2019-12

OPTIMIZE OR DIE: IMPLEMENTING DYNAMIC AND INNOVATIVE DEPLOYMENT MODELS FOR FIRE DEPARTMENTS

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MONTEREY, CALIFORNIA

THESIS

OPTIMIZE OR DIE: DYNAMIC AND INNOVATIVE DEPLOYMENT MODELS FOR FIRE DEPARTMENTS

by

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December 2019

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2019	**3. REPORT TYPE AND DATES COVERED** Master's thesis	
4. TITLE AND SUBTITLE OPTIMIZE OR DIE: DYNAMIC AND INNOVATIVE DEPLOYMENT MODELS FOR FIRE DEPARTMENTS			**5. FUNDING NUMBERS**
6. AUTHOR(S) Tyler B. McCoy			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

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14. SUBJECT TERMS fire department, optimization, innovation, deployment modeling			**15. NUMBER OF PAGES** 127
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

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OPTIMIZE OR DIE: DYNAMIC AND INNOVATIVE DEPLOYMENT MODELS FOR FIRE DEPARTMENTS

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)

from the

NAVAL POSTGRADUATE SCHOOL
December 2019

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ABSTRACT

This thesis analyzes current fire department practices and explores how resource deployments can be modified by innovation and optimization to result in improved services to customers. Alternative response vehicles, mobile integrated healthcare, technology adoption, accreditation, and leveraging data for policy analysis are five opportunities examined in this thesis with data used from 10 fire departments, including Dayton Fire Department. The findings show that implementing alternative vehicles for responding to medical emergencies, leveraging technology, and using data for policy implementation to adopt a mobile integrated healthcare program may decrease the cost of providing services and improve response times to meet national standards. These findings may be beneficial to fire departments across the country that are experiencing budget reductions coupled with increased demand for services

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LIST OF ACRONYMS AND ABBREVIATIONS

ALS	advanced life support
AMAR	automatic mutual aid response
ARM	Advanced Resource Medic
ARV	alternative response vehicle
AVL	automatic vehicle location
BLS	basic life support
CAD	computer aided dispatch
CARES	Community Assistance, Referrals, and Education Services
CBA	collective bargaining agreement
CETA	Comprehensive Employment Training Act
CFAI	Commission on Fire Accreditation International
DFD	Dayton Fire Department
DOJ	Department of Justice
ED	emergency department
EKG	electrocardiograms
EMD	Emergency Medical Dispatching
EMS	emergency medical services
EMT	emergency medical technician
GIS	geographical information systems
GPRS	general packet radio service
GPS	global positioning system
HFD	Honolulu Fire Department
IAFF	International Association of Firefighters
ISO	International Organization for Standardization
ISU	Incident Support Unit
LA	low acuity
LAFD	Los Angeles Fire Department
MDT	mobile data terminal
MIH	mobile integrated healthcare
MPG	miles per gallon

MRT	Medical Response Team
MVP	minimum viable product
NFIRS	National fire incident reporting system
NFPA	National Fire Protection Association
NIST	National Institute for Standards and Technology
NP	nurse practitioner
NYPD	New York Police Department
OFIRS	Ohio fire incident reporting system
PFD	Phoenix Fire Department
PPC	Public Protection Classification
RDC	regional dispatch center
RMS	records management system
RRV	rapid response vehicle
SCBA	self-contained breathing apparatus
SMFR	South Metro Fire Rescue
SOP	standard operating procedure
SPC	System Planning Corporation
SUV	sport utility vehicle
SVI	social vulnerability index
UHU	unit hour utilization

EXECUTIVE SUMMARY

The fire service is changing at a monumental pace. Over the past 50 years, the fire service has evolved from a firefighting to an all-hazard emergency response profession. This change has led to an increased demand for services and the need for expanded firefighter training. At the Dayton Fire Department (DFD), this upward trend in run volume coincides with a downward or flat trend in department budgets. Understanding how fire departments are adjusting to an increasing workload with a reduction in fire apparatus and manpower is the focus of this thesis. This issue was studied by analyzing fire departments that have implemented innovative practices and optimized the remaining resources for lessons learned.

Cities across America are seeing a reduction in fires and an increasing demand for emergency medical services (EMS). Fire departments have been providing EMS across America since the late 1960s, and today, are equipped with advanced life support equipment and skills. The overall numbers of emergencies fire departments are responding to increases yearly. The increased workload has led to an increased wear-and-tear and shorter service-life of fire apparatus. While existing fire apparatus are responding to an increasing number of emergencies yearly, response times are also increasing; exactly the opposite of what is needed in a scenario where lives may depend on timely responses. Fire departments must find ways to provide innovative services, while simultaneously optimizing their existing resources to address these emerging challenges.

The DFD protects a rust-belt city that was once a thriving and innovative community currently in the process of rebranding itself in the 21st century. The DFD has experienced a reduction of in-service engines, ladders, and EMS transport units. As has been the case with fire departments across America, the DFD is dealing with an increasing number of medical emergencies on a yearly basis. To cope with this increasing workload, the DFD needs to innovate and optimize its operations.

To overcome the problems fire departments are facing, optimization of existing fire department resources is needed. National standards can be utilized as benchmarks to

measure a fire department's' ability to meet the customer's needs. The National Fire Protection Agency (NFPA) provides standards for which leaders of cities look to for fire and EMS response time and deployment. In addition to national standards, fire departments may also strive to become accredited by the Commission on Fire Accreditation International (CFAI) and by attaining an International Organization for Standardization (ISO) rating of one; demonstrating to their jurisdiction political leaders and citizens a commitment to excellence. Fire departments have also turned to performance management practices that have been utilized by police departments to combat problems with analytical data. The final aspect assessed in optimizing fire departments is employing geographical information systems (GIS) to assess where and when fire department apparatus is optimized for deployment.

This thesis addresses innovative practices that are allowing fire departments to respond efficiently and quickly to emergencies. Fire departments are sending apparatus closest to the emergency by utilizing automatic vehicle location (AVL) technology. Two new aspects the fire service is embracing is sending more efficient, faster, and cheaper sport utility vehicles (SUV) to medical emergencies in lieu of traditional engine and ladder companies, and hiring nurse practitioners and social workers to implement mobile integrated healthcare (MIH) to meet the socioeconomic demands of citizens. These initiatives are designed to lessen the load of the overburdened EMS system.

Finally, this thesis analyzes the responses and lessons learned from nine fire departments that have implemented innovative practices and deployment optimization. A consensus about best practices is assembled for each topic. These best practices can be utilized to assist fire departments when implementing new policies and procedures regarding innovation and optimization.

ACKNOWLEDGMENTS

I would first like to thank the city of Dayton for sponsoring me to attend this prestigious program. Without its support and letters of recommendation, I would have not been able to attain this degree.

I would like to thank all the members of the Dayton Fire Department, especially alumnus Naval Postgraduate School (NPS) Director and Chief Jeffrey Payne, Deputy Chief Jeff Lykins, Assistant Chief Andrew Braun, and Assistant Chief Nicholas Hosford. Your support of my attendance at NPS, and your assistance in constructing my analysis for the thesis, was invaluable. I would like to thank District Chief Michael Stewart, District Chief David Wright, Captain Bob Barnes, Lieutenant Robert Lotz, and Kevin Shoup for your assistance in gathering data for the analysis of Dayton Fire Department operations.

I would be remiss in not mentioning the one person who has pushed me to complete this program, who has been the backbone of our household during this challenging 18 months, my amazing wife, Ashley McCoy. Each of the countless times I wanted to quit the program, you encouraged me to continue writing and to finish the race. To my children, I hope I have inspired you to shoot for the moon and to persist when you tire or when curveballs come your way.

To my advisors, Shannon Brown and Nicholas Dew, thank you for your time and wisdom, and to my writing coach Noel Yucuis, thank you for your valuable insight to the creation of this work. To all the instructors, teachers, and firefighters I have worked with through the years who have pushed me to further my fire service education, I thank you. To all my family and friends outside the fire service, thank you for all the assistance you have provided me and my family through this program. Finally, to the outstanding NPS faculty and staff, there is not a finer cadre of academia in Homeland Defense and Security. Thank you for your passion and perseverance in our pursuit to become homeland security practitioners.

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I. INTRODUCTION

This thesis analyzes the struggles of the Dayton Fire Department (DFD) to deal with increasing demand in a time of decreasing budgets and what lessons can be learned from other fire departments. At its peak in 1979, Dayton, Ohio, employed 485 firefighters, who staffed 15 engines, seven trucks, four medic units, and responded from 15 firehouses. By 1995, this number decreased to 13 engine companies and six ladder companies.[1] Today, the DFD employs 322 firefighters and paramedics and staffs 12 firehouses with seven engines, four ladders, seven medics units, two district chiefs, and one incident support unit.[2] These numbers reflect a reduction of nearly 40 percent in suppression apparatus able to respond to the increasing number of emergencies. The population in Dayton peaked at 262,323 in 1960; in 2018, it is home to 140,371 people.[3] The loss of population has decreased the revenue Dayton receives from incomes taxes. To aggregate the problem in 2015, Ohio reduced its local government fund, a revenue sharing arrangement in place since 1930, from $11.1 million to $6.59 million.[4] The reduction in state funding has reduced the budget to staff and equip the DFD. Despite the marked population decrease, however, the run volume for the department has increased by 33 percent in the last decade.[5] Dayton is not the only fire department experiencing an increasing demand for service coupled with a decreased budget. An industry-wide review shows Syracuse, Milwaukee, and Cleveland—among many other fire departments—have experienced a reduction in

[1] Larry Ables, *Dayton Fire Department: 150 Years of Professional Firefighting* (Atlanta: Peachtree Portraits, 2014), 7.

[2] City of Dayton, *Dayton Fire Department Statistical Report for 2017* (Dayton, OH: City of Dayton, 2018), 6.

[3] "Quick Facts: Dayton City, Ohio," Census Bureau, accessed April 3, 2019, https://www.census.gov/quickfacts/daytoncityohio.

[4] Steve Bennish, "Cities Cry Foul over Budget Cuts," *Dayton Daily News*, July 25, 2015, https://www.mydaytondailynews.com/news/state--regional-govt--politics/cities-cry-foul-over-budget-cuts/tN2eZPzcVTLhH4Sc5J8ZfM/.

[5] Jeffrey Payne, *American Fire Act Grant Application 2017* (Dayton, OH: City of Dayton, February 2, 2018), 8.

workforce and apparatus but an increased demand for service.[6] The increasing demand for service is ostensibly because Americans are relying more heavily on emergency medical services (EMS) than in the past, calling 9-1-1 for less-critical or even non-emergent issues that shifts traditional family doctor visits to emergency room care in non-emergent situations.[7]

Firefighters today are also responding to a broader variety of emergencies with more emphasis placed on EMS than on fire suppression, which increases the number of responses and the amount of time spent training for these emergencies. Fire apparatus cost more to purchase and maintain than before, but their heavier use has led to a shorter fleet lifespan. Finally, the increased workload with fewer resources has arguably led to low morale; many DFD members have left for fire departments that respond to fewer emergencies.[8] In sum, the DFD, like many fire departments, is struggling with a convergence of problems: staffing and retention, mission shift, budget shortfalls, and fleet acquisition, and maintenance. Despite numerous attempts at alternative staffing models and deployment adjustments, these problems persist.

It appears, assuming these challenges remain steady, that the DFD must adapt, innovate, and optimize to survive. Fire departments elsewhere are implementing adaptable apparatus and deployment models, rapid response vehicles, ladder tenders, dynamically

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[6] Chris Baker, "Will the Next Syracuse Mayor Make Cuts to the Fire Department?," Advance Media New York, October 10, 2017, https://www.syracuse.com/news/index.ssf/2017/10/syracuse_mayoral_candidates_firefighters.html; Mark Gillispie, "Cleveland Mayor Frank Jackson Announces Cuts in the City Workforce," Advance Ohio, April 27, 2011, https://www.cleveland.com/cityhall/index.ssf/2011/04/cleveland_mayor_frank_jackson_14.html.

[7] Kerri Hatt, "Preparing Fire-Based EMS for the 'Silver Tsunami,'" *Fire Recruit*, June 6, 2018, https://www.firerecruit.com/articles/383811018-Preparing-fire-based-EMS-for-the-silver-tsunami.

[8] Wayne Baker, "These Local Fire Departments Are Looking for More Full-Timers, Matching a Larger Trend," *Dayton Daily News*, September 28, 2018, https://www.mydaytondailynews.com/news/these-local-fire-departments-are-looking-for-more-full-timers-matching-larger-trend/C4rwS1CJ2tyWuvDDSxXuoK/.

staffed dual apparatus, and peak-demand staffing.[9] Analysis and cost-modeling is needed to determine the relative strengths and weaknesses of these emerging practices, identify the dynamic and innovative deployment model or models most feasible for the DFD, and propose implementation based on learned smart practices.[10]

A. RESEARCH QUESTION

How can the DFD optimize and innovate for its internal and external customers?

B. LITERATURE REVIEW

The literature review is composed of three sections. The first section examines data and policy regarding fire department deployment and operations. Regional, state, and national data provide information on the services of fire departments. The second section investigates how the fundamentals of innovation and optimization can advance the fire service in deployment and technology. The third section provides information on how fire departments across the nation have implemented adaptable resource deployment.

1. Fire Specific Data and Policy

Literature on local, statewide, and national fire departments contain government reports, statistical reports, and official guidance in managing government organizations. The DFD produces documents related to efficiency and discipline in managing the fire department. These documents include general orders, rules and regulations, standard

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[9] Phoenix Fire Department, *Ladder Tender Response*, Phoenix Regional Standard Operating Procedures, MP 205.10 (Phoenix: City of Phoenix Fire Department, 2003), 1, https://www.phoenix.gov/firesite/Documents/074793.pdf; Steven Knight, "Alternative Deployment Models for the Fire Service," *Fire Chief*, June 11, 2018, https://www.firerescue1.com/fire-chief/articles/384194018-Alternative-deployment-models-for-the-fire-service/; Jarrel Wade, "Study on Tulsa Fire Department Recommends Shifting Personnel for Medical Calls," *Tulsa World*, August 14, 2016, https://www.tulsaworld.com/news/government/study-on-tulsa-fire-department-recommends-shifting-personnel-for-medical/article_83bead18-6a03-5466-83b3-e5ac034fe1de.html; Michael Baker, "Replace Big Apparatus for Better Fire Service EMS Resource Deployment," *Journal of Emergency Medical Services* 39, no. 2 (February 2014): 5, https://www.jems.com/articles/print/volume-39/issue-2/features/replace-big-apparatus-better-fire-servic.html; Alan M. Petrillo, "LAFD Begins Fast Response Vehicle Trial Program," *Fire Apparatus*, February 2016, https://www.fireapparatusmagazine.com/articles/2016/02/lafd-begins-fast-response-vehicle-trial-program.html.

[10] The business model canvas is a strategic management and entrepreneurial tool. It allows the user to describe, design, challenge, invent, and pivot a business model.

operating procedures, and bulletins.[11] The included policies dictate the daily manpower used to staff and deploy the resources of the DFD to fulfill its mission statement. The city of Dayton also produces policies and procedures to ensure departments within the city provide exceptional customer service. These documents include personnel policies and procedures, civil service rules and regulations and contracts with the city's unions including the International Association of Firefighters, (IAFF) Local 136.[12]

Dayton Firefighters IAFF Local 136 has negotiated a firm stance that all engine and ladder companies be deployed with three firefighters and an officer. This staffing level ensures both firefighter and citizen safety on the fire scene. The staffing of four personnel is common in urban departments but not in suburban fire departments. Having four firefighters leads to safer fire department operations and life-saving capabilities but comes at a higher cost to cities. As Jeff Payne of the DFD states, "Four-person staffing is the optimal number of personnel who should be on board each fire apparatus for maximum efficiency and crew safety."[13] The DFD strives to meet standards produced by the State of Ohio and the National Fire Protection Association (NFPA) that produces consensus codes and standards for the elimination of death, injury, property, and economic loss due to fire.[14] NFPA 1710 is the standard for career fire department staffing and resource deployment; it sets the benchmark for fire departments in equipping and deploying manpower to fires and other emergencies.

Compiling data regarding fire department responses helps to show the trends for emergency services. The DFD collects data regarding run volume from its records management system (RMS.) The DFD's RMS shows a 12-percent increase in run volume

[11] "About the Dayton Fire Department," City of Dayton, January 13, 2019, https://www.daytonohio.gov/314/About.

[12] International Association of Firefighters, Local 136, *Agreement of the City of Dayton, Ohio, and International Association of Firefighters, Local 136* (Dayton, OH: IAFF and City of Dayton, 2018), 4.

[13] Jeffrey Payne, "Optimizing Fire Department Operations through Work Schedule Analysis, Alternative Staffing, and Non-Productive Time Reduction" (master's thesis, Naval Postgraduate School, 2014), 5, https://www.hsdl.org/?abstract&did=760178.

[14] "NFPA Overview," National Fire Protection Association, accessed January 13, 2019, https://www.nfpa.org/overview; and Ohio Rev. Code Ann. §124.42 (2003), http://codes.ohio.gov/orc/124.42.

and a decrease in structural fires for the DFD over the last 20 years.[15] This increase aligns with state and national trends. Fire departments across Ohio submit their run volume to the State of Ohio using the Ohio Fire Incident Reporting System (OFIRS.) OFIRS has noted an increase in run volume across Ohio, rising from 740,503 reported emergencies in 2007 to 1,248,145 in 2017, but also showed an overall decrease in the number of fires.[16] The National Fire Incident Reporting System (NFIRS), which is managed by the U.S. Fire Administration and the NFPA, has also noted a national increase in emergencies.[17] Not all fire departments submit their fire department data via NFIRS, so the data provided by the U.S. Fire Administration is skewed, and only captures datasets from 71 percent of fire departments across the country. The lack of total data reporting leads to estimating the country's fire department run volume statistics and fire threat.[18]

With the noted decrease in fires, a call to change fire department staffing levels has been addressed by newspaper columnists addressing the existing fire department model and the cost of fire services.[19] The city of Dayton surveyed 1,500 Dayton citizens on the services they received, as well as which departments they considered essential.[20] Seventy-two percent of respondents ranked the DFD as the most essential services department, and over 70 percent of those respondents were satisfied with the DFD's services.[21] The survey,

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[15] Payne, *American Fire Act Grant Application 2017*, 12.

[16] Andrea Lemaster, email message to author, January 18, 2019.

[17] "U.S. Fire Statistics," U.S. Fire Administration, February 11, 2019, https://www.usfa.fema.gov/data/statistics/index.html; "Fire Department Calls," National Fire Protection Association, last modified May 2018, https://www.nfpa.org/News-and-Research/Data-research-and-tools/Emergency-Responders/Fire-department-calls.

[18] U.S. Fire Administration, *Data Sources and National Estimates Methodology Overview for the U.S. Fire Administration's Topical Fire Report Series*, vol. 19 (Emmitsburg, MD: U.S. Fire Administration, National Fire Data Center, 2018), 11, https://www.usfa.fema.gov/downloads/pdf/statistics/data_sources_and_national_estimates_methodology_vol19.pdf.

[19] Fred McChesney, "Fewer Fires, so Why Are There Far More Firefighters?," *Washington Post*, September 4, 2015, https://www.washingtonpost.com/opinions/2015/09/04/05316abe-517c-11e5-933e-7d06c647a395_story.html?utm_term=.f9ee6c0f496c.

[20] OpinionWorks, *2018 Dayton Survey* (Dayton, OH: Public Spirited Research, 2018), 22, https://www.daytonohio.gov/DocumentCenter/View/5808/2018-Dayton-Survey-Final-Report.

[21] OpinionWorks, 22, 25.

conducted by Opinion Works, did not investigate what specific services the citizens of Dayton wanted from the DFD. Fire departments may need to adapt to what the customers' needs are, and not what the fire department needs or wants.

Data regarding fire department budget and staffing levels is available locally, within the State of Ohio, and nationally. Research regarding the desired services citizens of Dayton request of the DFD is lacking, which in turn, can increase the amount of funding the DFD receives.

2. Innovation and Optimization

As Eric Ries notes, the fire service has traditionally deployed resources based on response time and fire station travel distances rather than on the demand for services.[22] The faster the fire department is able to respond to emergencies, the less damage to be mitigated.[23] The fire service can look to optimization and innovation to facilitate service delivery. Several fire departments have implemented Lean Six Sigma for optimization and Eric Ries's "Lean startup method" when implementing innovation.[24] Optimization is defined as "an act, process, or methodology of making something (such as a design, system, or decision) as fully perfect, functional, or effective as possible."[25] According to Yao, Zhang and Murray, the fire service is beginning to benefit from the innovative deployment of resources using geographical information systems (GIS) and mathematical modeling to optimize service delivery.[26] Departments are increasingly choosing optimization because in it they "find a good, or preferably the proven best, solution to the problem given certain

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[22] Knight, "Alternative Deployment Models for the Fire Service."

[23] Jing Yao, Xiaoxiang Zhang, and Alan T. Murray, "Location Optimization of Urban Fire Stations: Access and Service Coverage," *Computers, Environment and Urban Systems* 73 (January 2019): 184, https://doi.org/10.1016/j.compenvurbsys.2018.10.006.

[24] Sara Beukeboom, "Case Study: Maximizing the Response of Fire Services to Medical Calls," iSixSigma, accessed January 11, 2019, https://www.isixsigma.com/implementation/case-studies/case-study-maximizing-the-response-of-fire-services-to-medical-calls/; Eric Ries, "Principles," Lean Startup: Methodology, accessed February 20, 2019, http://theleanstartup.com/principles.

[25] *Merriam-Webster*, s.v. "optimization," September 7, 2019, https://www.merriam-webster.com/dictionary/optimization.

[26] Yao, Zhang, and Murray, "Location Optimization of Urban Fire Stations," 1.

conditions and restrictions."[27] The Swedish Fire service has optimized deployment of resources based on analysis of run volume, not response times. Innovation can be viewed as resulting "when ideas are applied by the company in order to further satisfy the needs and expectations of the customers."[28] The fire service can innovate in how the services are delivered to its customers to meet their needs better.

Innovation in the fire service has been studied and implemented, from the National Institute of Technology studying the number of firefighters needed to complete critical fireground tasks safely and efficiently, to the Phoenix and Honolulu Fire Departments deploying automatic vehicle location (AVL) systems to reduce response times.[29] Innovation is defined as "the successful exploitation of new ideas."[30] A controversial issue in innovation involves deploying non-traditional alternative response vehicles (ARVs) to medical and smaller fire emergencies.[31] Los Angeles County Fire, Tualatin Valley Fire and Rescue Department, and the Tulsa Fire Department have deployed rapid response vehicles (RRVs).[32] Michael Baker states, "Fire personnel may see the deployment of RRVs as an attempt to cut overall staffing and argue that these changes threaten the public's and responder's safety."[33] To ensure the safety of the citizens and firefighters, RRVs should be implemented to supplement and not replace staffed apparatus.

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[27] Anna Ulander, "Optimization Based Decision Support Tools for Fire and Rescue Resource Planning" (master's thesis, Linköping University, 2015), 4, https://doi.org/10.3384/lic.diva-114320.

[28] *Business Dictionary*, s.v. "innovation," accessed February 25, 2019, http://www.businessdictionary.com/definition/innovation.html.

[29] "Landmark Residential Fire Study Shows How Crew Sizes and Arrival Times Influence Saving Lives and Property," NIST, April 28, 2010, https://www.nist.gov/news-events/news/2010/04/landmark-residential-fire-study-shows-how-crew-sizes-and-arrival-times; R. C. Burch, "Automatic Vehicle Location System Implementation," in *Proceedings of Position, Location and Navigation Symposium* (Atlanta: IEEE, 1996), 689–96, https://doi.org/10.1109/PLANS.1996.509146.

[30] Anahita Baregheh, Jennifer Rowley, and Sally Sambrook, "Towards a Multidisciplinary Definition of Innovation," *Management Decision* 47, no. 8 (September 2009): 13, https://doi.org/10.1108/00251740910984578.

[31] Baker, "Replace Big Apparatus," 3.

[32] Baker, 4.

[33] Baker, 6.

A wealth of books and research on innovation and optimization are available, although not specifically written for the fire service. The failure to apply known techniques for innovation adoption has stalled progress in the nation's fire service. This gap exists both in the literature and in practice.

3. Fire Department Comparative Analysis

Fire departments across the country are adapting their deployment models for the changing service delivery model. The System Planning Corporation (SPC) subsidiary of TriData Corporation has conducted studies that show the fire service in America is responding to fewer fires and a higher number of medical incidents, which precipitates a need for adaptation.[34] Fire departments have a rich history of including technology advances in their operations, going from horse-drawn apparatus to smaller motorized, specialized apparatus to deal with increasing run volume and decreasing manpower.[35] A consensus shows that fire departments need to innovate deployment models as long as manpower is not reduced.[36] The budgeting allocated to staffing adaptable resources is typically met with resistance from labor groups.[37] What is missing is analytical data citing the costs and benefits of implementing adaptable and dynamic deployment models. According to Rick Markley, the safety of firefighters and the citizens requires attending to data. Actionable solutions using data secure their safety.[38] As the NASFM has confirmed, actionable, accurate data regarding how fires begin, the response to fires, and the effort to

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[34] Philip Schaenman, *Fire Rescue Service Demand Update and Rapid Response Vehicle Staffing and Deployment Review: City of Portland, OR* (Arlington, VA: TriData Division, System Planning Corporation, 2011), 38, https://www.portlandoregon.gov/fire/article/397493.

[35] Bill Adams, "The Rochester (NY) Fire Department's Apparatus Purchasing Committee," *Fire Apparatus and Emergency Equipment* 17, no. 6 (June 1, 2012), https://www.fireapparatusmagazine.com/articles/print/volume-17/issue-6/features/the-rochester-fire-departments-apparatus-purchasing-committee.html.

[36] Schaenman, *Fire Rescue Service Demand Update*, 53; Baker, "Replace Big Apparatus," 5.

[37] Schaenman, 73.

[38] Rick Markley, "The Fire Service Future Will Be Data-Driven," *Fire Chief*, December 2, 2016, https://www.firechief.com/2016/12/02/the-fire-service-future-will-be-data-driven/.

prevent fires, is needed.[39] Such data would help departments better adapt to deliver better, more targeted services.

Several fire departments across the country have documented—and made publicly available—the details of their deployment model innovations. For example, a report released by the Akron, Ohio Fire Department provides valuable information on the response benefits of its ARVs to respond on "low acuity emergencies," which thus eliminates minor emergencies from their medic units.[40] The Overland Park, Kansas, Fire Department created a detailed analysis regarding its successful squad concept to reduce the workload on engine and ladder companies.[41] The Rockford, Illinois, Fire Department implemented a quick response vehicle to replace ladder companies responding to EMS emergencies and noted a reduction in response times and maintenance costs.[42] The Tulsa, Oklahoma, Fire Department implemented a squad company concept to replace engine and ladder companies responding to EMS emergencies at their most utilized stations.[43] However, Tulsa has abandoned the squad company concept due to a "lack of management and analysis."[44] To combat the cost of operating ladder companies on medical and rescue emergencies, the Phoenix, Arizona, Fire Department implemented a "ladder tender" concept several decades ago, and has found success, from both a management and labor perspective.[45]

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[39] National Association of State Fire Marshals, *Conquering the 'Unknowns': Addressing Undetermined and Unknown Origin and Cause Entries in Fire Incident Reporting*, *Electronic "Toolkit" of Resources for the First Responder (Table Version)*, Appendix 8b (Maitland, FL: NASFM Research Education Foundation, 2013), 4, http://www.firemarshals.org/resources/Documents/Fire%20Incident%20Data%20 Collectin/Appendix8bToolboxTableFormatNASFM.pdf.

[40] Akron Fire Department, email message to author, January 11, 2019.

[41] Overland Park Fire Department, email message to author, February 26, 2019.

[42] Derek Bergsten, "Quick Response Vehicle Program" (PowerPoint, Rockford, IL, 2012).

[43] Baker, "Replace Big Apparatus, 4; Wade, "Study on Tulsa Fire Department."

[44] Michael Baker, email message to author, September 21, 2018.

[45] Phoenix Fire Department, *Ladder Tender Response*, 1.

C. RESEARCH DESIGN

The author's preliminary research yielded a set of nine cities whose fire departments, by virtue of size or staffing, are similar to Dayton's and have implemented innovation and optimization. The following nine fire departments were chosen for analysis: Akron, OH; Tulsa, OK; Overland Park, KS; Vancouver, BC; Rockford, IL; Los Angeles City, CA; Tualatin Valley, OR; North Charleston, SC; and Salt Lake City, UT.

That set of nine is neither definitive nor comprehensive but is believed to be representative of the innovations across the discipline and the levels of challenges fire departments face in implementing innovation and optimization. Information gathered from their respective innovation and optimization policies was analyzed to make recommendations on how the DFD should move forward toward innovation and optimization. At the end of the thesis, best practices discovered are used to make recommendations in steering the future of the DFD.

Several avenues remain open for research implementing innovations at the DFD, including the police department's use of CompStat for the fire service.[46] Another research avenue concerns the role accreditation by the Commission on Fire Accreditation International (CFAI) may have on resource deployment and innovation abilities. If the DFD attains accreditation, it will emphasize the department's commitment to customer service and continuous improvement through innovation and adaptation.[47] The focus of this thesis is technological and cultural shifts within fire services; both how innovation is adopted and promoted by departments and how members respond to these changes. Research in blending the service delivery model by implementing innovation, for internal and external customers, also remains to be undertaken.

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[46] Michael D. White, "The New York City Police Department, Its Crime Control Strategies and Organizational Changes, 1970–2009," *Justice Quarterly* 31, no. 1 (2014): 74, https://doi.org/10.1080/07418825.2012.723032.

[47] "Accreditation Overview," Center for Public Safety Excellence, accessed March 15, 2019, https://cpse.org/accreditation/.

D. CHAPTER OUTLINE

This thesis has six chapters. Chapter II addresses the history and demographics of the city of Dayton, Ohio, as well as the historical perspective of the DFD. The information regarding the DFD addresses its rise and fall in manpower and in-service fire apparatus, and analyzes the rising number of emergencies the DFD attends to on a daily basis. Chapter III addresses how the DFD and fire departments across the country are optimizing their resources to ensure timely and accurate emergency responses are made to save lives and property from destruction. Chapter IV provides background information to fire departments adopting technology, ARVs, mobile integrated healthcare (MIH), and accreditation to further their efforts in optimizing resources. Chapter V analyzes the findings of nine fire departments across the country that implemented the subheadings of Chapter IV. Chapter VI gives recommendations for the DFD and fire departments across the country to implement innovation and optimize manpower and equipment.

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II. CITY OF DAYTON AND THE DAYTON FIRE DEPARTMENT

Imagine an iconic, booming city in the late 1800s and early 1900s, with manufacturing smoke stacks on every corner and jobs for everyone. Now, envision a city that has over 10,000 vacant homes and commercial structures, and some of the poorest citizens in America. This is a tale of the same city—Dayton, Ohio. The city of Dayton and the DFD have a diverse story that has impacted the American way of life. Dayton began as a humble small town, which rose to an industrial city that has manufactured many of the products Americans use on a daily basis. The number of manufacturing jobs in Dayton—as well as the population—peaked in the 1960s. Dayton is currently in the process of rewriting its history and economic stability. The DFD has followed the city's rollercoaster budget over the years. Its manpower and staffing peaked in the 1970s and have steadily been reduced since that time. Decreases in the DFD's budget coincide with increasing numbers of emergency calls every year.

The DFD has been tested to its limits in 2019. It responded to a multitude of disasters and nefarious attacks in 2019: a planned KKK rally involving over 600 citizens from the extreme left and right, 14 deadly tornadoes on Memorial Day, a terrorist using an automatic rifle who killed 10 citizens and injured dozens in the Oregon District on August 4, and a citizen experiencing a psychotic episode who stole a police cruiser that crashed into multiple vehicles and killed two six-year-old girls and injured over a dozen citizens. These events demonstrate the necessity to have a well-equipped and optimally staffed DFD able to respond to the many hazards today's society present.

A. DAYTON'S HISTORY AND POPULATION

Dayton has a rich history, both in terms of individuals and manufacturing. Ohio joined the Union in 1803, and on March 8, 1841, Dayton was granted its city charter.[48] The Miami-Erie canal, which ran between Dayton and Cincinnati, was completed in 1830

[48] "Brief History of Dayton," City of Dayton, November 12, 2015, https://web.archive.org/web/2015 1112155224/http://www.cityofdayton.org/cco/Pages/BriefHistory.aspx.

that contributed to the rise in population and manufacturing in Dayton.[49] Dayton was home to numerous Fortune 500 companies including National Cash Register, Mead Paper Company, Standard Register, Reynolds and Reynolds, Delco, Frigidaire, and General Motors.[50] In 1900, Dayton had claimed more patents per capita than any other city in America for innovations, such as the automobile self-starter, cash registers, airplanes, pop-top cans, electric wheelchairs, stepladders, and parking meters, to name a few.[51] Leading these companies were the Wright brothers, John Patterson, Edward Deeds, and Charles Kettering.

The population has changed dramatically in Dayton, as have the demographics of its citizens, due to the loss of manufacturing careers. The population of Dayton in 1870 was 30,000, and the population quadrupled to 120,000 by 1910. At this time, Dayton was adapting its factory output from wooden rail cars and iron plows to cash registers, gasoline engines, and electric generators, and was keeping pace with worldwide technological advances.[52] By the start of the 1960s, Dayton had peaked at 262,332 residents.[53] The number of residents began to decline throughout the decade due to an exodus of educated, young parents choosing to raise their families in the suburbs.[54] At the same time, a phenomenon termed "white flight" occurred as the educated were replaced by an influx of less-educated Southerners.[55] Historian Adam Millsap states:

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49 "Miami Erie Canal System," Touring Ohio, 2019, http://touringohio.com/day-trips/miami-erie-canal.html.

50 Samuel Staley, "Dayton, Ohio: The Rise, Fall and Stagnation of a Former Industrial Juggernaut," New Geography, August 4, 2008, http://www.newgeography.com/content/00153-dayton-ohio-the-rise-fall-and-stagnation-a-former-industrial-juggernaut.

51 Lewis Wallace, "Why Did Dayton Produce so Many Inventors and Inventions? WYSO Curious Pops Open an Answer," WYSO, August 1, 2014, https://www.wyso.org/post/why-did-dayton-produce-so-many-inventors-and-inventions-wyso-curious-pops-open-answer.

52 Adam A. Millsap, *How the Gem City Lost Its Luster and How It Can Get It Back: A Case Study of Dayton, Ohio* (Arlington, VA: Mercatus Center at George Mason University, 2018), 8, https://www.ssrn.com/abstract=3102666.

53 Millsap, 20.

54 Millsap, 22.

55 Millsap, 30.

> The de jure segregation and racial discrimination in the South that impeded the human capital attainment of blacks ultimately impacted northern cities such as Dayton. The influx of poorly educated workers combined with the outflow of high-human-capital, high-skill workers negatively affected Dayton's ability to innovate and adapt and so played a role in the city's decline during the latter half of the 20th century.[56]

The less-educated citizens of Dayton found careers working in the numerous manufacturing plants that allowed these citizens to be paid a living wage to support their families. With the fall of manufacturing in Dayton, the opportunities for the less educated to find living-wage careers decreased. In addition to white flight, Adam Millsap believes that the construction of Interstate 75 through downtown Dayton—that allowed faster and easier access to the suburbs and exploded growth outside the city—also contributed to the decline in Dayton's population during the 1970s.[57] As Figure 1 shows, the population in Dayton peaked in the 1960s, and has steadily decreased since then. The population appears to have leveled off around 140,000 citizens as of 2019.

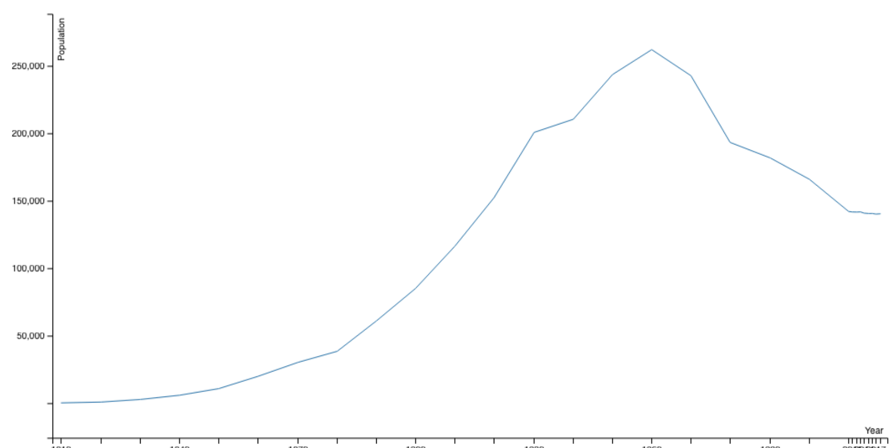

Figure 1. Dayton's Rise and Fall in Population.[58]

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56 Millsap, 40.

57 Millsap, 32.

58 Source: "Dayton Population by Year," World Population Review, July 11, 2019, http://worldpopulationreview.com/us-cities/dayton-population/.

The rise and fall of Dayton's population—from a peak of around 300,000 to its current level of 140,371 residents in 56 square miles—has resulted in urban decay. Thousands of homes and factories in Dayton, once housing residents and workers, stand vacant and are vulnerable to arson. The remaining residents of Dayton are susceptible to life's hardships, with 19 percent considered vulnerable populations—under age five or over age 65—who may require additional services from EMS. Nearly a third of Dayton's residents live below the poverty line, which places them at an increased risk of fire-related incidents.[59] The majority of residents in Dayton are in their 20s, which find themselves living in a city that cannot offer the employment opportunities in manufacturing that once were the mainstay, and leads to increasing numbers of young people living below the poverty line.[60] As shown in Figure 2, certain areas of Dayton encompass citizens who are living with a high social vulnerability index (SVI) score in the city of Dayton. An SVI score is created by analyzing citizens' socio-economics, housing composition, residents with disabilities, minority status, languages spoken, and housing and transportation. An SVI score assists in identifying areas in the community most likely in need of assistance before, during, and after a hazardous event. The closer the SVI score is to 1, the higher the vulnerability.[61]

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[59] Census Bureau, "QuickFacts."

[60] World Population Review, "Dayton Population by Year."

[61] International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis—Dayton Fire Department* (Washington, DC: International Association of Fire Fighters, 2019), 13.

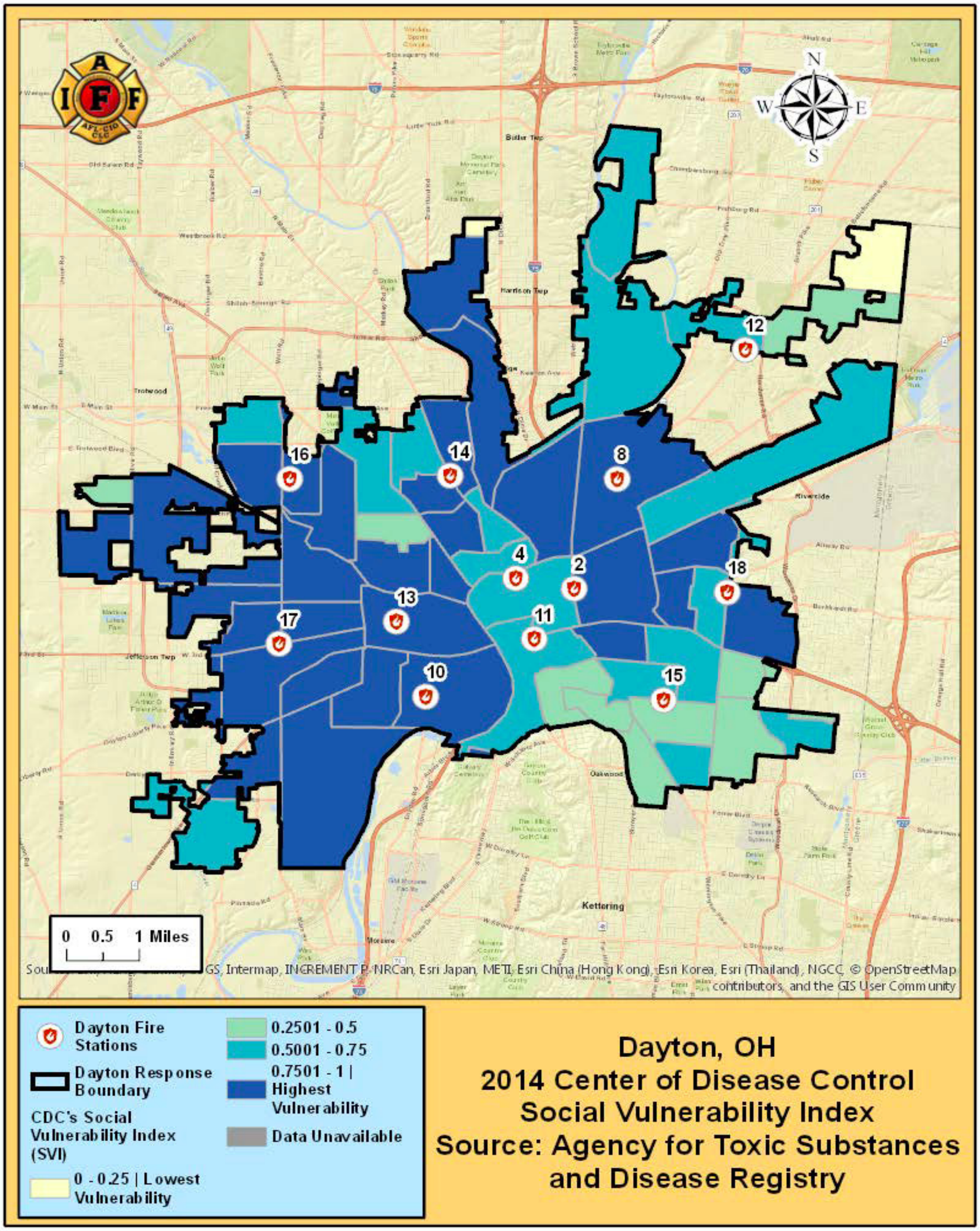

Figure 2. Dayton Social Vulnerability Index.[62]

62 Source: International Association of Fire Fighters, 13.

B. DAYTON FIRE DEPARTMENT: INCREASING CALLS AND DECREASING BUDGET

The DFD has protected the city of Dayton for over 150 years, starting as a volunteer force and evolving to a paid department. As a volunteer fire service in 1846, the DFD comprised three fire companies: the Independence, the Vigilance, and the Safety.[63] By 1880, the DFD had expanded to 78 men who staffed 12 firehouses.[64] Manpower and equipment levels have followed pace with the rise and fall of Dayton's population and generated taxes. Figure 3 shows the distribution of the 12 remaining firehouses across Dayton.

63 J. E. Brelsford, *Illustrated History of the Dayton Fire Department* (Dayton, OH: Dayton History Books Online, 1900), https://www.daytonhistorybooks.com/page/page/1500032.htm.

64 Brelsford.

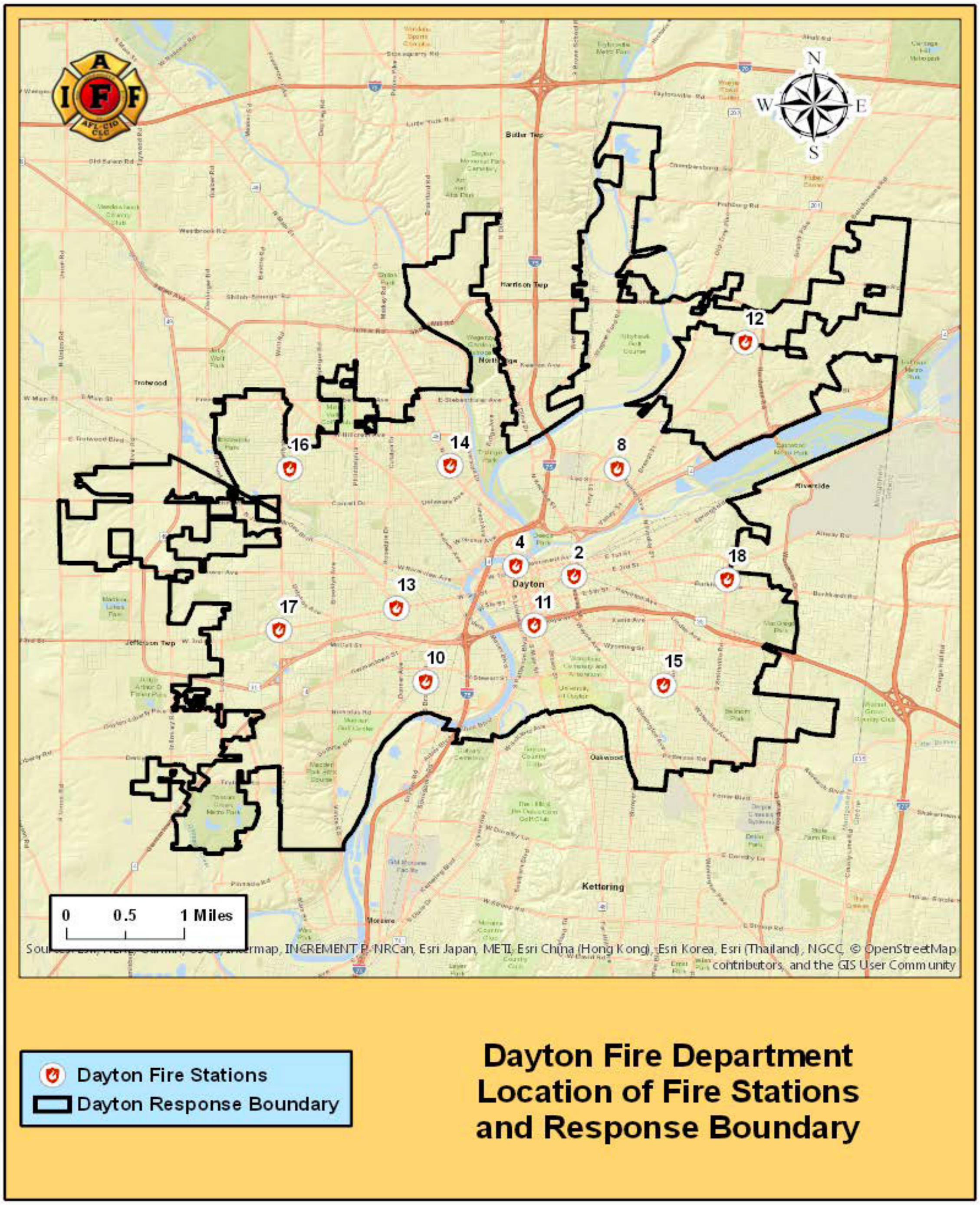

Figure 3. Location of Dayton Fire Stations.[65]

65 Source: International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis*, 10.

The DFD has strategically placed firehouses to cover the city of Dayton. The DFD is currently divided into East and West districts, and each district has six firehouses strategically located to deliver a prompt response to the citizens' emergency calls. The East District comprises four engine companies (2, 8, 12, 15), two ladder companies (11, 18), and four medic units (2, 11, 15, 18). The West District comprises three engines (4, 16, 17)—as well as Engine 10 when workforce allows—two ladder companies (13, 14), and three medic units (13, 14, 16).

A downward trend in business and manufacturing, leading to fewer tax dollars, has resulted in a reduction in manpower and apparatus. Dayton generates its budget from income tax and Ohio's local government fund. The budget allocated DFD has fallen from a high of $53.6 million in 2000 to a low of $39.8 million in 2019, a 25.74 percent decrease. Figure 4 shows the reduction in budget through the last several decades. This reduction accounts neither for inflation nor for the increase in wages the (IAFF Local 136 had negotiated. To staff equipment effectively, 301 members work at the Emergency Services Bureau. To account for members on non-productive leave (i.e., earned days off, vacation, sick leave, or injury leave), each platoon is assigned 100 members. The daily minimum manning is currently 61 members. Overtime firefighters and paramedics fill the vacancies when staffing falls below 61 members.

The Emergency Services Bureau is responsible for mitigating fires, auto accidents, medical emergencies, and natural and man-made disasters. This bureau responds primarily to fire or EMS emergencies. Fire emergencies made up approximately 13 percent of emergencies in 2017.[66] The number of fires the DFD responds to has decreased over the years to 362 structure fires in 2017.[67] This reduction can be attributed to a reduction in vacant houses and aggressive arson patrols. While the number of fires in Dayton has decreased, the number of emergency medical incidents has increased. The number of medical responses for the DFD has increased from 23,315 in 1995 to 30,340 in 2017, a 30 percent increase. The total number of incidents the DFD responded to in 2017 was 39,013,

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[66] City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 2.

[67] City of Dayton, 3.

a 15.7 percent increase.[68] The increased workload has resulted in less time for company training and out-of-service fire prevention programs. Figure 4 shows that while the budget the DFD receives has decreased every year in the last two decades, the number of emergencies the DFD responds to increases every year.

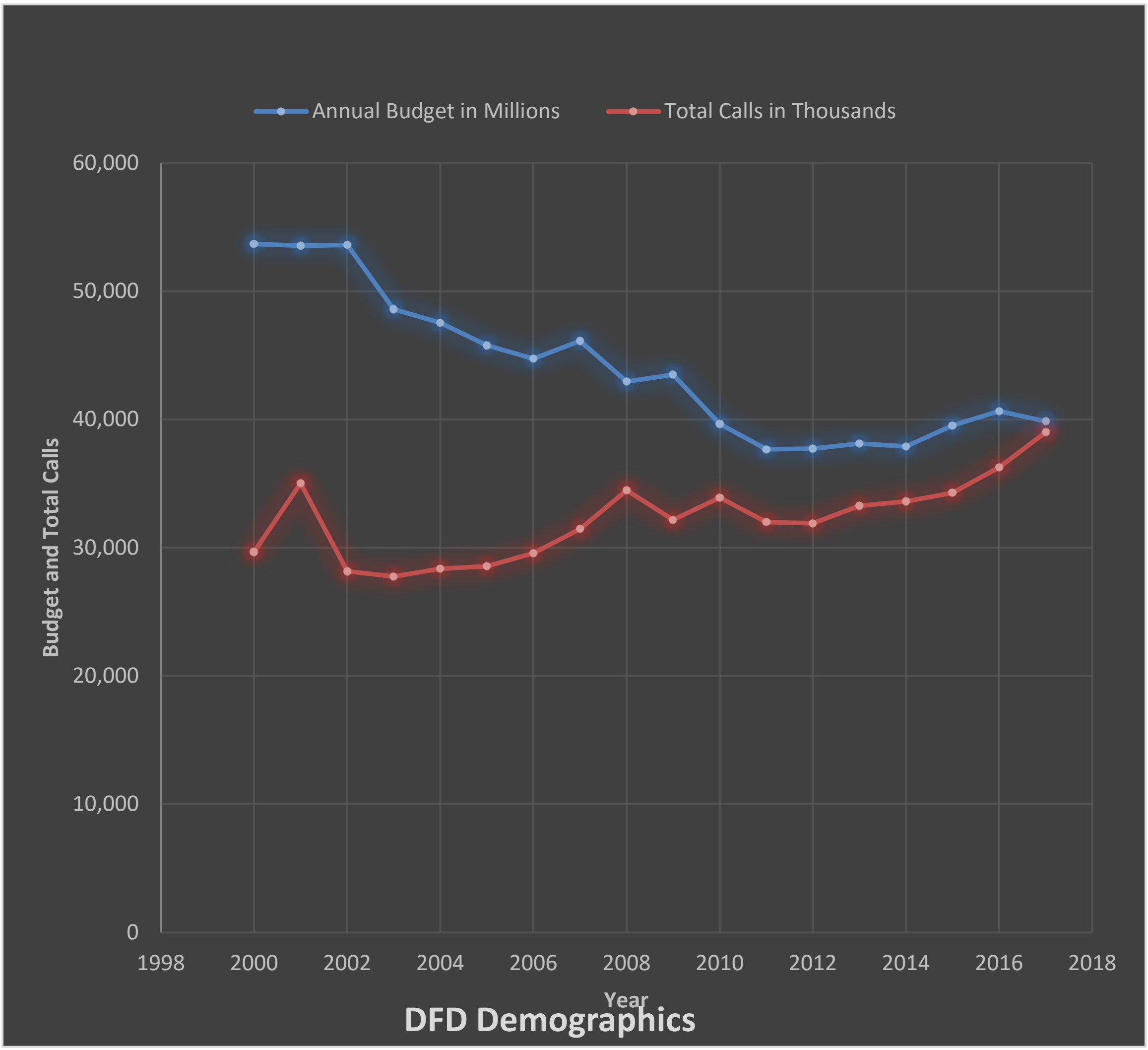

Figure 4. Dayton Fire Annual Budget, Total Calls for 2017.[69]

68 City of Dayton, 9.

69 Source: City of Dayton, 9.

Dayton has provided EMS since 1950, when the Dayton Police Department transported the sick and injured.[70] In 1979, the DFD began staffing medic units with paramedics by utilizing the Comprehensive Employment Training Act (CETA).[71] Since 1979, the DFD has staffed medic units with trained paramedics.[72] In 1999, all paramedics were transitioned over to a firefighter/paramedic status, provided they passed the exams and the six-month academy. Firefighter/medics rotated staffing fire apparatus (engines and ladders) and medic units. In 2010, the DFD began hiring civilian emergency medical technicians (EMTs) to staff the medic units. Civilians were hired when the Department of Justice (DOJ) found discrimination in the DFD's hiring of firefighters, because "the City engaged in a pattern or practice of race discrimination against African Americans with respect to employment opportunities as police officers and firefighters."[73] It would be five years before the DFD could hold a firefighter recruit academy, and attrition rates were the highest in those years among the firefighters. The DOJ gave former DFD Fire Chief Redden the authority to hire EMTs, which thus allowed firefighter/paramedics to staff the fire apparatus. The DFD extended the hiring of EMTs to include paramedics that further allowed firefighter/paramedics to staff additional spots on fire apparatus. Today, the DFD staffs seven medic units with one EMT and one paramedic.

The DFD operates a three-tiered EMS system embedded within the fire stations: pre-arrival instructions by the regional dispatch center (RDC), first responder/medic assist utilizing engine and ladder companies, and advanced life support (ALS) medic transport.[74] Sending the appropriate fire department resource to a medical emergency begins with the processing of the 9-1-1 call at dispatch. Dispatchers use emergency medical dispatching

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[70] Ty Tyson, email message to author, August 28, 2018.

[71] President Richard Nixon signed the Comprehensive Employment Training Act (CETA) into law on December 28, 1973. The CETA's goal was to provide training and careers to individuals experiencing low-income and long-term unemployment. The City of Dayton hired civilian paramedics under the CETA program funding in 1979.

[72] Ty Tyson, email message to author, August 28, 2018.

[73] *United States v. City of Dayton, Ohio*, 3:08-cv-348 (TMR) (2009), 1, https://www.justice.gov/sites/default/files/crt/legacy/2010/12/15/daytoncd.pdf.

[74] City of Dayton, *General Order 16 EMS Action Guide* (Dayton, OH: City of Dayton, 2018), 1.

(EMD) protocol to determine the correct response to the medical emergency. A certified EMD dispatcher is a person who "is a trained public safety telecommunicator with the additional training and specific emergency medical knowledge essential for the efficient management of processing 9-1-1 calls and other emergency medical communications."[75] In systems that employ both ALS and basic life support (BLS) resources, the EMD dispatcher plays a significant role in sending the appropriate apparatus and resources to a medical emergency. According to a report issued by the *American Society for Testing and Materials*, "In systems that vary levels of response, dispatch protocols should specify which situations require an ALS versus a BLS response." These protocols are important in tiered EMS systems, such as Dayton's, because they allow a rapid response from the appropriate EMS personnel.[76] The EMD determines the medical emergency using the answers to key questions by the 9-1-1 caller, and then one of the six proper dispatch determinant codes can be selected (Alpha through Echo).[77] Alpha is basic medical emergencies (illness, small laceration) while Echo is cardiac arrest, where a citizen is not breathing and has no pulse. The lower the alphabet designation, the more critical the medical emergency is.

C. STAFFING AND CALL TRENDS

The trends outlined in the previous section show the EMS run volume rising without a correlating increase in medic units. The DFD tracks response data by month, day, and hour to examine trends in emergency calls. Fire management can utilize this analytical data to place additional resources strategically into service during the peak times, and redistribute resources when they are underutilized. An examination of Table 1 illustrates the peak months for responses in the years 2000 to 2010 showed that July, May, and August

[75] American Society for Testing and Materials, "Elements of an Emergency Medical Dispatch System," in *Standard Practice for Emergency Medical Dispatch Management*, Appendix G 1a (West Conshohocken, PA: ASTM, 1994), 15, https://icsw.nhtsa.gov/people/injury/ems/PandemicInfluenza/PDFs/AppG.pdf.

[76] American Society for Testing and Materials, 18.

[77] Jeff Clawson and Kate Dernocoeur, "Determinant Codes Versus Response. Understanding How It Is Done," in *The Principles of Emergency Medical Dispatch*, ed. Gordon W. Cottle et al., 3rd ed. (Salt Lake City, UT: The Principles of Emergency Medical Dispatch, 2001), 5, https://www.emergencydispatch.org/articles/princdocpull03.pdf.

were the busiest months while February, November, and April were the slowest for responses. Table 2 displays the years 2010 to 2018 and shows July, August, and May were the busiest months while November, December, and October were the slowest. The call volume clearly shows that the summer months are the busiest months, while the call volume decreases, as the weather turns colder. This data could be used to staff peak-time apparatus during the summer months.

Table 1. Busiest Months for Total Calls for Dayton Fire Department, 2000–2010.[78]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	4789	4245	4329	4601	5212	4762	5074	4895	4713	4844	4303	4968
2001	4705	4318	4868	4759	4801	4725	5023	5082	4862	5040	4418	4645
2002	4786	4232	4760	4384	4718	4875	5074	4845	4912	4514	4280	4342
2003	4796	4361	4495	4364	4789	4322	4657	4568	4471	4808	4512	4607
2004	4875	4317	4217	4144	4524	4490	4488	4435	4387	4383	4302	5127
2005	4731	4149	4638	4252	4695	4446	4599	4637	4531	4528	4291	4316
2006	4036	3818	4596	4306	4909	4681	4976	4706	4689	4668	4375	4730
2007	4519	4590	4814	4630	5169	5125	5033	5393	5122	5186	4794	4959
2008	5002	5003	5246	4892	5026	5448	5288	5006	6051	5026	4638	5172
2009	4552	3870	4346	4553	4780	4671	4789	5029	4856	4851	4413	4680
2010	4536	4246	4657	4643	5184	5378	5103	5044	4967	5136	4540	4459
Total	**51327**	**47149**	**50966**	**49528**	**53807**	**52923**	**54104**	**53640**	**53561**	**52984**	**48866**	**52005**

Table 2. Busiest Months for Total Calls for Dayton Fire Department, 2011–2018.[79]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	4596	5055	4606	4490	4965	4983	5285	4870	4908	4899	4451	4411
2012	4526	3977	4909	4304	4898	5103	5538	5266	4909	4989	4655	4930
2013	5239	4436	4819	4891	5230	4903	5158	5150	5057	4917	4925	4610
2014	5697	4303	4852	4706	5090	5049	5064	5473	5436	5141	4789	5091
2015	5058	4574	5093	4950	5534	5485	5600	5403	5048	5237	4983	5154
2016	4916	4996	5538	5434	5545	5637	5893	6169	5823	5663	5394	5764
2017	6075	5618	5860	6367	6342	5810	6524	5919	5634	5857	5397	6020

78 Adapted from Lieutenant Robert Lotz, email message to author, May 13, 2019.

79 Adapted from Lieutenant Robert Lotz, email message to author, May 13, 2019.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	5706	4763	5158	5293	6025	5805	6030	6472	5779			
Total	**41813**	**37723**	**40835**	**40435**	**43629**	**42775**	**45092**	**44722**	**42594**	**36703**	**34594**	**35980**

Certain days of the week tend to bring a higher number of emergencies to which the DFD responds. Table 3 shows that in the years 2000–2010, the busiest days of the week for the DFD were Friday, Monday, and Tuesday, in that order. The slowest days of the week were Sunday, Saturday, and Wednesday in that order. Table 4 demonstrates that in 2010–2018, Monday, Friday, and Tuesday were the busiest days, in that order. Sunday, Saturday, and Thursday were the slowest days of the week. Friday and the beginning days of the week were the busiest days for the DFD. This data could be used to staff peak-time apparatus on Mondays, Fridays, and Tuesdays.

Table 3. Busiest Days of the Week for the Dayton Fire Department 2000–2010.[80]

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
2000	8060	7904	8042	8105	8494	8358	7772
2001	8680	8066	8110	8206	8392	8219	7573
2002	8200	8379	8137	7524	8295	7997	7190
2003	7990	8099	8143	8057	8027	7317	7117
2004	7611	7695	7570	8118	7978	7491	7226
2005	7942	7939	7496	7943	7652	7603	7238
2006	7784	7945	8053	8020	7751	7514	7423
2007	8917	8972	8723	8246	8424	8175	7877
2008	9136	9090	9018	8584	8962	8476	8532
2009	7876	7636	7943	8325	8236	7944	7430
2010	8246	8407	8178	8413	8810	7932	7907
Total	**90442**	**90132**	**89413**	**89541**	**91021**	**87026**	**83285**

[80] Adapted from Lieutenant Robert Lotz, email message to author, May 13, 2019.

Table 4. Busiest Days of the Week for the Dayton Fire Department 2011–2018.[81]

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
2011	8278	8518	8444	8389	8294	8145	7451
2012	8633	8308	8428	8603	8310	7853	7869
2013	9118	8743	8467	8327	8746	8134	7800
2014	8980	8701	8868	8810	8920	8260	8153
2015	9091	8940	8910	8934	9030	8730	8484
2016	9698	9705	9340	9434	9921	9592	9082
2017	9932	10397	10346	10175	10515	9885	10173
2018	7640	7178	7348	7433	7471	7042	6919
Total	**71370**	**70490**	**70151**	**70105**	**71207**	**67641**	**65931**

The DFD operates in 24-hour shifts with the minimum manning of apparatus—61 personnel—staffed the entire time. Minimum staffing levels has inversely decreased through the years, as the number of emergencies has increased. The peak-response times for the DFD can be assessed to determine whether additional staffing is needed. Figures 5, 6 and 7 reflect the DFD's peak times for fire, medical, and structure fire responses. Fire responses range from gas leaks, fire alarms, auto fires, and auto accidents. Medical responses are for ill and injured members. Structure fires represent any structure (house, commercial building, garage) that is on fire.

Figure 5 shows that structure fires statistically occur from noon to 4:00 p.m. and from midnight to 6:00 a.m. The danger with structure fires in the middle of the night is that structures are typically occupied with sleeping occupants. Research supports that the severity of fires increases during this time period. The greater severity of fire, and time it occurs, places citizens in danger of injury or death from smoke and fire. This data shows that structure fires occur at all hours, and while the total number of emergencies the DFD responds to drops off after hours, the likelihood of a fire occurring increases. Fire apparatus should not be browned out or taken out of service at night, as catastrophic fires may occur during that time.

[81] Adapted from Lieutenant Robert Lotz, email message to author, May 13, 2019.

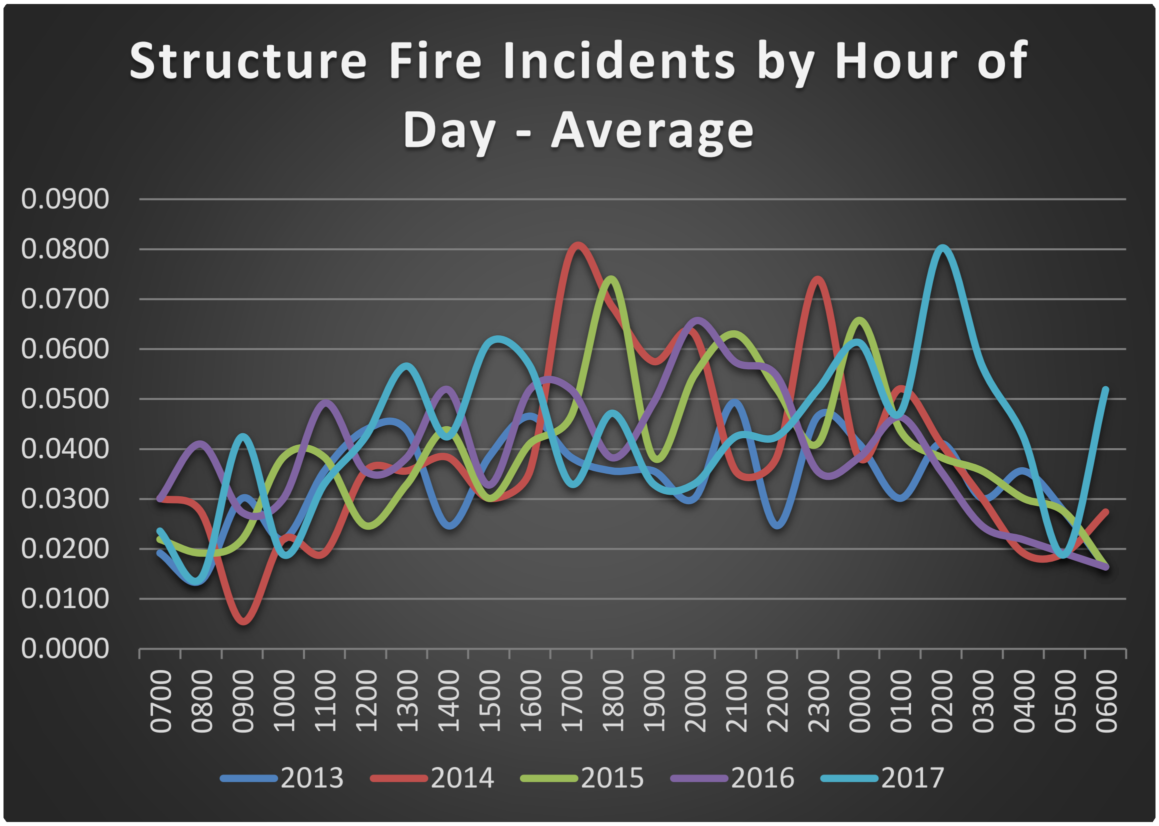

Figure 5. Structure Fire Incidents by Hour of Day Average.[82]

Dayton engine and ladder companies respond to a multitude of fire emergencies that do not involve a fire. These range from activated fire alarms in residences, schools and commercial buildings, to carbon monoxide leaks, auto accidents, and utility emergencies (water, natural gas and electrical in nature.) Figure 6 shows that non-structure fire incidents in Dayton tend to happen from 2:00 to 9:00 p.m. with the peak time being 5:00 p.m.

82 Adapted from Lieutenant Robert Lotz, email message to author, July 27, 2019.

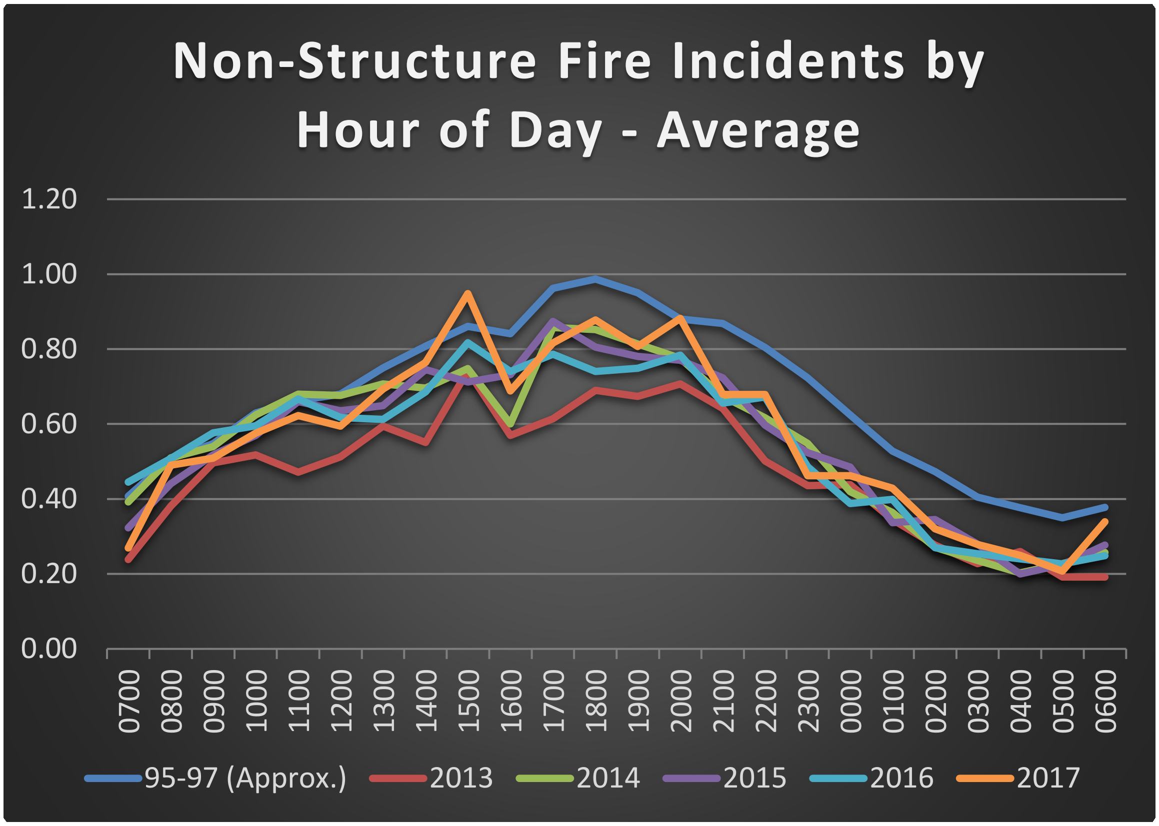

Figure 6. Non-Structure Fire Incidents by Hour of Day Average.[83]

Medical emergencies in Dayton tend to occur during business hours, when residents and visitors to Dayton are awake. Figure 7 shows that the peak time of day for DFD medical responses is from 10:00 a.m. to 10:00 p.m. with the peak being 3:00 p.m. to 5:00 p.m. This data set shows the need for additional staffed peak-demand medic units between the hours of 10:00 a.m. and 10:00 p.m.

[83] Adapted from Lieutenant Robert Lotz, email message to author, July 27, 2019.

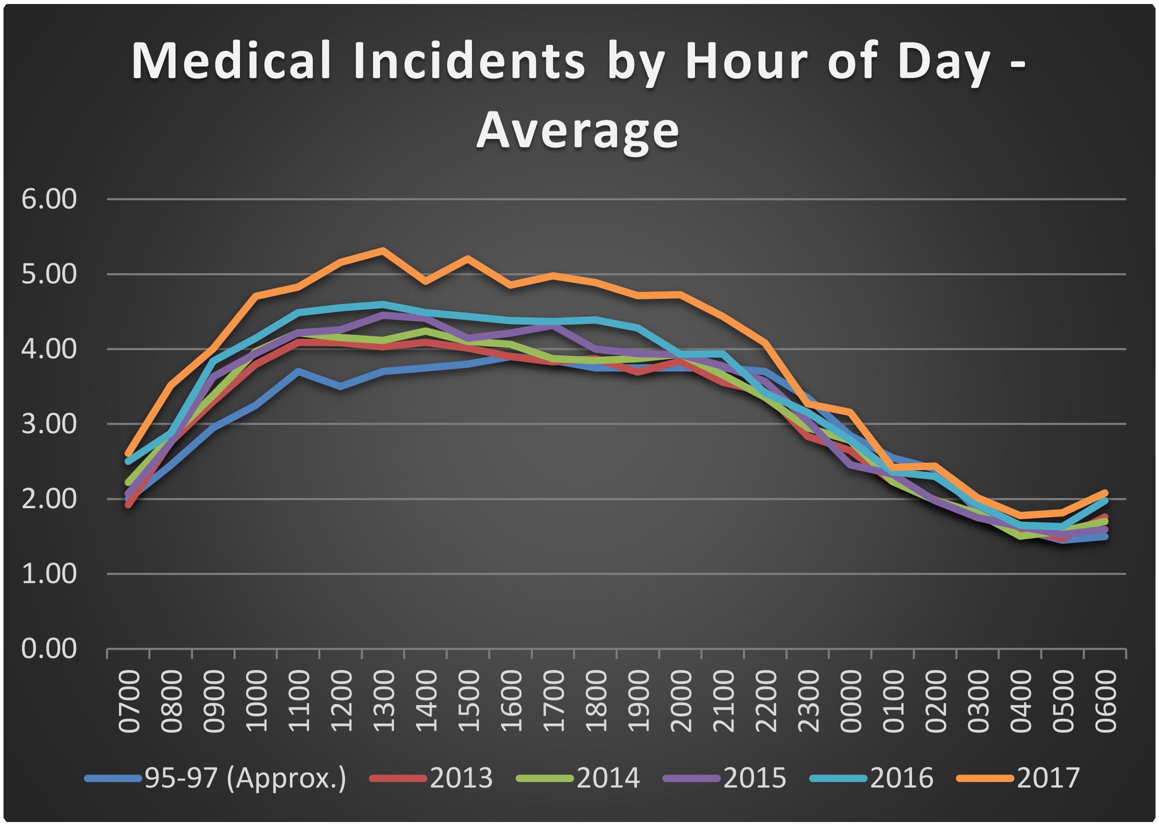

Figure 7. Medical Incidents by Hour of Day Average.[84]

The data regarding the DFD's deployment and responses indicate the pattern of increasing responses and peak times for service. Figure 8 clearly shows that while the number of in-service apparatus (i.e., engine, ladder, and medic units) has decreased by nearly 40 percent, the number of emergencies the remaining apparatus attend to has increased by nearly 16 percent.

84 Adapted from Lieutenant Robert Lotz, email message to author, August 18, 2018.

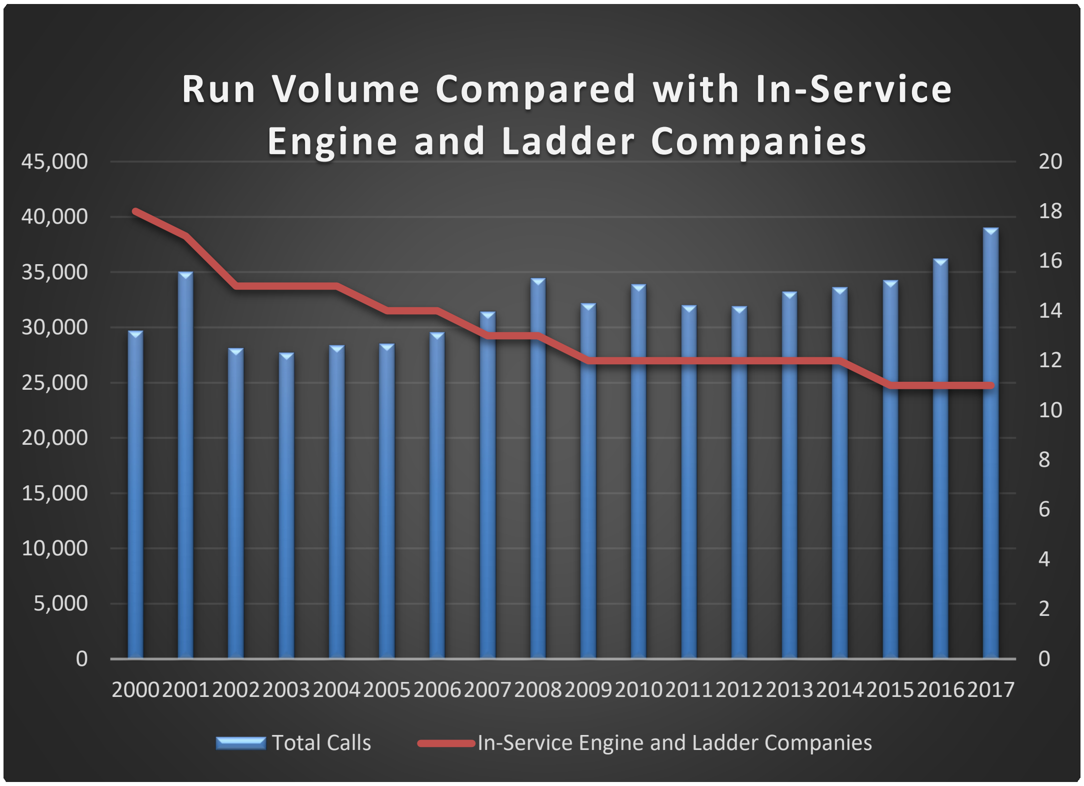

Figure 8. Comparative Analysis of Total Calls to In-Service Fire Apparatus.[85]

The increasing workload has strained the Emergency Services Bureau. These data sets could be used to justify upstaffing equipment and manpower in the busier summer months, Fridays, Mondays, and Tuesdays and daytime hours for medical emergencies to meet the increased demands for service. Upstaffing equipment could take the strain of the increased run volume off the existing apparatus. The increasing number of emergencies to which fire apparatus respond to increases the wear and tear and the associated costs of maintaining fire apparatus.

D. PURCHASING AND MAINTAINING FIRE APPARATUS

Fire apparatus are some of the largest capital expenses for cities. A typical fire engine costs in excess of $500,000 while a new aerial ladder cost nearly $1 million. The

[85] Adapted from City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 9.

cost to purchase fire apparatus increases 3–5 percent each year.[86] Dayton purchased two engines from E-One in 2018 at a cost of $550,000 each and a 137-foot aerial ladder for $852,000.[87] Fire apparatus have a target life span of 15 years in front-line use and 10 years reserve before they are replaced, which aligns with NFPA standards.[88] Fire apparatus may not reach this goal due to an increasing number of emergency responses, or a lack of preventative maintenance.

Ladders are the costliest fire apparatus to purchase and maintain, and are responding to more and more emergencies in Dayton every year. In 2000, DFD ladder companies responded to 6,409 emergencies with five companies. In 2011, ladder companies responded to 8,876 with four companies. In 2017, ladder companies responded to 12,576 with four companies. The increased workload has resulted in ladder companies remaining out of service for extensive maintenance. In September 2019, the DFD could only operate three ladder companies due to three front-line and three reserve ladders out of commission due to mechanical issues.

Dayton currently has a replacement schedule for apparatus, based upon mileage or years of service for apparatus replacement.[89] The DFD fleet currently consists of eight frontline engines, four frontline ladders, seven frontline medics, and maintains five reserve engines, three reserve ladders, and six reserve medics. Maintenance of fire apparatus is proportional to the workload placed on that vehicle. Fire apparatus utilized more frequently require more frequent repainting, parts replacement, and general maintenance. The Shreveport Fire Department has established a useful spreadsheet of the cost of fire apparatus maintenance. Shreveport has found that average repair costs for engines and ladders are as follows: oil change costs $175, a set of tires costs $1,800, a complete brake

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[86] Schaenman, *Fire Rescue Service Demand Update*, 53.

[87] Matthew McClain, email message to author, July 7, 2019.

[88] Jim Juneau, "The True Cost of Operating Worn-Out Fire Apparatus," *Fire Apparatus and Emergency Equipment*, April 15, 2015, https://www.fireapparatusmagazine.com/articles/print/volume-20/issue-4/departments/fama-forum/the-true-cost-of-operating-worn-out-fire-apparatus.html.

[89] Andrew Braun, email message to author, October 28, 2019.

job costs $3,600, and a battery and alternator $1,600.[90] Dayton does not have specific data for these line items, but that reasonable cost estimates are available for common expenses associated with operating apparatus.

The DFD has established the cost of operating fire apparatus on a yearly basis based on preventative maintenance, repairs, and fuel costs. Table 5 analyzes the total cost to operate engine, ladder, and medic companies. As an example, in 2018, the DFD spent $60,460 on maintaining Ladder 11, which had been driven a total of 9,973 miles. The bottom of the table lists the incident support unit (ISU), a 2014 Chevy Tahoe staffed daily by one lieutenant/paramedic to respond to life-threatening EMS calls and working fires, who functions as a senior paramedic and safety officer. The ISU is an example of the cost of operating an ARV at the DFD.

Table 5. DFD Apparatus Maintenance, Fuel, Miles, and Total Cost Chart.[91]

Apparatus	Maintenance	Fuel Gallons	Miles driven	Total Cost	Fuel MPG
Ladder 11	$60,459.64	5,214.17	9,973.00	$75,960.50	1.90
Ladder 13	$54,125.57	4,511.14	10,665.00	$67,877.44	2.36
Ladder 14	$40,236.84	4,147.02	10,402.00	$52,673.27	2.50
Ladder 18	$41,801.41	4,624.11	10,625.00	$41,935.09	2.29
Average	$49,155.86	4,624.11	10,416.25	$59,611.58	2.26
Engine 2	$9,117.93	2,607.17	12,235.00	$17,289.94	4.69
Engine 4	$29,381.04	3,806.08	15,043.00	$40,884.59	3.95
Engine 8	$20,922.83	2,832.06	9,127.00	$29,281.82	3.22
Engine 10	$15,634.57	2,250.37	7,230.00	$22,330.36	3.21
Engine 12	$40,416.09	2,135.98	11,814.00	$42,126.04	5.53
Engine 15	$27,289.52	1,946.43	14,868.00	$33,082.92	7.63
Engine 16	$25,737.43	2,998.58	11,844.00	$34,744.50	3.94
Engine 17	$9,926.97	3,559.05	13,517.00	$21,786.29	3.79
Average	$22,303.30	2,766.97	11,959.75	$30,190.81	4.50

90 Schaenman, *Fire Rescue Service Demand Update*, 48.

91 Source: Kevin Shoup, email message to author, July 29, 2019.

Apparatus	Maintenance	Fuel Gallons	Miles driven	Total Cost	Fuel MPG
Medic 2	$31,880.11	2,383.84	17,773.00	$39,049.61	7.45
Medic 11	$31,619.77	4,345.24	19,027.00	$44,811.10	4.37
Medic 13	$21,747.61	4,866.20	27,144.00	$36,403.20	5.57
Medic 14	$8,597.06	4,383.36	35,930.00	$22,062.17	8.19
Medic 15	$6,653.62	3,524.46	6,485.00	$7,106.35	1.83
Medic 16	$7,994.27	4,848.59	34,850.00	$22,604.90	7.18
Medic 18	$27,142.60	319.52	23,789.00	$28,364.26	5.77
Average	$19,376.43	3,524.46	23,571.14	$28,628.80	5.77
ISU	$1,685.22	1,411.60	13,636.00	$5,815.58	9.65

Operating fire apparatus is costly for cities and fuel is one aspect in operating fire apparatus. Ladder 11 currently travels 1.9 miles per gallon (MPG). In 2018, the DFD spent $15,501 in fuel to operate Ladder 11. In 2018, the ISU, a position that utilizes an SUV, was considerably less expensive to operate: $1,685 was spent on maintenance, $4,130 in fuel costs, which gave the ISU a 9.65 MPG. Assuming Ladder 11 averages 9,900 miles per year at 1.9 MPG, and the ISU averages 9.65 MPG (a difference of 7.75 MPG), responding in an ARV like the ISU can result in 1,277 gallons of fuel saved. The DFD currently pays $2.43 per gallon of diesel and $2.49 per gallon of gasoline.

Departments that have utilized an ARV have noted a reduction in fuel costs. If Dayton were to implement an ARV, it could see savings in fuel costs. An ARV with a diesel engine would cost $3,104 to operate the 9,900 miles, and $3,181 to operate an ARV with a gasoline engine. If the DFD would utilize an ARV for all 9,900 miles, this would result in savings of approximately $12,360. The estimated cost savings is high, because Ladder 11's crew can still utilize Ladder 11 for fire and rescue emergencies, and training. The DFD could implement the ARV program at all four ladder companies to see an increased savings. Should DFD implement an ARV at all four ladder companies, approximately $49,440 dollars could be saved, if the ARV replaced all of the ladder companies' miles. Again, this situation would not occur, and the exact amount saved would not be known until many years' worth of captured data.

Operating ARVs for medical emergencies could result in total savings to operate such a vehicle. The four ladder companies in Dayton averaged $59,611.58 in total operating costs in 2018. The DFD spent $5,815.58 in total costs operating the ISU in 2018. The DFD could save approximately $215,184 in total costs if the ARV were to be utilized in lieu of the four ladder companies, when accounting for the fuel and maintenance savings. The DFD purchased a new ISU vehicle in 2019 for approximately $50,000. Additional money would need to be budgeted for radios, EMS equipment, and safety equipment. The cost to purchase four ARVs would cost approximately $200,000 plus equipment.

In researching the means for reducing costs and wear and tear on apparatus, the DFD could pilot an ARV program to allow data to be gathered and assessed on the true savings of the program, as well as unintended consequences that need addressing. Several options on the deployment of the ARV could be tested and data gathered and analyzed. The first pilot uses the crew of Ladder 11 to respond in the ARV for medical emergencies that Ladder 11 normally responds to, and leaves Ladder 11 in quarters, staffed with only the driver. Ladder 11 was chosen due to being the busiest ladder in the city, since it responded to 3,267 emergencies in 2018.[92] Data to be benchmarked with Ladder 11 compared to the ARV for reduced wear on Ladder 11 include: response time of the ARV, availability of the ARV and engine and ladder companies for additional emergencies, missed working fires, and rescue emergencies Ladder 11 would normally respond to if not staffing the ARV, the consequences of the first-due ladder not being able to respond with the full crew complement due to the crew being on the ARV, and a possible reduction in fuel and maintenance costs associated with Ladder 11 with the deployment of the ARV. Table 6 speaks to the options in staffing the ARV at the DFD.

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[92] City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 7.

Table 6. Alternative Response Vehicle Iterations.

Idea	Value	Cost/ Cons	Needs
Two-man staffing with extra personnel	1.No overtime spent 2.Minimum Viable Product to test	1. In-service dependent upon manpower	1. Extra manpower 2. SUV and medical equipment
Cross-Staffed with Ladder 11 utilizing all personnel	1. Four personnel for safety and manpower 2. Saves wear and tear on Ladder 11 3. May reduce response times	1. Out of service while ARV is on runs, thus taking Ladder 11 OOS. 2. Missed fires/ rescues	1.SUV and medical equipment
Cross-Staffing with Ladder 11 utilizing two firefighters on back	1. Ladder remains available for fire runs to meet the ARV on scene	1. Does not meet four man staffing clause 2. Captain not with ARV responding to medical emergencies	1.SUV and medical equipment
Cross-Staffed with Ladder 11 utilizing the Captain and two Firefighters	1.Ladder remains available for fire runs and ARV will meet ladder on scene. 2. Maintains Captain with crew of ARV for safety.	1.Does not meet four man staffing clause 2. Captain not with Ladder 11 responding to the fire run.	1.SUV and medical equipment
Staffed with Safety Captain and One-Forty Hour Personnel	1.No overtime spent 2. Ability to generate data	1.Safety Officer and forty-hour position not staffed during timeframe	1.Extra Captain and a willing forty-hour member

The second hypothetical pilot involves placing the ARV in service with extra personnel and responding from Stations 15 or 17. These two stations have the longest response time in the city of Dayton. The ARV would be deployed at Stations 15 or 17 and would respond to medical emergencies to which Engines 15 or 17 traditionally responded. The hypothesis is the engine companies would remain available for fire and additional medical emergencies, and the ARV would reduce response times to the emergency compared with the traditional engines. Data capture points with Engine 15 and Engine 17 compared to the ARV for a reduction in response times include the following. Will the

ARV reduce response times in the districts that have been addressed in the IAFF GIS study that currently do not meet the NFPA 1710 240 seconds of travel time or less to 90 percent of incidents? The response times for apparatus in the city of Dayton are increasing at a rate of 5.6 percent. First-due Fire Districts 2, 4, 15, and 17 had a 90th percentile travel times greater than four minutes.[93] The second data capture point assesses whether the ability for engine and ladder companies to remain available for duplicate emergencies that occur within their respective districts would increase with the deployment of the ARV.

E. CONCLUSION

The city of Dayton and its fire department reached their height in terms of population and manpower in the 1960s. The loss of citizens has not correlated with the number of emergencies the DFD responds to on a yearly basis. Medical emergencies have increased through the years, but the number of apparatus to meet these demands has decreased. The cost to operate fire apparatus continues to rise with the increasing purchase price and increase in usage. Analysis was conducted that found that the summer months, and Saturday, Monday, and Tuesday were the busiest days for emergencies for the DFD. Therefore, the DFD should optimize its deployment of resources. National standards and benchmarks should be utilized to ensure proper optimization modeling is implemented for the greatest effect, both for citizens and employees of the DFD.

The increasing number of emergencies has created a perfect storm of increasing costs on apparatus and wear and tear to the apparatus and members of the DFD. Innovative deployments to deal with the increasing workload should be assessed and piloted. The ARV is one area in which many fire departments across the country have been successful. Utilizing an SUV to respond on medical emergencies could result in savings towards fuel and maintenance costs. Utilizing national standards and metrics could assist the DFD in optimizing its services to serve its customers better.

[93] International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis*, 102.

III. FIRE DEPARTMENT OPTIMIZATION AND INNOVATION

As explored in Chapter II, the DFD, like fire departments across the United States, is experiencing a mounting workload due to an increasing demand for EMS, yet also experiencing a reduction in budget and workforce. This perfect storm has necessitated those fire departments to innovate and optimize tools to provide services to their customers. This chapter addresses how national response standards for the fire service can be utilized as a benchmark for response times and the optimum number of firefighters who should be responding to fires. The chapter further discusses how fire departments can optimize their resources using accurate data to create performance statistics and goals to optimize available capital. The utilization of the services of an accreditation process and insurance standards can further the fire department’s ability to optimize its deployment. The final aspect of this chapter addresses a study conducted by the IAFF utilizing GIS mapping, as well as relevant technological and support innovations, such as sending an ARV to medical emergencies and an integrated MIH platform, to address healthcare needs within the community.

A. NATIONAL STANDARD FOR RESPONSE AND DAYTON’S METRICS

To save lives and property, a prompt response from the fire department is necessary. The NFPA sets the minimum response time for the first arriving engine at the scene of fire at 240 seconds, or four minutes. The entire full-alarm assignment must arrive on scene within 480 seconds, or eight minutes, to allow for the completion of needed fireground activities A fire can reach the flashover stage, when the room is fully engulfed in fire, in as little as eight minutes; or sooner if modern building materials are involved. At the point of flashover, trapped occupants in the fire will not survive.[94] Considering the time it takes to discover the fire, call 9–1-1, dispatch the appropriate fire companies, and allow travel time to the scene, the time allotted for survival prior to the fire departments arrival quickly fades. A fast response time is of utmost importance in limiting fire spread and rescuing trapped

[94] International Association of Fire Fighters, 15.

occupants prior to flashover. Staffing below the minimum of four firefighters' delays fireground activities and allows the fire to progress toward the flashover stage.

The NFPA also recommends the minimum number of firefighters that should be assembled to fight a fire. For example, in a low-hazard fire, such as a house fire, 15 firefighters should assemble within eight minutes. The DFD is capable of meeting NFPA 1710 requirements to a low-hazard fire for 66.9 percent of city roads. For a medium-hazard fire, such as an apartment fire, 28 firefighters should arrive within eight minutes. The DFD is capable of meeting NFPA 1710 requirements to a medium-hazard fire for 38.8 percent of city roads. For a high-hazard fire, such as a high-rise fire, 43 firefighters should converge within 10 minutes, 10 seconds.[95] The DFD is capable of meeting NFPA 1710 requirements to a high-hazard fire for 38.8 percent of city roads. Figures 9–11 illustrate the ability of the DFD to meet NFPA 1710 response standards to low, medium, and high-hazard fires, and the roads within these capabilities are highlighted. These figures are based the availability of all engine and ladder companies to respond, and not be tied up with existing emergencies.

[95] National Fire Protection Association, *NFPA Standard 1710: Organization and Deployment of Fire Suppression Operations, EMS and Special Operations in Career Fire Departments* (Quincy, MA: National Fire Protection Association, 2016), 2, https://services.prod.iaff.org/ContentFile/Get/30541.

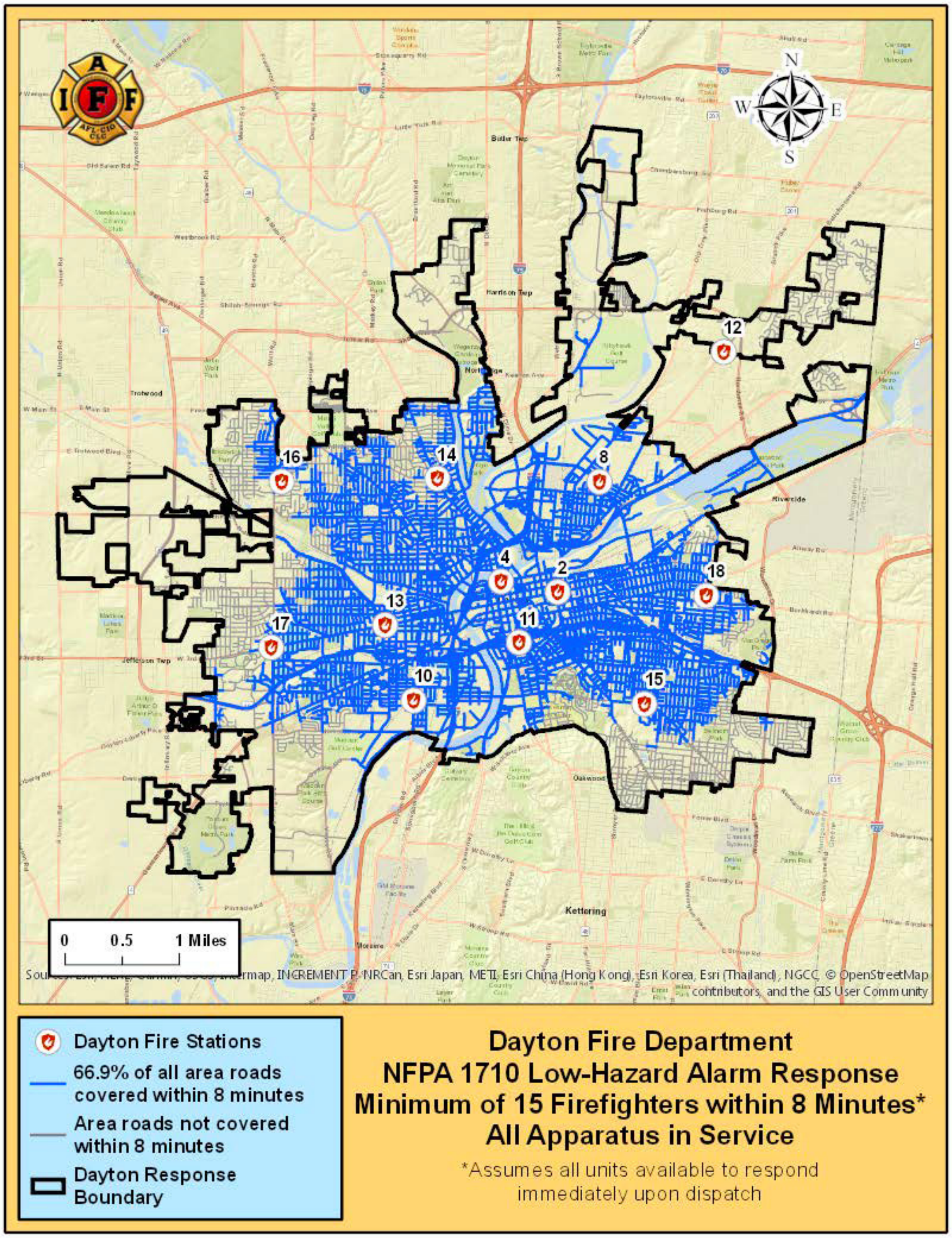

Figure 9. NFPA 1710 Low-Hazard Alarm Response.[96]

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[96] Source: International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis*, 54.

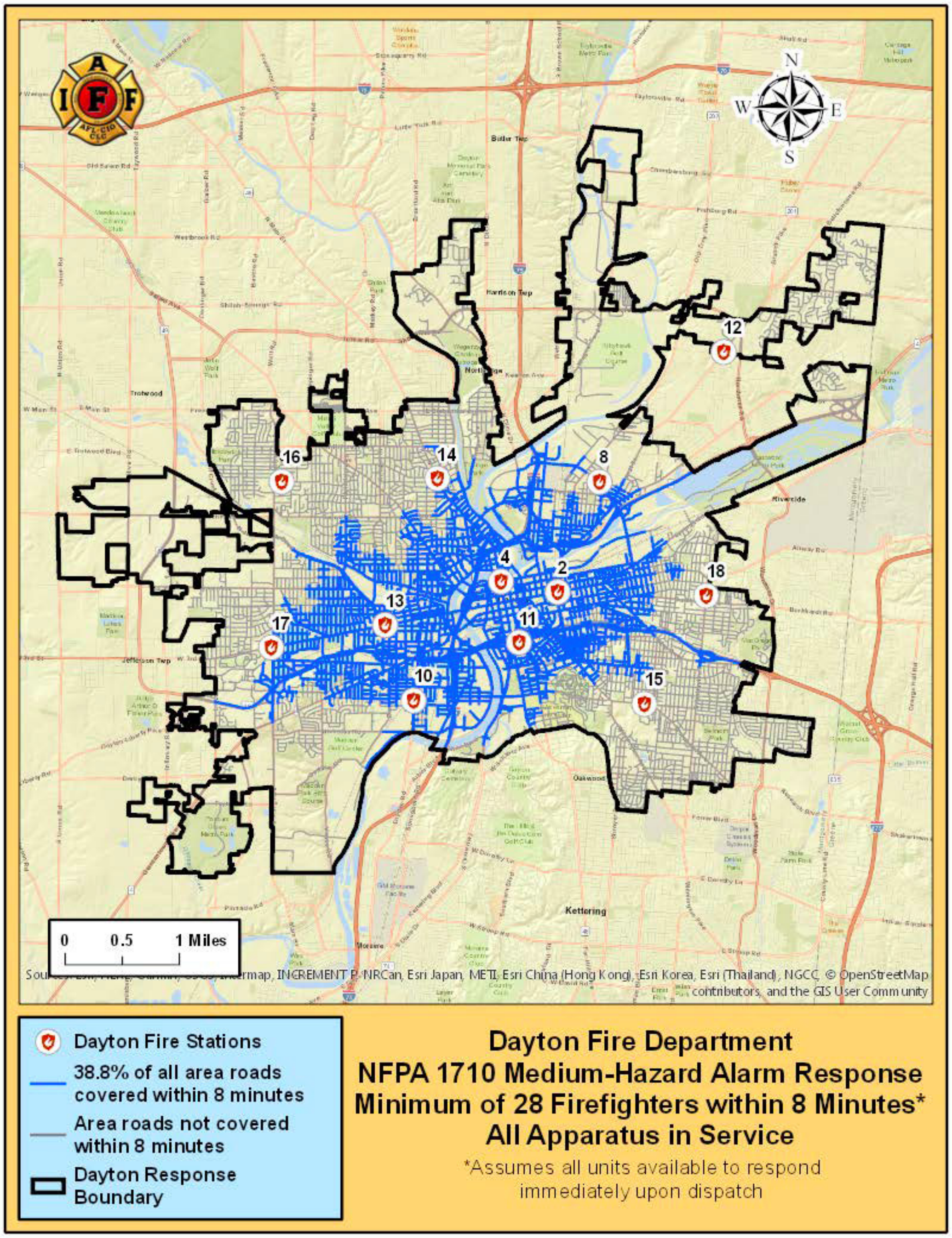

Figure 10. NFPA 1710 Medium-Hazard Alarm Response.[97]

[97] Source: International Association of Fire Fighters, 55.

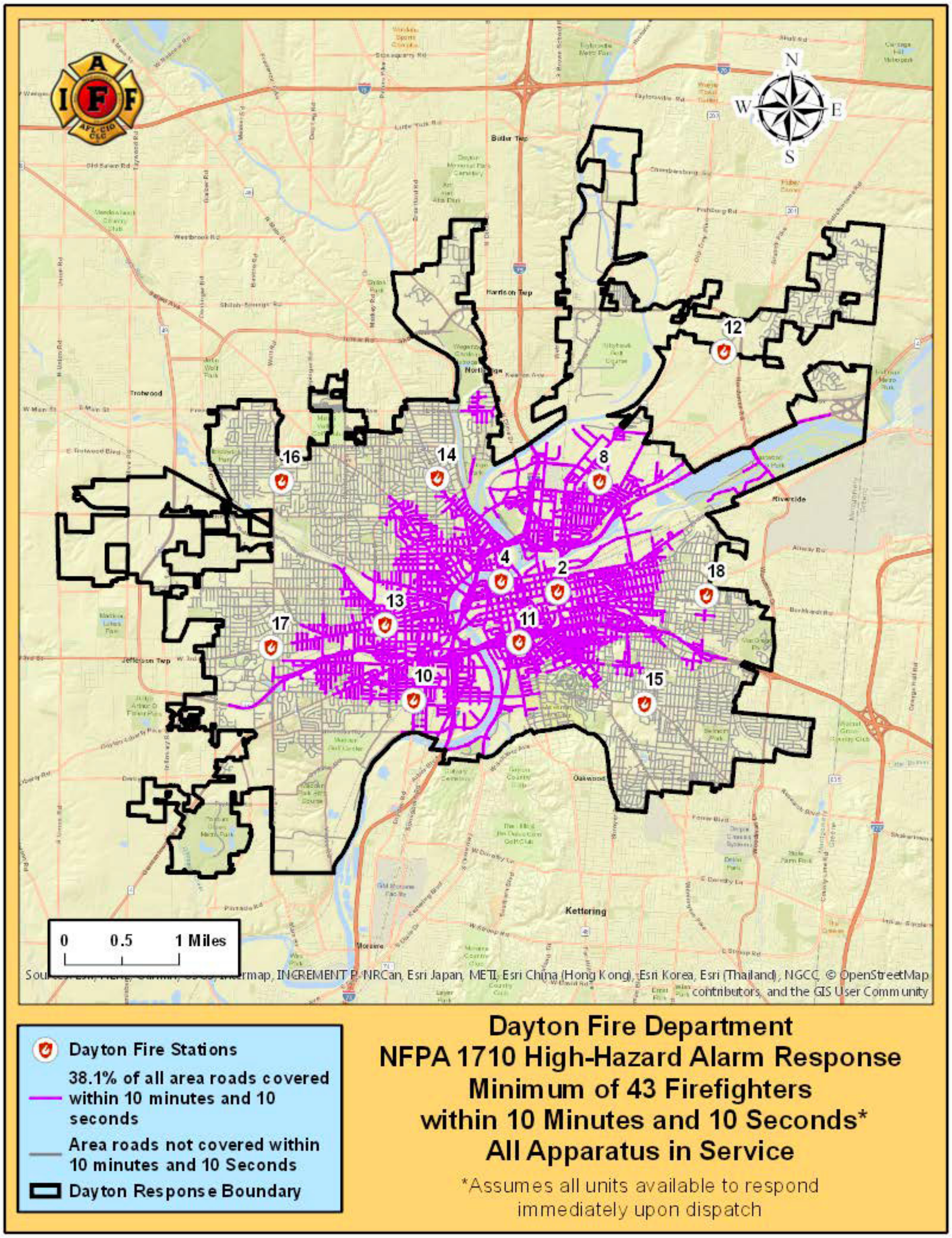

Figure 11. NFPA 1710 High-Hazard Alarm Response.[98]

[98] Source: International Association of Fire Fighters, 56.

Four-member staffing is considered the optimal crew size for safety and efficiency.[99] The National Institute for Standards and Technology (NIST) conducted experiments to determine the efficacy of three- and four-person fire companies and their ability to complete critical fireground tasks. The experiment found that four-person crews could complete these tasks 25 percent faster than three-person crews.[100] Response time, coupled with the needed number of firefighters assembled on the fireground to complete ideal fireground tasks, saves lives and properties. The DFD currently staffs in-service engine and ladder companies with one officer and three fighters.[101] Dayton is fortunate to staff in-service engine and ladder companies with the recommended number of firefighters. If fire apparatus is not staffed with the optimal crew size, more fire apparatus is needed to respond on the initial response to meet national standards. The more apparatus needed to respond, the total travel time for the entire response is likely to increase. The faster the response, the greater the likelihood of saving lives and property.

When a citizen is experiencing a life-threatening medical emergency, the response time of the ALS provider is what matters. Presently, response times are used to measure the effectiveness of EMS and fire department deployment. Studies have found that when individuals are experiencing acute coronary syndrome (a heart attack), they should receive definitive care at a hospital within one hour. The faster a heart attack patient receives reperfusion therapy to the heart, the greater the likelihood of survival afterward. NFPA 1710 stipulates, "480 seconds or less travel time for the arrival of an ALS unit at an emergency medical incident, where this service is provided by the fire department provided a first responder with AED or BLS unit arrived in 240 seconds or less travel time."[102]

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99 Payne, "Optimizing Fire Department Operations," 68.

100 International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis*, 19.

101 International Association of Firefighters, Local 136, *Agreement the City of Dayton, Ohio and International Association of Firefighters, Local 136*, 19.

102 National Fire Protection Association, *Second Revision No. 3-NFPA 1710–2014 [Section No. 4.1.2.1]* (Quincy, MA, National Fire Protection Association, 2014), 2, https://www.nfpa.org/Assets/files/AboutTheCodes/1710/1710_A2015_FAC-AAA_SD_SRStatements.pdf.

Two factors facilitate the increased chance of survival, a reduction in time before reperfusion (door-to-balloon time) and pre-hospital administration of aspirin to the patient. Fire departments that perform ALS care can administer electrocardiograms (EKG) to determine whether an individual is experiencing a heart attack, and then notify the hospital to reduce the door-to balloon time, and administer aspirin to the patient.[103] When fire departments arrive on the scene more quickly, the time to administer an EKG and aspirin is reduced; thus, increasing the chance of survival.

The DFD provides ALS first-responder engine and ladder companies staffed with a minimum of one firefighter/paramedic from 12 strategically located firehouses to supplement the ALS medic units. First responding reduces the time for paramedics to arrive on scene. Each engine and ladder company at DFD is staffed with a minimum of one paramedic and carries full ALS equipment. The higher number of paramedics on scene for a cardiac arrest allows faster interventions to occur. The ideal number of personnel on scene for a cardiac arrest in six (at least two paramedics) to perform the following interventions: a lead provider, an airway manager, two providers to interchangeably deliver chest compressions, a provider to establish an intravenous medication line and administer medications, and a provider to operate the monitor.[104] The average response time for DFD in 2017 was 340 seconds, which is 100 seconds above the national standard of 240 seconds, which increased 5.6 percent since 2017.[105] This increase results in a delay in providing ALS measures.

To meet national standards, Dayton should take steps to reduce its response time, with additional resources and use of optimized technology. Dayton is fortunate to staff in-service engine and ladder companies with the recommended number of firefighters, but

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[103] Denise Daudelin, "Improving Use of Prehospital 12-Lead Electrocardiography for Early Identification and Treatment of Acute Coronary Syndrome and St-Elevation Myocardial Infarction," *Circulation: Cardiovascular Quality and Outcomes* 3, no. 3 (May 2010): 316–23, https://www.ahajournals.org/doi/10.1161/CIRCOUTCOMES.109.895045.

[104] International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis*, 44.

[105] City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 2.

can benefit from taking measures to reduce the response time of initial arriving apparatus and the total alarm response times. A key factor in reducing response time is having accurate data to base decisions upon, and utilizing the services of outside agencies that specialize in optimized deployment of the workforce.

B. OPTIMIZATION

Fire departments today need to make decisions based upon robust data regarding what and where to deploy those resources. As William Bratton notes, "a lack of timely, accurate data results in "flying blind" when making decisions."[106] To prevent flying blind, the DFD needs to gather data regarding response times, apparatus costs, and amount of time apparatus is unavailable for emergencies. Gathering and interpreting data will allow the DFD to deploy resources where needed and strategically placed effectively. "Big data" is beginning to be used in the fire service for predictive deployment of resources. Having the ability to assess all factors, that in the past were not assessed, will allow the fire service to make accurate decisions for placing resources, such as the placement of fire stations based upon projected real-time response times. According to Quinn and Roden,

> Response time of the initial unit to arrive was often viewed as the conduit metric between the caller and fire department intervention; but this has become cloudy, as any fire department can experientially tell you that measurable response time should also involve the arrival of the entire complement of units dispatched for a particular incident. Through Big Data and data analysis, we can paint a more complete picture of the response time process that have long surrounded the response time conversation. Are there local conditions that have a significant effect on response times, such as traffic patterns, street conditions, population density, or any of an array of other possibilities?[107]

One new initiative in optimizing resources in government based upon achieving measurable results started with William Bratton, New York Police Department (NYPD)

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[106] David Weisburd et al., *The Growth of Compstat in American Policing* (Washington, DC: Police Foundation, 2004), 2.

[107] Matt Quinn and Eric Roden, "Big Data in the Fire Service: A Primer," *Fire Rescue* 9, no. 12 (December 1, 2014), https://www.firerescuemagazine.com/articles/print/volume-9/issue-12/technology-and-communications/big-data-in-the-fire-service-a-primer.html.

commissioner in 1994. Bratton had the goal of "reducing crime by 10 percent the first year, by another 15 percent in the second year, and by a total of 40 percent over three years."[108] Bratton was going to optimize the performance of the NYPD in 1994 by utilizing four aspects: accurate and timely intelligence, rapid deployment, effective tactics, relentless follow-up, and assessment.[109]

For a government body, such as the NYPD, to implement a program based upon a specific performance effectively, it must begin with a specific purpose. For example, a fire department might set a purpose of "reducing response times of fire apparatus, reducing the cost of operating fire apparatus or increasing the availability of fire apparatus for emergencies." Bratton chose to reduce the crime in New York City by creating NYPD CompStat, which is short for compare statistics.[110]

Bratton created CompStat to manage the police precincts, but quickly noted he needed data to make decisions effectively. Bratton believed the key to successfully implementing CompStat was to focus on achieving specific results. Bratton believed in setting the goals and objectives at his level but allowed the precinct-level commanding officers to manage how best to meet the goals and objectives. The NYPD is subdivided into 76 precincts.[111] CompStat allowed commanders the discretion to make decisions, yet protection of these decisions by the commander's supervisors still had to exist for the program to work. The leadership of an organization has to decide which subunits will be allowed discretion in their decision making. Robert Behn states, "The leadership team needs to make an analytical, conscious, explicit, and visible choice."[112] Police departments across the country, as well as in other countries, are implementing CompStat, including Boston, Los Angeles, Lowell, Massachusetts, and Queensland, Australia.

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[108] Robert D. Behn, *The Performancestat Potential* (Cambridge, MA: Ash Center for Democratic Governance and Innovation, 2014), 37.

[109] Behn, 39.

[110] Behn, 60.

[111] Behn, 86.

[112] Behn, 90.

Several fire departments across the county are utilizing PerformanceStat to optimize their resources and service delivery. PerformanceStat is a variant of Bratton's CompStat that analyzes data for specific purposes to assist in reaching set goals. The Montgomery County, Maryland Fire Department is utilizing its version of PerformanceStat titled "CountyStat" to assist in meeting NFPA 1710's recommendation for first engine response times to structure fires in the county.[113] The Los Angeles Fire Department created its version of PerformanceStat titled "FireStatLA" that measures the components of fire department response times. FireStatLA tracks call processing time at dispatch, the time it takes fire apparatus to leave the firehouse (i.e., "turn out"), and travel time to the emergency. This data is compared to NFPA 1710 standards to ensure compliance with national standards.[114] Fire departments can utilize data for strategic placement of key apparatus and personnel to ensure optimization for both the citizens (reducing response times to emergencies) and fire department assets (less wear and tear on apparatus and firefighters.)

The Insurance Services Office created the fire suppression rating schedule to analyze the quality of fire protection a community is afforded by the respective fire department by utilizing a Public Protection Classification (PPC) rating scale. The rating is based upon the fire department's apparatus and staffing, water supply, communications, and community risk reduction programs.[115] A PPC of 1 represents a superior level of fire protection, while a 10 represents a fire department that 'does not meet the minimum qualifications. The assigned number is based upon the deployment of the fire department's resources, water supply available, and emergency communications. Insurance companies base their fire protection assessment for homeowners on their respective fire departments'

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[113] "90th Percentile Arrival Time for First Engine to Structure Fire in Urban Areas of the County," CountyStat: Montgomery County Performance and Analytics, June 2018, https://reports.data.montgomerycountymd.gov/stat/goals/qucz-i7xn/ukf5-w9cm/345w-jm6a.

[114] "How We Calculate Results," Los Angeles Fire Department, August 11, 2015, https://www.lafd.org/how-we-calculate-results.

[115] Robert Andrews, "New PPC Fire Protection Classes to Benefit Insurers, Communities," Verisk, April 1, 2014, https://www.verisk.com/insurance/visualize/new-ppc-fire-protection-classes-to-benefit-insurers-communities/.

ISO rating.[116] Dayton attained an ISO rating of 2 on August 1, 2016. Cities can optimize their fire departments by working with the ISO to improve fire department capabilities based upon their recommendations.

The Center for Public Safety Excellence created the CFAI to innovate and optimize fire departments by self-assessing itself against best practices and accountability through an external peer review.[117] The CFAI states that fire agencies that have attained accreditation “are often described as being community-focused, data-driven, outcome-focused, strategic-minded, well organized, properly equipped, and properly staffed and trained.”[118] The accreditation process allows fire departments to determine the level of service they provide their citizens, and to set benchmarks for future delivery of services. Dayton is not an accredited agency. It could pursue accreditation to reach the apex level for innovation and optimization in the fire service by showing the elected officials of Dayton that the DFD is an organization that fully meets the needs of its customers.

Fire departments that utilize data to optimize their services are finding success in meeting the needs of the citizens and members of the fire department. One measure of success fire departments achieve is attaining an ISO rating of one, and accreditation through the CFAI. These successes allow the citizens and politicians to feel they are protected by an elite fire department. An additional step towards optimization utilizes computer mapping software for the ideal placement of fire stations and apparatus.

C. IAFF GIS STUDY FOR DFD MEDICS AND MUTUAL AID USAGE

One way to decrease response time is through a GIS study. The IAFF conducted a workload analysis using GIS mapping software to examine call volume, call demand, and the deployment of resources.[119] The IAFF evaluated different staffing and deployment

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[116] Andrews.

[117] “Accreditation Overview,” Center for Public Safety Excellence, accessed July 14, 2019, https://cpse.org/accreditation/.

[118] Center for Public Safety Excellence.

[119] International Association of Fire Fighters, *Geographic Information System Emergency Services Response Capabilities Analysis*, 1.

configurations and whether each iteration meets the NFPA 1710 standard of the four-minute initial response with four fire personnel.[120] With eight engine companies staffed, the DFD is capable of the first engine arriving on scene within four minutes to 51.6 percent of city roads.[121] As shown in Figure 12, with eight engine companies and four ladder companies staffed, the DFD can assemble a minimum of four firefighters to 72.8 percent of city roads within the first four minutes.[122] The figure illustrates the streets (seen as green) that the DFD is able to provide four firefighters on scene within four minutes.

[120] International Association of Fire Fighters, 3.

[121] International Association of Fire Fighters, 52.

[122] International Association of Fire Fighters, 53.

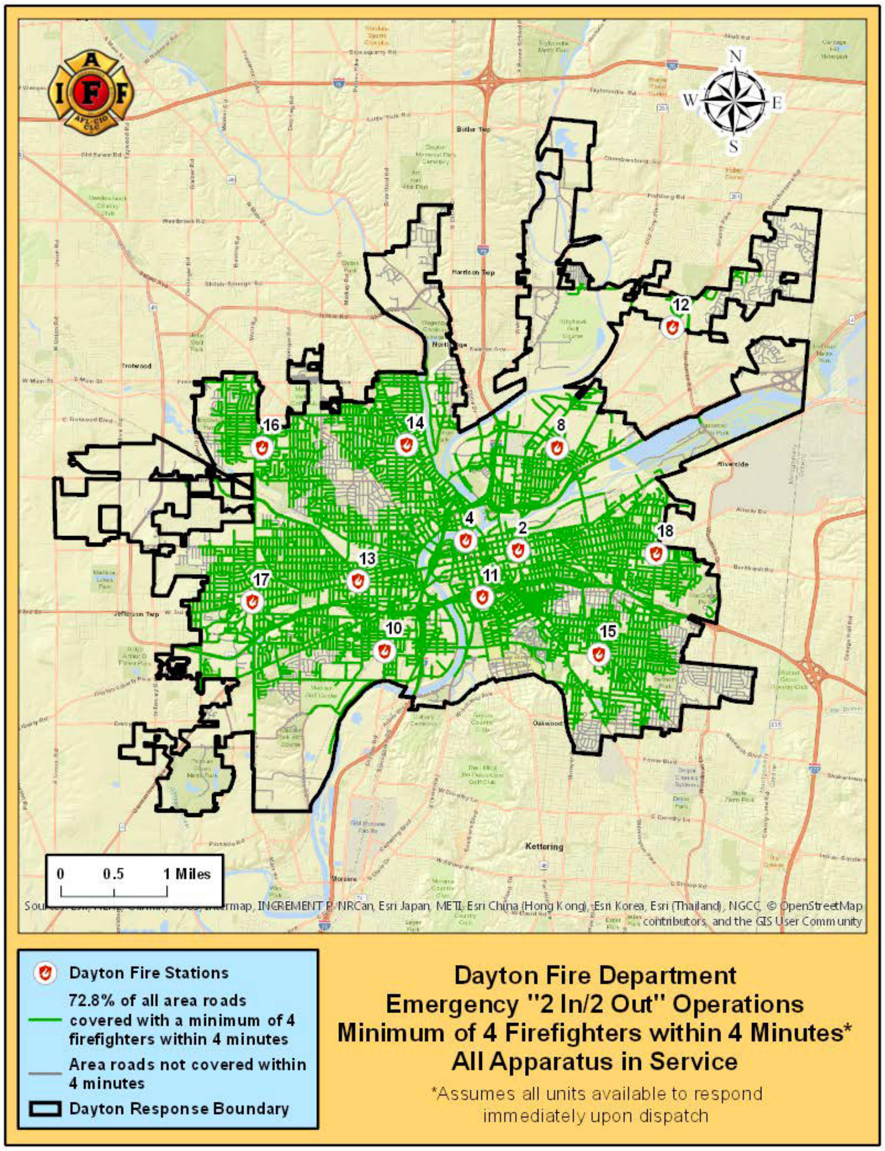

Figure 12. Percentage of DFD Assembling Four Firefighters in Four Minutes.[123]

The IAFF GIS study assessed the time DFD medics were utilized on emergencies to assess and transport ill and injured citizens compared with their time available to respond, and termed this process unit hour utilization (UHU). According to the IAFF, "An efficient UHU for fire-based EMS transport is 0.35-0.45 which allows a good balance

[123] Source: International Association of Fire Fighters, 53.

between system use for EMS, system readiness and availability for response to other incidents."[124] Given that Dayton staffs seven medic units, the average medic unit UHU is 0.51 with an average EMS workload of 603 incidents per week. A UHU of 0.51 means that more than 12 hours are spent attending to and transporting patients, which reduces the time for training, readiness, and fitness training. In calculating an eighth 24-hour staffed medic unit, the UHU would reduce to 0.45. A ninth staffed medic would reduce the UHU to .40, and a tenth medic to 0.36.[125] The UHU analysis shows Dayton would benefit from staffing one or two additional medics on a daily basis. Table 7 shows a visual range of how the UHU rating is related to the number of medic units staffed.

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[124] International Association of Fire Fighters, 87.

[125] International Association of Fire Fighters, 90.

Table 7. Dayton Fire Medic Unit Hour Utilization.[126]

Medic Units	Incidents (Total 88,370)	UHU
Medic 2 & Medic 8[88]	11,514	**0.47**
Medic 10[89]	2,109	0.09
Medic 11	12,506	**0.51**
Medic 13	13,136	**0.53**
Medic 14	11,334	**0.46**
Medic 15	11,277	**0.46**
Medic 16	10,506	**0.43**
Medic 18	10,195	**0.41**
Medic 208 (Cross-Staffed)[90]	523	0.03
Medic 308 (Cross-Staffed)[91]	283	0.02
Mutual Aid Medic Units	4,897	0.20
Reserved Medic Units	90	0.001
7 Medic units *(Current staffing and deployment)*	88,370	**0.51**
8 Medic units *(Current medic units and Medic 8 or 10 placed in service full-time)*	88,370	**0.45**
9 Medic units *(Current medic units and Medics 8 and 10 placed in service full-time)*	88,370	**0.40**
10 Medic units *(Current Medic units and Medics 8, 10, and 308 placed in service full-time)*	88,370	**0.36**

The DFD is also relying heavily on mutual-aid medic units from surrounding fire departments. Many times each day, the DFD runs out of transport medic units and has to rely on mutual aid to provide support. Mutual aid takes away from the surrounding communities' resources.[127] Mutual aid consists of two distinct types. An automatic mutual aid response (AMAR) occurs when communities that lie on the outskirts of Dayton automatically send a fire apparatus or medic unit to Dayton for emergencies. This response

[126] Source: International Association of Fire Fighters, 90.

[127] Katie Weddel, "Soaring Overdoses Strain Emergency Crews from Neighboring Cities," *Dayton Daily News*, June 23, 2017, https://www.mydaytondailynews.com/news/local/soaring-overdoses-strain-emergency-crews-from-neighboring-cities/juAsI1ix9wTcXzNbxZQjBM/.

occurs when the AMAR agency has a fire apparatus or medic unit closer to the emergency than a DFD resource, which thus reduces the response time to arrive at the emergency. However, when the DFD exhausts its fire or EMS resources, it relies on surrounding fire departments to provide the needed equipment, which is called mutual aid. Unlike AMAR, mutual aid has to be requested; in other words, it is not automatic. In 1996, 320 AMAR and 120 mutual-aid responses were received into Dayton. By 2017, this number skyrocketed to 852 AMAR and 730 mutual-aid responses from other jurisdictions.[128] The increase in AMAR and mutual aid has placed a burden on the surrounding cities' fire departments to provide medical coverage for Dayton's citizens. The AMAR fire departments do collect the EMS billing fees but remain unavailable to respond to the citizens in their jurisdictions. Dayton's Fire Chief, Jeffrey Payne states:

> We have hit the limiting factor. . . . We only have so many medic units, so we are having to bring in medic units from as far away as Brookville and Beavercreek. . . . Kettering's coming so much into Dayton that Washington Twp. has to go into Kettering, creating a domino effect in which municipalities further away from the city are subsidizing Dayton's operations.[129]

The loss of EMS transports due to AMAR and mutual-aid fire departments transporting patients also results in a loss of income for the city of Dayton. According to the Department of Health and Human Services, BLS units are staffed with one EMT, whereas ALS units are staffed with at least one paramedic. A difference in billing exists for ALS1 compared to ALS2, where ALS2 adds the use of three medications administered by a paramedic and an advanced interventional procedure.[130] Dayton currently bills $512 for every BLS, $870 for ALS1, and $1,075 for ALS2.[131] In 2017, the DFD responded to

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[128] City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 2.

[129] Weddel, "Soaring Overdoses Strain Emergency Crews from Neighboring Cities."

[130] Department of Health and Human Services, *CMS Manual System Publication 100–02 Medicare Benefit Policy* (Woodlawn, MD: Centers for Medicare and Medicaid Services, 2016), 7, https://www.cms.gov/Regulations-and-Guidance/Guidance/Transmittals/Downloads/R226BP.pdf.

[131] Cornelius Frolik, "City Bills for Ems Runs, but Rarely Collects Cost of Service," *Dayton Daily News*, July 29, 2018, https://www.daytondailynews.com/news/local/city-bills-for-ems-runs-but-rarely-collects-cost-service/eCKOYsxoEE3tj6K5knb0cK/.

5,950 BLS, 13,895 ALS1, and 552 ALS2 calls. With 1,582 transports provided by surrounding fire departments, the DFD has lost more than $1.3 million in EMS billing (based on an average bill of $870.)[132] The loss of billing has to be weighed against the cost of staffing additional medic units to take up the additional workload. The Table 8 shows the breakdown of ALS and BLS responses by the DFD for 2015–2017.

Table 8. Percentage of Dayton Fire Department ALS and BLS Emergencies.[133]

Service Mix	**2015**	**2016**	**2017**
BLS	7006	7136	5950
BLS Percent	33.5%	33.3%	29.2%
ALS 1	13,730	14,079	13,895
ALS 1 Percent	65.6%	65.7%	68.1%
ALS 2	187	222	552
ALS 2 Percent	0.9%	1.0%	2.7%

The number of EMS responses has increased over the years. In 2000, the DFD staffed five ALS medic units that responded to 13,676 emergencies for an average of 2,735 emergencies per medic unit. In 2007, this number increased to 23,175 with six ALS transport medic units, an average of 3,862 emergencies per medic. In 2017, the busiest units were Medic 11 with 5,079 emergencies and Medic 13 with 5,201 emergencies. Figures 13 and 14 show the total number of EMS emergencies in 2000–2017 and the total number of runs for individual medics. Figure 15 visualizes the number of medic runs from 2000 to 2017, which has doubled in that time period.

[132] City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 1.

[133] Adapted from Kevin Kuntz, email message to author, August 23, 2018.

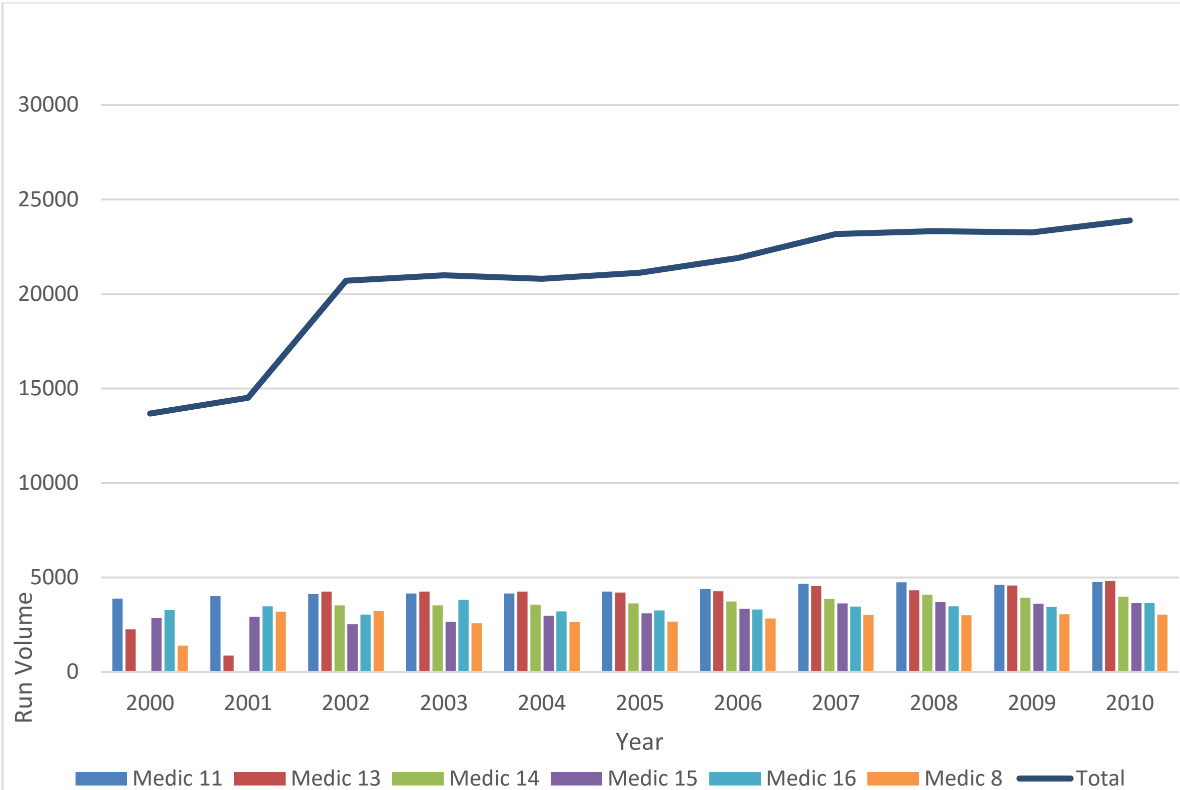

Figure 13. Dayton Fire Department Medic Unit Responses, 2000–2010.[134]

134 Adapted from Lieutenant Robert Lotz, email message to author, January 2, 2019.

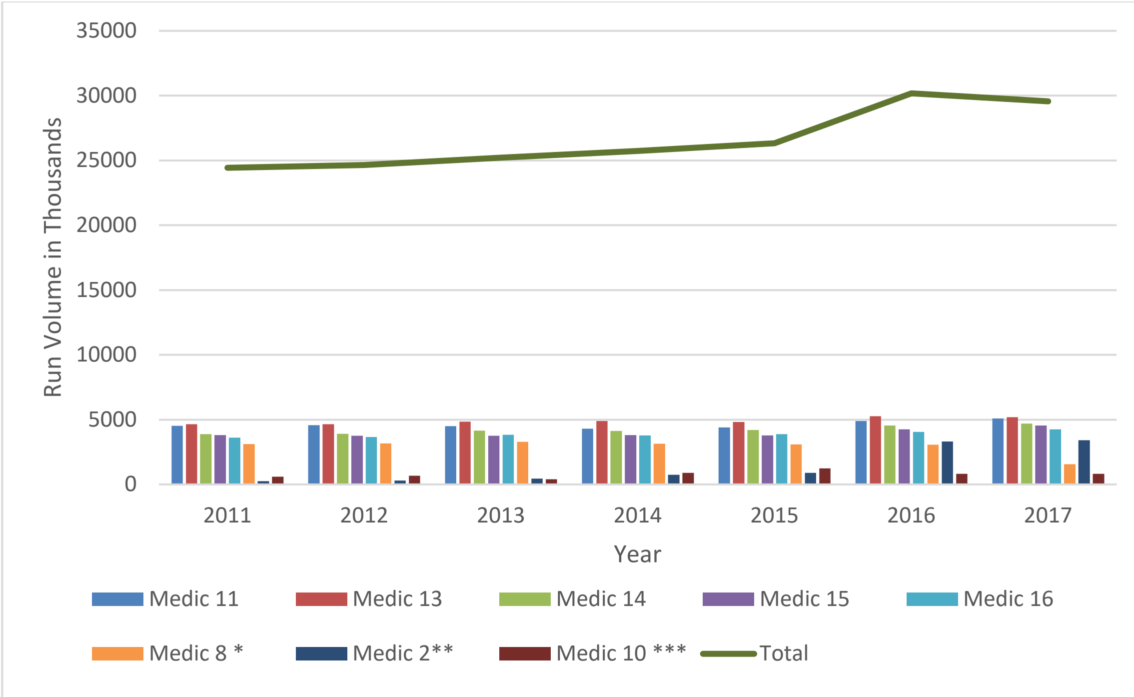

Figure 14. Dayton Fire Department Medic Unit Responses, 2011–2017.[135]

135 Adapted from Lieutenant Robert Lotz, email message to author, January 2, 2019.

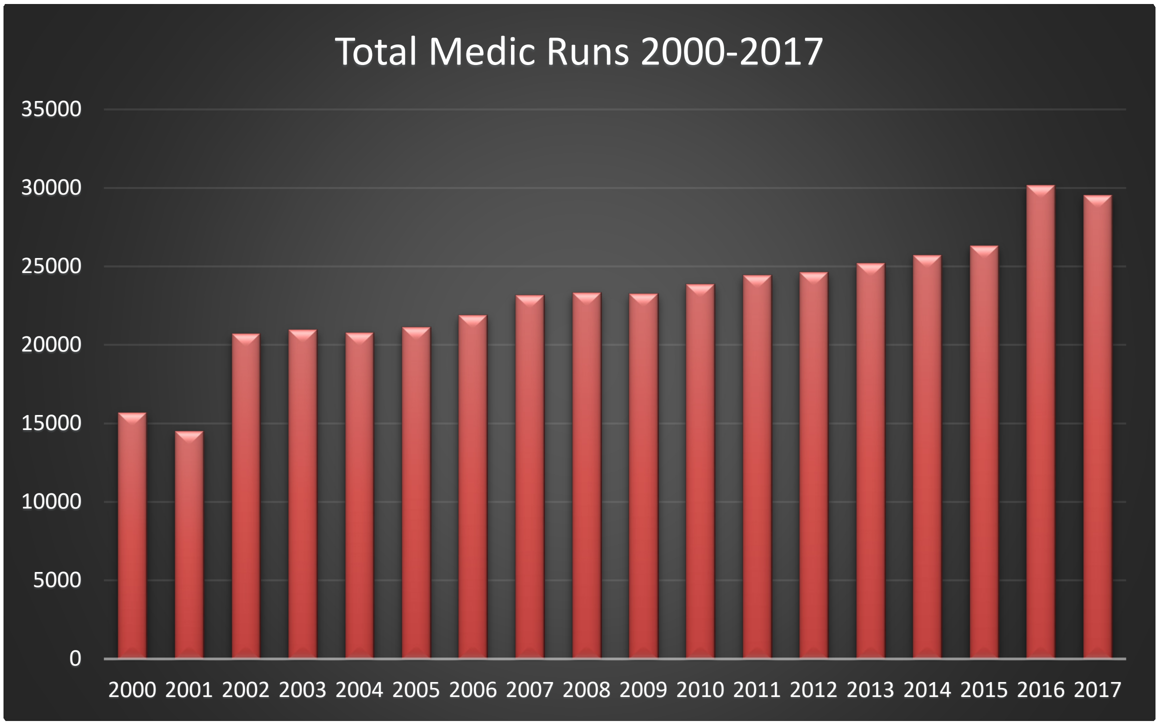

Figure 15. Total Number of Medic Runs, 2000–2017.[136]

The following section provides information in which fire departments have instituted innovative resource deployment methods, ranging from ARV and MIH to resource optimization based on data mining and technology implementation. The city of Dayton has an established professional fire department that mitigates fires, rescues, and medical emergencies. The DFD has experienced cuts in manpower and apparatus due to a decrease in revenue from taxes, and has been met with an ever-increasing demand for services. The increase in demand requires to innovate the way services are provided to the customers, as well as to optimize those services.

D. INNOVATION

The fire service has traditionally used response time as the metric for efficiency in providing emergency services. The faster the fire department arrives at a fire or medical emergency, the greater the likelihood of success. The advent of lightweight building

[136] Adapted from Lieutenant Robert Lotz, email message to author, May 13, 2019.

construction, which causes fires that grow faster and burn hotter than in years past, necessitates rapid response times. Fire stations built decades ago were evenly distributed across the city to allow all areas to be within a certain distance from the nearest station. While these stations remain fixed, the demographics and workload demand of various neighborhoods has changed drastically. To optimize service deployment, the fire service is turning to data analysis and computer modeling to distribute resources where they are needed. Such data include capturing accurate call information from the computer-aided dispatch (CAD) system and analyzing these data based on UHU and demand for service. Optimizing the placement of the workforce and apparatus will assist in responding to emergencies but is not the only solution. AVL systems are designed to dispatch the closest, most appropriate response to fire and medical emergencies. Innovative deployment methods involve an MIH and ARVs to serve internal and external customers better.

Innovation in the fire service goes back to the late 1800s when members of the fire service looked for creative ways to deliver fire suppression to its citizens. The fire service has evolved from using apparatus pulled by horses to motorized apparatus, from climbing downstairs to sliding down the fire pole to the apparatus, and from entering a fire without breathing assistance to fighting the fire while wearing a self-contained breathing apparatus (SCBA). The most significant milestone for the fire service is the increased use of emergency medical services and the concurrent decrease in fires. EMS itself is changing with the presence of an MIH, which serves citizens' healthcare needs before they call 9-1-1 for medical emergencies.

1. Automatic Vehicle Location Systems

Fire departments across the country are adopting technology to decrease response times by sending the closest fire apparatus based on physical location, and not the location of the firehouse, a practice termed AVL. The Montgomery County RDC provides 9-1-1 dispatch for Dayton Fire. When the DFD is called to respond to an emergency, the RDC dispatcher inputs the emergency into the CAD program, Motorola PremierOne. This program has pre-assigned districts for all fire apparatus using the physical location of the firehouse as a reference. The

DPD currently has 202 fire districts encompassing Dayton. Figure 16 shows the multiple districts that make up each firehouse response zones (the red symbols.)

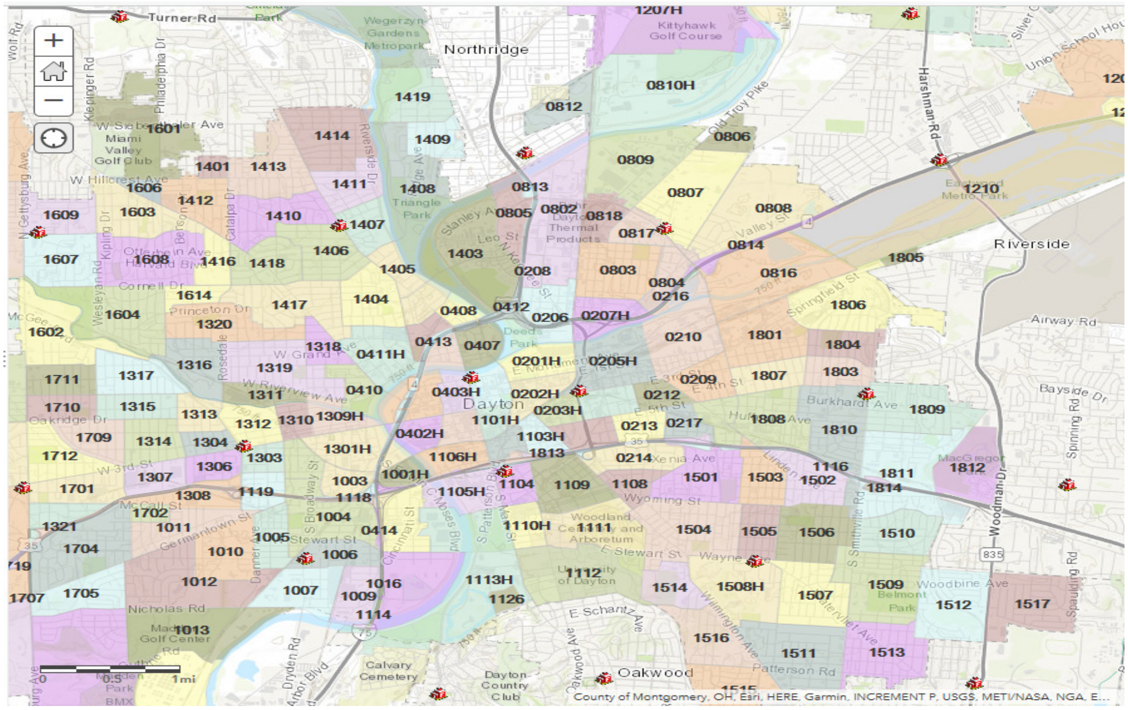

Figure 16. DFD Districts in CAD.[137]

CAD currently assumes fire apparatus are located at the firehouse at all times. Fire apparatus in Dayton are spending more time away from the firehouse due to an increased number of emergencies, training hours required in the district, and an increased emphasis placed on community services (e.g., inspections, pre-fire planning, and school education activities). Whether the fire apparatus are in quarters or available in district, the RDC does not know their physical location. If another fire apparatus is closer to the emergency than the one pre-designated by CAD, the officer will need to inform the dispatcher on the radio to assign a closer apparatus and cancel the firehouse's apparatus, which causes a delay in response and ties up the radio with unnecessary traffic. If the closer fire apparatus does not

[137] Source: Brian Lewis, email message to author, December 15, 2018.

hear the emergency dispatched or chooses not to "jump" the emergency, the apparatus farther from the firehouse responds, which places Dayton's citizens at a disadvantage.

AVL was not created for fire departments, but is being adopted by fire departments. The intent of AVL is tracking a fleet of vehicles. AVL technology is made possible by the integration of three technologies: navigational technologies, such as the global positioning system (GPS), database technologies, such as the GIS, and communication technology, such as the general packet radio service (GPRS).[138] The majority of fire departments implement an AVL system using a radio modem connected to a mobile data terminal (MDT) that receives and transmits a signal to GPS. This GPS coordinate sends a message to the CAD system, which has a base-layer source map, and selects the closest, most appropriate type of fire apparatus based on the extent of the emergency (e.g., heart attack, car accident, house fire, or commercial building fire) and the location of apparatus. The location of apparatus can be displayed on the MDT and on screens located in dispatch. The display on the MDT increases the safety of responding fire apparatus, due to all responding fire apparatus maintaining situational awareness of each other. Dispatchers in CAD are able to see the physical location of apparatus, which enhances safety should members require emergency assistance and are not within radio contact.

Fire departments across the country have implemented AVL technology to reduce response times, improve efficiency, and instill safety for members. The Phoenix, Arizona, Fire Department (PFD) implemented an AVL system in August 1994. Trimble Navigation installed the AVL on all PFD apparatus.[139] The PFD's primary objective was "to enable the CAD system to rapidly identify and dispatch the closest, most appropriate units to emergencies"[140] The PFD was successful in equipping fire apparatus with AVL technology, and reduced response times. Fire departments off the mainland are also implementing AVL. The Honolulu Fire Department (HFD) beta-tested AVL technology in

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[138] O. Aloquili, A. Elbanna, and A. Al-Azizi, "Automatic Vehicle Location Tracking System Based on GIS Environment," *IET Software* 3, no. 4 (August 2009): 255, https://doi.org/10.1049/iet-sen.2008.0048.

[139] Burch, "Automatic Vehicle Location System Implementation," 2.

[140] Burch, 2.

2005 with the goal of reducing the response time of apparatus based on their dynamic, physical location when the apparatus are dispatched, not the legacy firehouse location.[141] The HFD noted that installing AVL reduced the response time of fire apparatus but concluded that drive time was one of many factors that affected response time, and a workflow analysis looking at all facets of response time should be studied.[142]

The Los Angeles Fire Department (LAFD) implemented AVL technology in 2017 to reduce the response time for paramedic ambulances (termed rescue ambulances), with positive results.[143] Los Angeles has noted a reduction in response times with AVL, as well as some positive cultural changes. AVL tracking of LAFD rescue ambulances has reduced the time members spend out of service at the hospital completing EMS documentation (termed "wall-time"). If the rescue ambulance is showing as out-of-service at the hospital on the MDT, yet the AVL tracks the medic leaving the hospital, a message is sent to the crews reminding them to return to service. One unintended consequence of the program is that fire crews have bypassed the AVL system by turning off the modem.[144] By turning off the modem, the CAD systems is not able to track their location. This situation has been dealt with by implementing policy that does not allow modifications to the computer systems.

The Portland, Oregon Fire Department implemented an AVL program in 2017 using its in-house GPS shop (built-in maps seen on the MDT) and Versiterm, its CAD program. The Portland Fire Department has noted that with AVL, some fire apparatus have become busier in responding to emergencies than in the past, and some firefighters struggled with adopting and relying on the AVL technology. Portland relies on mutual-aid fire departments to supplement emergency response, and these departments do not use

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141 Gary Lum, *Impact of Automatic Vehicle Locators on Incident Response Times in the Honolulu Fire Department* (Emmitsburg, MD: National Fire Academy, 2008), 10, https://www.hsdl.org/?view&did=6916
05.

142 Lum, 30.

143 Los Angeles Fire Department, email message to author, December 13, 2018.

144 Los Angeles Fire Department, email message to author, December 13, 2018.

AVL. For the CAD system to believe mutual-aid companies are available for the AVL to pull from, the mutual-aid company is assigned a 150-second delay. This delay is the average time it takes a Portland Fire dispatcher to call the mutual-aid fire departments dispatcher and then time for that dispatcher to send the mutual-aid company. If the AVL system shows the mutual-aid company closer (with the 150-second delay), AVL will send the mutual-aid company. Portland has seen a reduction in response times and improved customer service with AVL technology.[145]

2. Alternative Response Vehicle

Fire departments across the country are innovating the deployment of resources to emergencies by using the most efficient, appropriate apparatus. To reduce the workload placed on engine and ladder companies, fire departments are implementing an ARV. The concept is to send a SUV vehicle to medical emergencies in place of the traditional engine and ladder companies. Many positive attributes have been found with the ARV concept. The concept can reduce the response time to arrive at the emergency, reduce the time leaving the firehouse, reduce the initial purchasing of apparatus (SUV cost versus $350,000 per engine and $1 million per ladder truck) and reduce the fuel and maintenance cost of apparatus. Michael Baker, a lead researcher in ARVs, states:

> The fire service's role as a medical first responder is rarely challenged. What is often debated is the expense of getting the right resources to the right place in the right amount of time. The right resource, right place and right time paradigm has become the key concept for the deployment of fire EMS first-response resources. Embracing a clinical, financial and operational theme, changing and "rightsizing" EMS resources appears to be the answer to many of the challenges faced by departments today.[146]

3. Mobile Integrated Healthcare

A multitude of factors has influenced the future of emergency healthcare in the United States, from EMS to the emergency rooms. The delivery of EMS by fire departments has increased across the United States, and is provided by the 200 highest

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[145] Portland Fire Department, email message to author, December 18, 2018.

[146] Baker, "Replace Big Apparatus," 6.

populated cities in America.[147] The increasing workload of EMS has placed a strain not only on fire departments but also on hospital emergency departments (EDs). Health care trend researcher Tara O'Neill Hayes states:

> Patient volume in EDs has been growing faster than the population for decades. In 1997, annual visits to the ED totaled 94.9 million (35.6 per 100 people). In 2015, ED visits had reached 136.9 million, or 43.3 per 100 people—a 7 percent increase from 2006 on a per capita basis.[148]

A study conducted by Evolution Health Management found that chronically ill and frail elderly populations have resulted in elevated number of EMS responses and readmission rates to EDs.[149] The Patient Protection and Affordable Care Act increased the focus on reducing medical expenses in EMS and emergency departments by innovating the delivery of EMS. Patients should receive care at the right place, time, and setting based on their medical issues. MIH has established an innovative approach to integrating EMS and hospital care to coordinate care, reduce the cost of providing medical care, and improving patient quality.[150] Targeted populations who may benefit from an MIH program are high utilizers of emergency services transported to emergency departments for low acuity emergencies, and patients at risk of readmission to the hospital.[151] MIH has established an

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[147] International Association of Fire Fighters, *Fire Service-Based EMS Electronic Tool Kit: Resources for Leaders* (Washington, DC: International Association of Fire Fighters, 2016), 1, http://services.prod.iaff.org/ContentFile/Get/20247.

[148] Tara O'Neill Hayes, "PRIMER: Examining Trends in Emergency Department Utilization and Costs," *American Action Forum*, 2, November 1, 2018, https://www.americanactionforum.org/research/primer-examining-trends-in-emergency-department-utilization-and-costs/.

[149] Brooke Roeper et al., "Mobile Integrated Healthcare Intervention and Impact Analysis with a Medicare Advantage Population," *Population Health Management* 21, no. 5 (October 2018): 1, https://doi.org/10.1089/pop.2017.0130.

[150] Roeper et al., 1.

[151] MIH-CP Knowledge Center, "EMS and Home Health: Partners in Improving Patient Outcomes and Lowering Costs," National Association of Emergency Medical Technicians, accessed October 2, 2019, https://www.naemt.org/docs/default-source/community-paramedicine/mih-cp-toolkit/ems_homehealth.pdf?sfvrsn=2.

innovative approach to integrating EMS and hospital care to coordinate care, reduce the cost of providing medical care, and improve patient quality.[152]

Several fire departments across the country have implemented MIH deployment modeling successfully. The Akron, Ohio, Fire Department implemented its Community Assistance, Referrals, and Education Services (CARES) program in 2018. Akron created the program to further citizens' standard of living and reduce EMS calls. The program focused on fall prevention and high utilizers of EMS.[153] The CARES program will pair up an Akron firefighter/paramedic with an intern caseworker from Akron University's School of Social Work to meet the needs of the citizens of Akron, from partnering with social service agencies to installing fall-prevention equipment.

The Rockford, Illinois, Fire Department has teamed up with the SwedishAmerican Medical Center to implement an MIH program. The Rockford MIH has the goal of optimizing home care to reduce avoidable ED visits and hospitalizations by visiting citizens captured as high utilizers of EMS and the emergency room.[154] Rockford's program utilizes a firefighter/paramedic and registered nurse from SwedishAmerican, who serves as a case manager. The firefighter is responsible for fire safety checks of the residence while the nurse obtains prescribed medications if needed, explains physicians' orders, and arranges medical transportation.[155]

The Olathe, Kansas, Fire Department began an MIH in 2014 in partnership with the Olathe Medical Center to connect citizens with the most appropriate resources for non-emergency services, coordinate health care, prevent emergencies from occurring, and reduce the cost of providing services by pairing a firefighter/paramedic with a nurse practitioner, Monday through Thursday, 7:00 a.m. to 5:00 p.m.[156] In 2018, the Olathe MIH

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[152] Roeper et al., "Mobile Integrated Healthcare Intervention and Impact Analysis with a Medicare Advantage Population," 1.

[153] Akron Fire Department, email message to author, January 11, 2019.

[154] Rockford Fire Department, email message to author, February 26, 2019.

[155] Rockford Fire Department, email message to author, February 26, 2019.

[156] Olathe Fire Department, email message to author, July 11, 2019.

unit responded to over 500 non-emergency calls for service, assisted citizens by assessing their medical needs, and bridged the hospital and fire department care provided.[157]

The South Metro Fire Rescue (SMFR) Authority in a suburb of Denver, Colorado, adopted an MIH program termed the Advanced Resource Medic (ARM). The goal of the ARM is to furnish advanced medical assessment and care and provide an alternative to hospital transport. Any SMFR crews can consult with the ARM for assistance.[158] One firefighter/paramedic and one nurse practitioner staff ARM. In 2018, ARM responded to 350 incidents and saved over $1.1 million in medical expenses.[159]

E. CONCLUSION

This chapter established the general avenues fire departments have pursued to innovate deployment and optimize resources. National standards set the benchmark in looking toward innovation. The focus was on adopting AVL technology to reduce response times. Fire departments have implemented smaller, adaptable SUVs to respond to medical emergencies to save wear and tear and also reduce response times and measure success based on performance metrics. Agencies outside the fire service can be partnered to assist in the accreditation process, most notably the CFAI and the ISO. The healthcare industry has found success collaborating with the fire service in creating an MIH to reduce minor medical emergencies and preventable injuries and illnesses. Chapter IV discusses the topics in a narrower scope, regarding fire department implementation of the topics, and lessons learned for the fire service.

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[157] Olathe Fire Department, email message to author, July 11, 2019.

[158] South Metro Fire Rescue Authority, email message to author, April 29, 2019.

[159] South Metro Fire Rescue Authority, email message to author, April 29, 2019.

IV. FIRE DEPARTMENT POLICY RESULTS

The research methodology for this thesis consisted of attaining policies with nine fire departments across America. Six fire departments were chosen based on their similarities to Dayton in terms of city demographics or fire department staffing. Three departments were chosen as leaders in the fire service for innovative deployment modeling or technology adaptation or their ability to optimize resources tailored to citizens. Department chiefs and officers obtained a list of policies and the thesis proposal to gain an understanding of the project. Each chief and department voluntarily participated in the process. All participants received the thesis for validation and confirmation of facts and quotes prior to publication.

Specific themes emerged from the policies, including innovation within the fire service, ARV use, system improvement tools, and MIH, which this chapter analyzes and discusses. Each section highlights departmental benchmarks, as well as unintended consequences that need addressing. For example, in implementing an ARV program, fire departments noticed reduced apparatus costs, wear and tear for apparatus and personnel, and environmental friendliness, but also experienced resistance from firefighters and union leaders. The implementation of MIH platforms has successfully addressed some socioeconomic problems plaguing many Americans. One key to success for an MIH program is partnering with a healthcare organization to share the human resource burden and costs to minimize the use of the emergency room for minor illnesses, injuries, and psychological care. Table 9 represents the demographics in terms of the total number of emergencies responded to in 2017, the number of ARV staffed, and the terminology for the ARV.

Table 9. Fire Department Comparative Table.

Department Name	Total # of Emergencies in 2017	# of staffed ARVs	Nomenclature for ARVs
Dayton, OH	39,013	0	N/A
Rockford, IL	28, 378	2	Rescue
Salt Lake City, UT	31,185	2	Medical Response Team
Los Angeles City, CA	455,667	4*	Advanced Practitioner**
Vancouver, BC	66,837	6	Medic
Tualatin Valley, WA	49,337	6	CARS
Akron, OH	54,524	1	Alpha Truck
North Charleston, SC	20,902	2	Rescue
Overland Park, KS	22,358	4***	Squad
Tulsa, OK	57,000	3	Squad

* Four AP, one SOBER, one alternative destination
** Advanced practitioner (AP), SOBER unit, alternative destination unit
*** Two full-time, two cross-staffed

A. INNOVATION

Fire departments across America are experiencing an increased demand for service simultaneously with greatly reduced budget allocations. When this unique challenge appeared, fire chiefs across the United States examined the traditional deployment model of sending only engine and ladder companies to emergencies to which the fire department was called. The change brought about innovations in fire service delivery methods.

One chief implemented innovation based on the advice of a council member who sought better business practices within the fire department. Chief E performed innovative deployment modeling when a council member pointed out the following: "The number of fires is decreasing, the number of EMS numbers are increasing, yet you continue to ask for an increase in in-service engine companies. More emergencies do not equate [to] more engines." This argument prompted Chief E to compare the data on dispatch types (e.g., shortness of breath, assault, sick person) with data on the outcome (e.g., transported to a hospital or refused care). The findings showed that the majority of medical emergencies did not require four personnel. Therefore, Chief E piloted an ARV program using a SUV with one person going to "sick" emergencies. Concerning fire alarms, Chief E found that less than 1 percent in the department resulted in an actual fire. That analysis resulted in sending a car with one person to fire alarms in place of the traditional engine and ladder companies.

Three significant phenomena urged fire chiefs to innovate in their departments: increasing call (run) volumes due to changes in healthcare, environmentally friendly fire apparatus, and the longevity of engine and ladder companies remaining front-line. Three chiefs saw the need to innovate based on increased run volume for engine and ladder companies. Chief I noted elevated runs for Stations 22 and 27 and implemented a pilot "squad" company in 2007 to reduce the run volume. The third company, the squad, responded only to medical emergencies to reduce the workload on the existing engine and ladder company.

Due to the financial crisis in 2008, Chief I's department had to lay off 147 firefighters, even with an increasing number of medical emergencies. Layoffs resulted in closures of four engines and one ladder company. These layoffs resulted in Squads 22 and 27 placed out of service. To alleviate the reduction in workforce, Chief I pilot-tested a Quint company (an engine and ladder company in one apparatus) with four firefighters to respond to fire emergencies and a squad company with two firefighters to handle the medical emergencies at five firehouses. The core downtown areas tended to require fire department services frequently. Likewise, Chief A noticed an increase in run volume downtown, with an emphasis on the increased workload placed on two downtown ladder companies. Similarly, Chief B recognized a spike in medical emergencies in center city and wanted to reduce the alpha and beta (basic life support) medical emergencies to which the engine and ladder companies were responding. In the same way, Chief G noted an increase in emergencies without an increase in apparatus to respond to them. Budget restraints also forced Chief F to take one ladder company out of service. The increase in volume has not resulted in increased staffing for many cities. Fire chiefs have noted the increasing use of traditional fire apparatus to respond to these medical emergencies, and the reason citizens are calling 911 for emergencies is changing as well.

The Affordable Care Act changed the landscape of healthcare in America, including the utilization of EMS. Several fire chiefs noted an increase in emergencies they attributed to the Affordable Care Act. For example, Chief C began to see a 14 percent increase in Medicare EMS calls starting in 2014. The spike in emergencies caused him to start collecting and analyzing data for medical emergencies and creating algorithms for modern responses. Conversely, Chief F noted an increase in calls for service over nine years. While Chief F experienced an increase in the average 24-hour volume from 102 to 140 calls per day, Chief H noted an increase in EMS run volume by 70–80 percent. In response, Chief H sent out a survey to citizens, who rated EMS services as a higher priority than fire suppression services. According to Chief H, “If fire departments embrace EMS, the stakeholders must understand that fire suppression capabilities will be decreased based upon going on EMS emergencies and not being available for when the fire or accident occurs.” To deliver services to an increasing EMS system, without a correlating increase in budget, can result in a budget allocation shift from suppression apparatus staffing to EMS staffing. Reducing fire suppression capabilities will diminish the city’s ability to respond to fire and rescue emergencies quickly and effectively.

More cities have begun to emphasize becoming more environmentally friendly and reducing their carbon footprint. Two of the nine chiefs talked about being stewards of the environment, and this trend may continue across America. For example, Chief B found ways for the fire department to be “carbon footprint friendly” by utilizing SUVs that pollute less than more substantial apparatus. Likewise, Chief D implemented the department’s “medic” program to lessen the carbon footprint and reduce the amount of fuel used. He stated that using an SUV to respond to medical emergencies downtown would meet this objective. Chief D echoed the same sentiment by saying, ““West Coast Culture” is about being green and environmentally friendly.” Fire departments could implement programs to reduce their carbon footprint, by sending SUV’s to medical emergencies and using engine and ladder companies for fires. When engine and ladder companies respond to fewer emergencies, their life expectancy increases.

Fire apparatus, specifically ladder companies, should remain in service for 12–20 years under normal conditions. Higher utilization usually shortens this service life. As stated, the more emergencies and miles placed on apparatus, the greater the wear and tear on the equipment. Accordingly, six of the nine chiefs noted an increase in wear and tear, and thus a shortened service life of apparatus, which caused them to innovate in their deployment matrix. Some cites have not been able to replace aging fire apparatus and are employing outdated apparatus for medical emergencies. For example, Chief A stated ladder companies were over 20 years old and broke down daily, but budgets did not allow for replacements. In response, Chief B lessened the wear and tear on the downtown ladder companies by eliminating over 2,100 calls per year by sending the ARV instead of the ladder. Several chiefs wanted to reduce the number of low-acuity emergencies. Extending the life of engine and ladder companies by sending them on fewer emergencies was the intended goal of Chiefs D and G. Chief E needed the one-person staff CAR to handle lower acuity calls and reserve substantial assets for other incidents, which resulted in less wear and tear. In contrast, Chief H noted that his budget for fuel and maintenance had increased, and the department had spent its allocated money for fuel and maintenance costs.

B. ARV IMPLEMENTATION

Fire departments across the country are innovating in their deployment matrix to meet the significant problem of an increased workload with a decreased workforce. Implementing an innovative system, such as the ARV, requires a pilot program to test its feasibility and begin collecting data for analysis. Fire departments can use the three-step Lean Startup method, created by Eric Ries, to implement an innovative program. The foundation of the Lean Startup is a feedback-loop involving building, measuring, and learning.[160] In implementing an innovation, Ries emphasizes the ability for fast iterations and customer insight. When prototyping an idea, Ries recommends building or implementing the minimum viable product (MVP), which "enables a full turn of the Build-Measure-Learn loop with a minimum amount of effort and the least amount of development time."[161] The second aspect of implementation involves measuring the success of the product based on customer response. After data has been gathered on the innovation, the third step consists in determining whether to pivot or persevere in the project.

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[160] Eric Ries, *The Lean Startup* (New York: Crown Publishing Group, 2011), 21.

[161] Ries, 76.

Fire chiefs can employ the MVP when innovating with ARV deployments.[162] For example, Chief A moved one firefighter from an engine company to staff the squad initially, while Chief B started with two teams staffing the medical response team (MRT) Monday through Friday. Likewise, Chief C began the department's nurse practitioner (NP) program with a firefighter/paramedic and a nurse practitioner in an ambulance. Conversely, Chief D initially used firefighters from the ladders to place the "medic" in service; all four members from the ladder went on the Medic. Chief E initially staffed the CAR 40 hours per week in May 2010. Likewise, Chief F implemented the ARV for basic emergencies from 7:00 a.m. to 5:00 p.m., Monday through Thursday. Similarly, Chief G deployed the "squad" from 8:45 a.m. to 8:45 p.m. with overtime. In a different configuration, Chief H implemented an ALS squad with one firefighter and one firefighter/paramedic for medical first responder emergencies to reduce maintenance and fuel costs. Moreover, differently still, Chief I initially applied the squad as the third piece at Stations 22 and 27. Many of the initial ARV deployments changed because of data. The crucial beginning of ARV programs was the fire chief's ability to pilot it to begin collecting data to make decisions regarding the concept. Table 10 shows what staffing models fire chiefs employed in their first ARV program.

[162] Fire departments have termed used different nomenclature for ARVs. Chiefs A and G use the term "rescue." Chief B uses the term "medical response team" for its ARV. Chief C uses "nurse practitioner." Chief D uses the term "medic." Chief E uses the term "CARS" because NIMS uses it for this type of apparatus. Chief F uses the term "alpha truck," based on the apparatus' responding to alpha emergencies, and Chiefs H and I use the term "squad" for their ARVs.

Table 10. Initial Staffing Model Table.

Department	Initial Alternative Response Vehicle Staffing
Chief A	Moved one firefighter from two engine companies to place the rescue in service
Chief B	Implemented two teams Monday through Friday with overtime
Chief C	Implemented the NP unit with one paramedic and one nurse practitioner
Chief D	Initially placed all four firefighters from the ladder company onto the Medic to respond on medical emergencies
Chief E	Initially deployed the CAR on a 40-hour basis 9 a.m. to 7 p.m.
Chief F	Alternative response vehicle staffed 7 a.m. to 5 p.m. Monday through Thursday with two paramedics
Chief G	Two peak-hours squad staffed 8:45 a.m. to 8:45 p.m. with one firefighter/EMT and one firefighter using all overtime
Chief H	Initially staffed squad with one firefighter/paramedic and one firefighter/EMT
Chief I	Staffed a squad at Firehouses 22 and 27 with two paramedics to lessen the burden of ALS emergencies in these districts

1. ARV Iterations

Several chiefs tweaked and pivoted their ARV programs to meet the needs of internal and external customers using data and analysis. Two of the nine fire chiefs altered the time the ARV was in service, based on the peak time of medical emergencies in their jurisdictional boundaries. For example, Chief B directed the MRT program to one team Monday through Wednesday 8:30 a.m. to 9:00 p.m. and a second team Thursday through Saturday 8:30 a.m. to 9:00 p.m. Likewise, Chief E iterated the program to 10-hour days Tuesday through Friday 7:00 a.m. to 5:00 p.m. One fire chief expanded the type of emergencies the ARV responded to and increased the number of emergencies to reduce the wear and tear on more burdensome apparatus. Conversely, Chief F developed the types of non-emergent runs the ARV was responding on to include psychological crises, lift assists, and mobility help to citizens needing such help. Two of the nine chiefs iterated their ARV program by "cross-staffing" the ARV with the ladder company, instead of independently staffing the ARV with separate crews. When a ladder company responds to a medical emergency, the ladder crew responds in the ARV instead of the ladder truck. Chief H placed the ARV in service with the two ladder companies, and the officer remains back at the firehouse. In a larger implementation, Chief I put five "squads" in service at five Quint companies in 2009, as mentioned previously. One of the chiefs implemented a pilot based upon the long response times of an ARV when an ALS engine was available nearby. In response to the squad's responding from far distances on emergencies when an engine company was within minutes of the crisis, Chief G noted a need for change. Accordingly, he determined that if the squad were farther than 2.5 minutes from an ALS call, the engine would be added with the squad to reduce response times. In response to a different set of problems, Chief D staffed additional medics on a full-time basis at the busiest fire halls because the department received more funding from the city hall.

a. Impediments to Implementing

Implementing change in the business world, and especially in the fire service, comes with resistance. One unofficial motto of the fire service is 150-years of tradition, unimpeded by progress, which centers around the notion that firefighters hate two things more than anything, the way things currently are, and change. Successfully implementing a cultural shift is difficult, and the chiefs experienced setbacks in implementing an ARV concept. Fire chiefs can learn lessons based on their experiences and carry them forward into changing the culture of the fire department. The first lesson is engaging the union and getting them a seat at the table. IAFF Local 413, the union for Chief A's department, filed two arbitrations in court over the rescue concept. The union wanted the squad in service with additional personnel and not "jumped to" with the ladder company's firefighters. An arbitrator ruled in favor of the city in implementing the rescue "jump vehicle" concept stating, "the City nevertheless had the right to temporarily assign members of a company to a jump company, at least under circumstances where the assignments would not have an 'effect of diluting the minimum manning levels required by Section 4.1.'"[163] The implication is that, when implementing an AVR, remaining within managements' rights concerning staffing and deployment of resources is essential, as is involving the union in a collaborative way at every step.

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[163] Elliott H. Goldstein, *Interest Arbitration Opinion and Award in the Matter of Interest Arbitration Between City Fire Fighters Local 413, IAFF, AFL-CIO ('Union' or 'Bargaining Representative') and City of Rockford ('City' or 'Employer')* (Rockford, IL: City of Rockford, 2013), 6, https://www2.illinois.gov/ilrb/arbitration/documents/s-ma-12-108.pdf.

The safety and continued training of the firefighters operating an ARV are to be a primary concern of the fire chief. A fear brought up by several fire chiefs concerned the safety of crews working on the highway by themselves. An SUV is a small vehicle compared to a massive engine or ladder company and harder to see on the road. Initially, Chief B's department sent the MRT to auto accidents on the highway, which Chief B eliminated due to the apparatus being too small for the roadway. All nine chiefs recommended not sending the ARV to highway emergencies for the crew's safety, or supplementing the ARV with an engine or ladder. Continuing education in firefighting is an important aspect of a firefighter's career, especially for firefighters who respond to a majority of medical emergencies. With changes comes the need for leadership.

b. Lessons Learned in Implementing an ARV Program

One key to achieving a cultural change, according to all nine chiefs, is to publicize the new procedures. Chief A noted the need to inform all fire department members and the union by holding numerous in-service trainings on the topic and any accompanying issues. One method to increase buy-in from the department is to include members from all ranks in the implementation process. In the process, Chief D leaned to solicit more information from line personnel and create a broad operational change committee, whose job is explaining why the program is being implemented and facilitate in-depth discussions. Members of the department may ask straightforward questions to challenge why the department needs to change its response culture, and the key is to answer with data that has been analyzed.

Another critical aspect is to leverage data when presenting cultural change. For this process, Chief D suggested giving the budget case with numbers and justifying the recommendations with data. Chief I noted several operational deficiencies with the department's squad program and reiterated the importance of being data-driven when making decisions. As Chief I stated,

> Data must be at the core and knowing what data you need to capture and analyze before implementing an innovative resource deployment model. Use data from Records Management Systems and from CAD to assist in attaining fuel and maintenance costs, the initial cost of apparatus, and

> staffing and workforce cost. Knowing what goals the department is attempting to attain are key using correct data.

Further, Chief I then spoke to changing the culture of the fire service using business intelligence. To change minds, Chief I applied data to analyze

> how responding with an ALS or BLS actually made a difference in patient outcome; when someone has had the flu for two weeks, and now calls 911, is sending a first-responder a waste of recourses, or does it make a positive patient outcome? Where is the demand for service highest and should we place additional resources there? Using business intelligence, we found that the homeless population, frequent callers, and lift assists used up many of our resources.

Fire chiefs can learn from these lessons, and ensure data is at the core of their decisions, as well as to educate themselves in business intelligence and apply these lessons learned to the fire service. After communicating the issue department-wide and the solutions are clearly understood, implementing the ARV program needs to occur. The majority of emergencies fire departments are responding to are medical. Some members of the department enjoy medical emergencies more than others do. Morale and skills were pointed out and addressed with members assigned to an ARV. Several fire chiefs noted that members did not like being assigned to the squad because they no longer went to fires. The reduction in fires was dealt with by explaining the advantages of the squad company and EMS being the majority of emergencies attended to daily. Reiterating the importance of pre-hospital EMS to the members of the department was a priority, and his department's culture embraced the importance of pre-hospital EMS. The low morale could also be dealt with by sending the ARV to working fires, as a supplement to crews, or rotate members assigned to the ARV.

In a further investigation of losing firefighting as a chief mission, Chief I noted some department members did not appreciate being assigned solely to the squad and considered themselves "no longer firefighters." To address this issue, Chief I recommended first reaching out to members who enjoy EMS and assigning them to the program. Having members who voluntarily work on the ARV will benefit the department and the citizens it serves, with better morale and customer service. Likewise, Chief I also recommended implementing an incentives program for those members assigned to the squad. The incentives could be in the form of extra pay or additional time off. Ensuring rookie firefighters understand the importance of responding to medical emergencies, and the reduction in fires in America has changed the scope and nature of the firefighter's job.

Change without understanding the reason driving decision making breeds resentment and anxiety among members of the fire service. To implement change, strong leadership must be present to explain the reasons for change and the process to implement new business practices. When performing a cultural change program, Chief I recommended strong leadership. When upper management implements a plan without a clear vision and scope of practice, the program will fail or not attain the results it was created to accomplish. This department is currently in the process of downsizing its ARV program due to a lack of precise data and leadership in the program. As Chief I warned, "The conceptual model has to be appropriately managed." In Chief I's department, district chiefs ran the squad companies as they saw fit, with no consistent operational procedures enforced. From this unhappy experience, Chief I concluded, "Implementing a cultural change takes leadership, starting at the top. The fire chief must then appoint an upper-management chief officer to be in charge of the program and the analysis of the data created from the program." When not meeting goals while implementing a cultural change, the ability to pivot and adjust must occur. In a final caution, Chief I explained that the ARV program failed because of the inability to pivot.

Accurate data is the keystone for implementing a cultural change, paired with the ability to provide a lean model that can pivot based upon the analysis of generated data. Management starts at the top, and the fire chief has to be firm in the direction and control of the program. Regarding pivoting, Chief I advised that the program must have the ability to change, based upon precise data. If the data shows the majority of EMS emergencies are of the BLS type, place BLS squads into service. Putting ALS resources where they were not needed and a poorly managed program guaranteed program failure for Chief I's department. As he noted, "We needed the ability to have a modular response based upon the type of emergencies (ALS or BLS)." When data shows a change is needed, a department must allow creativity from the members in how best to pivot the program for success. Purchasing the proper equipment is key to a successful program.

When implementing an ARV program, the department must ensure that the appropriate type of apparatus is purchased, based upon the goals of the program. As Chief I illustrated the problem,

> The department purchased a fancy apparatus (mini-pumpers) that did not meet the needs of the intended purpose of the deployment model. The mini-pumper had a pump and hose when, in fact, it was created for medical emergencies, and not fire emergencies. The intended purpose of medical emergencies requires a simple truck with storage for medical equipment.

Outfitting an ARV with a fire pump and hose, when the intent of the program is to respond to only medical emergencies, is a waste of equipment that adds weight and decreases efficiency.

A negative consequence of implementing a full-time ARV with only firefighters responding to medical emergencies involves the loss of fire-related skills. For example, Chief H noted a decrease in fire skills (driving and operating the engines and ladders) for those members assigned to the squad. The department dealt with this decrease by conducting more training in these areas. In a different vein, Chief H noted that assigning two firefighters to the squad and not having an officer represented on the squad or ARV can also cause problems and is analyzing the possibility of assigning officers to this equipment. A department should expect problems to arise when implementing a cultural change, and iterations and pivots to the program should occur. Overcoming the obstacles for implementation can lead to success and firefighters embracing the concept in the end, as Chief A identified it.

c. Did the ARV Solve the Problem?

Two of the nine chiefs mentioned the goal of reducing the fuel and maintenance costs associated with implementing an ARV. Chiefs A, E and G concurred about a reduction in fuel and maintenance, as well as a longer service life for the massive apparatus. Specifically, Chief G noted that the cost of staffing the squads with overtime is cost-neutral compared with these savings. Conversely, Chief I’s department cannot verify savings of the program, because it did not collect accurate data. By placing an ARV in service, surrounding fire companies remain available to respond to emergencies.

Several departments implemented the ARV to reduce the workload on surrounding fire companies. Specifically, Chief B stated the MRT initially was dispatched to 60 percent of ALS emergencies and 40 percent of BLS emergencies and was staffed to respond to BLS emergencies. His department repeated the response of the MRT to 60 percent BLS and 40 percent ALS emergencies to ensure the most significant impact to reduce the demand on the most burdensome fire apparatus. In this change, Chief I noted that the squad somewhat alleviated the need at the two busiest stations when it ran as the third company. When the department iterated from solely staffed squads to "jump" squads with its corresponding ladder companies, surrounding fire companies responding to emergencies did not experience a reduction. Smaller ARV apparatus can leave the firehouse sooner and navigate city streets with agility, which thus reduces response times.

Fire departments using an ARV have noted a reduction in response time to emergencies. A smaller vehicle can quickly and safely navigate urban streets and attain traveling speeds faster than a heavy ladder company. The decline in response time occurs if the ARV is "jumped" by the ladder company, and the ARV has all necessary ancillary equipment (radios, EMS equipment, gear). Time is lost when equipment is transferred between vehicles, which goes against the goal of the program. Chief A noted a reduction in both times spent leaving the firehouse and travel time to the emergency in the ARV. Chief D said response times were not decreased due to transferring equipment between the ladder and the "medic." He solved this problem by equipping the heavy apparatus and the "medic" with the same equipment to allow the medic to respond immediately.

2. Peak Demand Staffing

As seen in analyzing Dayton, the type of emergencies and the total number of emergencies fluctuate at different times of the day. Deploying resources when they are needed based upon volume is termed peak demand staffing or a dynamic staffing model. A fire department analyzed data and determined that two-thirds of its department's emergencies occurred from 9:00 a.m. to 5:00 p.m., and only one-sixth of the emergencies to which the department responds happened after midnight. The chief adjusted staffing based upon these times, to staff extra equipment from 9:00 a.m. to 5:00 p.m. and reduce staffing after midnight. This practice is controversial because no one can accurately predict when a working fire or cardiac arrest will occur. In one example of pushback, Chief A's fire department does not include staffing peak demand units because of collective bargaining agreement (CBA) limitations agreed upon with the union. Yet, Chief E implemented peak demand staffing of four engines to cover gaps created with the increased run volume between 9:00 a.m. and 7:00 p.m. After 7:00 p.m., these engines go out of service. To increase staffing to full time, Chief E is phasing in this model gradually for these four engines. In other resistance, the union for Chief F's department has negotiated not to staff apparatus dynamically at this time. Dayton has not implemented policies to address peak-demand staffing at the time of this thesis. Making changes to fire department deployment capability, as in dynamic staffing, require the approval of the political leaders.

3. Implementing New Policies

To ensure successful implementation of new programs, the stakeholders must be convinced that the program represents their best interests. The needs of the internal customer and the needs of the external customer should be balanced when implementing new policies and procedures. To assist in seeing all aspects of new policy implementation, a department can utilize the Mission Model Canvas. The Mission Model Canvas helps to "mobilize resources and a budget to solve a particular problem and create value for a set of beneficiaries."[164] Figure 17 identifies the nine areas used to assist in visualizing key elements of implementation.

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[164] Steve Blank, "The Mission Model Canvas—An Adapted Business Model Canvas for Mission-Driven Organizations," *Steve Blank* (blog), February 23, 2016, https://steveblank.com/2016/02/23/the-mission-model-canvas-an-adapted-business-model-canvas-for-mission-driven-organizations/.

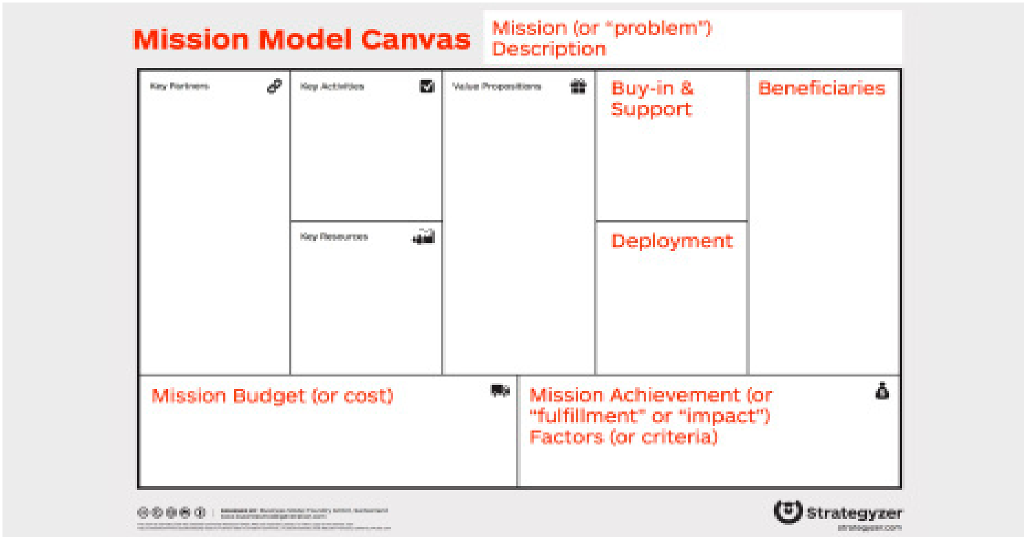

Figure 17. Mission Model Canvas.[165]

Several chiefs recommended considering the stakeholders when considering an ARV program. "When considering what you are implementing, ensure it is for the right reasons and, know what should be the best outcome, and ensure no firefighters or citizens are hurt by the changes." stated Chief A. Chief F wanted to create a program that "provided a service that is better, not worse, from what we had." Chief G states, "We are always evaluating the call types and evaluating what we can do better to serve the citizens and firefighters."

C. SYSTEM IMPROVEMENT TOOLS

One method to ensure a fire department is meeting the needs of the internal and external stakeholders is to be accredited by a third party. The ISO and CFAI are accrediting bodies for the fire service. The fire chiefs spoke to the process of accreditation and how it expanded their ability to innovate and optimize their deployment of resources in ways not previously addressed. Chief A credited the Center for Public Safety Excellence for its continued ability to innovate and meet its customer's needs. Chief D's department is pursuing accreditation by CFAI but admits the process can be long and involves utilizing

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165 Source: Blank.

many human resources. In collaborating with the CFAI, Chief G's department in 2015 was granted accredited status that resulted from innovations to better the department. The CFAI certified Chiefs H and I's departments, which has recognized both departments as a "progressive and innovative fire department." Chief D used Darkhorse, a Canadian company, to study the department's standard business practices and make recommendations, which it implemented for efficiency. Chief H states that having a third-party accreditation that supports the department's efforts helps reach and attain goals set. Chief F's department is not accredited but had the University of Akron conduct a Lean Six Sigma study to implement efficiency. Chief F learned through this process that following up on issues is key to achieving change. Chief B stated his department attained an ISO class 1 rating, one of only 373 fire departments in the country. The DFD currently has an ISO rating of 2, one of 1,673 fire departments in the country, and is not accredited at this time.

Innovative integration of EMS and hospitals involves combining efforts to combat the increased workload, both pre-hospital and at-hospital resources, titled MIH. Several fire departments across the country are not only addressing the increased workload with ARVs but also curbing the frequent utilizers of 9-1-1 experiencing socioeconomic disparities. Partnering with hospital networks that provide social workers and advanced practitioners (physician and nurse) to solve a healthcare crisis can reduce the patient volume for fire departments and hospitals.

Several chiefs spoke about hiring both social workers and NPs or physician assistants to work side-by-side with the fire department paramedics making field calls. For example, Chief A was the first in his state to implement an MIH program. By the same token, Chief C applied a NP unit, staffed with one paramedic and one NP. The NP program was created to address the high volume of homeless and high utilizers who needed care but not at an ER via ambulance. For the same reason, Chief C iterated the NP program to move from hiring NPs to physician assistants (because of less pay and more availability to engage.) Further, Chief C then implemented a "sober unit" to deal with the high volume of serial inebriates in a concentrated area of downtown to reduce the number of emergencies the medic units were responding to within this area. To address the problem differently, Chief F implemented community paramedicine to reduce the call volume of repeat utilizers and reduce the number of non-emergent calls. In assessing the program, Chief F expanded the community paramedicine with an "ARV" to handle the low acuity (LA) emergencies. Chief F defined LA as psychological lift assists, and helping citizens into their houses. Likewise, Chief I hired a social worker to address the needs of the homeless and frequent utilizers. The goal is to reduce 70 percent of repeat callers from calling 911 within 30 days. High utilizers and citizens who experience frequent falls were the first target population. Integrating an MIH program will reduce the number of emergencies fire departments attend to and improve the quality of life for the citizens. Implementing innovative methods for a paradigm shift in the approach fire departments address concerning increasing workloads should also be coupled with optimizing existing resources and technologies.

D. OPTIMIZATION

The fire service wants to optimize its workforce to place resources where they are needed effectively and to reduce the time it takes fire apparatus to arrive on the scene. Three ways to accomplish this optimization are gathering accurate data for analysis, applying analysis to data to deploy the workforce, and leveraging technology by employing AVL platforms.

1. Data-Driven

The fire service has traditionally underused data for the decision-making process. Innovative chiefs rely daily on accurate data. In this line, Chief A wanted to manage a data-driven department effectively to reduce maintenance costs and response times based upon their reuse concept. Similarly, Chief B wanted to use data to show how to reduce the number of ALS emergencies to which his department was responding. To do so, Fire Department B initiated this project based upon the work Seattle Fire had commenced on the premise of reducing the number of ALS compared to BLS responses. In this line, Chief C worked in conjunction with the city's information technology department to use data and algorithms to determine whether the correct algorithms were sent and iterated questions dispatchers ask to ensure the appropriate ALS or BLS units respond appropriately, based upon the nature of the emergency. Taking the data of citywide response times, Chief D posts those times to televisions in all the firehouses. Chief D's department has created a Business Operations Division strives to achieve maximum operational efficiency through the research and study of optimal business practices and the identification of requisite change and innovation through the mining and analysis of department data. One aspect addressed is positive reinforcement to encourage crews to have a faster out-the-door- and response time to initiate emergency care. The fire crew with the quickest response time gets to play volleyball and have dinner cooked by the chief every month. Likewise, Chief D is looking at the feasibility of placing clocks that start down from the moment of dispatch until the apparatus leaves the firehouse. The clocks and TVs will assist the firefighters in meeting out-the-door benchmarks. Captured data is useless unless it is analyzed and applied.

Optimizing a fire department requires the ability to analyze data accurately and make objective decisions on the analysis. To assist in data mining, Chief D hired a strategic planning assistant chief to implement innovation. In the same way, Chief E hired two data analysts, while Chief F hired a program analyst to ensure data-driven decisions. Likewise, Chief G hired a credential manager to assess the data of weekly and monthly peak-times of service and used data to eliminate first responding the squad and engines to Alpha emergencies, based upon the analysis that their response had no positive effect on patient outcome. This change reduced the call volume by 5,000 calls, which resulted in a savings of fuel and wear and tear on the apparatus and firefighters. To determine this usage, Chief G calculated the average cost of fuel per type of apparatus per emergency and the average cost of maintenance per emergency. Assuming the reduction of 5,000 medical calls was from engine and rescues, Chief G's department saved a total of $53,800 in fuel and maintenance costs. The Table 11 shows the numerical values that Chief G used to reach these savings.

Table 11. Chief G Fire Department EMS Costs.[166]

NCFD Costs for EMS Assistance (FY 2016)(Overtime)	
Average distance to and from an EMS response	
Engines & Rescues	3.47 miles
Aerials	4.27 miles
Squads	3.29 miles
Average fuel cost (Based on Dept. fuel usage and average diesel cost of $3.01/gallon and gasoline cost of $2.70/gallon)	
Engines & Rescues	$1.74/call
Aerials	$2.41/call
Squads	$0.53/call
Average maintenance cost (Based on parts & labor and miles run)	
Engines & Rescues	$9.02/call
Aerials	$18.83/call
Squads	$1.21/call

If Dayton were able to reduce its call volume by eliminating Alpha first-responder runs for engine and ladder companies, it could result in substantial cost savings. In 2017, the DFD responded to 5,950 BLS emergencies. The DFD does not currently track the average response distance to emergencies for apparatus, as noted in Table 10.

2. Technology Adoption-Automatic Vehicle Location

AVL technology for the fire service exists to send the closest, most appropriate piece of apparatus to an emergency. Whether the fire apparatus is in quarters at the firehouse or out in the district conducting training, inspections, or testing fire hydrants, dispatch will know their exact location via the AVL and CAD. An example is a fire that occurs within Engine One's district. Engine Two is driving by the fire, yet without AVL technology, Engine One will be dispatched.

Many of the chiefs have optimized their responses using AVL technology. For example, Chiefs A and D implemented AVL technology in all apparatus to ensure the closest apparatus responds. In his experience, Chief A warned of the unintended consequence that with the higher call volume downtown, companies that were in service "on the air" (or in the area) around the core area continually got chosen for responses while the outlying companies call volume reduced. The firefighters termed this "getting caught

166 Source: Matt Rhoton, email message to author, June 4, 2019.

in the toilet bowl" who would then go out of their way not to drive downtown. To address this problem, Chief D applies AVL to send the closest appropriate apparatus. AVL data can be used for performance data, as Chief C used for his FireStat program. Data captured from AVL implementation, in conjunction with CAD assistance, can assist in placing resources where best used, as Chief E accomplished. When fire departments are implementing new CAD systems, chiefs should ensure AVL capabilities are built-in. For example, Chief F implemented a new CAD system with Tyler Technologies with built-in AVL capabilities and was successful. AVL technology can augment automatic mutual-aid dispatches; Chief G implemented AVL via the Metro dispatch and the closest fire apparatus in the surrounding jurisdictions respond, and his department implemented AMAR agreements once surrounding departments placed AVL onboard apparatus. To accomplish this goal, Chief G obtained the AVL and MDTs through a grant program to facilitate their purchase. Human error can occur when creating status change via the MDT, and the AVL bets on accurate status changes. Errors are a result of personnel hitting the wrong button. Therefore, crews must ensure they touch the correct button on the MDT to ensure availability so that AVL selects the correct apparatus. AVL technology can reduce response times, and ensure appropriate apparatus are responding. The distance fire apparatus respond from is a key attribute in reducing response times.

3. Equitable Distribution of Recourses

Historically, the distance a fire horse could pull the fire engine before becoming exhausted defined the distance between firehouses. With the advent of gasoline, and then diesel engines, fire apparatus have become faster and more powerful through time. The loss of horses has allowed fewer firehouses to be strategically placed in cities while maintaining the response time frames set forth by NFPA standards. Economic setbacks to cities have also resulted in closing key-located firehouses and fire companies or reducing the redundancy built in for multiple fires occurring at the same time.

To distribute firehouses efficiently, some chiefs have used innovative means to optimize firehouse locations. Thus, Chief A moved a firehouse to reduce response times and redistributed the four ladder companies to optimal locations for city coverage. In the same way, Chief E analyzed increased demand for service and response times that do not meet NFPA standards in a specific area of the district. His department implemented a brush truck staffed with two members, 40 hours a week, during the peak call-volume for that district. To test location, Chief H purchased a residential house in an area that had response times over NFPA ALS standards and was a “resource suck” for the surrounding companies. The residence was purchased and re-zoned for a firehouse. The newly acquired residence required modification with alarm alerting equipment, watch office, sleeping quarters, and workout equipment, for a total cost of $120,000. The typical firehouse costs $180–$200 per square foot. In a related way, Chief I’s department conducted a Resource Allocation Report in 2017. Using data and recommendations within this report, the department moved two fire stations for equitable distribution and reduced response times. Fire departments could analyze optimized firehouse locations to place firehouses where they are needed based on response time and high-utilization areas.

E. SUMMARY

The policies provided across the nine fire departments have addressed how innovative resource deployment measures and optimization of resources result in an efficient, economical approach to delivering fire and medical services to customers. One major theme involves using precise data that analyze the problem from the 30,000-foot level. The data can be used to understand the issue at heart and what is causing the need to implement an innovative approach or to optimize resources. Data can be used to assist fire chiefs and medical directors in determining what level of EMS care results in positive patient discharge outcomes, and which current EMS standards are wasteful. Sending fire department apparatus to medical emergencies that do not make a difference strains personnel, apparatus, and fellow citizens who may be experiencing a life-threatening medical emergency or structural fire at the same time.

Implementing change requires open communication with all stakeholders involved; making a change requires precise, accurate data regarding the decision for change. ARVs can aid in reducing response times, operating costs, and wear and tear. Fire departments are experiencing an increased demand for EMS and are combating this demand with MIH and other partnerships within the healthcare industry to meet the socio-economic needs of economically depressed citizens.

V. CONCLUSIONS, RECOMMENDATIONS AND IMPLEMENTATION STRATEGY

Fire departments across the nation are finding themselves bounded by tighter budgets and fewer staff. Fire departments are having to “brown-out” or close fire companies, as well as distribute the workload to existing fire apparatus. Placing an increased burden on the remaining engine and ladder companies results in higher costs for fuel and a shorter service life for equipment. Along with the decrease in budgeting, fire departments are facing an increased demand for service, specifically in EMS calls. Fewer fire companies and personnel lead to increased response times outside NFPA recommendations that ultimately lead to both larger, and severe fires, and slower care rendered to citizens experiencing ALS emergencies. An industry-wide review suggests that the DFD is one small fish in an ever-expanding pond of fire departments suffering resource scarcity.

Fire departments are turning toward innovative deployment methods and initiatives to optimize their service delivery. Implementing ARVs and an MIH, and adopting technology in the form of AVL, employing data-driven decision making using a FireStat program, and pursuing accreditation with an increased ISO rating, have the potential to reduce the effects of the escalating budget and staffing crises. The ARV and MIH programs may reduce the run volume of engine and ladder companies, which thus reduces the budget spent toward maintaining apparatus, and also results in more money available to staff additional equipment. Optimizing the placement of resources based on data analysis while implementing AVL technology may reduce response times that can thus align with NFPA recommendations. Attaining accreditation and raising the ISO rating to 1 ensures that fire departments like the DFD can become the innovative emergency teams its citizens deserve.

A. RECOMMENDATIONS

This thesis examined the DFD’s problems related to funding and manning, as well as how innovative approaches to problem solving might improve the ability of the DFD to deliver services and manage resources. The methodology used to explore these matters relied on policies of other fire departments to examine how other agencies are adapting to the challenges of reduced or flat resourcing and increased demand for services. The DFD and similar fire departments across the country can apply lessons from the research findings to optimize their workforce and innovate deployment capabilities. The first two recommendations surround optimizing existing resources. The first recommendation is to employ a data analyst and to create a data analyst program. Data will become the foundation for the decision-making process at the DFD. After data is gathered, technology will be leveraged on fire apparatus in the form of AVL to send the closest fire apparatus to emergencies. The final three recommendations are innovative measures for the DFD. The first innovation is piloting an ARV response concept operating smaller vehicles for medical emergencies. The second innovation is to partner with a local hospital to pilot an MIH platform to reduce the medical demands for the DFD and local hospitals. The final innovation surrounds the DFD pursuing accreditation by two outside agencies.

1. Employ a Graduate Student for Data Analysis and Create a FireStat Program

The DFD should foster a workforce that embraces data analytics by leveraging a data analyst position to create, analyze, and disseminate data to the command staff and members of the DFD. Aggregated data could be used to optimize the department's operations and ensure efficient delivery of services. All nine chiefs spoke to the need of concise, accurate data in decision making. For example, Department B introduced aggregating data initiated on the premise of reducing the number of ALS responses compared to BLS responses. The department needed data to first delineate the number of responses, and then analyze the data. Chief D, too, spoke of his department's success in applying data to response times and the time it took crews to leave the firehouse when responding. As the policies have shown, a fire department that prioritizes data analytics thrives on innovating pilot programs and modifying programs based on data.

The DFD could pilot this idea by employing a college intern who is attaining a master's degree in business analytics, or a related field focused on the collection, study, and visualization of data. This individual could experiment with the DFD's current and future data to understand their full capacity. The intern would model a FireStat program based on best practices. The FireStat program was created by the LAFD to quantify the performance of fire and EMS crews and uses this data for management strategy. The FireStat program would enable the DFD to analyze data and make operational decisions based upon accurate facts. The partnership with the intern gives the intern real-world experience in business intelligence, problem solving, and communicating analysis-based decisions. The city of Dayton would benefit from an experienced data analyst whose sole responsibility would be to analyze data and one whose sole responsibility was big data. Having a dedicated analyst could foster a culture of continual improvement. Typically, innovation requires a dedicated person to focus just on that topic; otherwise, it can be overshadowed by daily operating priorities. Long-term projects tend to lose out to daily emergencies. Out of an eight-hour workday, a senior fire department official may have 30 minutes of management for innovative creation. If an intern proves beneficial for data mining and creative strategy, the DFD should then consider hiring a full-time data analyst to support the DFD's optimization and innovation programs.

The DFD should also provide training and education for the rank and file members on captured data, the necessity for accurate data, and how information is translated into visualizations for a clear understanding of the concepts. Ensuring DFD members understand the power of data will foster buy-in for expanding captured data and analytics for crucial decision making. The DFD should rely on members to obtain accurate data to develop existing innovate practices and assist in implementing new concepts that grow out of existing programs. The ability to attain, decipher, and disseminate data is the core for the remaining recommendations.

2. Implement Automatic Vehicle Location Technology for the DFD apparatus.

Adopting technology in the fire service can assist fire departments in reducing response times and improving situational awareness of fire apparatus. One aspect of technology is AVL. AVL technology should be placed on all front-line and reserve DFD apparatus. AVL will assist in lowering response times for the city of Dayton by sending the closest apparatus to the emergency. The average response time for the DFD in 2017 was 340 seconds, which is 100 seconds above the national standard of 240 seconds, and has increased 5.6 percent since 2017.[167] Chief D applied AVL to send the closest appropriate apparatus, and lowering response times would allow the DFD to come in-line with NFPA 1710 response standards.

AVL technology improves the safety of firefighters because it indicates the fire apparatus location displayed on the MDT, both for the dispatchers and firefighters. Responding fire apparatus could respond from altered intersections to avoid collision opportunities, and dispatch is able to see the physical location of apparatus at all times, which expands the safety element. Implementing an AVL program could generate data for use in a FireStat program. Chief C used data from his AVL platform as the foundation for his FireStat program. Data captured from AVL implementation, in conjunction with CAD assistance, can assist in placing resources where best used, as Chief E accomplished. The DFD could pursue grant funding to reduce the cost to implement the program. Chief G was able to purchase his department's AVL platform by utilizing grant funding. Should grant money not be attained, the DFD should emphasize a budget line item for the installation and implementation of a AVL platform.

A committee should be formed, led by the command staff of the DFD and management of the RDC. Outside agencies (manufacturers of CAD software and hardware) would need to be included in discussions. The CAD software would need to be upgraded to allow the use of AVL and training for the DFD and RDC members is necessary prior to implementation. Generated data from CAD should be utilized to its fullest capabilities in fulfilling the mission of the DFD.

3. Pilot an ARV Response Concept

To improve service and reduce costs, the DFD should pilot an ARV program. The ARV concept can be steered in several formats, from the jump concept (firefighters and officer from ladder companies respond with the ARV instead of the ladder to medical emergencies) to the ARV being staffed solely to respond to medical emergencies. The staffing could occur 24 hours per day or during peak times to reduce the load on current

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[167] City of Dayton, *Dayton Fire Department Statistical Report for 2017*, 2.

engine and ladder companies. The goals of the ARV pilot program are to reduce response times, minimize fuel usage and wear and tear on existing engine and ladder companies, and reduce costs by increasing the in-service life of heavy, expensive engine and ladder companies. ARVs also have the associated benefit of reducing emissions and the carbon footprint of fire department apparatus.

The DFD should pilot the program with Ladder 11 using an existing SUV and medical equipment to respond with the ARV to medical emergencies. Implementing the pilot with existing equipment creates the minimum viable product from which to gather data. To implement this program, Chief A moved one firefighter from an engine company to staff the squad, which reduced the staffing on the engine companies but allowed the squad to be piloted. Chief B, on the other hand, started the pilot with two teams staffing the MRT Monday through Friday by utilizing overtime funds. Employing existing vehicles would allow fire departments to pivot or change the program to fit their needs best before fully committing to the program and buying new vehicles and equipment. An analysis of what medical equipment has been found essential for an ARV program should occur. When the DFD finalizes the staffing model for Ladder 11, the program should be expanded to all four ladder companies.

Should the previous pilot find success in saving wear and tear, a second ARV model might involve the DFD's staffing of one or two ARVs from 10:00 a.m. to 10:00 p.m. with two paramedics. The location of the apparatus would be changed on the premise of greatest impact, with regard to workload and response times. Staffing supplemental ARVs would require additional workforce and equipment. However, staffing "jumped" or supplemental ARVs should not result in the closing of current engine and ladder companies, which would reduce the DFD's ability to respond to emergencies within ISO and NFPA guidelines.

To ensure the program's success, the DFD command staff should establish an ARV committee and engage members from all ranks to generate input into the process. A key member of the committee would be a representative of the union to ensure a collective voice of the membership is heard. The committee should employ the Mission Model Canvas to ensure all stakeholders and key elements are addressed. The committee should create a standard operating procedure (SOP) that addresses the operational and safety aspects of the ARV. The SOP should be modified when roadblocks are met or updated best practices are published. Meetings must occur with the entire department to allow in-depth discussions considering the goals of the program and addressing questions about it. The DFD must gather data for the jumped ARV to assess missed structural fires and rescues that do not receive the ladder company usually assigned by CAD. Aggregated data gathered from the AVL program can assist in analyzing missed emergencies. The decision to implement an ARV program or cultural change should be for the right reasons and ensure no firefighters or citizens are hurt by the changes.

4. Pilot a Mobile Integrated Healthcare Platform

With the emphasis of lowering the cost of providing health care with the passage of the Patient Protection and Affordable Care Act, fire departments have partnered with hospitals to reach the goal of lowering healthcare costs while optimizing healthcare delivery. Dayton would benefit from piloting an MIH platform to meet the underserved populations who need socioeconomic assistance. Targeted communities (e.g., homeless, low-income, elderly, and those without health insurance) and the highest users of EMS (often-termed frequent flyers) would benefit from such a program. As described in Chapter IV, Chiefs A, C, F, and I successfully partnered with a local hospital that employed a NP and social worker, with a fire department paramedic to deliver a broader level of care. The MIH should be staffed on a 40-hour workweek, with the days of the week and hours staffed fluid based on generated data from the pilot.

Members of the DFD should be apprised of the MIH program, and will need to provide accurate patient demographics to the supervisor of the MIH program to determine those who would benefit from an MIH evaluation. The MIH could be staffed with a NP or physician's assistant to allow definitive care in the home setting and lessen the burden of transports to the emergency room. The cost of this program would be shared with a local hospital group to alleviate the financial and resource burden on the fire department and hospital. A committee consisting of DFD command staff and the partnering hospital would need to be formed to create an SOP regarding the metrics and goals of the program. To merge staff from the hospital setting and the fire department successfully into a mutual program will be met with cultural and workplace differences. This issue can be addressed by implementing lessons learned from fire departments that have successfully implemented an MIH program.

The MIH program could be expanded to staff a low acuity (LA or Alpha)–type apparatus. Chief F, for example, implemented an LA unit to respond to basic, non-emergency calls. Such an LA/Alpha apparatus would respond to the least severe medical emergencies occurring in Dayton. The LA unit could be staffed during peak-times with two EMT-Basics. Alpha and Omega emergencies coming into the 9-1-1 dispatch center would be stacked until the unit could respond and mitigate the crisis. DFD members would need to receive training regarding the LA/Alpha apparatus to understand the program, and the intended uses and metrics for the program. The program could be expanded with analyzing the amount and type of apparatus responding to BLS emergencies.

The DFD command staff should partner with the medical directors of local emergency rooms to analyze EMS response algorithms and assess where changes to emergency responses should occur, with the goal to reduce the frequency of engine, ladder, and medic units responding to emergencies that do not have a positive effect in patient discharge outcomes. Chief E embraced data to determine whether dispatch was prompting 9-1-1 callers for the necessary medical details, which thus ensured the appropriate ALS or BLS units responded. Sending fire apparatus to obtain vital signs and provide psychological care is no longer cost effective or a best practice with the budget and staffing model afforded the DFD. Working with the RDC to modify the EMD cards would be required to reduce the number of engines, ladder and medic units responding to LA emergencies. Changing the response algorithms should result in cost savings and reduced fatigue for DFD members.

5. Pursue Accreditation by the CFAI and Attain an ISO Rating of 1

Pursuing accreditation from the CFAI and attaining an ISO rating of 1 would further the DFD's commitment to delivering superior customer service. When setting goals to meet national benchmarks and standards, utilizing CFAI in the process enables peer recommendations and networking for new ideas. The accreditation process through the

CFAI requires a self-assessment of over 200 performance indicators, 100 of which are essential benchmarks. After the self-assessment, a CFAI representative conducts a site visit to the fire department. The board can either approve final recommendations or make suggestions for implementation. The CFAI recommends attending an accreditation process conference by the CFAI prior to application. The conference networks fire departments that have reached accreditation with those aspiring towards the goal. The network exchanges lessons learned.

Attaining an ISO rating of 1 would allow Dayton to become a member of an elite number of fire departments in the United States well equipped and staffed to respond to a comprehensive number of fire and medical emergencies. Lowering the ISO rating to 1 would reduce insurance premiums on businesses and citizens residing in Dayton. Chief B spoke to his department's attaining a class 1 rating, which has enabled the department to serve the residents proactively and innovatively. To attain an ISO rating of 1, Dayton would be required to increase its in-service engine company staffing, improve water supply flow capabilities, and the infrastructure and staffing of the dispatch center. The DFD would need an increase to the budget to achieve the objective to lower the ISO rating to 1.

B. POLICY IMPLEMENTATION

These five recommendations will ultimately save money for the city, which could be allocated for peak-demand staffing of medic units and ARVs, while improve services with a reduction in response times. Implementing the five recommendations will come at an upfront cost to the city of Dayton. The budget allocated for the DFD is being reduced in 2020, and the monies needed to implement changes would require a temporary increase of the DFD's budget. Chiefs A and F initiated an innovative policy change because of a reduction in budget. However, the temporary budget increase could be offset by future savings and improved response times.

Implementing innovative policies requires the support of a vast array of stakeholders. The employee groups most affected by policy changes are the DFD firefighters and paramedics. IAFF Local 136 represents the rank and file of the DFD, except for the command staff. Support from the firefighters and paramedics is essential when implementing innovative policies. Fire departments across the country that have implemented innovative programs have met resistance from the union. Chief A formed a joint-committee with fire management and the union when piloting and implementing cultural change policies. Ensuring the union has a voice when implementing innovative deployment changes is essential. Also, an important part of this process is helping the union understand that the changes suggested in this thesis can actually lower the stress and risks experienced by DFD firefighters, which thus makes their jobs more—not less—attractive.

The political entities of cities must remain apprised of fire department operational changes. The fire chief reports to the city manager and city council in Dayton, who must be apprised of deployment changes and given their blessing. Departments in city hall, including human resources and the legal department, should be at the table when a new policy is created. Including ancillary departments in the process ensures that the city and employees are legally protected and that the new system will meet intended goals.

The citizens of Dayton should be apprised when the DFD implements deployment changes. The media can be a voice of the DFD to enable the citizens to understand policy changes. When the new policies discussed are in place, the citizens of Dayton will continue to receive superior fire and medical protection, with added efficiency and innovation. The implemented changes are not the end for innovating the DFD, just the beginning. The fire service is rapidly changing, and the recommendations of this thesis will need continued analysis and modifications based upon demographics and best practice.

C. OPPORTUNITIES AND NEEDS FOR FUTURE RESEARCH

The thesis addressed innovative deployment modeling, but many areas remain to be researched. Regarding an ARV deployment, an analysis of what firefighting and medical equipment should be carried to maximize the program should occur, from existing programs. Further research in the areas of an MIH, technology adoption, and accreditation needs to continue. The fire service is continually evolving in its deployment and services provided, which requires continual research and analysis.

This thesis examined a small part of asset management and resource deployment for fire departments, with many areas remaining open for exploration. This thesis has brought to light several issues that demand further exploration to assist cities in dealing with an increased demand for fire services and a decreasing budget to provide them. Many areas were not addressed: apparatus procurement, variants of the ARV, and the long-term benefits of EMS response in patient discharge from the hospital.

Research into funding fire apparatus at Dayton could address the feasibility of leasing engines, ladders, and medics. The long-term capital replacement of fire apparatus ensures the latest technology and safety equipment are utilized on DFD fire apparatus. Dayton would be a candidate for acquiring of new apparatus every five to 10 years due to the high level of wear and tear placed on it. Leasing fire apparatus would require the leaders of Dayton to invest more money for future apparatus acquisitions but should result in reductions in maintenance costs. A comparative analysis of fire departments that lease apparatus, as well as outside industries, such as commercial aircraft leasing and long-haul truck leasing, could be explored for the practice in Dayton. All aspects in apparatus replacement require accurate data, and a definitive apparatus replacement schedule for the DFD should be created and approved by the city leaders.

Accurate data should be generated when implementing new programs. Ensuring the data itself is accurate, and the DFD members are implementing the recommended policies will increase the likelihood of success. Should the DFD apply an ARV with the ladder companies, structural fires and rescues that do not receive the ladder company usually assigned by CAD need to be analyzed when responding to a medical incident with the ARV. Generated data from CAD should be utilized to its fullest capabilities in fulfilling the DFD's mission.

D. CONCLUSION

Imagine the city of Dayton protected by a fire department that has optimized resources and successfully implemented innovative practices. The DFD has lowered its ISO rating to 1 and implemented recommendations from the CFAI, and with the city council's consent, restored staffing two engine companies and two additional full-time medic units, to distribute the workload. Two EMS ARVs are handling emergency medical incidents during peak times, which have reduced the response times to ALS emergencies.

Engine and ladder companies remain available to respond to fires and life-threatening rescues, and the ladder companies are no longer responding to medical incidents, which have reduced wear and tear on the equipment and prolonged their in-service life. The LA unit now handles the BLS emergencies, which is staffed Monday through Thursday, based on analytics. The NP unit responds to Omega-level emergencies handled within the home and visits the top five addresses for EMS emergencies to apply preventative healthcare needs. The citizens of Dayton are receiving optimized healthcare based on need, which has resulted in a healthier and happier Dayton. The DFD has partnered with the University of Dayton to create a data analyst intern position. The department funnels data into a FireStat program, which has become the foundation in decision making, which is underpinned with reliable and accurate data collected by firefighters on a daily basis. The city of Dayton is protected by a fire department that has embraced innovation and optimized the allocated resources to thrive in the coming decades.

The preceding is a vision of an ideal DFD fully supported by the political entities and citizens who fund the fire department. The vision is attainable if the needed funding is provided to the DFD and the stakeholders fully embrace the vision. Educating the stakeholders, from the politicians, to the citizens, to the DFD members is unquestionably needed to fulfill the innovative platforms and optimization of the workforce. The education is predicated on the desire for the city of Dayton to be protected by a paramount fire department that fulfills the needs of all participants. This fulfillment will take time and iterative steps, with stumbling blocks encountered on the way toward greatness.

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