services in 2017 ("2017 National run survey," 2017, p. 6). However, busy is a subjective word and is not easily defined by call-load. The time spent responding to calls, time spent at the emergency scene, and the time spent recovering from calls are all highly variable in nature. Fire example, in the District, ME53 (an

advanced lifer support Type-1 engine assigned to Baker, California) responded to 873 calls for service in 2017 and had an average response time of 32 minutes 34 seconds, while ME224 responded to 6,923 calls for service in 2017 and had a response time of 4 minutes 31 seconds.

Using the number of emergency incidents that ME53 responded to (873 incidents) versus how many emergency incidents that ME224 (6,923 incidents) responded to in 2017 would indicate that ME224 is clearly busier. But when combing the response times to the call load, the difference becomes much more negligible. ME224 spent 519 hours and 14 minutes responding to calls while ME53 spent 473 hours and 53 minutes. ME224 responded to 6,050 more calls than ME53, but this equated to a difference of fewer than 47 hours in total time spent responding to calls (this means that ME224 was 9% busier than ME53 responding to emergencies despite responding to 6,050 more emergency incidents).

This addition of just the response time demonstrates that call load is not an accurate method of determining the workload. In fact, other factors must be considered into determining how busy a crew is, including the total time spent on and returning from the call, recovering and preparing the crew and apparatus for the next response, and the mandates that communities, local, state, and federal governments place on fire department personnel that require time out of each day to complete. All of these factors are required to determine a crew's overall workload.

This ARP recognizes that many factors and mandates are part of the total workload on the apparatus crew and each factor and mandate diminishes the amount of time available for a crew to respond to emergencies. In this recognition, this ARP seeks to reconcile the nuances of emergency and non-emergency call loads and determine how these contribute to the total available workload of a fire engine crew.

This ARP is designed to meet two of the four United States Fire Administration (2014) strategic plan goals. Goal number two is to "improve local planning and preparedness" (p.9). This ARP does this by determining many factors related to an emergency crew's ability to respond and suggests a method for determining a benchmark for adding additional resources. Likewise, goal three of "improving fire and emergency services' capability for response to and recovery from all hazards" (p.9), is met in the research of this ARP by determining the appropriate amount of apparatus and crews needed to respond and recover in an all-risk environment.

Finally, this ARP applies to the specific content of the National Fire Academy, *Executive Development* (ED) course. The major goals of the ED course are to "improve the executive fire officer's ability to build high-performance teams, exercise adaptive leadership skills, and use critical thinking skills to develop applied research projects" (National Fire Academy [NFA], 2016). This research does this by using the critical thinking skills needed for research, by demonstration of the adaptive leadership skills required to change an organization in high-volume (uncertain) time, with the result of building a high-performance emergency response team.

Literature Review

Locating literature to review that determines workload efficiency or conducts a comprehensive workload study for fire suppression crews is difficult. Very few all-inclusive studies of the workload factors encountered in the daily operations of a fire department could be located, despite extensive searches through many library catalogs, the internet, and through direct requests with consulting firms that regularly conduct fire department operations analysis. Many studies of ambulance efficiencies could be located and were used in this ARP, but none of

these compared to the scope of the extensive non-emergency workload a fire department must undertake (i.e. fire prevention activities, public events, fire-related training, etc.).

To provide as much literature research as possible, it was decided that the research review be undertaken in categorized topics including public safety workload analysis, standards of cover documents, maximum call-load of emergency apparatus, unit-hour-utilization, local, state, and federal work mandates, and the impact of fatigue on firefighters. In addition, the following non-profit professional sources were considered: National Fire Protection Agency (NFPA), the Insurance Service Office (ISO), the Occupational Safety and Health Administration (OSHA), the Center for Public Safety Excellence (CPSE), the Commission of Fire Accreditation International (CFAI), as well as a review of other comparable fire departments standards of cover (SOC) documents, strategic plans, and deployment analysis.

To accomplish this research, a thorough effort was undertaken at the National Emergency Training Center Library, the world wide web, the California State University library system, San Bernardino city and county library systems, the University of Redlands library, and direct requests for literature from non-profit and for-profit organizations.

Public Safety Workload Analysis

Portland Fire and Rescue, Oregon (PF&R) conducted a service delivery resource study in 2006 and 2011 with the goal to determine current and future demand for fire apparatus resource deployment. This study determined that "how busy units are is important for establishing their availability for the next call and because it provides insight on how much capacity various units have to handle more work, or whether additional units are needed" (TriData, 2006, p. 75). The methodology PF&R used to study their deployment included the time spent on calls multiplied by the average number of calls responded to in a 24-hour period. The study makes a clarification

on the definition of workload as used in the study as being "emergency workload only, not all the training and other tasks undertaken at the station, nor the paperwork for calls" (TriData, 2006, p. 75). This inclusion of emergency workload and not the non-emergency workload is an important distinction to make, as it is only accounts for a percentage of the total workload.

DataTech911, a leading ambulance analytics firm, writes in a whitepaper on EMS workload analysis states that "workload analysis is used to calculate the amount of work being imposed on each member of the paramedic unit" (DataTech911, n.d., p. 1). This total workload analysis considers both the emergency call-load and the non-emergency day-to-day activity each member of an emergency response team must undertake during a work shift. DataTech911 states that it uses its fire workload analysis to provide "a point system to measure personnel workloads and performance" (DataTech911, n.d., p. 2). It is a calculation based on individual tasks that field personnel perform daily. These tasks range from non-emergency transfers, post changes, to high-stress cardiac emergencies (DataTech911, n.d., p. 5). To do this, DataTech consults with the individual agency to determine what workload is important to that agency and build a model that includes emergency response and the non-emergency day-to-day activities crew members must perform.

Las Vegas Fire and Rescue (LVFR) calculates workload in a unique way. In an International City/County Management Associations (ICMA) report (International City/County Management Association [ICMA], 2012) on fire and rescue service of the LVFR, the workload process was described by ICMA as:

> The LVFR utilizes 90th percentile of total deployed time for each unit's two types of transport calls (EMS transport calls and non-transport calls). The LVFR then adds 10 minutes on to the 90th percentile times, then multiplies this

> time by the unit's average number of transports and non-transports per day to arrive at the daily workload (p. 84).

This methodology of calculating workload was designed by LVFR to attempt to calculate emergency and non-emergency workload. In the report, ICMA (2012) wrote that "ICMA is unaware of any other fire department that deploys this workload model". ICMA provided a correction to LVFR reported workload using the actual time spent on the cumulative annual workload averaged to a daily workload. In one example of a rescue (ambulance), this produced a difference of the LVFR reporting of an average of 9 hours 26 minutes to ICMA's calculated workload of 5 hours. ICMA's calculated workload is almost one-half of the workload attributed by LVFR with its unique formula.

Maximum Call Load of Emergency Apparatus

During the literature review, it was noted that maximum fire apparatus call load was a commonly posed question by city managers, fire chiefs, and other administrators. A Chesterfield County, Virginia Fire & EMS administrator posted on the ICMA forum that they "have been using an informal workload indicator of 1000 calls/year/station to begin looking at whether additional stations are needed in surrounding areas" (Edinger, 2003, para. 1). The administrator asked if anyone could advise on a workload indicator of when additional apparatus should be placed into a fire station. Although the ICMA forum is a commonly used governmental management forum, only two responses were received that vaguely suggested that the post originator research NFPA 1710 and to consult with a neighboring fire district. In the several discussion posts that were read involving this topic, no clear direction was provided by the post contributors.

In the Portland Fire and Rescue service delivery study, TriData described a benchmark based on “very high” (3,000-3,999 responses per year) and “extremely high” (>4,000 responses per year). In the study, TriData (2006) states that the “3,000–3,200 response level (indicated as a very high category in the sentence above) is the point at which units are often considered “busy” and their availability needs to be evaluated”. The study qualifies this by indicating that the responses above are in generalization, and that total emergency call workload is a better indicator of how busy a unit is (p.76).

Las Vegas Fire and Rescue in 2012 used a formula to determine the maximum call load of an emergency apparatus. In a report to Las Vegas Fire and Rescue administrators, ICMA (2012) states that when “daily call volume gets to fifteen calls per shift, LVFR administration advocates adding more employees, equipment, and/or stations” (p.84). This call-load of fifteen calls per shift equates to 5,475 emergency responses per year.

Unit Hour Utilization

Most of the literature pertaining to apparatus call-load comes in the form of UHU studies found in pre-hospital ambulance transportation efficiency studies, standard of cover (SOC) documents from fire departments, and from apparatus response reliability studies. Most of these studies relate to a fire crew’s workload is responding to and from emergency incidents; not many studies could be located that calculated the non-emergency workload of an employee or apparatus crew.

Generally, workload efficiency research focuses on emergency medical transportation UHU. Even though research is sparse in defining UHU for fire apparatus, UHU appears to be a concept widely used and applied to all emergency response vehicles (fire and ambulance) in the emergency services industry reporting.

In documents and reports that study emergency services, UHU appears to be defined in different manners by different authors. The Scottsdale (Arizona) Fire Department states that "Unit hour utilization is an important workload indicator. It is calculated by dividing the total time a unit is committed to all incidents during a year divided by the total time in a year" (Emergency Services Consulting International, 2015, p. 54). Through the literature review, this definition of UHU seems to be the most prevalent.

The second and least common definition is defining unit hour utilization as the number of transports an ambulance can undertake in an hour. Fitch and Associated states that "many EMS services, calculate UHU by dividing the number of EMS transports by the number of hours a unit is in service (Fitch & Associates, 2017, p. 1). This second less prevalent definition does not often to appear to be the definition referenced or construed in articles on UHU. Using this definition, it would be possible to quantify how many calls were completed in an average hour by a fire apparatus, but it is not a true measurement of the time required by a fire crew in a given time frame.

To avoid confusion, the American Ambulance Association defines the amount of EMS transports by the number of hours a unit in service as a "productivity ratio" (Evans & Dryar, 2010) abbreviates this version of unit hour utilization as U:HU while the term referencing the amount of time a unit is committed to an incident divided by the time it is service is abbreviated as UHU. This is the only literature that could be found differentiating between the terms.

Table 1 demonstrates the differences between the two concepts and compares the two ratios.

Table 1
Comparison of UHU and U:HU

UHU Ratio =	Total time a unit is committed to all incidents / Total number of hours that units are staffed and fully-equipped
U:HU Ratio =	Number of EMS transports / Total number of hours that units are staffed and fully-equipped

These two terms are used interchangeably in SOC documents and in most literature reviewed. In a separate article for the International Cities/Counties Association, Fitch (2017) included the difference between the uses of the term unit hour utilization:

> One commonly used measure is unit hour utilization (UHU), a ratio that is typically calculated by dividing the number of transports by the number of unit hours. In other words, an ambulance that performs four transports in a 12-hour shift has a UHU of 4/12 or 33%. However, some agencies will calculate UHU by using the total number of hours that EMS units are engaged on calls by the total number of hours that those units are staffed and fully-equipped. Neither method is right or wrong, and each has advantages—an agency worried about recouping costs might want to focus on transports, while an agency more concerned with

> staff performance and preparedness levels would be more concerned with the percentage of time ambulances are available. (p.5)

The term *utilization* alone without the preface *unit hour* is likewise prevalent in describing how much time an emergency response vehicle (i.e. squad, ambulance, Type-1 fire engine) is used in a specific time-period. While literature could not be found defining just the term utilization in reference to emergency services, in a strict business terminology sense, "utilization is the ratio of the time that a resource is actually activated relative to the time that it is available for use" (Chase, Jacobs, & Aquilano, 2006, p. 160). Using this definition, utilization is just simply a reference of a resource's availability without a specific reference to a time frame.

Often, UHU performance measures are given in fire departments standards of cover documents. Generally, these are referenced to a 30% emergency call upper threshold; a UHU rate of 30% indicates that a unit is committed to emergency calls for 7 hours and 12 minutes per day.

In an executive summary to the Chico, California city council, Fire Chief Bill Hack stated that "Historically, the International Association of Fire Fighters (IAFF) has recommended that 24-hour units utilize 0.30, or 30% workload as an upper threshold" (Hack, 2015, p. 33). The Illinois Fire Chiefs Association Consulting Services (2012) state that "for static or fixed deployment systems such as the traditional fire station, the maximum UHU is closer to 25 to 30% depending on factors such as geography or the transportation network and other workload that must be accomplished" (p. 52).

The Castle Rock Fire Department states in their standards of cover document that "typical fire service UHU for medic units is between 25% and 30%. When a unit exceeds 30%

UHU, then consideration must be given on how to reduce the UHU" (Castle Rock Fire and Rescue Department [CRFD], 2018, p. 103).

The Illinois Fire Chiefs Association Consulting Services acknowledges that "It should be noted at .30% UHU a 24-hour company does not have time for inspections, training of new personnel, public education activities, or personal time for studying or other self- improvement" (IFCA, 2012, p. 52). Fitch (2017) agrees with this sentiment and suggests that UHU does not have a set standard. He states that "EMS agencies responding solely to 911 calls typically target a lower unit hour utilization (between 30 and 50% UHU) than nonemergency ambulance transport providers… Agencies whose providers work longer shifts, such as 24 hours, also often aim for lower UHUs due to concerns over fatigue and safety (p. 5).

San Diego Fire-Rescue Department's *Standards of Response Cover* takes a slightly different approach on recommendations for maximum UHU. In this document, prepared by Citygate (2017), the reader is reminded that during the 9-hour (work day) of a 24-hour shift, emergency crews have other duties (non-emergency workload) that must be completed. Citygate suggests that if a 30% UHU is exceeded during that 9-hour (day work period) then fire crews will not be able to complete the non-emergency workload. The report then recommends that ambulances or squads can obtain a 40-50% UHU, but in these high UHU scenarios, the crew should have duty days scheduled to obtain training only and not be available for responses.

Standard of Cover Documents

Many standards of cover (SOC) documents were reviewed during the literature review. Some of the common SOC material (such as UHU) has been discussed above. Other common SOC subject matter includes key indicators for emergency workload considerations including total response time, determining response statistical analysis or a quantitative analysis of the

types of incidents responded, distribution of the emergency call load, and the frequency of emergency response, and determining response reliability.

Total response time.

The total response times is a measurement from the receipt of the alarm in the dispatch center public safety answering point (PSAP) to the point of when the first emergency response unit has arrived and is initiating an action or intervening to control the incident. CPSE (2016) defines this as the total cumulative time of three-time components: alarm handling, turnout, and travel" (p.6). Total response time plays a part in the emergency workload of a unit starting with the actual call being relayed to the emergency response crews during the alarm handling time and ending with the unit arriving at the emergency scene and initiating action.

Response statistical analysis.

Response statistical analysis often discuss peak demand for service times, the number of simultaneous responses received in prior years, the number of incidents by the hour or day of the year, and the number of each incident type. This information is critical to analyze to determine how response demand effects workload in various ways.

Response reliability.

Reliability of a fire apparatus crew being available to respond to emergencies is a major consideration. The Anaheim Fire and Rescue (2018) standard of cover document states "response reliability is defined as the probability that the required amount of staffing and apparatus will be available when a fire or emergency call is received" (Anaheim Fire and Rescue [AF&R], 2018, p. 51). This definition corresponds exactly with the CPSE response reliability definition. CPSE (2016) further states that "this is a function of the average amount of time that

a fire unit is unavailable for a dispatch because it is already committed to another response" (p.160).

The City of Riverside Fire Department is one of the few fire departments that was found to have assigned a maximum call-load amount in its Standards of cover document but did so not as a threshold to add an additional emergency response apparatus and crew, instead Riverside Fire Department linked a maximum call-load to reliability. Riverside Fire Department states that "a single unit station with 3500 calls will not be able to serve its' area with 90% compliance (City of Riverside Fire Department [RFD], 2017, p. 56). Other jurisdictions define the point at which reliability cannot be maintained by percent of apparatus utilization. Scottsdale Fire Department states that in its case "performance is measured at the 90th percentile, unit hour utilization greater than 10 percent means that the response unit will not be able to provide on-time response to its 90 percent target even if response is its only activity" (Scottsdale Fire Department [SFD], 2015, p. 54). Response reliability is tied closely to response times. If an agency lengthens its acceptable response time, then reliability will increase. During the research review, cities comparable to the City of San Bernardino in demographics, population, and population density, provide 90th percentile ranges from the 7 minute 30 second time standard to 9 minute 30 second time standard. NFPA 1710 (2016) suggests agencies adopt a standard for response time within 5 minutes 90 percent of the time for all priority emergency medical calls and within 5 minutes 20 seconds 90 percent of the time for fire emergencies.

Sleep/Rest Cycle

Firefighters in San Bernardino County Fire Protection District work at least a 48-hour shift. These shift-lengths can often extend into 96-hour or longer shifts, depending on fire department needs during large emergencies. Sleep occurs during a shift but often occurs in

fractured time periods, with sleep likely to be interrupted one to several times throughout the night depending on call-load. Sleep in the fire service can be a difficult measurement and the amount of sleep that a firefighter should have during a shift has not been researched conclusively.

Fatigue in the fire service can be dangerous, Falleti, Maruff, Collie, Darby and McSteven (2003) studied and reported that the fatigue of being awake for 18 straight hours was the equivalent of a blood-alcohol concentration of .05% and staying awake an entire 24-hour shift was the equivalent of a blood-alcohol content of almost .1% (p. 265). The longer an individual stays awake, Falleti et al suggest, the more likely they are to make mistakes and be involved in accidents. As likely as these accidents may be, Fitch (2017) states "it's often extremely difficult to know just what role it plays when it comes to vehicle crashes, fire-ground injuries, or medical errors" (p.1).

Our bodies need to have sleep. Dongen et al. (2003) suggest that humans have a sleep reservoir, which they must keep full. We increase our reservoir when we sleep, and we deplete it when we are awake. If the reservoir is not full, then we have a sleep debt condition. Our reservoir can become depleted by either a single episode of deprivation or by continually not sleeping more than 8 hours on multiple nights (Van Dongen, Rogers, & Dinges, 2003). Both conditions exist whether it is a single episodes of a long length of sleep deprivation and multiple nights of less than 8 hours of sleep are prevalent in units with high night time call loads.

The military is taking a strong approach to decrease deprivation and it is using science to determine and document soldiers sleep needs. The military is starting to believe that less than 8-hours of sleep will put soldiers at the same risk as if they had alcohol before they engaged in military activities. The National Sleep Foundation suggests that "lack of sleep likely contributed

to both friendly fire incidents in the 1991 Persian Gulf War and the navigational error that led to the 2003 capture of Army Private First-Class Jessica Lynch in Iraq" ("Soldiers and Sleep," n.d., para. 2). The article continues on to explain that the military is now asking its leadership to create sleep schedules and sleep-plans to assist soldiers with their safety and health.

Fatigue in the fire service may be attributed to long shift schedules. Sleep deprivation is not obtaining enough sleep within a 24-hour period, such as waking many times in the night and not achieving the recommended 8 hours of sleep. Fortunately, many industries face this problem and it is becoming well studied. But sleep desynchronization also exists and is just as problematic. "Sleep desynchronization is forcing our body to remain awake (or asleep) out of synch with its circadian and homeostatic mechanisms" (*The science of sleep*, n.d., p. 19). In the fire service shiftwork, emergency incidents at night, or constant waking are all experiences almost all firefighters can relate to; sleep desynchronization and sleep deprivation can be problematic.

Barger et al., (2006) worry about the lack of sleep. In a study conducted through several hospital emergency rooms, the authors discovered that fatigue can cause significant errors. Their findings suggest "that interns working extended-duration shifts (defined as at least 24 hours continuously at work) had significantly more polysomnographically recorded attentional failures and made significantly more serious medical errors than those scheduled to work shifts 16 hours or longer" (p.45). Firefighters in the United States work many different shift schedules. There is not a universal standard shift length, the number of hours worked in a workweek varies, as does the amount of time off-work between shift. Frequently, 24-hour or longer shifts are encountered as part of normal scheduling.

The United States Forest Service (and other federal wildland fire agencies) follow the rest-ratio rules set forth in the *Standards for Interagency Management* (National Wildlfire Control Group [NWCG], 2018, Chapter 10.13). This document outlines the requirements of the work/rest guidelines including the maximum days worked, the required amount of days off in between the maximum length assignment (14-days), the shift-length (24 hours), and more importantly it clearly defines the ratio of the maximum amount of work hours to the rest hours as 2 hours of work per one hour of rest. Firefighters who work for an agency that follows these NWCG guidelines can only work 16-hour shifts and (with very few exceptions) then must be granted 8 hours of rest.

Most municipal fire agencies who work a 24-hour shift schedule do not appear to have written work-rest guidelines. Fitch (2017) suggests that limited studies have occurred that "research on firefighter cognitive performance after lengthy shift" and continued to state that "Firefighters working 24-hour shifts, with at least a 24-hour rest period in between, recovered better than those who worked consecutive 14-hour night shifts". A Canadian study researched five different shifts including 24-hour, 48-hour, and 10 to 14 hours shift length schedules. This study determined that all five shifts were able to "sustain cognitive performance acceptably as long as there are no alarms during the night" (Paul & Miller, 2005, p. 7). The report determined that waking up one time for an alarm in the night did not allow cognitive recovery despite rest periods between shifts unless at least four days were taken off in between shifts.

Las Vegas Fire and Rescue has adopted a unique methodology for rest. According to ICMA (2012), LVFR "determines firefighters working a 24-hour shift should have a minimum of 5 hours when they are not responding to rescue or fire calls or involved with daily station/organizational work as downtime". This downtime is calculated based on the average

non-emergency workload of an LVFD employee (9 hours) and then adding the total amount of time spent to mitigate emergency incidents plus adding 10 minutes per call.

Sacramento Fire Department conducted a sleep study and determined that "Four hours per night as (is) the equivalent of zero hours of sleep, or in other words once a person has slept less than four consecutive hours in a 24-hour period their deficits will be the same as someone who has not sleep at all" (Saylors, 2016, para. 4). Based on the study Saylors recommends a formal policy be developed to attempt to allow crews at least 4 hours of sleep per night.

Work Breaks

Like sleep breaks, a review of local, state, and federal laws did not determine a requirement for a set meal or rest break that occurs without the possibility of any interruption for emergency workers. California requires that employers must provide to a non-exempt employee an unpaid 10-minute rest break for every 4 hours of work. In addition, the employer must provide a 30-minute meal break for every 5 hours of work and the meal and rest breaks cannot be combined, they must be kept separate (Labor Code, 1937/2011). Firefighters are exempt from this labor code.

California Proposition 11, set for a general election vote on November 6, 2018, may change how meal and rest breaks are provided for private ambulance providers. The California Legislative Analyst Office writes in their summary of Propositions 11 that in the decision of *Augustus v. ABM Security Services* 2016, the California Supreme Court ruled that on-call breaks violate state labor law. Instead, employers must provide breaks that are off-duty and not interruptible, even if an emergency occurs. Proposition 11 attempts to prevent mandatory breaks by allowing the popular vote in the November 2018 election to exclude private ambulance

emergency workers from this ruling. If this proposition passes, it will not immediately concern public fire department members.

Governmental and District Regulations

While the exciting part of a workload efficiency study is the amount of time a unit is being utilized on an incident, the daily non-emergency workload of a crew is the large factor. Typically, organizations, localities, state and federal government place mandates on employees that require time on a daily, weekly, monthly, and annual basis. Many non-profit or for-profit organizations exist to provide benchmarks or suggested standards for organizations to adopt.

Examples of local mandates include might include hydrant maintenance and non-permit required business inspections. Organizations might impose (by policy or organizational norm) mandates such as daily briefings and pass-down of information, training requirements, community outreach, public education, or public relations. State and federal guidelines might include the department of motor vehicles inspections, rest-periods and meal breaks, training mandates.

Operational Directives

The San Bernardino County Fire Protection District's Operational Directives are found on the department's intranet homepage, FireNet. These directives were searched for all operations directives that mandated certain activities occurred every shift. The following directives were located that matched this criterion: Operations Directive (OD) 2133, *Physical Fitness and Wellness Training Program*, OD 3550 *Incident Response Documentation and Reconciliation*, OD 5008, *Training Program-Records and Reports*, and OD 5710 *Company Level Training Program- Records and Reports.*

Operations directive 2133.

Operations Directive 2133, *Physical Fitness and Wellness Training Program* states that the "exercise program is part of the daily schedule and is a mandatory on-duty program" (San

Bernardino County Fire Protection District [SBCFPD], 2008, p. 1). This directive mandates that physical fitness is undertaken at least one hour per day.

Operations directive 3550.

Operations Directive 3550, *Incident Response Documentation and Reconciliation* applies to all department records including National Fire Incident Reporting System (NFIRS) and patient care records. The directive states that "company officer will ensure all documentation is complete by the end of the twenty-four (24) hour shift in which the response took place" (San Bernardino County Fire Protection District [SBCFD], 2018). The amount of time required to be spent completing the records is not dictated, this is due to the variable amount of records that might need to be completed per day.

Operations directive 5008.

Operations Directive 5008, *Training Program-Records and Reports* (1995) indicates that 20 hours of training must be completed per employee each month. The directive describes the training as to be completed with an average of 2 hours per day. It states that accurate training records must be completed by the company officer to fully document the training provided.

Operations directive 5710.

Operations Directive 5710 *Company Level Training Program- Records and Reports* (2013) directs (similar to OD 5008) that department members must undertake at least 20 hours of training per month while on-duty during their normal working hours.

NFPA

A review of National Fire Protection Agency (NFPA) 1710 indicates that in Urbanized Cluster Area Deployment resources should be deployed in six minutes or less for the arrival of the first engine company to eighty percent of the fire-related incidents and medical emergencies

and an additional engine company and at least one chief officer within ten-minute response time with an 80% fractile. (National Fire Protection Agency [NFPA], 2016). This premise is based on the gathering of an effective response force at the scene that is needed to stop the escalation of an emergency incident.

CPSE

The Center for Public Safety Excellence (CPSE) Community Risk Assessment: Standards of Cover manual (Center for Public Safety Excellence, Inc. [CPSE], 2016) does not set-forth standards for utilization, deployment, or any other workload component. Instead, the manual focuses on preparing community risk assessment and standards of cover documents. The text indicates that the uniqueness of each community drives the deployment of resources (including the measurement of the workload and standards of deployment for emergency apparatus).

The Commission of Fire Accreditation International (CFAI) is the accrediting body of the CPSE organization. This commission likewise does not set base accreditation on standards for fire departments to implement. Instead, it recommends an assessment of community risks, the public expectations of the emergency services levels, and the resources required to meet the public expectation to mitigate the community's risks.

ISO

The Insurance Services Organization (ISO) reviews and rates the capabilities of municipal fire departments to respond to and extinguish fires. The ISO Fire Suppression Rating Schedule (FSRS) performs this rating by evaluating to fire flow capabilities, deployed and reserve fire department resources, and by an evaluation of the municipalities water supply system. Fire departments are then classified on a scale of 1 (highest) to 10 (lowest), based on the total of ratings received for each category. According to TriData (2006) an organization wanting

to achieve the highest ISO score, would not consider emergency and non-emergency workload, reliability, or utilization of a fire apparatus, but would instead focus on ensuring that "one station (be placed) for every 4.5 square miles" of jurisdiction (p.67). ISO guidelines are considered by fire department management as mandates if the organization attempts to score as high as possible on the FSRS. An example of an ISO requirement that requires significant time is personnel training.

OSHA

The Occupational Safety and Health Administration (OSHA) develops regulations to protect workers and "assure safe and healthful working conditions by setting and enforcing standards and by providing training, outreach, education and assistance" (https://www.osha.gov/about.html). There are many OSHA regulations that apply to firefighting operations, but the one of the most critical to workload is 29 CFR 1910.134 which sets forth the requirements for respiratory protection in IDLH (immediately dangerous to life and health) atmospheres, which includes man types of firefighting activities. This regulation requires that personnel work in teams of two individuals, with two personnel operating inside the IDLH and two personnel outside the IDLH (to rescue the inside personnel if they become trapped or injured). Commonly, OSHA 29 CFR 1910.134 is called the "Two-in/Two-out" rule. A literature review of OSHA regulations did not find any sleep, rest, meal breaks, or any other emergency/non-emergency workload regulations.

Literature Review Summary

The comprehensive literature review found that while many organizations, departments, and professional groups utilize many methods for determining emergency call workload. The research also showed that emergency response methodology is well researched.

The Center of Public Excellence has provided an excellent template for those agencies wishing a self-assessment of their response abilities and improve on their understanding of the community's risk and ultimately understand their organizational apparatus deployment needs (based on public expectations). Many organizational reviews demonstrate that quantitative data analysis research is well understood and prevalent in fire service management ideologies.

Using prudent methodology, a good self-assessment, and understanding an organization's quantitative data has led some agencies to the philosophy of increasing emergency apparatus based on community expectations and a community risk-analysis, but most appear to benchmark additional staff an equipment to the response reliability of their desired total response times.

Fitch (2017) recognizes non-emergency workload and writes "it is important to note that unit hour utilization traditionally does not capture productivity outside of responding to emergency calls, such as the completion of required documentation and training" (p.5). Despite this sentiment, very few published studies on non-emergency call load and/or the effects that non-emergency call load has on the response ability of an apparatus crew exist. Only two studies could be located, both by Citygate and Associates (2017), that suggests that greater than a 30% UHU during normal workday hours effects non-emergency workload. No studies could be located that fully researched and documented the many of the components of a crew's non-emergency workload.

It appears that most of the references to a UHU standard are in reference to emergency medical services (EMS) transporting units, despite the UHU not always being clearly delineated as such in SOC documents reviewing the performance of fire apparatus and crews. This is evidenced by most of the reviewed documents defining a 30% UHU standard and on occasion sometimes referencing only EMS transport standards and studies.

An example of this is a reference by Hack (2015) in his city council memorandum discussing Chico's Fire Departments standards of cover. In this document, he states "the 4th edition of the IAFF EMS Guidebook no longer specifically identifies an upper threshold". A copy of the IAFF EMS Guidebook could not be located, but the title of the guidebook itself indicates that it is a guide for emergency medical services and not fire suppression. This is further evidenced by a graph located later in the standard of cover document that indicates that Chico's Fire Departments busiest fire suppression unit has a utilization rate of 8%.

Finally, the term unit hour utilization is confusing in the industry by having two common definitions. Fitch (2017) advises that if "unit hour utilization is measured simply on the basis of the number of patient transports during a specified period, the resultant UHU will also fail to capture the time spent responding to emergency calls that do not result in patient transports (p.5). Defining unit hour utilization by describing the amount of time committed (in a percentage) in an emergency-workload capacity in a given amount of time is a much easier understood definition. For the purposes of this ARP, the term UHU shall mean the percentage that a resource is committed to emergency workload activity and it will be calculated by dividing the total time a unit is committed to all incidents during a year divided by the total time.

Sleep studies exist that demonstrate the harmfulness of lack of quality sleep, but only a single study from Sacramento Fire Department could be found demonstrating a fire department establishing measures to attempt to facilitate sleep for emergency crews. The military appears to be aggressively recognizing the effects of lack of sleep and aggressively working to solve sleep deprivation and sleep desynchronization. Sleep breaks without interruption will probably continue to be problematic.

Through the literature review, it is obvious that while meal and rest breaks are given, a set amount of time is not generally given or considered as a standard part of the workday utilization. A passage of California Proposition 11 could change how private ambulance crew's availability for the emergency and the non-emergency workload is considered and this may eventually in-turn affect public agency firefighters and paramedics.

Organizations like National Fire Protection Agency (NFPA), the Insurance Service Office (ISO), and the Occupational Safety and Health Administration (OSHA) all play a small part in the emergency and non-emergency workload. Their standards influence policies, laws, and community expectations. Some of these standards may dictate that additional personnel and apparatus be added for safety, lower insurance rates, and fire protection despite a lack of workload demand. These considerations should be carefully considered by an organization to determine that an effective response force exists.

Finally, it was clear that missing from almost all fire service documents, the workload is considered only to be the response to the scene of an emergency incident and the amount of time required for the crew to mitigate the incident. It is apparent that many organizations do not appear to have a full understanding of their department's non-emergency activities or the workload mandates that exist (in policy or in culture) that an emergency crew must accomplish each day.

Procedures

The purpose of this Applied Research Project (ARP) is to determine what the maximum emergency, non-emergency, and non-work activity that contributes to a total workload for a fire apparatus crew and then to define at what emergency workload expressed in unit utilization a fire

apparatus crew would be considered too busy. From this analysis, a maximum emergency call-load can be calculated.

The research procedures used in this ARP was guided by the following questions: a) Which tasks/commitments are formally and informally required (either by law, ordinance, policy, culture, etc.) that crews must undertake daily? b) How much time (on average) do these commitments take to complete daily? c) How much time is left remaining after the required tasks are completed for emergency calls and discretionary tasks? d) At what utilization percentage is a unit overtasked to meet all the crew's daily and emergency-call commitments and do any San Bernardino County Fire Protection District, Division Two apparatus exceed this overtasked utilization percentage?

Literature Review

Literature review for this project commenced March 20, 2018 at the Learning Resource Center (LRC) and the National Fire Academy by searching the LRC extensive catalog for literature on the following topics: fire and EMS workload, fire and EMS utilization, call-volume, apparatus deployment, Fair Labor Standards Act (FLSA), and fire service activities. The same subjects were searched on the World Wide Web using Google Scholar, Google, and Bing search engines. These searches produced very little results on fire service workload but did produce several EMS transportation studies on UHU and standards of cover documents from several different comparable fire departments to the San Bernardino County Fire Protection District.

The literature review identified major gaps in the available information needed for this ARP and some of the literature that was located was vague or contained inconsistencies to other published literature. With these information gap areas and inconsistencies identified, a search began for industry experts who might have the knowledge needed for completion of the ARP or

have knowledge of where the information might be located. Interviews were conducted starting in August 2018 to start compiling information to bridge the knowledge gaps in current published literature.

Emergency Workload Study

To retrieve the emergency apparatus utilization, Deccan International's Computer Assisted Dispatch Analyst (CADA) was used to calculate the data from July 1, 2017, to June 30, 2018, to determine utilization for each piece of apparatus. Deccan CADA produces apparatus utilization by calculating the total apparatus utilization time, then divides the utilization time by the date range calculated by CADA. In this case, 365 days were analyzed (the number of days during July 1, 2017, to June 30, 2018 timeframe) to produce an average daily utilization percentage.

Emergency station crew workload was then calculated by combining the utilization rates of the all the apparatus assigned to a single-crew at a fire station. This is necessary since apparatus is often cross-staffed at a fire station. Cross-staffed, in this case, means that a fire crew may have multiple apparatus assigned to their fire station. The crew may respond on one type of apparatus for a brush fire, and a different apparatus for a structure fire. For example, fire stations 226 and 231 (as well as other stations in Division Two) have brush engines and structure fire engines assigned to their stations, but the crew that must choose which apparatus to staff. In these cases, the utilization rates of all the apparatus assigned to the station are added together to determine one utilization rate for the station. This produced an average daily utilization expressed in a percentage. The utilization percentage was then expressed in minutes by multiplying the utilization percentage by 1,440 (the number of minutes in a single day).

Non-Emergency Workload Study

A non-emergency workload study was conducted with fire apparatus crews over a one-month period. This study was conducted by a written survey and assigned to ten different fire company officers to complete. The study determined that the following activities regularly occurred on a shift (as imposed by the cultural norms, organizational directives, or state and federal mandates): daily-pass-down (morning briefing), apparatus and equipment checks, physical training (exercise), purchasing and procurement, training, emergency response, public relations/public service, special projects, meals, and sleep.

A letter (Appendix A: Workload Study Introduction Letter) was forwarded to the company officers involved in the study, explaining the study, the importance of correct documentation, and asking for their willingness to participate. All company officers receiving the study elected to voluntarily participate in the study and received instructions on how to perform and document the findings (Appendix B: Study Instructions). Participants also received a specific description of activities that must be timed (Appendix C: Task Breakdown) and a sheet to document findings (Appendix D: Time Record Sheet).

Interviews

Interviews were required to finalize the research required for this ARP. These interviews were required for three reasons. First, literature review indicated that major gaps in the available information on fire service workload existed. Second, the published literature that was located offered conflicting definitions. Finally, the workload concepts located in literature are on occasion not clearly defined.

Those individuals interviewed were either industry experts that had published four or more articles or white papers on workload analysis or one or more of the factors contributing to

workload, principal partners in large consulting firms that had undertaken large complex fire department analysis studies, and the executive leadership of the District. In total eight individuals were contacted either in person or via phone to be interviewed.

After a thorough literature review to determine which local, state, or federal laws may have a non-emergency workload time commitment, Attorney Curt Varone was contacted. Attorney Varone is a retired Providence Fire Department deputy assistant fire chief, a practicing law attorney, author of two fire textbooks on legal considerations for fire departments and fire officers, and principal instructor in fire department classes on labor-law subjects such as the Fair Labor Standards Act ("About Curt Varone,"). The telephone interview centered on FLSA, work-rest guidelines, meal breaks, and other possible legal implications that might affect productivity or require time to complete.

Fire service data analyst Paul Rottenberg was interviewed in person on August 9, 2018. Mr. Rottenberg is a data analyst who focuses on the emergency deployment of fire and EMS apparatus and he owns FireStats, LLC., a “highly specialized class of consulting services (that) focuses principally on statistical and spatial analysis of fire department operations” ("FireStats," n.d., para. 1) Mr. Rottenberg is a regular speaker at Center for Public Excellence conferences and instructs regular courses on data analysis for the fire service. The interview focused on resource-reliability, daily workload implications, and ways to reduce workload without effecting an apparatus’s ability to respond to emergencies.

On August 8, 2018, an in-person interview with Doctor Steve Knight occurred. Dr. Knight leads Fitch & Associates fire service practice and has been the principle on many studies in fire service efficiency, deployment, and standards of cover (S. Knight, Personal Communication, August 8, 2018). The focus of the interview was to determine if a call-load was

ever a consideration in SOC documents and how the utilization of an apparatus affected workload.

Doctor Raj Nagaraj corresponded two times via email on June 26, 2018, and was interviewed in person on July 24, 2018. Dr. Nagaraj founded Deccan International and currently serves as its Chief Technological Officer. Deccan International offers custom built software to support real-time operations and strategic planning, including analyzing department data and predicting future trends ("Deccan International," 2018). Interviews with Dr. Nagaraj centered around defining “busyness”, the concept of resource use factors (RUF), and sleep-related health perspectives.

Retired-fire chief, Stewart Gary, MPA was interviewed via telephone on September 10, 2018. Chief Gary is the retired fire chief of the Livermore-Pleasanton Fire Department in Alameda County, California and is the principle of Citygate’s public safety practice areas (including law enforcement, and fire/EMS services). During his employment with Citygate, Chief Gary has led “all of Citygate’s Standards of Coverage studies, and he has been working on public safety studies of all types for over a decade” ("Stewart Gary," n.d., para. 1).

Chief Gary’s interview focused on how non-emergency workload and emergency workload interrelate and his thoughts on the 30% utilization rate often quoted in SOC documents. When asked if Chief Gary knew of any non-emergency workload studies, Mr. Gary indicated that he had “yet to find a department who accurately accounted for non-emergency activities”. Mr. Gary provided several documents for literature review consisting of several standards of cover volumes for the City of Sacramento Fire Department and the City of San Diego Fire-Rescue Department.

Additional interviews were conducted with San Bernardino County Fire Protection District executive leadership (composed of the Fire Chief Mark Hartwig, Deputy Chief of Operations Don Trapp, and Deputy Chief of Administration John Chamberlin) on September 24, 2018. These interviews were necessary to determine fire department's executive leadership's expectations for community outreach/education and engine company preplan/business inspections as these activities were not identified as daily activities by the company officers who participated in the work task survey.

Prior to the interview, the workload study was explained including the task analysis. The executive chiefs were informed that public education included public outreach, school visits, presentations to community groups and educational classes such as a Cardio Pulmonary Resuscitation (CPR) class. The executive leadership chiefs were told that fire prevention activities included business company inspections, preparing building emergency plans, and neighborhood fire prevention programs.

Limitations

Several limitations were identified in this study. Due to the complexity of the workload study, these limitations are broken down in the subheadings below.

Emergency workload study limitations.

Utilization rates are not only for the emergency response workload. Utilization times end when the apparatus is available for another call. The time returning from the call is not captured in the utilization time and is considered non-emergency workload. The difficulty with this is determining the amount of time an apparatus spends returning from a call. Likely this time is very close and slightly slower than the actual response time to the call, but this cannot be verified.

Non-emergency workload study limitations.

Several limitations should be noted that occurred within the non-emergency workload survey. These include individual biases, work-study interruptions, sample size, and fluctuations in daily activity.

Individual biases may exist in that the company officers participating in the survey may have placed added emphasis or crew-urgency on the tasks studied. This emphasis may have prompted members to engage in the tasks in a more thorough manner than what would have been undertaken if the task was not timed. This added emphasis might have increased or decreased the amount of time it takes to engage in the task(s).

It is also difficult to determine how emergency incident response relates to the time required to complete each task. Interruptions that occur while undertaking the tasks likely increase the amount of time required to complete each task, but this cannot be easily measured. A task might also have been deemed completed due to the interruption occurring near the end of the task or a task may not have been restarted due to emergency incidents.

Daily tasks are also difficult to determine. Not all tasks that are required to be completed occur on every shift. For example, a citizen may come to the station and ask for a crewmember to take their blood pressure or inquire if the fire department teaches CPR classes. These workday interruptions are not tracked and do not occur on a predictable basis.

In addition, some tasks take longer to complete on certain days. An example of this is apparatus maintenance checks. The time required to complete daily apparatus checks were tracked during the study. However, on every the second, third, and fourth Monday of a month, a thorough weekly apparatus check occurs. Likewise, an even more thorough monthly check

occurs on the first Monday of the month. These weekly and monthly checks cause a larger apparatus maintenance workload on those days.

This study was not a blind study. The company officers performing the actual timekeeping of the tasks were aware that the tasks were part of a non-emergency work study. This may have decreased the accuracy of the workload study results. The timekeeping was not undertaken by a neutral third party.

Finally, only one company officer per station was selected. This was due to the number of unfilled company officer positions within the station sample. Company officers were not considered if they had a new employee on their shift who may take longer than average to complete a task due to unfamiliarity. Despite the efforts for uniformity, it should be noted that all company officers and crew members who work at the same station, but on different shifts, may still take more or less time to complete each task based on perceptions and crew expectations.

Break time, mealtime, and sleep time limitations.

Firefighters fall under FLSA standards. Break time, mealtime, and sleep times are given on the clock and do not have any set time requirements. A single study cannot be located that states how much sleep a firefighter should have daily; nor can a study be located that studies break and mealtime requirements in the fire service. The assumptions applied to this study are based on military and civilian sleep studies as well as the California labor code, but further research is needed to completely define the amount of time should be allocated to each activity.

Interview limitations.

Interviews were conducted after a thorough description of the research was provided to the interviewee. This description was necessary to focus the interviewee on the subject matter

required for the interview. This type of research description could alter interviewee responses than if a blind-subject interview had occurred.

Interviews were conducted with a non-standardized list of questions; most interview participants are experts in their individual field and were sought out for their expertise. A standard question list would not have been applicable for all interviewees and may have produced answers that would be based on biases or gut-feelings and not because of a strong familiarity with the subject matter.

Results

The research was designed to answer the following questions: a) which tasks/commitments are formally and informally required (either by law, ordinance, policy, culture, etc.) that crews must undertake daily? b) How much time (on average) do these commitments take to complete daily? c) How much time is left remaining after the required tasks are completed for emergency calls and discretionary tasks? d) At what utilization percentage is a unit overtasked to meet all the crew's daily and emergency-call commitments and do any San Bernardino County Fire Protection District, Division Two apparatus exceed this overtasked utilization percentage? The research was able to adequately produce results through a combination of the literature review, interviews, and a survey of other departments.

Question 1

The first research question asked which tasks/commitments are formally and informally required (either by law, ordinance, policy, culture, etc.) that crews must undertake daily? Research determined that both non-emergency workload and a non-work activity existed that must be completed each work day. The non-emergency workload is defined as the work-related activities that crews must perform as defined by their job requirements; examples include

apparatus and equipment maintenance and training activities. Non-work activity can be defined as activities that a crew performs that are not part of their job requirements but must be undertaken daily; examples of this include sleep, work breaks, and meals.

The research conducted was able to determine that emergency response and mitigation, personnel education and training, vehicle checks and maintenance, equipment checks and maintenance, shopping, and procurement, reporting and documentation, to receive and pass-down information to oncoming crews, physical conditioning, station cleaning and maintenance, special projects, and physical conditioning were included daily in every crew's workload. In addition, it was discovered that while public education and fire prevention activities did not occur each shift, it was management's expectations that these activities occur and be included in a daily workload.

Question 2

The second research questions asked how much time (on average) do these (non-emergency workload) commitments take to complete daily? This question was answered by a non-emergency workload and activity survey, research review, interviews with industry experts, and by interviewing District executive staff.

Non-emergency workload.

The research conducted was able to determine that training, vehicle checks, and maintenance, equipment check, and maintenance, shopping, and procurement, reporting and documentation, to receive and pass-down information to oncoming crews, physical conditioning, station cleaning and maintenance, special projects were all norms during a firefighter's work day.

A non-emergency workload and activity study was conducted with fire apparatus crews over a one-month period. This study results indicated that significant time is required to meet the workload and activities that culture, department, and legal mandates require.

The activities studied are defined in Appendix D: Task Breakdown.

Table 2 shows the non-emergency workload as reported by company officers involved in the non-emergency workload study.

Table 2
Non-Emergency Workload Survey Results

Station	Apparatus maintain	Reporting	Station maintain	Pass-down	Training	Purchasing	Special projects	Total Time
9	56	103	72	52	120	44	137	584
23	79	78	49	64	120	49	123	562
75	50	43	123	26	120	43	49	454
221	62	63	114	35	120	29	78	501
222	71	54	124	48	150	35	63	545
224	94	73	32	41	150	23	59	442
226	63	79	69	54	120	37	46	468
227	45	85	56	34	120	24	33	397
228	48	122	53	45	120	51	74	513
229	176	78	80	48	120	63	92	557
231	55	67	74	28	145	22	39	405
232	54	48	74	39	120	58	66	459
Average	63	74	77	43	120	39	72	491

Note. Average daily time as compiled and reported by company officers participating in the non-emergency workload study. Time is rounded to the nearest minute.

On average, a fire station crew will need 491 minutes to complete the crew's non-emergency workload.

Non-workload activity.

Identified in the study are the need for rest, meal, and sleep breaks. Attorney Curt Varone was interviewed during a phone call on August 1, 2018 (J.C. Varone, Personal

Communication, August 1, 2018). Attorney Varone was asked if any applicable laws pertained to rest, meal and sleep period. Attorney Varone stated that firefighters in "California are exempted" from set uninterrupted meal break times. Attorney Varone stated that while there is not an OSHA requirement for breaks, OSHA does have a general duty requirement that requires an employer to provide a workplace that is free from recognized hazards.

Attorney Varone stated that if sleep deprivation was a recognized hazard for an employer, the employer would be under an affirmative obligation to remedy the hazard an employer who failed to remedy a recognized sleep deprivation hazard could be cited by OSHA.

Firefighters are exempt from certain Fair Labor Standards Act standards. This allows fire service employers to not assign specific rest break, meal, and sleep periods. Likewise, the District does not have cultural norms, policies, or guidelines for rest, meal, or sleep periods. The difficulty is determining how much time should be allotted to these activities.

As with FLSA requirements, the California labor code does not apply to FLSA exempt employees. The California labor code requires that a non-exempt employee is given an unpaid ten-minute rest break for every 4 hours of work. In addition, the employer must provide a 30-minute meal break for every 5 hours of work and the meal and rest breaks cannot be combined, they must be kept separate (Labor Code, 1937/2011).

In absence of a standard, the California labor code was utilized in this ARP to determine work and meal breaks. Using this law as a guideline would indicate that employees working 24 hours be assigned six, ten-minute, breaks and four half-hour meal breaks per shift. This equates to 3 hours of break and meal periods. Firefighters typically fit these breaks and meal periods into their day in between their emergency responses.

Sleep is also not mandated by law or by fire department directive. But Saylors (2016) argues that at least 4-hour blocks of uninterrupted sleep and many of the sleep studies cited in this ARP indicate that at least 8 hours is required, or sleep deprivation can occur as our sleep-banks slowly erode.

Finally, District Fire Chief Hartwig (Personal Communication, September 24, 2018), when interviewed on the components of a workload study, contemplated that a workload study that did not allocate 8 hours for the purpose of sleep could be conceding less than an average of 8 hours of rest for the District's personnel. This is very similar to building any workload that does not include time for a specific activity. If the time is not planned for on a regular basis, then the time to perform that activity will only occur on slower-than-average emergency workload days.

For this study, 8 hours was used as a baseline for the studies calculations. As workload fluctuates from one shift to the next shift, crews experience sleep desynchronization during a normal night sleep; sleep desynchronization cannot be easily avoided during a 24-hour work shift without removing an engine crew from service. To counter-act sleep desynchronization, an adequate sleep workload factor of 8 hours is justified.

For this study 50 minutes of break time, 120 minutes of mealtime, and 480 minutes of sleep time were calculated for a total of 650 minutes of total non-work specific activity. This activity while not required by law, should be the cultural norm to ensure the safety, strength, and cognitive abilities of emergency crews.

Non-emergency workload interviews.

During the research, several tasks were discovered that were not being completed every shift but were expected to be completed by District leadership. Interviews conducted with Fire Chief Mark Hartwig, Deputy Chief Don Trap, and Deputy Chief John Chamberlin indicated that

emergency preplans activities, public education, and business inspections were all important to include in the everyday work schedule.

Deputy Chief of Administration John Chamberlin (J. Chamberlin, Personal Communication, September 24, 2018) was interviewed during a phone call on September 24, 2018. Chief Chamberlin explained that he expected fire crews to participate in fire prevention and public education activities daily. Chief Chamberlin indicated that fire prevention activities included business inspections, preplanning buildings, and ensuring our citizens are fire safe. Chief Chamberlin stated that he believed that 30% of the normal workday should be spent on fire prevention and public education activities. When asked to clarify the time in the normal workday, Chief Chamberlin stated he meant 8 hours and that 15% (72 minutes) of this time should be spent on fire prevention and 15% (72 minutes) should be allocated to public education.

Deputy Chief of Operations Don Trapp Chamberlin (D. Trapp, Personal Communication, September 24, 2018) was interviewed on September 24, 2018, via the telephone. Deputy Chief Trapp stated that he expected fire crews to participate in public education and fire prevention activities daily. When asked how much time he expected the fire crews to spend on these activities, Chief Trapp stated that one-hour per activity (fire prevention and public education) or a total of 2 hours was necessary. Chief Trapp stated that on some days, fire crews might spend 2 hours on fire prevention, but on the next day, they might spend 2 hours on public education.

Fire Chief Mark Hartwig (M. Hartwig, Personal Communication, September 24, 2018) was interviewed in-person. Chief Hartwig was asked his expectations for fire prevention and public service activities and stated that these activities were expected to be completed when the crews had time available. Chief Hartwig was initially hesitant to provide a length of time that this should be completed per shift, stating that emergency call response should always be given a

priority over public service and fire prevention duties. When the non-emergency workload study was explained to Chief Hartwig and an explanation that his expectations were a necessary part of the model, Chief Hartwig stated that he provided 4 hours of public education or fire prevention activities per shift-cycle (this equates to one-hour per shift) when he was a company officer. Chief Hartwig believes that this is a reasonable expectation of time to engage in these activities.

The results of these interviews indicate that District executive leadership, on average, believed that a total of 108 minutes should be allocated per day on fire prevention and public education activities.

Question 3

The third research question asked how much time is available to respond to emergency calls after the required non-emergency workload and activities are completed? This question is answered with a summation of the non-emergency workload and non-work specific activity time requirements. The currently performed non-emergency workload activities were determined to take 491 minutes daily, the expected (but not currently performed) non-emergency workload (fire prevention and public education) was determined to be 108 minutes, and the non-work specific activities required 650 minutes daily to complete. The total time required for all categories of non-emergency activities is 1,249 minutes.

A total of 1,440 minutes is in a day, 1,440 minutes minus 1,249 minutes of non-emergency workload and activities leaves 191 minutes daily available for response.

Question 4: Part 1

The fourth question asked at what utilization percentage is a unit overtasked to meet all the crew's daily and emergency-call commitments and do any San Bernardino County Fire Protection District, Division Two apparatus exceed this overtasked utilization percentage? In

answering the first part of this question, when is a utilization percentage met that effects the non-emergency and emergency workload, there are two considerations that must be considered. First, when is an emergency crew overtasked with the combined emergency, non-emergency, and non-work activity workload and second, when is a unit overtasked with the emergency workload alone.

Overtasked combined workload.

The research indicated that on average in Division Two, there are 191 minutes available per day for emergency responses. There are 1,440 minutes in a day; 191 minutes (available time for responses) divided by 1,440 (minutes in a day) equals a 13.26% UHU available on average for emergency response. Any apparatus that exceeds 13.26% UHU is then considered overtasked.

Overtasked emergency workload.

One more important UHU consideration is reliability. During the literature review researching workloads in the fire service, it became apparent that standards of cover documents found in comparable jurisdictions attempt to meet a response reliability in 90% of their responses. Response reliability is an important factor for a jurisdiction to consider while calculating the total workload of an engine crew. If the workload threshold is considered less than maximum and if the response reliability is not met, workload (in the form of emergency call response) must be reduced.

Fire service data analyst Paul Rottenberg (P. Rottenberg, Personal Communication, August 9, 2018) was interviewed in-person and asked his opinion on what constituted a fire crew's maximum workload and if 90% reliability was a true factor in deciding to add additional fire apparatus to a response area. Mr. Rottenberg stated that 90% was a subjective number and

gave the example that a unit at 89% or 91% reliability, was that unit 1% too busy or 1% too slow? He continued that 89% utilization was very similar to 90%; why was 90% chosen and not 89%? Mr. Rottenberg advised that establishing maximum utilization percentage "trigger points" may not be in the best interest of a department. He advised that if an agency has a fire apparatus at 25% utilization and then the agency adds a second apparatus, the effect is to drop both units down to a low 12.5% utilization. Instead, Mr. Rottenberg advised looking at the agency's options to reduce workload before simply adding apparatus.

One-way Mr. Rottenberg suggested that this may be accomplished is to look at collateral duties (non-emergency workload) and determine if the workload could be allocated to a lower paid non-suppression employee. (An example of this might be to hire an additional fire prevention officer to undertake small business inspections, instead of utilizing an expensive suppression fire crew to perform the same task.)

Finally, Mr. Rottenberg suggested peak-time staffing should be considered as a more prudent fiscal model over adding a 24-hour unit. An example of this would be adding a fire apparatus during a known daily period of high call volume.

Retired fire chief, Stewart Gary, MPA (S. Gary, Personal Communication, August 9, 2018) was interviewed via a phone call. During the phone call, Chief Gary was asked his thoughts about Citygate's use of a 30% utilization rate hour after hour often found in their SOC documents as a benchmark for unit reliability and as a maximum emergency workload threshold. Chief Gary stated that in his professional opinion, a 30% utilization percentage for many consecutive hours where organizations expected their employees to participate in at least 2 hours of training on-duty plus of course other essential duties between incidents and mandated breaks. Chief Gary continued that if a crew is utilized over a 30% utilization hour after hour, then he

would suggest that training occurs on a non-duty day. Mr. Gary suggested that a 30% utilization percentage could much more appropriately be applied as a maximum utilization threshold during the nine-hour fire service traditional workday than it could be applied as a maximum utilization threshold averaged over an entire 24-hour period.

Dr. Nagaraj (R. Nagaj, Personal Communication, June 26, 2018) wrote in an email discussing fatigue management, that the longer the shift, the smaller percentage a unit should be utilized. This concept agrees with Citygate SOC documents and the opinions expressed by Steward Gary. Dr. Nagaraj continued that a unit should not be so busy that it does not have the needed readiness for ensuring adequate response time.

Defining when an emergency crew is overtasked with emergency call-load is not set to a general fire service standard. While a 90% reliability is often quoted, individual jurisdictions themselves set the parameters of response times. Increasing the response time in effect increases unit reliability. For this study, Deccan International software indicated that all apparatus met a response reliability of 90% of 7 minutes 30 seconds.

Question 4: Part 2

The second part of question 4 asked if any San Bernardino County Fire Protection District, Division Two apparatus exceed this overtasked utilization percentage.

To answer which of the Division Two apparatus that were overtasked, each of the City fire apparatus's emergency workload was calculated by Deccan International's CADA software. Deccan CADA analyzed the computer-aided dispatch information from July 1, 2017, to June 30, 2018, and calculated the average daily utilization percentage.

Table 3

Apparatus Utilization %

Apparatus Identifier	Utilization %[a]	Adjusted crew utilization %[b]	Adjusted emergency workload minutes[c]
Medic Engine 75	11		
Brush Engine 75	0.19	11.9	171
Medic Engine 221	16.72	16.72	240
Medic Engine 221A	16.54	16.54	238
Medic Truck 221	4.8	4.8	69
Medic Engine 222	17.1	17.1	246
Medic Engine 224	21	21	302
Medic Truck 224	8.2	8.2	118
Medic Engine 226	14.5		
Brush Engine 226	0.13	14.63	211
Medic Engine 227	12.6		
Brush Engine 227	0.24	12.84	185
Medic Engine 228	7.1		
Brush Engine 228	0.14	7.24	104
Medic Engine 229	7.5	7.5	108
Medic Engine 231	8.2		
Brush Engine 231	0.23	8.43	121
Medic Engine 232	6.3		
Brush Engine 232	0.21	6.51	94

Note. Utilization rates are shown as the average utilization percentage per day from July 1, 2017, to June 30, 2018. Utilization % is produced from Deccan International CAD Analysis ™ system.

[a]Utilization % of a single resource

[b]Adjusted crew utilization is the combination of the utilization % of two cross-staffed units located at the same location. A single crew staffs both units.

[c]Adjusted crew workload is the average crew workload expressed in minutes. This is the combination of the utilization % of two cross-staffed units located at the same location. A single crew staffs both units.

Table 3 shows three pieces of key information. First, the utilization percentages of different apparatus assigned to fire stations analyzed in this study are demonstrated. The second piece of information demonstrated is the *adjusted crew utilization.* Adjusted crew utilization is the combination of the utilization percentage of two cross-staffed units located at the same

location where a single crew staffs both units. The third piece of information is the *adjusted crew workload in minutes*. This calculation takes the adjusted crew utilization percentage and expresses the results in minutes. This third calculation is important in that it allows the emergency workload study results to be expressed in the same value (minutes) as the non-emergency and non-work activities.

The table demonstrates that the medic engines from fire stations 221 (includes both medic engines 221 and 221A), 222, and 226 are overtasked with emergency call-load and will have difficulty meeting non-emergency workload and non-work-related activities.

Discussion/Implications

Firehouse magazine may have been incorrect in the 2017 National Run survey when they ranked ME224 as the 5th busiest fire engine in the United States with a call-load of 6,923 responses for emergency services ("2017 National run survey," 2017, p. 6). As demonstrated in this ARP, UHU is a much more reliable workload measurement than call-load; call-load simply defines how many calls for service a unit undertook in a given time-period and ignores the actual time commitment spent over the course of delivering the emergency calls.

The Firehouse magazine Run (2017) Survey ignores the non-emergency workload and the non-emergency activities that a crew undertakes daily and how this effects ho busy a fire engine is. As indicated by this ARP research, significant time is required for the non-emergency workload that must be undertaken by fire crews to ensure that they are prepared to respond to emergencies. Factoring in the emergency workload, the non-emergency workload, and non-work activities that a crew undertakes daily is an import part of determining the total daily workload. Using ME224 as an example, with a 21% UHU, the total workload that ME224 crew undertakes daily indicates that the unit is overtasked by almost 7%. This means that on average,

either the crew's sleep periods are less than 8 hours or that the crew is not completing non-emergency workload and activities on an average daily basis.

San Bernardino County Fire Protection District, Division Two has four engine crews from fire station 221 (both ME221 and ME221A), 224, and 226 that are working over the calculated maximum workload threshold.

While organization, state, and federal work guidelines do not exist for rest and sleep, research by Falleti et al (2003) indicates that lack of sleep leads to the equivalent of having increased blood-alcohol content. Van Dongen, Rogers, and Dinges (2003) suggest that humans have a sleep reservoir, which they must keep full, he suggests that sleep is like a bank, with sleep contributing to the overall bank and deprivation removing from the bank. Finally, Barger et al., (2006) study indicated that lack of sleep leads to errors and accidents.

Van Dongen, Rogers, and Dinges (2003) research align with the National Sleep Foundations (n.d.) study that corresponds to relationships with sleep and sleep reservoirs and indicates that any rest period is better than not sleeping. These military, hospital, and fire service sleep studies indicate the importance of sleep and its interrelationship with a safe work environment, which Attorney Varone (J.C. Varone, Personal Communication, August 1, 2018). indicates is a fundamental OSHA general duty requirement requiring an employer to provide a workplace that is free from recognized hazards. This sleep research and Chief Hartwig (Personal Communication, September 24, 2018), stating that calculating a workload on anything less than 8 hours could cause a crew to have nightly sleep-depravation justifies a workload model including 8 hours of sleep.

The FLSA and California labor code do not specifically state when meal and rest breaks should occur as both allow exemptions to laws for firefighters. While the breaks are unpaid and

not at any guaranteed point of the day, calculating a workload must include these breaks as they are considered by cultural norm as part of the daily activities. The labor code, used as a guideline, would then recommend that the District calculate workloads based on California labor code standards utilizing a 10-minute rest break for every 4 hours of work and a 30-minute meal break for every 5 hours of work (Labor Code, 1937/2011).

Adding an additional unit to augment responses to emergency incidents may be indicated depending on jurisdictional desire, but Paul Rottenberg (personal communication, August 9, 2018) provided thought-provoking alternatives to address workload including evaluating the possibility of allocating work to a different less-expensive employee or by the consideration of adding a unit during the peak-hours of emergency incidents. Further research is needed to determine the opportunity costs, conduct a cost-benefit analysis of each approach, and to determine culture and union considerations in utilizing these approaches.

Recommendations

Based on the ARP findings, the District should calculate emergency and non-emergency workload and activities on an annual basis. Non-emergency workload and activities will likely change over time and should be evaluated to ensure that each task is relevant, compliant with legal and department mandates, and a review should be completed to determine if any new tasks should be added. Non-work activities should include rest and meal breaks which follow the California labor code guidelines, but labor laws should be continually monitored to ensure the district is aware of any future legislation that may require specific amounts of time or specific time-periods for meals and rest breaks for firefighters.

The district should monitor and intervene as necessary to ensure crews have at least four-hour blocks of sleep time. A formal operations directive should be written that directs company

officers to monitor and manage their crew's sleep. Consideration should be given to allow the company officer to coordinate with a battalion chief to remove a crew from service if severe sleep deprivation occurs. Company officers should strive to allow their crews at least 8 hours of sleep per day.

Finally, it is recommended that the District evaluate emergency call UHU to determine if a crew is overworked (based on annually calculated non-emergency workload and activities). If it is determined that a crew is above the UHU threshold, action should be taken to reduce either non-emergency or emergency workload.

Using this ARP research, a maximum of 13.26% emergency call-load UHU should be adopted by the District as the maximum UHU for any individual crew unless consideration of reducing non-emergency or emergency workload is undertaken. For the future and current overtasked resources, it is recommended that these crews not participate in public education or fire prevention activities until non-emergency or emergency workload can be reduced. Further research is required to determine appropriate solutions to reducing the crew's workload, but it is recommended that peak-time staffing, allocating public-education and fire prevention duties to other crews, or hiring other employees to assist with the non-emergency or emergency workloads be evaluated soon.

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Appendix A: Workload Study Introduction Letter

Dear Participant,

I am working on an applied research project (ARP) for the Executive Development course at the National Fire Academy, Executive Fire Officer. This ARP is e a workload study of our fire department that focuses on the total workload (which includes both non-emergency activities and emergency activities). A large part of this study is determining the total time our non-emergency workload encompasses on an average daily basis.

I am asking select company officers who are assigned to the fire stations located within San Bernardino City (and the immediately surrounding areas) to complete this study; company officers are selected who do not oversee probationary employees and are not on probation themselves.

This study is voluntary and may add a moderate amount of time to your schedule daily for 10-shifts. If you would be willing to participate, please reply to this email and I will forward you a set of instructions, a task breakdown, and a time record sheet.

If you have questions, please do not hesitate to call me at 760-774-2569.

Thank you,

Dan Munsey

Appendix B: Study Instructions

Captain__ (Insert the last name here) ___,

I am researching our departments daily non-emergency time commitments as part of my applied research project for the Executive Development course at the National Fire Academy. To research these commitments, I am conducting a workload-study for each of the fire stations located in Division Two.

Thank you for agreeing to take part in this study.

Instructions:

Over the next ten-shifts please keep track of the time needed to complete each of these activities. If the activity is interrupted by an emergency response, please stop the time-keeping and restart the time-keeping when you return to the task.

Each task has a job breakdown listed on page 2 of this document. A separate record keeping sheet is provided to keep track of the next ten shifts. Time should be kept in whole minutes. Round up or down to the nearest minute as appropriate. If you are not at your normal assigned station or miss a shift, just indicate so on the form and do not keep track of the time required to complete the tasks on that day. It is important to only time-keep on your regularly assigned shifts while you are with your regularly assigned crews.

If you have any questions, please do not hesitate to call.

Thank you,

Dan Munsey
760-774-2569

Appendix C: Time Record Sheet

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7
Shift	**Apparatus &Equipment**	**Reporting and Documentation**	**Station Maintenance**	**Pass-Down and Briefing**	**Training and Education**	**Purchasing and Shopping**	**Special Projects**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Instructions: Place the total time (in minutes) for the task in the blank box. If a task is interrupted, stop the timer and restart the timer when the task can be resumed.

Appendix D: Tasks Breakdown

#1 Daily Fire Apparatus/Equipment Maintenance

This task is to document the performance of the daily apparatus maintenance as prescribed in Operations Directive 4700. This task also includes the cleaning and organizing of equipment. This task likewise includes the time required to check and maintain personal protective gear. Please keep track of all apparatus maintenance on separate score sheets and indicate whether the maintenance is for a Type 1 or 3 engine, a ladder truck, a squad, or a side-by-side (ATV).

#2 Daily Reporting and Documenting

This task documents all daily reporting requirements that are completed as a stand-alone activity (not while returning from a call in the apparatus). This includes all personnel records, staffing, training records, and incident reporting (ePCR & NFIRS).

#3 Daily Station Maintenance

This task is to document the performance of the daily fire station maintenance and cleaning. The interior of the station and the exterior of the station should be documented separately (as indicated) on the score sheet.

#4 Daily Pass-Down and Briefing

This task documents the length of time the morning pass-down requires to be completed. Add the time required at the beginning and at the end of the shift together to determine a total for each shift.

#5 Daily Training and Education

This task documents the length of time spent on each shift training your crew.

#6 Shopping and Purchasing

This task documents the length of time your crew spends daily purchasing (examples include groceries, auto parts, station supplies, and facility maintenance supplies). This time includes both in-person and online purchasing.

#7 Special Projects

This task documents the amount of time spent daily on special projects/ assignments.