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THESIS

DASHBOARDS FOR THE FIRE SERVICE

by

Alan L. Butsch

December 2017

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DASHBOARDS FOR THE FIRE SERVICE

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ABSTRACT

The purpose of this thesis is to examine how fire service agencies can best apply the principles of Business Intelligence (BI) toward constructing dashboards to improve agency performance. To accomplish this project, action research principles were applied to construct a first-generation model of such a dashboard. The model dashboard(s) constructed contains program measures and information that fire agency supervisors at different levels may use to improve subordinate performance and to support decision-making. It does appear possible for fire departments to apply modern BI principles toward improving fire department performance. Since the dashboard developed only represents the first generation of this process, it is recommended that further research focus on how to improve such dashboards through iteration and to examine the effects of such dashboards on agency performance to see if they are truly useful.

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LIST OF ACRONYMS AND ABBREVIATIONS

AED	Automatic External Defibrillator
AR	Action Research
BI	Business Intelligence
CAD	Computer Aided Dispatch
CFAI	Commission on Fire Accreditation International
CPR	Cardiopulmonary Resuscitation
ED	Emergency Department
eMEDs	A proprietary system in Maryland used to generate ePCRs
EMS	Emergency Medical Services
ePCRs	Electronic Patient Care Reports
FD	Fire Department
FTE	full time equivalent
ICMA	International City/County Management Association
IS	Information Services
ISO	Insurance Services Organization
MCFRS	Montgomery County Fire and Rescue Service
NEMSIS	National EMS Information System
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
OR	Operations Research
OTS	off the shelf
PPC	Public Protection Classification system
UASI	Urban Area Security Initiative

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EXECUTIVE SUMMARY

The purpose of this thesis project was to examine how to best to use principles of modern Business Intelligence (BI) and dashboards to support real-time decision making and performance improvement in a modern fire service agency. The problem that this project attempted to solve is the disconnect between personnel and organizational elements of a fire department and overall organizational goals and program measurement. Simply put, the average fire department employee does not see the connection between his work and the quarterly or yearly statistics that most fire service agencies use for performance measurement.

In terms of scoping, this thesis confined itself to the general knowledge necessary for a fire service agency to construct a first generation real-time dashboard for use in an iterative development process. The intent is for this dashboard to be used to support real-time feedback and decision-making. The thesis did not debate whether dashboards are in fact needed, nor did it debate the merits of the various styles of dashboards that are already extant in the business world. Nor did this thesis attempt to serve as a "consumer report" for the various software packages that are currently available to construct dashboards.

The methodology used in this thesis was a form of action research. The guiding principle was the two-interlinked-cycle theory of action research as proposed by McKay and Marshall.[1] As explained by McKay and Marshall, this method of research is ideal for solving new Information System problems and for solving practical problems while creating new knowledge. The first of the two interlocked cycles is that of research (in this case a literature search and review), and the second being that of a lean start up Build-Measure-Learn cycle.[2] The thesis only examined the research and build phases of these two cycles to construct a prototype dashboard.

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[1] Judy McKay and Peter Marshall, "The Dual Imperatives of Action Research," *Information Technology and People* 14, no. 1 (2001): 47, 50.

[2] Eric Reis, *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses* (New York: Crown Business, 2011), 200.

To lay the groundwork it was first necessary to understand performance measurement and improvement from a local government and fire service perspective. From the viewpoint of local governments, it was helpful to understand that performance measurement provides transparency and reassurance to citizens who want to slash unneeded spending but who also "care about the scope and quality of services being provided."[3] However, the most relevant purpose for performance measurement is to improve performance with all other purposes being secondary.[4]

With these factors in mind, performance measurement terms were defined. Effectiveness was defined as "how well a service does what it is supposed to do," while efficiency "is concerned with how well resources are used in providing the service."[5] Effectiveness is usually measured via outputs (tangible discrete products such as speeding tickets) and outcomes (more general "consequences of supplying public services to targeted recipients").[6]

From the business world, the concept of lead and lag program measures was found to be useful. Lag program measures are defined as "tracking measures…[of] performance that is already in the past," while lead measures are defined as the "measures of new behaviors that will drive success on the lag measures."[7]

Fire department measuring systems were then discussed. One traditional measure of fire service performance is that of the Insurance Services Organization Public Protection Classification (PPC) system, which measures fire department readiness for fire

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[3] David Edwards and John Clayton Thomas, "Developing a Municipal Performance-Measurement System: Reflections on the Atlanta Dashboard," *Public Administration Review* 65, no. 3 (May 2005): 369–76, doi:10.1111/j.1540-6210.2005.00461.x.

[4] Robert D. Behn, "Why Measure Performance? Different Purposes Require Different Measures," *Public Administration Review* 63, no. 5 (September 2003): 586–606, doi:10.1111/1540-6210.00322.

[5] Jennifer Flynn, "Fire Service Performance Measures" (report, National Fire Protection Association, November 2009), 5.

[6] XiaoHu Wang, "Perception and Reality in Developing an Outcome Performance Measurement System," *International Journal of Public Administration* 25, no. 6 (January 2002): 808, doi:10.1081/PAD-120003819.

[7] Chris McChesney, Sean Covey, and Jim Huling, *The 4 Disciplines of Execution* (New York: Free Press, 2012), 11.

suppression based on a static checklist.[8] Another measuring system that was examined was the Commission on Fire Agency Accreditation International (CFAI) process.

Robert Behn suggests that a combination of output and outcome measures is necessary to capture the whole of the state of organizational effectiveness. He suggests that by focusing internally on output measures, and improving such, organizations can realize gains in outcomes.[9] Both the National Fire Protection Association and CFAI recommend goals that seem to adhere to this principle; for example, three core fire suppression outcome measures that are proposed by both are the following: the percentage of times that a fire department confines a fire to the room (or structure) of origin, fire deaths and injuries per capita, and the number of firefighter injuries.[10] All of these externally reported outcome measures encompass a variety of subordinate output measurements.

Putting these concepts together led to the realization that it would be best to first decide upon the lag measurements that best define fire service performance and then work backwards through the relevant business processes to identify which lead measures can be most readily affected in a real-time manner.[11] These lead measures then can be displayed on a real-time dashboard as "it is well known that providing goals and feedback are two of the most effective interventions" for improving performance.[12] Other purposes of the dashboard would include monitoring completion of employees rote tasks, and the

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[8] "How the PPC Program Works," Insurance Services Office, accessed May 3, 2017, www.isomitigation.com/
program-works/how-the-ppc-program-works.html .

[9] Behn, "Why Measure Performance," 595.

[10] Flynn, "Fire Department Performance Measures," 20.

[11] Bruce F. Chorpita, Adam Bernstein, and Eric L. Daleiden, "Driving with Roadmaps and Dashboards: Using Information Resources to Structure the Decision Models in Service Organizations," *Administration and Policy in Mental Health and Mental Health Services Research* 35, no. 1–2 (March 2008): 114–23, doi:10.1007/s10488-007-0151-x.

[12] Richard P. DeShon et al., "A Multiple-Goal, Multilevel Model of Feedback Effects on the Regulation of Individual and Team Performance," *Journal of Applied Psychology* 89, no. 6 (2004): 1035–56, doi:10.1037/0021-9010.89.6.1035.

provision of situational awareness information such as traffic, weather, expected call loads, and hospital statuses.[13]

The desirability of having differing dashboards for differing levels of supervision was also examined. It appeared that functionally this was desirable, but that also all employees in an organization should have access to a "single source of truth."[14]

Dashboard graphic design principles were also discussed. There was near unanimity among the authors surveyed that dashboards should be simple to understand and fit on one screen, that indicators should be able to be drilled down upon (clicked on to display a second screen) to display more detailed information, and that the dashboards need to be designed in an iterative process with end-user feedback.[15] In terms of other visual characteristics, the most important information should be located on the upper left and center, and it is also important to consider colorizing and co-locating related information.[16]

The research suggests that by following the principles learned from the business world, fire service agencies can construct dashboards to improve performance. Prototype first-generation dashboards were able to be constructed. However, further research will be needed to examine if dashboards are effective at improving performance and what aspects of the dashboards are the most effective at doing so.

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[13] Amelia Cahyadi and Adi Prananto, "Reflecting Design Thinking: A Case Study of the Process of Designing Dashboards," *Journal of Systems and Information Technology* 17, no. 3 (August 2015): 286, doi:10.1108/JSIT-03-2015-0018.

[14] Ibid., 297.

[15] Michael K. Allio, "Strategic Dashboards: Designing and Deploying Them to Improve Implementation," *Strategy and Leadership* 40, no. 5 (2012): 24, doi:10.1108/10878571211257159.

[16] Wayne G. Bremser and William P. Wagner, "Developing Dashboards for Performance Management," *The CPA Journal; New York* 83, no. 7 (July 2013): 67.

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Gaining this degree has been a labor of almost four years. I first started the application process in 2014, but because of my underwhelming undergraduate grades, was encouraged by the admissions committee to take the Miller's analogies test to prove my ability to do graduate work and to reapply. I would like to thank Mr. Mark Fish for his encouragement through this process.

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I. INTRODUCTION

A. PROBLEM STATEMENT

The Montgomery County Fire and Rescue Service (MCFRS) has a mission statement that promises that it will "protect lives, property, and the environment."[1] But how can the citizens of Montgomery County know that the MCFRS is effective in fulfilling these aims and doing so in an efficient manner? How can the personnel of the MCFRS, at whatever level of responsibility, measure the connection between their own immediate individual and collective actions and the performance of the entire department? How can supervisors make real time decisions to improve performance?

MCFRS, as does the Montgomery County government as a whole, believes in performance measurement and reporting. Currently MCFRS generates public reports on a quarterly basis through "Countystat," which is a county-wide government program reporting effort. The purpose of Countystat, per County Executive Ike Leggett is to ensure that Montgomery County "provide(s) a more effective and efficient response" to the citizens of Montgomery County.[2] The Countystat reports for MCFRS include output measures such as 90th percentile response times for fires and serious medical calls, and some outcome measures such as the percentage of stroke and heart attack victims that receive timely and effective pre-hospital care.

Data for these aggregate reports is gathered from the following sources:

- Computer Aided Dispatch (CAD) records (locations of 911 calls, types of 911 calls, and incident response and clearance times).[3] CAD records are collected in real-time as the measured events occur.

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[1] "About," Montgomery County Fire and Rescue Service, sec. "Mission," accessed March 13, 2017, https://www.montgomerycountymd.gov/mcfrs/about/index.html.

[2] "Montgomery County, Maryland," CountyStat, accessed March 13, 2017, https://reports.data.montgomerycountymd.gov/countystat.

[3] In addition to location and call type information, a typical CAD system collects temporal information such as time 911 call is received, time that the call is dispatched, time that the dispatched resources respond on the call, time when the scene is reached, time the resources leave the scene, the time an ambulance reaches the hospital, and the time that the call is cleared.

- National Fire Incident Reporting System (NFIRS) compliant unit response and incident reports (types of incidents found, resources used to mitigate the incidents, occupancy types, fire losses, firefighter and civilian injuries (and deaths) due to fire). These reports are done at the conclusion of an incident. Within MCFRS, these reports are called FireApp reports.

- National Emergency Medical Services (EMS) Incident Reporting System (NEMSIS) compliant electronic patient care reports (ePCRs) (patient types, syndromes, symptoms, and care rendered by MCFRS personnel). Within MCFRS and Maryland, these reports are known as eMEDS reports. These reports are completed at the time of handover of a patient to the receiving hospital.[4]

The MCFRS Countystat measures do show the public that MCFRS performs in an effective manner; however efficiency, or value for the funds invested, is difficult to measure as there is no industry yardstick available to say that a department the size of MCFRS should achieve certain outcome measures with an *x* amount of resources.[5]

Further, except for the publically available quarterly Countystat measures, none of the aggregated information from the databases is available to any personnel below the rank of Battalion Chief.[6] And even Chiefs are limited in their ability to analyze information, due to the necessity to use various software packages to "pull" data into pre-defined reports that are limited to an individually defined time period and that reflect department-wide achievement. At present, there is no real-time feedback available to MCFRS personnel on how the MCFRS is fulfilling its program measures, and there is little to no feedback available at all for MCFRS supervisors to measure the contribution of their section of the organization to the success of the organization as a whole.

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[4] It is important to note that none of the publically available data includes protected health information for individual patients.

[5] CountyStat, "Montgomery County, Maryland."

[6] Ibid.

There are many approaches to measuring organizational performance, but performance measurement of individuals, in particular depends on the feedback cycle. In essence, human beings respond to goal setting and want to know how they are doing in meeting that goal.[7] If there is no performance feedback, then personnel have no incentive to meet a goal, or to make the improvements necessary to overcome gaps between the goal and their individual accomplishments. Indeed, the personnel lack the knowledge that there even is such a gap. This is the situation found today within the MCFRS.

This lack of feedback for personnel and supervisors is not only troublesome from a performance improvement perspective, but by its nature threatens any attempt to address problems that may exist. In the course of a day, the average MCFRS employee must fill out 10 to 12 FireApp and eMEDs reports. Each of these reports requires the completion of between 15 and 300 separate numerical or textual data elements that differ based on the type of incident dispatched, how it is found, and how it is mitigated. Some of these data fields are performance based but some are based on the conditions found upon arrival. Since the average MCFRS employee sees no feedback from his/her job performance and does not connect that the quality of his/her data entry efforts are important for such feedback, there is little incentive to ensure that reports are filled out beyond the minimum necessary to ensure that the software accepts the submitted report. Because of the volume of the reports and the lack of resources to do data quality assurance, there are also no checks and balances on the quality of the data entry.

In 2014, the MCFRS received grant funding through the Urban Area Security Initiative (UASI) to implement a data surveillance program called FirstWatch. The FirstWatch program promises to take data from disparate sources such as (but not limited to) CAD and eMEDs and aggregate them together to develop a near real-time performance measurement system that is available on a web page.[8] Such systems are commonly called "dashboards," and in the wider business world are part of Business Intelligence (BI) systems that assist organizations in meeting their goals.

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[7] Robert D. Behn, "Why Measure Performance," *Public Administration Review* 63 (2003): 590, doi:10.1111/1540-6210.00322.

[8] FirstWatch homepage, accessed September 25, 2016, https://www.firstwatch.net/.

These types of dashboards are new to the Fire Service and examples of dashboards already developed that were shown to the MCFRS largely displayed system-wide output measures such as response times. Although it is helpful to know some output on a real-time basis, system wide output measures by themselves do not speak sufficiently to the mission of improving individual or section performance. Outputs also do not address the means to geographically deploy resources during times of surging call load, nor assist the supervisor in making other real-time decisions based on data from his particular section or unit.

The off the shelf (OTS) package that the vendor was offering did not appear to meet the specific needs of the MCFRS. The vendor prides itself on its customization skills and offered to work with MCFRS to develop a tailored dashboard for the MCFRS. The MCFRS then needed to think conceptually about what was required in such a dashboard (in terms of data sources and derived measurements) to best meet its needs to provide real-time feedback and thus provide the tools necessary to identify gaps and improve performance.

The problem this thesis seeks to answer is: How can a real-time dashboard be best used to improve Fire Department performance? Successfully answering this question will assist the MCFRS in better reporting its performance externally and internally and will assist personnel to become more connected to the goals of the department.

B. RESEARCH QUESTION AND SCOPE

This thesis seeks to answer the following question: How can fire service agencies best use dashboards and Business Intelligence systems to support real-time decision-making and performance improvement?

1. Purpose of Thesis

It is hoped that the knowledge gained from this thesis project will enable the author to construct the first iterations of a dashboard for his agency; and that this dashboard will greatly assist in improving performance within the agency. It is also

hoped that this thesis will serve as a tool for other fire service chiefs and managers who may be considering deploying such technology in their own departments.

2. Limitations and Scope

a. Are Dashboards Needed?

For the purposes of the thesis, it is assumed that use of a real-time dashboard for the fire service is needed and is beneficial. The research will not consider whether using a dashboard will result in unintended or even negative consequences. If the thesis were to include debate about whether a dashboard is beneficial or not, its focus would be overbroad. Since there are no departments presently using a dashboard, perhaps this question is better left for the future so that a comparative analysis may be performed.

b. Kinds or Brands of Dashboards

The thesis will not attempt to examine the various kinds of dashboards that are currently being promoted by various business websites as the perfect match for a given scenario or weigh the particular merits of each style. Nor will the thesis make any judgment as to whether any particular type or brand of dashboard software is of more value than any other. The intent of this thesis is to derive general principles that fire departments can utilize to construct their own dashboards, not to serve as a "Consumer Report" for dashboard software purchasers.

c. Predictive Analytics and Operations Research

Although predictive analytics for purposes of forecasting the demand for calls for service will be touched on, this is not the focus of this thesis. Much work has been done in the arena of operations research towards this goal, and this thesis would be repetitive of work that has already been done if this thesis were to explore this area.

d. Scope

The scope therefore will be confined to the general knowledge necessary for a fire service agency to derive the necessary measures and design features to build the first generation of a dashboard for a process of iterative development through end user

feedback. The scope will not include the examination of machine "big" data, such as mouse clicks or time spent on computers or geolocation. This is perhaps an area worthy of exploration in later research.

C. RESEARCH DESIGN

1. Review of Designs

A literature search of research designs available to both study and solve real world business problems suggests use of operations research (OR) and/or action research (AR). Although there is some overlap, operations research seems to be more about the use of quantitative analytic models with data to improve business processes while action research is a more qualitative "approach to research that aims at both taking action and creating knowledge or theory about that action."[9]

Coughlan and Coughlan state that a literature review of operations research reveals that most OR consists of an external and clinical (in the sense that it is dispassionate about the result) observation in the form of "surveys, case studies or participant observation."[10] They contrast this to AR by stating that "AR focuses on research in action, rather than research about action" suggesting that the researcher is not external to the events being studied but intimately involved or embedded.[11]

In terms of applying models of AR towards novel problems, McKay and Marshall offer a theory of "two, interlinked cycles" one of which is directed towards problem solving and the other towards research.[12] Both interlinked cycles are reminiscent of the Deming cycle of "plan, do, check, act" in that they both feature iterative development and allow for change based on feedback gained during the process. However, this model is unique because not only does it "aim to bring about improvements through making

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[9] Coughlan and Coghlan, "Action Research for Operations Management," 220.

[10] Ibid., 222.

[11] Ibid.

[12] Judy McKay and Peter Marshall, "The Dual Imperatives of Action Research," *Information Technology and People* 14 (2001): 46.

changes in a problematic situation, (but) also aim(s) to generate new knowledge and insights."[13]

2. Chosen Design

As stated above, OR normally uses quantitative mathematical models to evaluate business problems, and in a sense relies on knowledge that is already known. However, AR uses a qualitative approach to discover new knowledge while simultaneously solving practical problems. The research question posed is a novel problem. When faced with the need to solve a new problem in Information Systems, Yang et al. chose to use AR as they saw it to be a better fit for the question at hand. Thus, action research seems to be a better fit for this research question as well.

The guiding principle for the research design will be the two- interlinked-cycle theory of action research as proposed by McKay and Marshall. This model is suggested as ideal for solving new Information System problems and seeks to solve practical problems while simultaneously creating new knowledge, understanding, and insights.[14] It is important to understand the two cycles are interdependent and inform each other. This is represented by Figure 1.

[13] Ibid., 50.

[14] McKay and Marshall, "Dual Imperatives of Action Research," 47, 50.

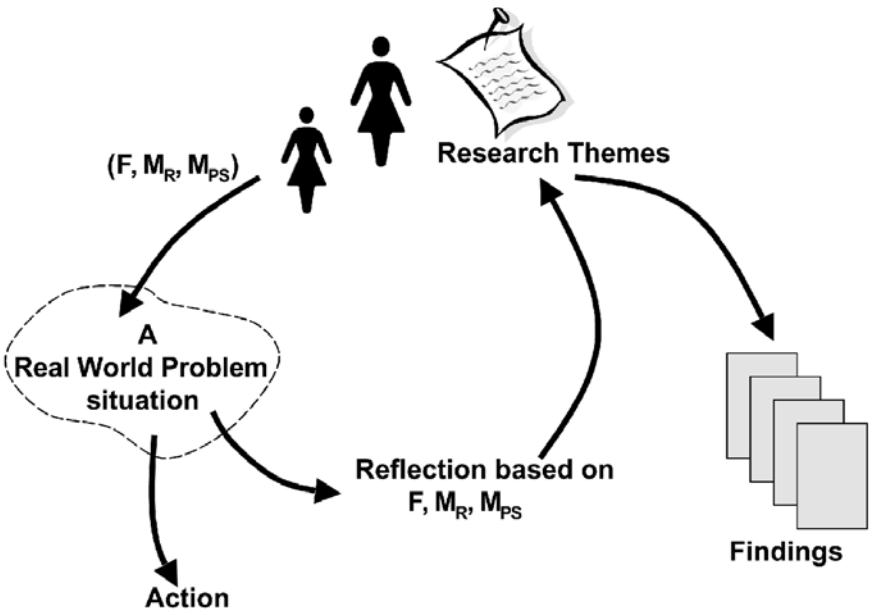

Figure 1. Two Interlinked Cycle Action Research Design[15]

The research design is broken into two parts: the Method -Research ("M_R") phase being that of a literature review; and, the Method -Problem Solving ("M_{PS}") phase being that of an Build-Measure-Learn cycle.[16] The thesis will only examine the research and build phase of one cycle. In other words, the literature review will be used to create a theoretical framework that will enable the building of a first iteration of a fire service dashboard.

The data sources will primarily be academic articles, books and studies. The academic literature will be consulted for background knowledge and theories necessary to develop a prototype dashboard. Since such dashboards are in their infancy within the fire service, literature related to Business Intelligence (BI) and program measurement in general will be surveyed, as well as literature dealing with considerations of dashboard design and display. The author will then analyze and synthesize the information gathered to theorize guiding principles for building the first iteration of the dashboard. The first

[15] Source: McKay and Marshall, "Dual Imperatives of Action Research," 54.

[16] Eric Reis, *The Lean Startup* (New York: Crown Business, 2011), 200.

iteration of the dashboard will then be built and any new knowledge gained during that process will be examined.

In order to guide the knowledge creation, the research will seek to answer the following more focused sub-questions regarding the implementation of a real-time dashboard for the Montgomery County Fire Rescue Service (MCFRS) in specific and to give guiding principles for developing performance measuring dashboards for the fire service in general:

- What data from which sources should be measured and/or displayed on the dashboard and why?
- How will MCFRS personnel use the dashboard to support decision making to improve organizational and individual effectiveness and efficiency?
- Who should have access to the dashboard and should all members having access to the dashboard have the same dashboard?

It is expected that the output of this research will not only guide the implementation of the MCFRS dashboard but also serve as a useful guide for other fire service organizations on how to think about implementing their own dashboards.

D. CHAPTER OUTLINE

The next chapter will be a survey of the existing literature on the subject. This chapter will be organized into four broad sections which will examine one progressive fire department's present use of data for performance measurement and planning. The second section will survey the present literature on fire department data usage and modeling. The third section will give an overview of selected literature regarding dashboard design principles. The fourth section will discuss dashboard usage within the fire service and within other industries such as health care and the military.

The third chapter will be a historical perspective on performance measurement within the fire service and discuss the limitations of these past efforts. It will also discuss the current fire service agency accreditation process and how this may help fire departments improve their performance or at least discover gaps in performance.

Chapter IV will discuss suggested systems of performance measurement derived from modern business practice and how these might be utilized in the fire service. It will also discuss best practices of dashboard and Business Intelligence utilization within other industries and how these practices might be applied to fire departments. Then it will briefly discuss dashboard graphic design principles. Finally, it will synthesize all of the knowledge learned from these examinations and provide examples of suggested first generation dashboards for the fire service.

Chapter V will contain a summary of lessons learned from the preceding chapters. It will discuss how fire departments can use the concept of lead measures to drive improvements in lagging measures. It will summarize how dashboards may best be used as feedback tools and as public checklist for rote tasks. It will give an overview of the concept of decision support systems and situational awareness. It will then give a very broad stroke glimpse of dashboard graphic design concepts. All of the above concepts will then be put together

Finally, Chapter VI will make a conclusion based on the research and then make recommendations for further research into this area.

II. LITERATURE REVIEW

Fire Departments in the United States, like many organizations, are beginning to explore and exploit the use of "big data" for real time, or near real time decision-making purposes.[17] The Montgomery County (Maryland) Fire and Rescue Service (MCFRS) has long been a proponent of using data to drive deployment decisions of personnel and resources. However, to date, the data has been analyzed after a period of months and as such decisions typically take months to implement.

The MCFRS is an all-hazards fire service providing emergency medical care and transport services, fire suppression services, hazardous material incident mitigation services and more. MCFRS serves a population of 1.1 million citizens in a 500 square mile jurisdiction and attends about 400 incidents a day. MCFRS transports approximately 250 patients a day to its seven in-county hospitals.[18] As mentioned above, every one of these incidents and patient encounters generates many data points through the Computer Aided Dispatch system (CAD), FireApp (an in-house program that collects National Fire Incident Reporting System (NFIRS) data elements post incident) , and eMEDS (an electronic patient care data collection system) reports.

The MCFRS attempts to use collected data to inform its strategic planning process. MCFRS sets goals and strategic direction by way of a six year Master Plan. Progress and next steps towards fulfilling these goals is documented in an annual Strategic Plan. To assist in its planning process MCFRS has found it useful to be accredited by the Commission on Fire Agency Accreditation International (CFAI); this process requires a rigorous self-assessment process. The Master Plan and Accreditation documents are mutually supporting and both set output and outcome measures such as response time, patient care quality, and other performance goals that the agency strives to meet. The shortest reporting period for these measures, to date, is a quarter year.

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[17] Matthew J. Liberatore and Wehnong Luo, "The Analytics Movement: Implications for Operations Research," *Interfaces* 40 (2010): 314, doi:10.1287/inte.1100.0502.

[18] "Fire and Rescue Service," Montgomery County Government, accessed March 13, 2017, http://www.montgomerycountymd.gov/OMB/Resources/Files/omb/pdfs/FY17/psp_pdf/43-FRS.pdf.

Quarterly measurement and reporting of progress means that there is a significant lag between the implementation of a change and understanding its effect upon outcomes. This lag would equally apply to any performance issues suffered by an entity in the department. This lag is undesirable for an agency that responds to time dependent emergencies on a daily basis but was the best MCFRS could do until recently.

Recently, MCFRS received a grant for the implementation of a data surveillance system (Firstwatch) intended to allow the agency to simultaneously survey CAD and eMEDs data. The MCFRS is very interested to develop this software such that it can assist real time and near real time decision-making to support performance improvement. The planned usage of this software is to develop real-time or near real-time dashboards (or scorecards) that provide real-time information to appropriate decision makers.

A literature review of fire service dashboards, as expected, yielded a paucity of sources. However, some insights may be gained when the literature review is broadened to include fire service data usage, general concepts in dashboard development and design, and dashboard usage in healthcare and other related industries.

A. FIRE DEPARTMENT DATA USAGE AND DEPLOYMENT MODEL RESEARCH

Most fire service (the term is used here to also include EMS) data usage has been focused on the problem of determining where to best position resources so as to maximize the possibility of having resources available to respond to incidents in the least amount of time. Resources include vehicles, stations, and personnel. Most fire departments have a dizzying array of resources that must be staffed by personnel with differing levels of qualifications. For instance, MCFRS has seven different types of primary vehicles (engines, ladder trucks, rescue squads, Basic Life Support (BLS) ambulance, Advanced Life Support (ALS) ambulance, ALS chase car, Battalion Chief). Dispatchers determine which type(s) of resource(s) and how many to send to each call based on pre-set algorithms and Standard Operating Procedures. This decision-making is complicated by the fact that fire departments have to worry about answering multiple

calls for service and thus must create a web of resources to ensure that no call for service goes unanswered.

The reason that fire service agencies are so concerned with using data to assist in the deployment of resources is that the deployment model directly affects their effectiveness and efficiency. Effectiveness of a fire department can be understood as "how well a service does what it is supposed to do" and this measurement is directly affected by the number of resources available; i.e., a department that has a fire engine on every corner will get to all fires quickly.[19] However, all fire service agencies have limited budgets and must balance the need to be effective versus expenditures. This balance may be understood as "efficiency." Efficiency of a fire department is determined by its effectiveness divided by its expenditures or inputs (i.e., staffing, vehicles and other expenses).[20] However, it is difficult to be both highly efficient and highly effective. In other words, a town that has one ambulance that is busy 24 hours a day has a highly efficient EMS system; but if the second or third calls for service suffer significant delays in response and patients suffer harm as a result; this system is not very effective.

Trying to find the right balance between effective and efficient use of resources has been the inspiration for many of the articles reviewed below. Most academic research in this area has been done in the discipline of operations research (OR), with some being done in the field of action research (AR). Since most fire service personnel are not familiar with these disciplines, it may be of value to explain what these disciplines are. Although there is some overlap, operations research seems to be more about the use of various analytic models with data to improve business processes while action research is "an approach to research that aims at both taking action and creating knowledge or theory about that action."[21]

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[19] Jennifer Flynn, "Fire Service Performance Measures" (report, National Fire Protection Association, November 2009), 16.

[20] Ibid.

[21] "What Is Operations Research?," INFORMS, accessed November 18, 2016, www.informs.org/About-INFORMS/What-is-Operations-Research; Paul Coughlan and David Coghlan, "Action Research for Operations Management," *International Journal of Operations & Production Management* 22, no. 2 (February 2002): 220–40, doi:10.1108/01443570210417515.

For example, Liberatore and Luo discuss the "Analytics Movement" as a valuable part of OR and offer a model of how to extract meaning from vast pools of data. They state that data should be "presented and analyzed….(then put through) predictive modeling techniques" and finally used with "optimization models…to find the optimal solution given a set of assumptions and constraints".[22] Specific to the emergency services, Aringheri et al. discuss many research papers that have attempted to use OR analytical and optimization models to understand how to deploy a limited number of ambulances available to an Emergency Medical Services (EMS) system.[23]

In an overview, Wright, et al. review OR within the various Homeland Security disciplines. They sort the efforts into four divisions: "early work, location and resource allocation, evacuation models, and disaster planning and response." The article was useful in the sense it talked about the application of various models to problems of resource allocation in varying degrees of resource starved environments and of moving resources (and patients) in the most efficient manner.[24] Both of these concepts could be used for real-time decision making. The authors did note a lack of OR on "the response phase" of Homeland Security.

Among other OR projects, the Rand Corporation Fire Project focused on fire department resource allocation during the 1970s and is still a relevant contribution to this field. Among other contributions, the Rand project was the first to determine the average speed that a fire company could travel and thus was able to determine optimal locations for new stations, articulated a novel "adaptive response" strategy that better matched resources to anticipated needs, and introduced a "fire company relocation algorithm

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[22] Matthew J. Liberatore and Wenhong Luo, "The Analytics Movement: Implications for Operations Research," *Interfaces* 40, no. 4 (August 2010): 316, doi:10.1287/inte.1100.0502.

[23] R. Aringhieri et al., "Emergency Medical Services and beyond: Addressing New Challenges through a Wide Literature Review," *Computers & Operations Research* 78 (February 2017): 358, doi:10.1016/j.cor.2016.09.016.

[24] P. Daniel Wright, Matthew J. Liberatore, and Robert L. Nydick, "A Survey of Operations Research Models and Applications in Homeland Security," *Interfaces* 36, no. 6 (December 2006): 519–22, doi:10.1287/inte.1060.0253.

which automatically rebalanced fire protection (when)…fire companies (were) already working at (other) fires."[25]

Although both adaptive responses and relocation algorithms are still employed to varying degrees by fire services across the country, they are driven by static protocols that do not change with varying resource availability.[26] However, McLay and Moore offer a refinement on the adaptive response model by examining the resources that are needed for serious EMS calls, emphasizing the quick response of equipped personnel, regardless of the type of vehicle used. This was intended to meet the most urgent response-time goals with minimal personnel. They argue that fire department leaders should focus on the truly important underlying goal of saving lives and develop performance measures that are effective in meeting this goal.[27]

In another OR project focused on resource deployment, Deo and Gurvich discuss hospital destination determinations for ambulances when trying to maximize EMS resource availability and decrease EMS hospital handoff times. In doing so, they contrast centralized diversion (the practice of an ambulance bypassing the closest hospital as decided upon by the fire department or another external entity) versus decentralized diversion (bypass status decisions are made independently by each hospital). Although decentralized diversion is the norm across the country, Deo and Gurvich conclude that this paradigm does not maximize EMS resource availability and decrease EMS hospital handoff times since most hospitals practice "defensive diversion" to avoid accepting patients that should have gone to other hospitals. They also find that many EMS agencies cancel diversion statuses when a critical mass of hospitals use diversion. Deo and Gurvich suggest that individual patient severity and travel time versus hospital wait time

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[25] Peter Kolesar, "Some Lessons on Operations Management Model Implementation Drawn from the RAND Fire Project," *Manufacturing and Services Operations Management* 14, no. 1 (Winter 2012): 4.

[26] Arthur J. Swersey, "A Markovian Decision Model for Deciding How Many Fire Companies to Dispatch," *Management Science* 28 (1982): 352, doi:10.1287/mnsc.28.4.352.

[27] Laura A. McLay and Henri Moore, "Hanover County Improves Its Response to Emergency Medical 911 Patients," *Interfaces* 42 (2012): 384, 380–394, doi:10.1287/inte.1110.0616.

should be considered by the EMS agency when making diversion decisions and that centralized diversion is a better strategy.[28]

Schooley and Horan looked at the use of inter-organizational information management systems in assessing end to end performance in an EMS system in San Mateo County, California.[29] The authors developed a thought model for understanding how to optimize the best way to exchange time critical information among organizations that are involved in dispatching (communications centers), responding to (first responding fire departments and an independent EMS transport service), and providing definitive care for (hospitals) patients that access the 911 system.[30] The article addresses the theory behind real-time quality measurement across a system and not just within one particular agency. However, it considered matters as they "should be" and not as they were, and admitted that more hands-on research needed to be done.

In conclusion, much research that has been done to assist fire departments in the use of data to drive decision-making has been done through operations research, rather than by employing action research to determine hands-on solutions. Moreover, much emphasis has been placed on studies of the same data sets compared over a period of quarters or years (longitudinal studies) to derive static models, versus the application of real time data to drive dynamic models of decision making.

B. DASHBOARD CONCEPTS AND DESIGN

As mentioned above, most fire service agencies collect a vast amount of CAD, NFIRS and EMS data related to incident response both during the response and afterwards. In determining how best to use this data and display it to provide actionable intelligence, it is important to consider dashboard concepts and design theories.

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[28] Sarang Deo and Itai Gurvich, "Centralized vs. Decentralized Ambulance Diversion: A Network Perspective," *Management Science* 57 (2011): 1314, doi:10.1287/mnsc.1110.1342.

[29] Ben L. Schooley and Thomas A. Horan, "Towards End-to-End Government Performance Management: Case Study of Interorganizational Information Integration in Emergency Medical Services (EMS)," *Government Information Quarterly* 24, no. 4 (October 2007): 755–84, doi:10.1016/j.giq.2007.04.001.

[30] Ibid., 757.

Forbes magazine business analytics author Bernard Marr offers ten points for making data-driven decisions. His points may be summarized by saying that businesses/agencies should focus on the strategic goals that matter most and then figure out how to best collect and display the data that will support decision making to achieve those goals.[31] Of course, cost/benefit calculations must be made as well to determine whether the effort is worth pursuing. The points on considering strategy, and what measures will define success towards meeting the strategy, seem to be particularly useful when considering how to develop a dashboard.[32]

Australian researchers Cahyadi and Prananto echo Marrs' arguments but offer much more detail. They agree that a dashboard should primarily aid organizations in achieving its key goals.[33] Of use in their article is a very detailed literature review of dashboard concepts and designs they used to inform their conclusions.[34] They argue that it is necessary to holistically understand the components of the dashboard (data and technology) as well as the organization and the roles of the personnel using the dashboard. In practice this means that dashboard designers need to involve end users in the development of effective dashboards.[35] Cahyadi and Prananto posit that an organization should have a single dashboard to inform all members but that different members should have the ability to view the underlying data to satisfy the varying needs of their roles.[36]

French authors Bharosa et al. look at the creation of dashboards for emergency services organizations and come to a different conclusion. Although they agree that dashboards should be "visual display(s) of the most important information needed to

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[31] For a discussion of MCFRS goals and program measures see the problem statement.

[32] Bernard Marr, "Data-Driven Decision Making: 10 Simple Steps For Any Business," *Forbes*, June 14, 2016, http://www.forbes.com/sites/bernardmarr/2016/06/14/data-driven-decision-making-10-simple-steps-for-any-business/#4ecba6377283.

[33] Amelia Cahyadi and Adi Prananto, "Reflecting Design Thinking: A Case Study of the Process of Designing Dashboards," *Journal of Systems and Information Technology* 17 (2015): 286, doi:10.1108/JSIT-03-2015-0018.

[34] Ibid., 288–90.

[35] Ibid., 292.

[36] Ibid., 298 (they refer to this concept as a "single source of truth").

achieve…objectives," they argue that separate dashboards should be developed for personnel working at strategic, tactical or operational levels within an organization.[37] The time frames covered by such dashboards would differ in the data measured and displayed and by the level of detail provided.[38] Bharosa et al. agree that involvement of the end user(s) is very important in the development of a successful dashboard.[39]

In summary, all of the articles reviewed agreed that a dashboard should display information that supports the goals of an organization and that dashboards should be developed with the active participation and approval of the end user(s). Further research is required to make a decision on whether a "single source of truth" (one dashboard fits all) is better for fire service organizations or whether tailored dashboards are needed for personnel making decisions at the strategic, tactical or operational levels.[40]

C. USE OF DASHBOARDS BY THE FIRE SERVICE AND RELATED INDUSTRIES

Since the use of real-time dashboards is a relatively new phenomenon, there are few articles available that examine this usage by fire service agencies or even other somewhat similar industries such as healthcare, police, or the military. However, a few instructive related case studies were found.

Yang et al. offer a fascinating look at the development of an emergency response information platform for use by the Beijing Fire Department during the 2008 Summer Olympics. They use the concept of decision support systems (DSS) that inform but do not direct the human decision maker.[41] They state that such a system has to be 100 percent reliable to gain acceptance by firefighters and must be used on a daily basis so that it will

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[37] Nitesh Bharosa et al., "Designing and Evaluating Dashboards for Multi-Agency Crisis Preparation: A Living Lab," in *Electronic Government*, eds. Maria A. Wimmer, Jean-Loup Chappelet, Marijn Janssen, and Hans J. Scholl, 6228: 182 (Berlin: Springer Berlin Heidelberg, 2010), http://link.springer.com/10.1007/978-3-642-14799-9_16.

[38] Ibid., 184.

[39] Ibid., 183.

[40] Cahyadi and Pranato, "Reflecting Design Thinking," 298.

[41] Lili Yang, Guofeng Su, and Hongyong Yuan, "Design Principles of Integrated Information Platform for Emergency Responses: The Case of 2008 Beijing Olympic Games," *Information Systems Research* 23 (2012): 765, doi:10.1287/isre.1110.0387.

be of maximum utility during emergencies. These ideas are so widely shared among experienced fire service managers, that they may be considered fire service dogma.[42] Yang et al. also discuss the use of action research in their project.[43] Although this project did not develop a dashboard per se (it instead developed a DSS to help mitigate the effect of fires in buildings within the Olympic complex), it does offer a template for others to follow when considering the development of Information Science (IS) projects for the fire service.

The healthcare industry has also contributed case studies in the use of dashboards. Stone-Griffith et al. examine the use of a dashboard in an emergency department (ED) that resulted in decreasing door-to-physician times, lessening of length of stay, and improving documentation and quality of care. These benefits were accrued even in the face of a significant rise in the number of patients presenting to the ED.[44] Stone-Griffith et al. explained that the designers of the dashboard drilled down into the many sub-processes that affect patient throughput in an ED so that the users of the dashboards could identify problem areas and fix them quickly during the course of a day.

Finally, a search through recent thesis published at the Naval Postgraduate School yields one examining the use of "Knowledge Visualizations" as part of proposed decision support systems available to officers of the United States Marine Corp.[45] Similar to Bharosa et. al, the authors discuss what information should be available to what level of supervisor and how that is to be accomplished. Interestingly, the authors do discuss the phenomenon of different levels of management deliberately not reporting information in an effort to produce desired outcomes among subordinates or supervisors. Although the work is not directly translatable to the fire service, Hudson and Rzasas' insight that "in order to be able to quickly glean actionable information…, the user must be able to

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[42] Merriam-Webster defines dogma as "something held as established opinion,"; *Merriam-Webster*, s.v. "Dogma," accessed July 13, 2017, https://www.merriam-webster.com/dictionary/dogma.

[43] Yang, Su, and Yuan, "Design Principles," 765.

[44] Suzanne Stone-Griffith et al., "Data-Driven Process and Operational Improvement in the Emergency Department: The ED Dashboard and Reporting Application," *Journal of Healthcare Management* 57, no. 3 (June 2012): 167–80.

[45] Paul C. Hudson and Jeffrey A. Rzasa, "Knowledge Visualizations: A Tool to Achieve Optimized Operational Decision Making and Data Integration" (master's thesis, Naval Postgraduate School, 2015).

quickly orient and interpret presented visualizations" would seem to be applicable to any time critical decision support system or dashboard.[46]

D. CONCLUSION

This literature review sought to survey existing published research on dashboard design and the real-time use of data to support decision making from a fire service perspective. Even though the research on fire service dashboard usage is extremely limited, there is a body of work that does support research into the subject of dashboard development for fire departments. Sufficient published research is available from other industries and the military to support theory development of fire service dashboard design and processes.

[46] Hudson and Jeffrey A. Rzasa, "Knowledge Visualizations," 93.

III. A BRIEF HISTORY OF PERFORMANCE MEASUREMENT IN LOCAL GOVERNMENTS AND FIRE DEPARTMENTS

In order to understand what is necessary to measure on a real-time fire department dashboard, it is instructive to look back at how fire service performance has been measured in the past. However, it is also necessary to look at this measurement process within the global context of government performance measurements.

> Americans suspect their government is both ineffective and inefficient. Yet if public agencies are to accomplish public purposes, they need the public's support. Performance measures can contribute to such support by revealing not only when government institutions are failing, but also when they are doing a good or excellent job.[47]

As captured in the quote above, in the last several decades, governments at all levels in the United States (and other countries) have turned to performance measurement as a way of improving services and to try to assure a suspicious electorate that their tax dollars are being used to fund worthy and productive programs. In the early part of the 21st century programs such as CityStat in Baltimore and the Atlanta Dashboard heralded a new era of transparency.[48] These types of publicly accessible reports quickly spread as governments sought to assure their citizens that tax funded municipal departments and agencies were both effective and efficient.

It is worth mentioning again that effective and efficient are not synonymous. As defined by Jennifer Flynn of the National Fire Protection Association, effectiveness is a measure how well one performs a certain task, and efficiency has to do with how few resources (monetary, personnel, and physical) one uses to accomplish that task.[49] It is intuitive that these two factors can sometimes compete with each other; i.e., in the pursuit of maximum efficiency, government managers can deprive programs of sufficient resources to be effective; or vice versa that the perfectly effective program would

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[47] Robert D. Behn, "Why Measure Performance," 591.

[48] David Edwards and John Clayton Thomas, "Developing a Municipal Performance-Measurement System: Reflections on the Atlanta Dashboard," *Public Administration Review* 65, no. 3 (May 2005): 371.

[49] Flynn, "Fire Service Performance Measures."

consume many more resources than desired. Edwards captures this dichotomy well by discussing citizens as being simultaneously owners who want to slash unneeded spending, and consumers who "care about the scope and quality of services being provided."[50]

So why do governmental agencies set up measuring systems? Robert Behn suggests that program measures are best used for improving performance, with all other considerations being secondary.[51] The International City/County Management Association (ICMA) states that governments should use performance measures "to promote greater accountability…and communication with citizens."[52] These approaches seem complimentary as it is important for governments to measure their effectiveness and efficiency to improve services, but to also "sell" themselves to those that must bear the burden of the costs so that resources are not cut by an ill informed electorate.

As with other municipal agencies, Fire Departments have certainly had to face this wave of measurement head on and for reasons that will be discussed later are perhaps more vulnerable than many other municipal agencies due to apparent low efficiency. This chapter will therefore consider historical program measures for fire departments in the context of improving services and proving value to citizens. To do this, this chapter will consider broad types of program measures and their applicability to the fire service. This chapter will then delve into the why and how of specific program measures that have been used in evaluating and improving fire department service delivery.

A. DEFINITION OF PROGRAM MEASURES

Governmental agencies, through their budgeting process, have long used the amount of financial resources invested as a staple of an input measurement. As a representative example, the two key pieces of input information contained in the

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[50] Edwards and Thomas, "Developing a Municipal Performance-Measurement System," 371.

[51] Behn, "Why Measure Performance," 588. Behn also notes that secondary considerations would include "evaluating, controlling, budgeting, motivating, promoting, celebrating, and learning" for both internal and external stakeholders.

[52] "Performance Management," ICMA, accessed December 10, 2016, http://icma.org/en/international/services/expertise/performance_management.

Montgomery County, Maryland annual budget book are spending and full time equivalent employees (FTE).[53] Spending is usually measured in actual dollars expended, and FTEs are usually measured in tenths of whole numbers based on the number of labor hours expended upon a task or function. Normally a FTE is considered to be 2080 labor hours per year and a FTE measurement can be derived by dividing the number of labor hours by 2080.[54]

After considering inputs, the results or effectiveness of government programs are usually broken down into outputs or outcomes.[55] Outputs are usually defined as a tangible, discrete products or processes; for example the number of speeding citations issued by a police department or the number of incident responses made by a fire department would both be outputs.[56] Outcomes are usually defined more broadly and "address the achievements or consequences of supplying public services to targeted recipients."[57] An example of an outcome for a fire department fire prevention program would be fewer fires per capita; or for a police department a reduction in crime rates for a community after hiring more police officers. Outcomes can also address the quality of programs or the perception of quality of programs by citing surveyed stakeholder or public satisfaction with a particular program or department. Effectiveness of services can thus be measured by either outputs or outcomes or sometimes even both. Efficiency is usually measured by the outputs (or outcomes) divided by the inputs.

How does an agency know which outputs or outcomes to measure so that it's effectiveness and efficiency can truly be measured? Both Wang and Behn separately

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[53] Montgomery County, Maryland Office of Management and Budget, "Montgomery County, Maryland FY 2017 Approved Operating Budget" (budget report, Montgomery County Maryland, 2016), http://www.montgomerycountymd.gov/OMB/Resources/Files/omb/pdfs/fy17/psp_pdf/FY17_Approved_MCG_Budget.pdf.

[54] Ibid.

[55] United States General Accounting Office, *Performance Measurement and Evaluation*, GAO/GGD-98-26 (Washington, DC: United States General Accounting Office, 1998), 3.

[56] Deborah Mills-Scofield, "It's Not Just Semantics: Managing Outcomes vs. Outputs," *Harvard Business Review*, November 26, 2012, https://hbr.org/2012/11/its-not-just-semantics-managing-outcomes.

[57] Xiao Hu Wang, "Perception and Reality in Developing a Performance Measurement System," *International Journal of Public Administration* 25, no. 6 (January 2002): 808, doi:10.1081/PAD-120003819.

suggest that both outputs and outcomes need to be related to the goals or core functions of an agency.[58] Flynn explicitly identifies this relation as a necessary step and states that the "first step to evaluating performance" (i.e., evaluating effectiveness) is to "clearly identify the goals and purpose of the department."[59] After the core functions of an agency are identified, goal setting may be done for outputs and outcomes. It is recommended that agencies seek the input of stakeholders in setting such goals. Stakeholders typically include citizens (or users of the service), funding bodies, and professional groups within the organization.[60] Goals should be "practical,…valid, reliable, and easy to understand."[61]

Measures of progress towards these output and outcome goals then seeks to understand what an agency is excelling at, where it needs to improve, and how to make changes to effect improvements.[62] Evaluation of said measures is usually done by benchmarking, which is the process of comparing achievement to historical data or data gathered from like entities or to standards set by trade groups. The purpose of such an exercise is to fix any gaps that are identified.[63] Edwards summarizes this process, stating "by comparing the operational profile of similarly situated organizations, opportunities for improved performance (effectiveness) can be uncovered."[64]

Behn flatly states that measuring is useless unless one intends to do something with the results.[65] To carry this thought to its logical conclusions, there is a reasonable argument to be made that an organization shouldn't measure unless it has the capacity to

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[58] Wang, "Perception and Reality," 808; see also Behn, "Why Measure Performance," 598.

[59] Flynn, "Fire Service Performance Measures," 44.

[60] Louise Kloot, "Performance Measurement and Accountability in an Australian Fire Service," *International Journal of Public Sector Management* 22, no. 2 (February 2009): 129, doi:10.1108/09513550910934538.

[61] Evan Berman and Xiao Hu Wang, "Performance Measurement in U.S. Counties: Capacity for Reform," *Public Administration Review* 60, no. 5 (September 2000): 411, doi:10.1111/0033-3352.00104.

[62] Behn, "Why Measure Performance," 596.

[63] Ibid.

[64] David Edwards, *Smarter, Faster, Cheaper: An Operations Efficiency Benchmarking Study of 100 American Cities* (Somers, NY: IBM, 2011), 21.

[65] Behn, "Why Measure Performance," 586.

do so and use the results. It is necessary that government agencies that propose to measure their programs have buy-in from elected officials and department heads. Other required capabilities include the ability to "relate outputs to operations; …collect timely data"; and to also have sufficient staff and IT resources to analyze performance data.[66]

In the book *The 4 Disciplines of Execution*, the authors discuss lead and lag program measures. Lag program measures are defined as "tracking measures…[of] performance that is already in the past," while lead measures are defined as the "measures of new behaviors that will drive success on the lag measures."[67] These concepts will be discussed more in depth in subsequent chapters but they are relevant to keep in mind while considering what the fire service has measured in the past. As will be discussed below, historically, fire service agencies have only tracked lag measures.

B. FIRE DEPARTMENT PROGRAM MEASURES

Fire Departments usually have required staffing levels, and as a result usually have personnel costs as a very high percentage of their budget. In a jurisdiction that has few fire incidents, that factor can make the Fire Department appear to be very inefficient and the public may perceive that firefighters have little to occupy their time besides administrative tasks such as checking and washing the trucks. It is important to note that many fire departments do provide other service lines such as emergency medical services (EMS), hazardous materials (HazMat) incident response and the like.

Fire Departments have historically identified their core goal as the protection of life and property, although due to the growth of the mission set of todays all hazards fire department this statement is perhaps too simplistic. The mission statement of the Montgomery County, Maryland Fire and Rescue Service (MCFRS) is a representative example: "The mission of the Montgomery County Fire and Rescue Service is to protect lives, property and the environment with comprehensive risk reduction programs and

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[66] Berman and Wang, "Performance Measurement in U.S. Counties," 418. Interestingly, the authors estimate that only one third of county governments across the U.S. use performance measures and of those counties, only one third have the capabilities necessary to support such programs.

[67] Chris McChesney, Sean Covey, and Jim Huling, *The 4 Disciplines of Execution* (New York: Free Press, 2012), 11.

safe, efficient, and effective emergency response provided by skilled, motivated, and compassionate career and volunteer service providers representing Montgomery County's diverse population."[68] But how does a fire department measure such lofty promises?

Traditionally, fire departments have measured the output of response times to fires and used them as a proxy measure to suggest effectiveness.[69] But does response time alone equal effectiveness? An average response time of 4 minutes to every fire sounds excellent, until one realizes that this means one fire engine with two minimally trained firefighters showed up to fight a 10 acre brush fire and failed to keep it from growing, but nonetheless met the output goal of a 4 minute response time. So this example would suggest that a more comprehensive way to measure fire department effectiveness is needed.

The oldest effort to comprehensively measure fire department effectiveness was developed by the Insurance Services Office (ISO). The ISO, now a private company, was at first developed by a consortium of insurance company rating bureaus that (among other insurance issues) were interested in assessing risk from fire loss.[70] The ISO theorized that by measuring fire department capabilities ahead of time, that one could infer reasonable judgements about Fire Department effectiveness. Thus, the ISO developed the Public Protection Classification system to rate fire protection services in particular localities, and offered these assessments to the insurance industry so that individual insurance companies had a way of calculating fire insurance premium rates in individual communities. The PPC was and still is a point system based on assessing a communities capabilities in the following areas:

- A fire departments ability to answer and dispatch emergency calls,
- Fire department equipment, staffing and training,
- The water available to fight fires (whether through a municipal distribution system or by accessible drought proof natural sources),

[68] Montgomery County Fire and Rescue Service. "About."

[69] Flynn, "Fire Service Performance Measures," 18.

[70] Marianne Bonner, "Insurance Services Office (ISO)," The Balance, last updated October 5, 2017, https://www.thebalance.com/insurance-services-office-iso-462706.

- The presence and enforcement of fire codes in a community.[71]

Although the PPC is mostly organized in a static checklist fashion (e.g., points are awarded based on how many 911 circuits a community has, and how many fire station and engines are present), the PPC rating scale does include some output measures such as how many training hours were completed by a fire department, and on average how many firefighters attended each fire incident. The ISO PPC system did (and to some extent still does) serve as a badge of Fire Department effectiveness, with the few fire departments having the best PPC Rating of "Class 1" proudly touting that feat on their publications and vehicles. However, in 2007 the inadequacies of the PPC rating system were dramatically exposed by the "Super Sofa" fire in Charleston, South Carolina, when the "Class 1" Charleston Fire Department suffered 9 firefighter fatalities while failing to keep a relatively small fire from growing to engulf the building.[72] Despite the Class 1 rating, a respected review panel found that the CFD was "inadequately staffed, inadequately trained, insufficiently equipped and organizationally unprepared to conduct an operation of this complexity in a large commercial occupancy."[73] As noted above, these are the various factors that the PPC is supposed to be rating a fire department on.

In the last two decades fire service industry groups have suggested but not mandated other possible output and outcome measurements. Among these groups are the National Fire Protection Association (NFPA), and the Commission on Fire Agency Accreditation International (CFAI), which make suggestions for measures on fire suppression outputs and outcomes. Fire service agencies that also perform Emergency Medical Services (EMS) can also look to the efforts of groups such as the American Ambulance Association, the American Heart Association, the Consortium of the U.S. Metropolitan Municipalities' EMS Medical Directors, and the EMS Compass project.

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[71] "How the PPC Program Works," Insurance Services Office, accessed May 3, 2017, https://www.isomitigation.com/program-works/how-the-ppc-program-works.html.

[72] "Nine Career Fire Fighters Die in Rapid Fire Progression at Commercial Furniture Showroom—South Carolina," Centers for Disease Control and Prevention, February 11, 2009, /www.cdc.gov/niosh/fire/reports/face200718.html.

[73] J. Gordon Routley et al., "Firefighter Fatality Investigative Report: Super Sofa Store" (after-action report, City of Charleston, 2008), 134, http://downloads.pennnet.com/fe/misc/20080515charleston report.pdf.

C. FIRE SUPPRESSION AND PREVENTION MEASURES

Behn suggests that a combination of output and outcome measures is necessary to capture the whole of the state of organizational effectiveness. He suggests that by focusing internally on output measures, and improving such, organizations can realize gains in outcomes.[74] Both the NFPA and CFAI recommend goals which seem to adhere to this principle; for example three core fire suppression outcome measures which are proposed by both are the following: the percentage of times that a fire department confines a fire to the room (or structure) of origin, fire deaths and injuries per capita, and the number of firefighter injuries.[75] All of these externally reported outcome measures encompass a variety of subordinate output measurements. It is useful to examine these in depth in turn to understand this process.

The effective ability of a fire department to successfully confine a fire to the room of origin is dependent on a host of output measures of timeliness, including how quickly 911 dispatchers receive and process the call (requires sufficient phone lines, trained 911 call takers, and trained dispatchers), how quickly responsible fire stations are dispatched (depends on a well thought out response plan, computer aided dispatch, and trained dispatchers), how quickly the fire stations respond to the call (requires thought out deployment of fire companies such that there are sufficient companies available for the fire), and how quickly water is applied to the fire (requires enough trained firefighters armed with the right tools and apparatus to do the job).

All of these subsidiary outputs can be objectively measured in their own right, but it is by putting them together in this one outcome measure of ability to confine the fire to the room of origin that the effectiveness of the fire department at fire suppression can be quantitatively measured. Conversely the fire department can show that degradations in any of the subsidiary output measurements will affect the overall outcome.

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[74] Behn, "Why Measure Performance," 595.

[75] Flynn, "Fire Department Performance Measures," 20.

This outcome measure is applicable to departments of all sizes as well. Smaller, more rurally situated fire departments can measure effectiveness by the percentage of confinement of fires to the room as well as by the percentage of times the fire is confined to the structure of origin. This recalibration of this outcome measure makes allowances for the geographic and staffing challenges faced by these departments, but lets the public know what is realistic to expect in terms of effectiveness of service delivery. Interestingly, fire brigades in Australia and the United Kingdom also use this measure.[76]

Similarly, the outcome measure of the amount of fire deaths and fire injuries per capita is dependent upon fire codes (requiring a robust lobbying effort by departments to overcome builder reluctance to install measures such as sprinklers and hardwired smoke and heat alarms), fire prevention efforts (to enforce codes and educate the public on their importance), dispatch procedures to tell callers to exit structures on fire, timely response by fire companies to rescue trapped occupants, and data analysis to understand if and why there are sub-groups amongst the population that are especially susceptible to fire injuries and deaths.

Finally, the outcome measure of the number of firefighter injuries encompasses the ability of a fire department to operate safely, but is sometimes directly related to the number of fires attended and is also sometimes inversely related to efficiency (i.e., if a fire is attended by less firefighters, the risk of injury rises).[77] Despite these variables, this measure may be important for benchmarking efforts (i.e., developing best practices) if fire service agencies can identify industry partners that are fairly similar in terms of size (of department and area/population served).

D. EMERGENCY MEDICAL SERVICES (EMS) MEASURES

Similar to fire suppression, EMS delivery effectiveness has been traditionally measured by the output measurement of response time; e.g., how fast does the ambulance

[76] Kloot, "Performance Measurement and Accountability," 136.

[77] Flynn, "Fire Service Performance Measures," 22.

show up to take Mrs. Smith to the hospital.[78] This measure, of course, is subject to the same issues identified with measuring fire incident response times, in that it does not really measure the outcome of the service delivered. It also ignores the reality that EMS agencies deal with a patient population that has a great deal of variety in terms of chief complaints and medical issues.

An EMS outcome measure that encompasses a variety of output measures is that of cardiac arrest survival.[79] This outcome is dependent on the following output measurements of timeliness: timely notification of 911 (requires recognition of the emergency by the public, sufficient phone lines, trained 911 call takers, and trained dispatchers), timely notification of responsible fire stations (depends on a well thought out response plan, computer aided dispatch, and trained dispatchers), and the timely response of personnel and equipment (requires thought out deployment of fire companies such that there are sufficient companies available for the incident). The effectiveness at ensuring cardiac arrest survival is also dependent on the skilled care of basic and advanced life support providers and on the availability of effective public CPR and AED deployment efforts, which is in turn dependent on public education programs and legislation to support such. All of these subcomponents can be measured by output measures.

Myers et al. criticized the reliance on response times for their respective loose association with patient outcomes, and also criticized measuring cardiac arrest survival since this measure focuses on only a tiny subset of the EMS patient population. They proposed a much broader range of output and outcome measures for a benchmarking process involving medium to large EMS agencies.[80] This earlier work led to subsequent collaborative efforts by the National Association of State EMS Officials and the National

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[78] J. Brent Myers et al., "Evidence-Based Performance Measures for Emergency Medical Services Systems: A Model for Expanded EMS Benchmarking: A Statement Developed by the 2007 Consortium U.S. Metropolitan Municipalities' EMS Medical Directors (Appendix)," *Prehospital Emergency Care* 12, no. 2 (January 2008): 142, doi:10.1080/10903120801903793.

[79] Myers et al., "Evidence-Based Performance Measures," 143.

[80] Myers et al., "Evidence-Based Performance Measures," 147. The authors propose measuring speed and completeness of detection and treatment for heart attack, congestive heart failure, asthma, seizure and trauma patients.

Highway Traffic Safety Administration to develop a broad set of EMS program output and outcome measures called the EMS Compass project.[81] This work is on-going but does show promise of being uniform and able to measure the effectiveness and efficiency of the service provided.

E. COMMISSION ON FIRE ACCREDITATION INTERNATIONAL

The Commission on Fire Accreditation International (CFAI) was established as a joint venture in 1996 by the International Association of Fire Chiefs and the International City/County Management Association and throughout its history has had significant representation from other fire service industry groups such as the ISO, the NFPA and the International Association of Fire Fighters.[82]

The stated goal of the CFAI Accreditation Process is to:

- "Determine community risk and safety needs and develop community-specific Standards of Cover.
- Evaluate the performance of the (fire) department.
- Establish a method for achieving continuous organizational improvement."[83]

The CFAI accreditation process encourages fire service agencies to measure themselves using a large range of output and outcome measures that provide insight into all of the functions that modern fire service agencies perform. Although these measures will be explored more fully in following chapters, an example of a typical CFAI output is measuring the ability of the fire department to respond to incidents in a stated number of minutes 90% of the time. A typical outcome measure is the aforementioned percentage of incidents when fires were confined to the room of origin. What the measures are is important but the process of assessment and improvement is what is key to the CFAI

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81 "About EMS Compass," accessed May 7, 2017, https://www.emscompass.org/about-ems-compass/.

82 "History of the Center for Public Safety Excellence," accessed May 7, 2017, www.cpse.org/about-cpse/cpse-history.aspx.

83 "About CFAI Accreditation," Center for Public Safety Excellence, accessed May 7, 2017, /www.cpse.org/agency-accreditation/about-accreditation-cfai.aspx.

process. In fact, in order to maintain accreditation, each accredited agency is required to identify gaps and show improvement in fixing those gaps.

The strength and the weakness of the CFAI approach is in its ability to be tailored to each agency. This is a strength because fire service agencies of all sizes and mission sets can participate, can determine what their local needs and goals are, and can work towards a process of constant improvement. It's a weakness because no two CFAI agencies are measured the same and they are all fulfilling (slightly or widely) different mission sets. Nor does CFAI require that agencies share their data or results; so it is up to each agency as to how much of their CFAI data that they publically release.

Despite the CFAI, and because of the lack of uniform goals, measurements, and transparency, external benchmarking in the fire service still remains difficult. For example, MCFRS as part of the National Capital Region, cooperates closely with neighboring fire service agencies but has no idea whether they are as effective at taking care of their patients but at a lower cost. Nor is there an ability to benchmark against the other several hundred accredited fire departments across the country. Joint benchmarking efforts should be encouraged in the fire service to assist with global improvement efforts as suggested by Behn and others.

In summary, the fire service as a whole, has moved from solely measuring simple program outputs, to examining program outcomes which better represent the effectiveness and efficiency of the services provided. All of these measures can be considered lagging measures. The CFAI Accreditation process, although it does have some limitations, does represent the current state of the art in fire service program measurement. Subsequent chapters in this thesis will more closely examine the CFAI Accreditation process as well as other modern program measurements. These systems of measurement should represent a natural springboard for developing a real-time fire department dashboard that would feature lead measures that would affect the lag program measures.

IV. APPLYING PRINCIPLES OF BUSINESS INTELLIGENCE TO THE FIRE SERVICE

Because dashboards are a new tool to the fire service, to answer the question of how fire service agencies can use Business Intelligence and dashboards to support decision making, it is necessary to examine modern Business Intelligence principles, look at other industry's use of dashboards, and then distill the principles learned to apply to the fire service.

A. INTERNAL FACTORS

In his brief Forbes magazine article "Data-Driven Decision Making," Bernard Marr states that "data leads to insights; business owners and managers can turn those insights into decisions…that improve the business."[84] In the article he argues that business owners should first focus on their strategic goals, and then figure out which one or two business areas most affect those goals. He then argues that the business needs to figure out how to measure and analyze the business area, and then finally how to present the results so that decisions can be made.

Similarly, in "The Four Disciplines of Execution," the authors recommend focusing on one or two important goals, and then figuring out a measure that captures progress towards meeting this goal. This measure is frequently a "lag" measure, which they define a measurement made in the past and over such a period of time that it is unable to be immediately affected by the business. The authors then recommend capturing a "lead" measure which can be analyzed over a short period of time and is affected by the actions of the business, and which in turn affects progressing towards achieving the lag measure. Both measures are to be displayed on a dashboard that is designed to clearly communicate the status of the measures at a glance. The use of this

[84] Bernard Marr, "Data-Driven Decision Making: 10 Simple Steps For Any Business," *Forbes*, June 14, 2016, http://www.forbes.com/sites/bernardmarr/2016/06/14/data-driven-decision-making-10-simple-steps-for-any-business/#4ecba6377283.

dashboard drives a weekly team work cycle of performance, measurement, and feedback.[85]

The HCA, Inc. company reported on the development of an Emergency Department (ED) dashboard which lead to improvements in the amount of emergency patients treated in several HCA owned hospitals. HCA identified that patient throughput (the amount of time that the patient spends in the ED) was the goal that needed to be improved, and decided to measure progress towards this goal by including four simple measures. These measures were derived after much internal study of processes inherent to a patient visit and included: time to put patient in a bed, time until patient was seen by a medical provider (Physician, Physician's Assistant, or Nurse Practitioner), time until the patient was discharged to other area of the hospital or to home, and time that patient physically left the ED. This dashboard was updated in real time and progress (or lack thereof) could be readily seen on any of these measures. Measures that were experiencing lack of progress were analyzed to further identify and overcome bottlenecks.[86]

This article did not specifically refer to lead and lag measures, nor weekly work cycles but the amount of patients seen in on a yearly basis compared to the average time spent in the ED by patients can be seen as the lag measure. Clearly HCA engaged in some profound introspection to come up with the five metrics mentioned above, which served as lead measures. In any case, HCA was able to drop the average time per visit by 20 minutes (10%), while increasing the patient volume by nearly 15%. Perhaps most importantly, time until patient contact with a provider decreased from 50 minutes to 25 minutes, or by nearly 50%.[87]

Bruce Chorpita et al. discussed the development of a dashboard to assist in measuring patient throughput and progress in a behavioral health practice. The authors went through a similar process to HCA to map internal business processes and milestones and chose to measure progress through intake and eligibility determination (measured in

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[85] McChesney, Covey, and Huling, *4 Disciplines of Execution*.

[86] Stone-Griffith et al., "Data-Driven Process."

[87] Ibid., 175.

days), and quality improvement processes. The authors chose to measure over a week, and the program featured weekly meetings between clinicians and supervisors and the use of an easy to understand visual dashboard. Again, the authors did not discuss lag or lead measures but their processes of establishing their dashboard program is analogous to those described by Marr and McCheney.[88]

Synthesizing from the Marr article, the *4 Disciplines of Execution* book, and case studies, it seems apparent that when establishing a successful dashboard program, the strategic goal and lag measures should be derived first, with lead measures established after a careful examination of business processes.[89] Lead measurement cycle lengths are also important so that team members can affect the measures and see the effects of their efforts.

Therefore, when discussing the establishment of a fire service dashboard, it would therefore seem logical to first decide upon the strategic goals and lag measurements. The MCFRS has a lag measure set reported quarterly on its public Countystat report card (Figure 1). This measure set represents a distillation of all of MCFRS performance and quality measurement goals into a representative scorecard that represents several functions of the department; i.e., fire suppression, fire prevention and Emergency Medical Services. These measures are jointly decided upon by the department and the Montgomery County Countystat Office, and are also based upon core competencies as determined by the CFAI process. However, the scorecard seems to be somewhat complicated, and the performance period of a quarter means that the data cannot be easily affected or measured on a day to day or real-time basis.

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[88] Bruce F. Chorpita, Adam Bernstein, and Eric L. Daleiden, "Driving with Roadmaps and Dashboards: Using Information Resources to Structure the Decision Models in Service Organizations," *Administration and Policy in Mental Health and Mental Health Services Research* 35, no. 1–2 (March 2008): 114–23, doi:10.1007/s10488-007-0151-x.

[89] Ibid., 117.

Figure 2. Montgomery County Countystat Scorecard[90]

Although the modern fire service provides many services, as discussed in Chapter 3 perhaps the ideal focused strategic goal and lag measurement for fire suppression is the percent of structure fires held to the room of origin. Similarly for Emergency Medical Services (EMS), perhaps the percent of stroke and heart attack patients transported to the ED within 30 minutes of calling 911, and with a complete "bundle of care"; and the percent of cardiac arrest victims who are resuscitated, provide lag measures that indicate overall effectiveness and quality of care.[91]

Therefore the next step should be to map business processes that make up these measures and then identify lead measures that can be easily affected. The diagram in Figure 3 would be a schematic of the business process to put out a structure fire; the diagram in Figure 4would represent the business process with measuring points added.

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[90] Source: "MCFRS Headline Performance Measurements," CountyStat, accessed July 13, 2017, https://reports.data.montgomerycountymd.gov/countystat/department/mcfrs.

[91] The "bundle of care" is a concept of measurement pioneered by the London (U.K.) Ambulance Service. The bundle includes the 4 to 5 key elements that predicts the quality of care for a certain syndrome. For instance, the bundle of care for a heart attack victim includes acquiring a 12 lead ECG, transmitting the 12 lead ECG to the hospital, administering aspirin and nitroglycerin to relieve chest pain, and taking the patient to a hospital equipped with a cardiac intervention unit. These elements are measured by their inclusion within the patient care report submitted electronically by the paramedic in attendance.

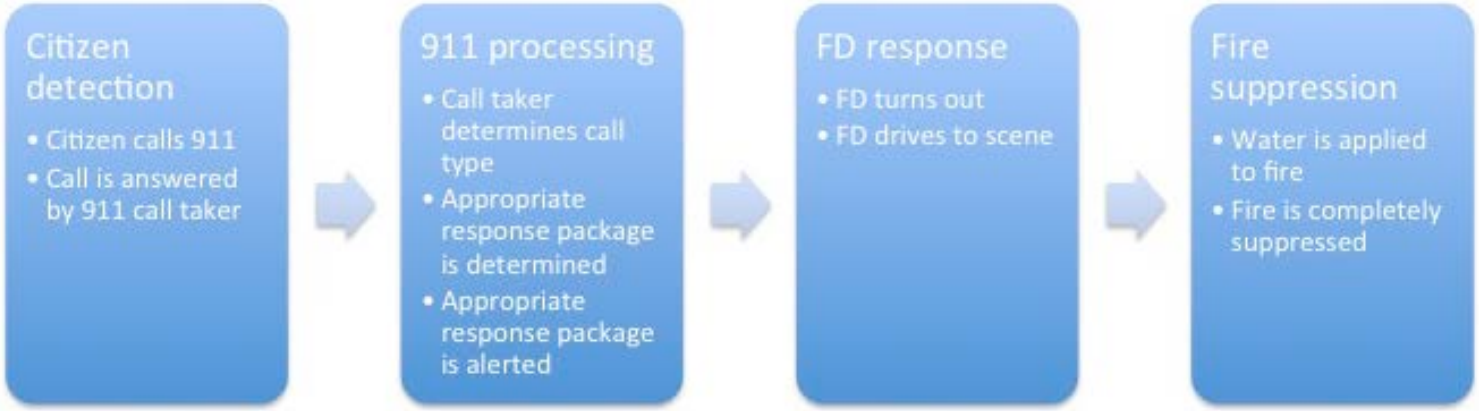

Figure 3. Fire Suppression Business Process

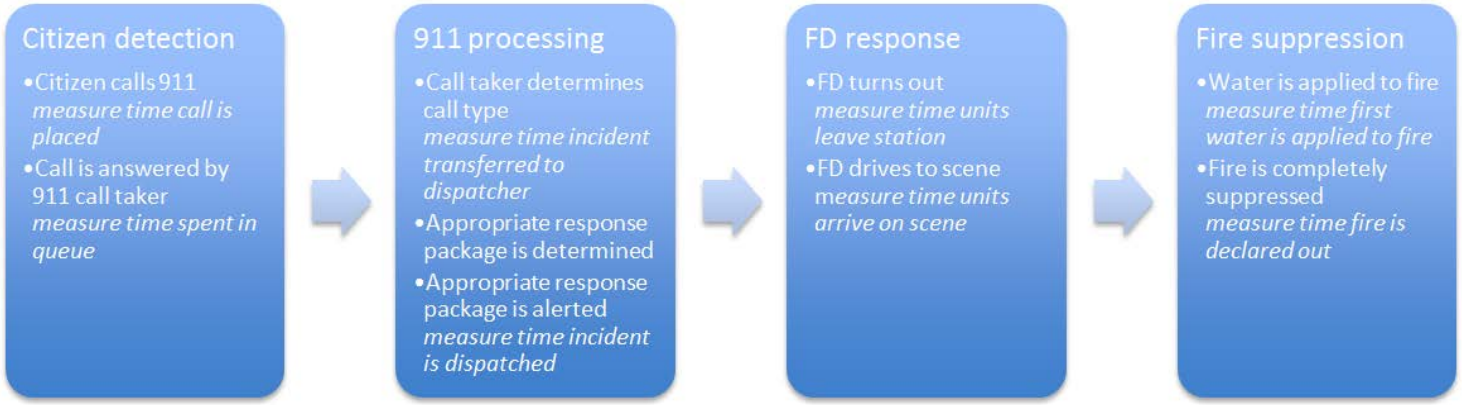

Figure 4. Fire Suppression Business Process with Measures

From this diagram, time intervals that can and cannot be affected by the fire service can be determined.

Interval 1 (Citizen Detection): The time from when the 911 call is placed by the citizen until the call is answered by 911 call taker. This measure is directly affected by the number of call takers available to answer calls. The availability of the call taker is secondarily affected by the call load, and the amount of time that each call taker takes processing each call.

Interval 2 (911 Processing): The time from when the 911 call is answered until the call is dispatched. This measure is affected by the amount of time the call taker takes figuring out what the caller needs, and by the amount of time the dispatcher spends figuring out what units to alert. To a large extent these tasks are automated by pre-determined question scripts and by pre-determined unit assignments based on location and call type. This interval is secondarily affected by call load and the number of dispatchers available to handle the call.

Interval 3 (FD Response): The time from when the call is dispatched until the arrival of first unit with water. This measure is affected by the amount of time it takes Fire Department (FD) personnel to walk to the units, get dressed in appropriate personal protective gear, board the units, and start driving out of the station. It is subsequently affected by travel time to the scene. This measure is secondarily affected by the availability of the closest units and traffic conditions.

Interval 4 (Fire Suppression): The time from the arrival of the first unit with water until the fire is completely suppressed. This measure is affected by how long it takes the FD personnel to apply first water to the fire. Generally the faster this occurs, the faster the fire goes out. Secondarily this measure is affected by an available water supply, and the expertise of the personnel responding to the event.

According to *The 4 Disciplines of Execution*, "a good lead measure…is predictive of achieving the goal and it can be influenced (affected) by the team members."[108] Using

[108] McChesney, Covey, and Huling, *4 Disciplines of Execution*, 12.

this guideline, the two most important metrics that can be affected by FD personnel are turnout time (part of interval 3), and time to first water on fire (part of interval 4). Therefore, improvements in these lead measures on a daily basis, should create improvements in the quarterly reported lag measure of percent of fires held to room of origin.

A similar process can be done with the Emergency Medical Services (EMS) component of the fire service. In this instance, even though the treatment procedures are different, the critical syndromes of heart attacks, strokes, and even trauma care can be lumped together by their commonalities into one process as per Figure 5.

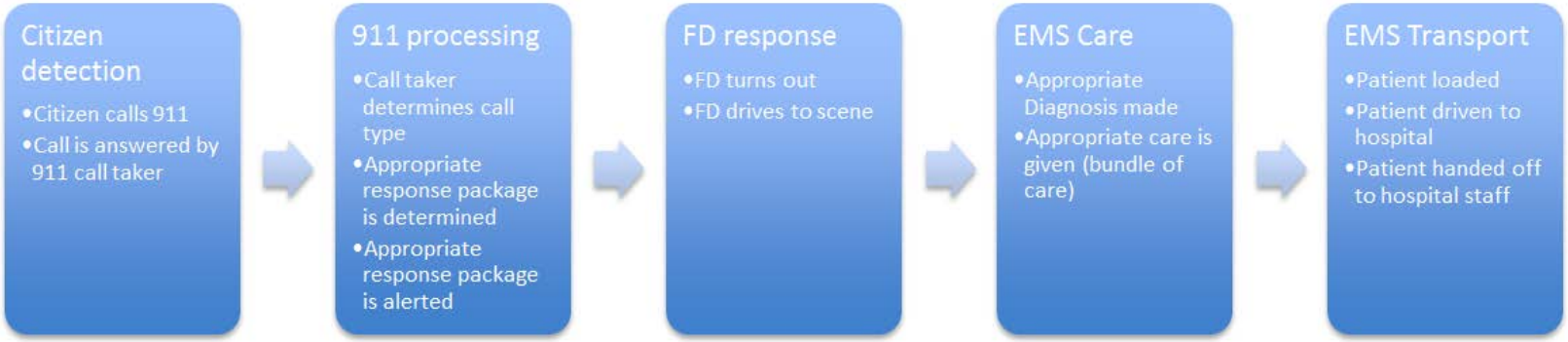

Figure 5. Business Process for Critical Care EMS Call

In this case, the lag measures would be the percent of critical patients presented to the ED within 30 minutes of calling 911 with the appropriate "bundle of care," and the number of patients who are resuscitated from cardiac arrest. These lag measures can be affected by improvements in the following time intervals that can and cannot be affected by the fire service (intervals 1 and 2 are the same as above):

Interval 3 (FD response): The time from the call dispatch until the arrival of first unit with a firefighter/paramedic. This measure is affected by the amount of time it takes FD personnel to walk to the units, board the units, and start driving out of the station. It is subsequently affected by travel time to the scene. This measure is secondarily affected by the availability of the closest units and traffic conditions.

Interval 4 (EMS Care and EMS Transport): The time from the arrival of the first unit with a firefighter/paramedic until the handoff of patient to hospital staff at the hospital. This measure is affected by how long it takes the FD personnel to diagnose the patient's condition, treat appropriately, and load the patient into the ambulance. It is also affected by the drive time to the hospital. Secondarily this measure is affected by the availability of a transport unit (ambulance), how crowded the ED is, and the expertise of the personnel responding to the event.

Interval 5 (post EMS Transport and pre FD Response): The time from the handoff of the patient at the hospital until the unit is ready for service: This measure is affected by how long it takes FD personnel to complete patient care reports, clean and restock the ambulance, and take care of any other needs.

The lead measures that FD personnel can readily affect and measure for EMS performance are:

- turn out time,
- the percentage of patients treated with the appropriate bundle of care, and
- the on scene (or patient loading) time (defined as the interval between the arrival of FD personnel and when the patient leaves the scene).

While there are, of course, other components that affect the EMS lag measures, the proposed lead measures are the ones that can be most readily affected by FD personnel, measured and reported upon in a near real-time manner.

Finally, it is necessary to decide upon a cycle length to measure and then subsequently review. Most career fire departments work some variation of a 24 hour shift schedule, with a formal meeting at the beginning of the shift. This meeting would be a natural inflection point to review the measures from the last shift, and to discuss any notable issues, and to set goals for the upcoming shift. Then progress towards meeting those goals could be readily measured and displayed throughout the shift.

B. HOW WILL THE DASHBOARD BE USED

DeShon et al. discuss improving performance thusly, "it is well known that providing goals and feedback are two of the most effective interventions."[109] Therefore, providing real-time dashboards with the above lead measures should provide a very effective feedback loop that will affect performance. In keeping with the principle that the lead measure should be influenced and readily viewable by the relevant personnel, the data would need to be aggregated or individualized in accordance with the level of supervision within the department.

There are also other lag measures affecting the health and safety of fire department personnel that should be reflected in a dashboard so as to achieve a Hawthorne like effect. Two such measures are number of firefighter injuries, and the number of collisions. Because these events receive scrutiny at the upper levels of management and the frequency of these events per quarter is low enough at the station/shift level; any number more than 0 is likely to produce renewed vigilance and increased efforts to prevent more occurrences.

[109] Richard P. DeShon et al., "A Multiple-Goal, Multilevel Model of Feedback Effects on the Regulation of Individual and Team Performance," *Journal of Applied Psychology* 89, no. 6 (2004): 1035, doi:10.1037/0021-9010.89.6.1035.

Although the preceding discussion has focused on the use of a dashboard as an improvement tool, dashboards can be and are used for more prosaic monitoring of employees tasks.[110] In the fire service context, especially at the lowest operational levels, a dashboard could be used as a supervisory tool to eliminate all of the routine but time consuming follow-up that goes on to ensure that personnel do basic rote tasks such as entering in reports, perform daily checks and the like. If this follow-up were automated, supervisors could tell at a glance whether these tasks were complete and if not, could drill down in their dashboards to see which personnel were non-compliant. Since the expectation is that these tasks will be always be completed, there is little sense in measuring the completion rate; rather the dashboard would simply be used to note exceptions or incomplete items.

Within MCFRS, day to day operational supervision is provided at three levels. Station officers (Captains) are responsible for the two to five units (engines, trucks, ambulances etc.) that respond from their station. Battalion Chiefs are responsible for the seven to nine stations within their Battalion. The Shift Operations Chief is responsible for the five Battalions that comprise the county (as seen in Figure 6) and is the highest ranking operational fire official on duty within Montgomery County at any one time. There are three shifts and the three SOCs report to the Operations Deputy Chief, who in turn reports to the Fire Chief.

[110] Cahyadi and Prananto, "Reflecting Design Thinking," 286.

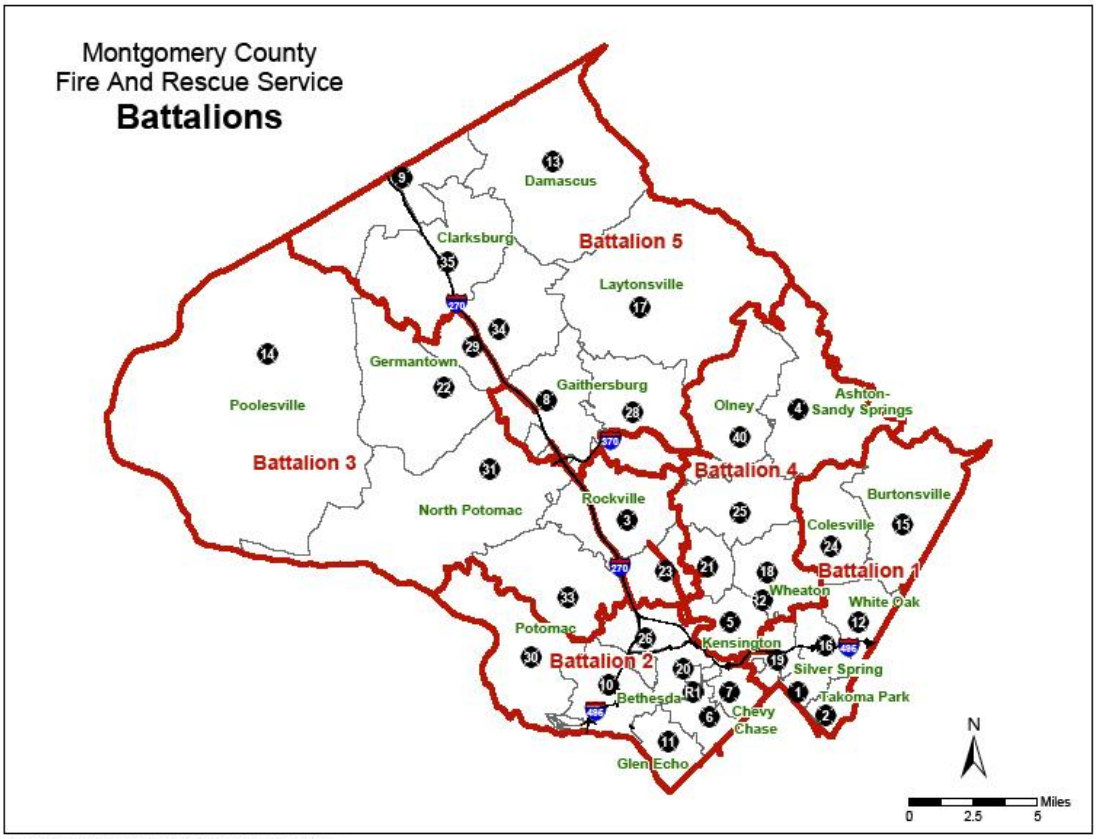

Figure 6. Map of MCFRS Battalions[111]

According to the design principles articulated above, at the station level, the station officer should be able to tell at a glance whether personnel under his or her supervision are improving upon or meeting established lead measure goals, or whether performance is declining. Similarly, the Battalion Chief in charge of several stations should be able to see overall performance for the Battalion, but should also be able to drill down to the individual station level so as to assess what work units are responsible for increases and decreases in performance. This same principle would also apply to the Shift Operations Chief, who should be able to see countywide performance but also be able to drill down to the Battalion level.

[111] Derived from an MCFRS internal document.

Cahyadi and Pranato cite in their case study of a university dashboard, the desirability of having a "single source of truth" for an entire organization.[112] They agree with the above contentions that each level of supervision should have its own dashboard, but also believe that all personnel in the organization should be able to access the organization wide dashboard. In a like manner, the dashboards of the Battalion Chiefs, and the SOC, should be accessible to lower level personnel.

C. EXTERNAL FACTORS, RESOURCE AVAILABILITY AND DECISION SUPPORT SYSTEMS

The preceding discussion has centered on the use of a dashboard as a dynamic almost real-time feedback tool. However, fire service agencies, especially those that serve densely populated areas, do not exist in static environments and factors beyond the immediate control of FD personnel will have impacts on the lag measures. As alluded to above, resource availability (whether dispatchers, vehicles, or EDs) plays a significant role in the successful fulfillment of strategic goals. Resource availability is very dynamic and much research has been done to identify the appropriate way to rebalance fire department and EMS resources when system demands (calls etc.) escalate.[113] According to Aringhieri et al., no rebalancing or redeployment method, including that done by humans while looking at a map, has shown any superiority over any other.[114] Therefore, an emergency services dashboard should also be able to be used to enhance the perception of situational awareness and allow personnel to make decisions based on changing conditions.[115] For example, Battalion Chiefs should be able to take a glance at their dashboard and know how many units of a particular type are available or not available, what activities units are tied up on, and be able to use that information to rebalance as warranted. Similarly, EMS providers should be able to look at their dashboard and assess ED crowding, wait times, and diversion status, and make decisions which minimize patient handover and unit cycle times. Minimizing patient handover and

[112] Cahyadi and Prananto, "Reflecting Design Thinking," 297.

[113] Aringhieri et al., "Emergency Medical Services and beyond," 8.

[114] Ibid., 13.

[115] Yang, Su, and Yuan, "Design Principles," 767.

unit cycle times would help to ensure that units get back in service quicker, thus making more units available for the next call.

Yang et al., when developing a decision support system for firefighters protecting the Beijing Olympics, divided decision support systems into five broad categories ("communication driven, data driven, document driven, knowledge driven, and model-driven") and concluded that for emergency services personnel, it was most important to have a decision support system that enhanced situational awareness but allowed the personnel to make the decisions.[116] For the purposes of maintaining and enhancing situational awareness Yang et al. developed a blended approach that incorporated all five types of decision support systems. For example, the incident commander at fires was provided a dashboard which showed which units were available for assignment, and a predictive model of where fire was likely to spread inside of a building (based on real-time sensor data from inside the building). Armed with this knowledge, the incident commander could deploy a unit to carry out tasks to prevent the anticipated fire spread. Similarly, in the pre-incident situational awareness environment, a predictive model could be developed which would show Battalion Chiefs, and Shift Operation Chiefs, where gaps in coverage exist due to units being committed on calls, and based on historical data, where future calls are likely to occur. The Chiefs could make decisions to redeploy units to meet anticipated demands based on their knowledge of the following:

- Travel times of redeployed units to the newly assigned area
- Anticipated cycle times of units already assigned on calls (this would vary based on call type and type of unit; for example an ambulance on an EMS call typically takes 60 minutes, while a Paramedic Engine on the same call can go back in service within 20 minutes)
- Whether units that are available are engaged in an activity which may preclude their routine movement (i.e., a training drill, a public safety demonstration at a local school etc.)

[116] Yang, Su, and Yuan, "Design Principles," 764.

Along the same vein, EMS personnel trying to decide which hospital a particular patient should be taken to would find the following information about hospitals useful:

- Travel time to each hospital based on traffic conditions
- The diversion status of each hospital,
- How many ambulances are presently at each hospital, and their real-time wait times for patient handover,
- What the wait time trend for the last three hours for each hospital is, and
- The acuity of the patients waiting for handover.

Informed by this information, the personnel could decide whether it is more expedient to bypass a particular hospital to achieve a faster handover time elsewhere and thus effect a lower total cycle time overall. Of course, the personnel would also have to take into account the specialties available at each hospital (for instance, not all hospitals are equipped and staffed to handle trauma patients) and the needs and desires of the patient.

A modest effort has already been undertaken in this direction within MCFRS. MCFRS staffs two on-duty EMS Duty Officers (Captains) who are responsible for liaising with hospital ED staff, and providing subject matter expertise on mass casualty incidents, critical care incidents, and the non-policy covered novel situations that occur every day in a large and busy EMS systems. At present, these officers have a dashboard provided by the state that displays hospital diversion statuses (an example is shown in Figure 7), and a single measure of almost real-time overall unit cycle time trends. Based on a pre-determined scheme of triggers, these Duty Officers are allowed to opt MCFRS out from honoring diversion statuses.

Hospitals | Counties | Reports

Show Alert Descriptions

Hospital	Yellow Alert	Red Alert	Mini Disaster	ReRoute	Trauma ByPass
Bowie Hospital Center					
Calvert Memorial Hospital					
Charles Regional (UM)					
Doctors Community Hospital					
Fort Washington Hospital					
Germantown EC					
Holy Cross Germantown					
Holy Cross Hospital					
Laurel Regional Medical Center					
Malcolm Grow					
Montgomery Medical Center (MedStar)					
Prince Georges Hospital Center					
Shady Grove Advent Hospital					
Southern Maryland Hospital (MedStar)					
St. Mary's Hospital (MedStar)					
Suburban Hospital (JHM)					
Walter Reed NMMC					
Washington Adventist Hospital					
Childrens National Medical Center					
George Washington Hospital	10:44				
Georgetown University (MedStar)	10:44	10:44			
Howard University Hospital					
MedStar Washington Hospital Center					
Providence Hospital					
Sibley Memorial Hospital (JHM)					
United Medical Center					

Figure 7. Maryland Institute for Emergency Medical Services Systems Region V Hospital Diversion Status Display

The Duty Officers only use this option when multiple hospitals have gone on diversion, and when cycle times are trending up. Opting out of the diversion program allows ambulances to transport to the closest hospital, prevents ED staff from practicing defensive diversion, and forces ED staff and administrators to concentrate on improving matters within their particular hospital instead of relying on other hospitals to absorb the extra demand in the system.[117]

D. DASHBOARD DESIGN FACTORS

There are many references on the visual design of dashboards. There is near unanimity that dashboards should be simple to understand, fit on one screen, that indicators should be able to be drilled down upon (clicked on to display a second screen) to display more detailed information, and that the dashboards need to be designed in an iterative process with end-user feedback.[118] In terms of other visual characteristics,

[117] Defensive diversion refers to the practice of ED staff placing their institution on diversion solely or in part because they observe that neighboring institutions are on diversion. See Deo and Gurvich, "Centralized vs. Decentralized Ambulance Diversion," 1302.

[118] Michael K. Allio, "Strategic Dashboards: Designing and Deploying Them to Improve Implementation," *Strategy and Leadership* 40, no. 5 (2012): 24, doi:10.1108/10878571211257159.

Bremser et al. offer some practical guidance on locating the most important information on the upper left and center, and colorizing and co-locating related information.[119] For instance, Bremser advises using bright colors against a dark background or vice versa, the use of traffic light like colors to signal the state of various measures (i.e., deficient measures would be red) and using white space judiciously to set different sets of data apart.[120] Bharosa et al. make the distinction between what displays should look like for tactical versus strategic dashboards. They advocate the use of simple "values and thresholds" for tactical dashboards, versus "graphics summarizing long term trends" for strategic dashboards.[121]

E. PUTTING IT ALL TOGETHER

The mock-up (Figure 8) of a MCFRS Shift Chief's dashboard attempts to bring all of the above mentioned factors together. The situational awareness table of unit availability by type and by Battalion is organized with EMS transport unit cycle time and with Battalion average turnout times and is located on the upper left. Recallable units presently unavailable for calls due to other assignments are located in the left middle. Important lag measures are on the bottom so that they serve as a reminder. A graph of expected calls versus actual demand for service is on the top right; this graph tells the chief how the day is proceeding and is likely to continue to proceed. A map showing hotspots, for the next two hours, where expected calls for demand may have longer than normal response times, allows the Shift Chief to consult with his Battalion Chiefs and move units where needed.

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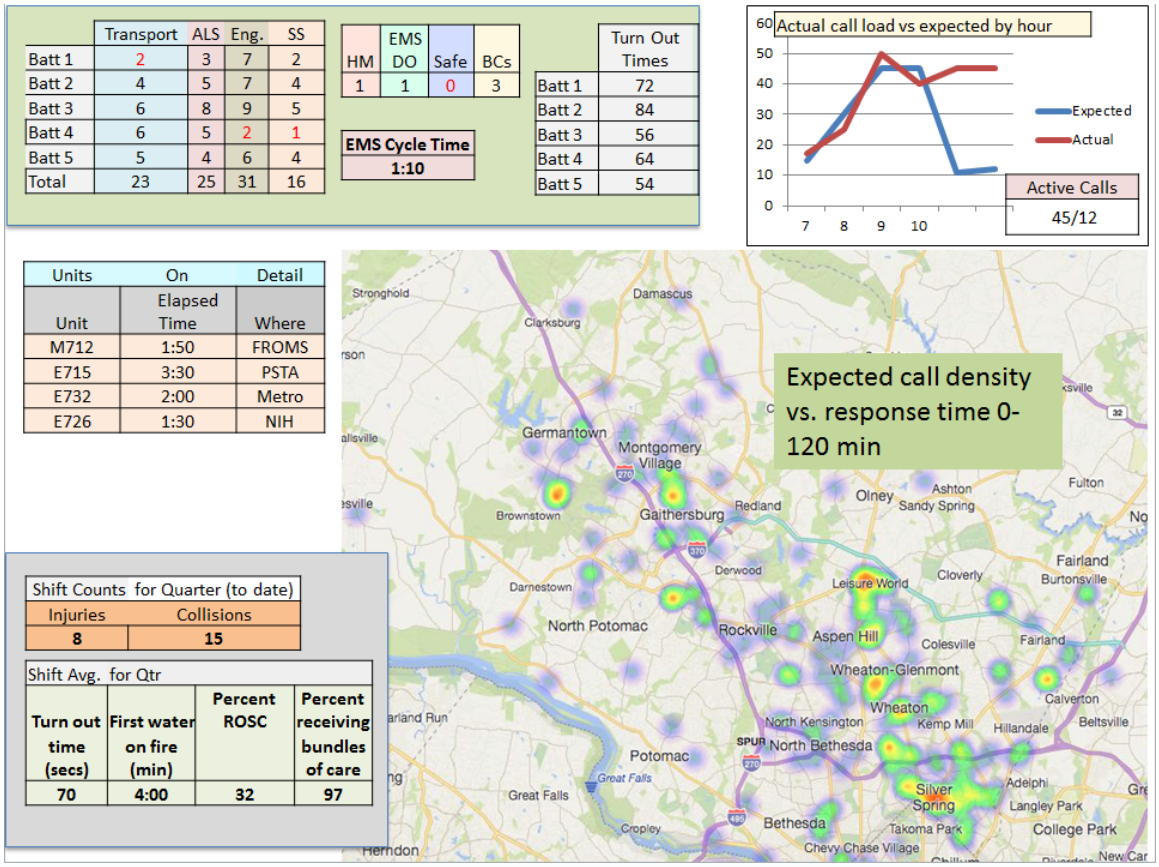
[119] Wayne G. Bremser and William P. Wagner, "Developing Dashboards for Performance Management," *The CPA Journal; New York* 83, no. 7 (July 2013): 67.

[120] Ibid.

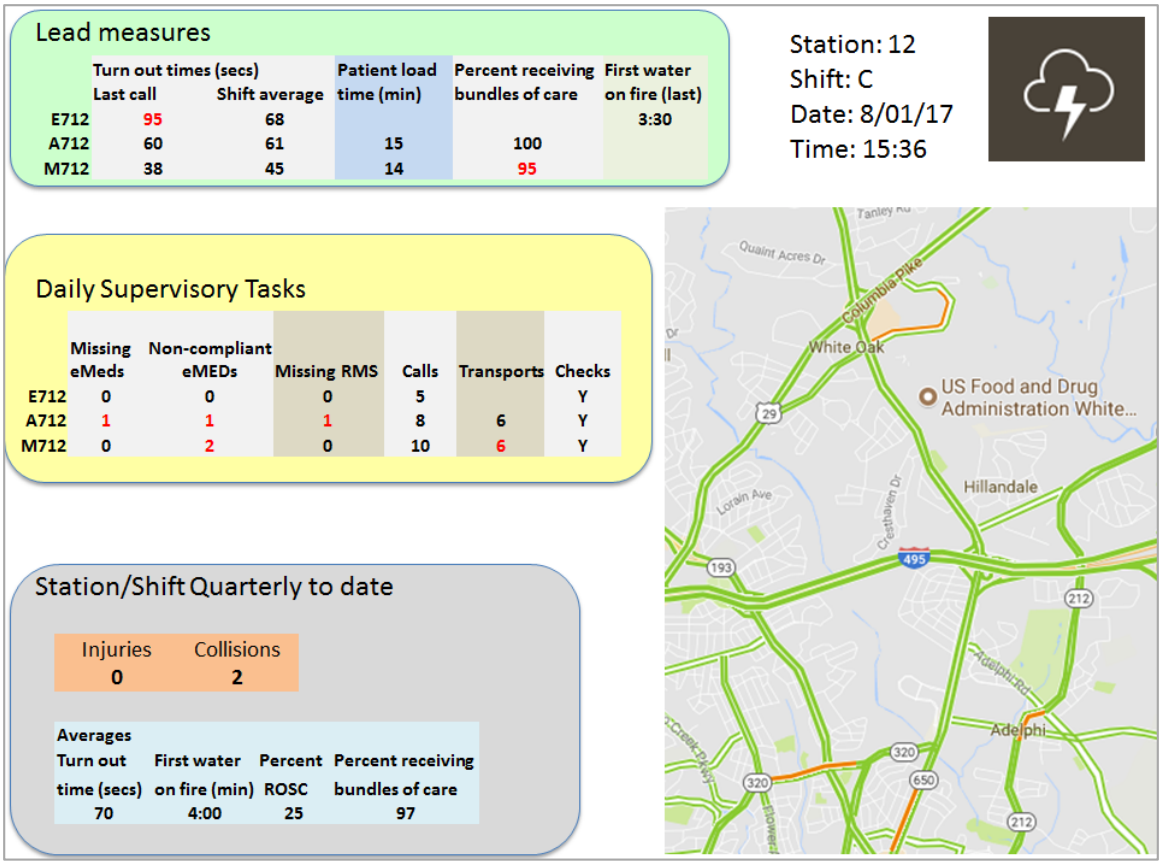
[121] Bharosa et al., "Designing and Evaluating Dashboards," 186.



Map retrieved from Google Maps.

Figure 8. Prototype Duty Operations Chief Dashboard

A dashboard for a station officer is illustrated in Figure 9. The lead measures are organized on the top left, and the green color of this box, indicates that most (if not all) targets are being met. Red lettering indicates which individual targets are not being met. Daily supervisory tasks are indicated on the mid left and the yellow surround indicates that there are some issues that require attention with again the measurements that are subpar in red lettering. With both the lead measures and the daily supervisory tasks, the station officer can easily see which units are falling short and can take immediate action to fix the issues. On the lower left important lag measures are presented so that they serve as a reminder of the goals that are attempting to be affected by the lead measures. A map on the right shows the traffic conditions in the station area so that the station personnel may adjust travel routes if necessary.



Map retrieved from Google Maps.

Figure 9. Prototype Station Officer's Dashboard

The dashboards in Figures 8 and 9 then serve as a feedback loop for supervisors at the appropriate level so that they can address leading measures on a near real time basis so as to ensure maintenance of effort or improvement in their lag measures. They also serve as job aides for mundane but necessary tasks as well as decision support systems for actions necessary to achieve real-time service needs. In their organization and use of visual components, they serve as an at a glance real-time depiction on what is going on within that supervisor's area of responsibility at any given moment.

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V. SUMMARY OF FINDINGS

The purpose of this thesis was to examine the use of Business Intelligence and dashboards for the fire service. Through a literature review this thesis examined the principles behind the use of BI and dashboards in other industries. The lessons learned by this examination were applied to fire department business processes to suggest model dashboards relevant and usable by fire service personnel and supervisors at all levels of an agency. The models developed depended on the key factors outlined in the following sections.

A. INTERNAL FACTORS AND DISTILLING BUSINESS PROCESSES

Similar to businesses, fire departments should focus on their strategic goals and figure out ways to measure obtaining those goals. Such measures can be divided into lag measures and lead measures. Lag measures are made over a longer period of time such as a quarter or a year and are not likely to be affected by the short term actions of an employee or supervisor. Lead measures are short term measures and can be affected by the day to day actions of employees. Through analysis of business processes, fire service agencies can figure out the lead measures which are most likely to affect the lag measures that matter to them. For example, keeping the lead measures of turnout times short and adhering to the bundle of care, is likely to result in improvements in the lag measure of cardiac arrest survival rates. Similarly, keeping the lead measures of turnout times short, and putting water on a fire as quickly as possible, is likely to yield improvements in the lag measures of the number of fires kept to the room of origin, and lessen the number of firefighters injured on a fire.

B. MEASURING PROGRESS

A cursory on-line search for the author of the maxim “what gets measured, gets done” yields multiple results; but the lack of clarity in the provenance of this phrase does not detract from its verity. Therefore, first and foremost, a fire service dashboard should serve as a real-time feedback loop for supervisors and employees alike in how they are affecting lead measures. Dashboards can also serve as feedback mechanisms for low

frequency lag measures, and such focus should serve as a reminder of the importance of these measures to the organization. Dashboards may also serve as a reminder for rote but needed tasks that are vital to the functioning of the organization. Finally, supervisors as different levels should have a primary dashboard which reflects their area of responsibility, but all personnel should have access to a single, organizational wide "single source of truth."

C. DECISION SUPPORT SYSTEM

As much as fire service agencies would like to be able to plan and anticipate every contingency, the reality is that not everything can be predicted. Call load and resource availability are dynamic variables that make every day slightly different for fire service managers. Therefore, dashboards can also provide situational awareness for supervisors to re-balance deployment, and also for EMS providers to not overwhelm particular hospitals. The use of predictive analytic software, which takes into account historical trends, and projects them into the near future, and then combines that knowledge with predicted response times, could be a game changer for fire chiefs who have had to heretofore just depend on intuition and a paper map to employ rebalancing strategies.

D. DASHBOARD DESIGN FACTORS

Dashboards have been around long enough in the business world for certain visual principles to be developed. The authors surveyed suggest that dashboards should fit on one screen and tell a story within 5 seconds. There should be the ability to drill down into more granular data. There should be a richness of color, and important information should be in certain positions; with related information located near each other. Finally, it is suggested that dashboards should be developed in an iterative fashion with ample feedback from the end users.

E. USING WHAT WAS LEARNED TO DEVELOP A PROTOTYPE

By applying the principles learned from the business world and other industries such as health care, important data for inclusion on fire service dashboards may be

discerned. Model dashboards were able to be developed by the application of the principles enumerated above and will serve as the first iteration for trial use by supervisors at various levels within a fire service agency.

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VI. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

A. CONCLUSION

The research question essentially asked if Business Intelligence and dashboards from the business world and other industries could studied to see if they could be applied to the fire service. The intent was to see if dashboards et al. could be of use to fire department officers and chiefs to improve performance.

This seemingly simple question led into subsidiary questions of how should fire service performance be measured and what kind of measures can be utilized for improving performance. Follow-up questions dealt with how to best affect performance by using such data, and how best to display it.

Answering these questions as outlined in Section VI has led to the first generation of an iterative process of developing fire service dashboards. It is hoped that these dashboard prototypes may be used by fire service leaders at all levels to influence organizational performance in pursuit of key strategic goals.

B. RECOMMENDATIONS FOR FURTHER RESEARCH

Since the thesis project produced only a first generation product, an obvious future research project would be to examine whether the use of these dashboards truly led to an improvement in a fire department's performance. In the same vein, future research could also examine what components of dashboards led the most improvement; i.e., is feedback more important the predictive analytics.

It is also hoped that this development will continue in an iterative process, with substantial end user input. Such input was not a feature of this project due to scoping and time limitations; however many authors of texts included in the literature review, felt strongly that end user participation was essential to the success of such projects. Therefore, future research, and or projects, should include end user input and an examination of whether that process would be truly useful for American firefighters.

This project also did not discuss the use of big data in the form of software and hardware generated machine data. For instance, large fire departments may have issues tracking cardiac monitors and laptops; but if all of these devices are web accessible, surely they are generating data about location and usage that may be of potential use to fire service managers.

This project also did not make more than a cursory touch on predictive analytics. Such software has been in use for a few years to try to predict areas of oncoming load demand for calls for service. However, the potential for using such software to try to predict future calls for service from former EMS patients, has not been explored. Perhaps in the future, when there are comprehensive cloud passed patient health records available; health care providers (fire service EMS among them) can predict which populations of patients may need proactive interventions to avoid future 911 calls and hospital visits.

LIST OF REFERENCES

Allio, Michael K. “Strategic Dashboards: Designing and Deploying Them to Improve Implementation.” *Strategy and Leadership* 40, no. 5 (2012): 24–31. doi:10.1108/10878571211257159.

Aringhieri, R., M.E. Bruni, S. Khodaparasti, and J.T. van Essen. “Emergency Medical Services and beyond: Addressing New Challenges through a Wide Literature Review.” *Computers & Operations Research*78 (February 2017): 349–68. doi:10.1016/j.cor.2016.09.016.

Behn, Robert D. “Why Measure Performance? Different Purposes Require Different Measures.” *Public Administration Review* 63, no. 5 (September 2003): 586–606. doi:10.1111/1540-6210.00322.

Berman, Evan, and Xiao Hu Wang. “Performance Measurement in U.S. Counties: Capacity for Reform.” *Public Administration Review* 60, no. 5 (September 2000): 409–20. doi:10.1111/0033-3352.00104.

Bharosa, Nitesh, Marijn Janssen, Sebastiaan Meijer, and Fritjof Brave. “Designing and Evaluating Dashboards for Multi-Agency Crisis Preparation: A Living Lab.” In *Electronic Government*, edited by Maria A. Wimmer, Jean-Loup Chappelet, Marijn Janssen, and Hans J. Scholl, 6228:180–91. Berlin: Springer Berlin Heidelberg, 2010. http://link.springer.com/10.1007/978-3-642-14799-9_16.

Bremser, Wayne G., and William P. Wagner. “Developing Dashboards for Performance Management.” *The CPA Journal; New York* 83, no. 7 (July 2013): 62–67.

Cahyadi, Amelia, and Adi Prananto. “Reflecting Design Thinking: A Case Study of the Process of Designing Dashboards.” *Journal of Systems and Information Technology* 17, no. 3 (August 2015): 286–306. doi:10.1108/JSIT-03-2015-0018.

Chorpita, Bruce F., Adam Bernstein, and Eric L. Daleiden. “Driving with Roadmaps and Dashboards: Using Information Resources to Structure the Decision Models in Service Organizations.” *Administration and Policy in Mental Health and Mental Health Services Research* 35, no. 1–2 (March 2008): 114–23. doi:10.1007/s10488-007-0151-x.

Coughlan, Paul, and David Coghlan. “Action Research for Operations Management.” *International Journal of Operations & Production Management* 22, no. 2 (February 2002): 220–40. doi:10.1108/01443570210417515.

Deo, Sarang, and Itai Gurvich. “Centralized vs. Decentralized Ambulance Diversion: A Network Perspective.” *Management Science* 57, no. 7 (July 2011): 1300–19. doi:10.1287/mnsc.1110.1342.

DeShon, Richard P., Steve W. J. Kozlowski, Aaron M. Schmidt, Karen R. Milner, and Darin Wiechmann. "A Multiple-Goal, Multilevel Model of Feedback Effects on the Regulation of Individual and Team Performance." *Journal of Applied Psychology* 89, no. 6 (2004): 1035–56. doi:10.1037/0021-9010.89.6.1035.

Edwards, David. *Smarter, Faster, Cheaper: An Operations Efficiency Benchmarking Study of 100 American Cities*. Somers, NY: IBM, 2011.

Edwards, David, and John Clayton Thomas. "Developing a Municipal Performance-Measurement System: Reflections on the Atlanta Dashboard." *Public Administration Review* 65, no. 3 (May 2005): 369–76. doi:10.1111/j.1540-6210.2005.00461.x.

Flynn, Jennifer. "Fire Service Performance Measures." Report, National Fire Protection Association, November 2009.

Hudson, Paul C., and Jeffrey A. Rzasa. "Knowledge Visualizations: A Tool to Achieve Optimized Operational Decision Making and Data Integration." Master's thesis, Naval Postgraduate School, 2015.

Kloot, Louise. "Performance Measurement and Accountability in an Australian Fire Service." *International Journal of Public Sector Management* 22, no. 2 (February 2009): 128–45. doi:10.1108/09513550910934538.

Kolesar, Peter. "Some Lessons on Operations Management Model Implementation Drawn from the RAND Fire Project." *Manufacturing and Services Operations Management* 14, no. 1 (Winter 2012): 1–6.

Liberatore, Matthew J., and Wenhong Luo. "The Analytics Movement: Implications for Operations Research." *Interfaces* 40, no. 4 (August 2010): 313–24. doi:10.1287/inte.1100.0502.

McChesney, Chris, Sean Covey, and Jim Huling. *The 4 Disciplines of Execution*. New York: Free Press, 2012.

McKay, Judy, and Peter Marshall. "The Dual Imperatives of Action Research." *Information Technology and People* 14, no. 1 (2001): 46–59.

McLay, Laura A., and Henri Moore. "Hanover County Improves Its Response to Emergency Medical 911 Patients." *Interfaces* 42 (2012): 380–94. doi:10.1287/inte.1110.0616.

Mills-Scofield, Deborah. "It's Not Just Semantics: Managing Outcomes vs. Outputs." *Harvard Business Review*, November 26, 2012. https://hbr.org/2012/11/its-not-just-semantics-managing-outcomes.

Montgomery County Government. “Fire and Rescue Service.” Accessed March 13, 2017, http://www.montgomerycountymd.gov/OMB/Resources/Files/omb/pdfs/FY17/psp_pdf/43-FRS.pdf.

Montgomery County, Maryland Office of Management and Budget. “Montgomery County, Maryland FY 2017 Approved Operating Budget.” Budget report, Montgomery County Maryland, 2016. www.montgomerycountymd.gov/OMB/Resources/Files/omb/pdfs/fy17/psp_pdf/FY17_Approved_MCG_Budget.pdf.

Myers, J. Brent, Corey M. Slovis, Marc Eckstein, Jeffrey M. Goodloe, S. Marshal Isaacs, James R. Loflin, C. Crawford Mechem, Neal J. Richmond, and Paul E. Pepe. “Evidence-Based Performance Measures for Emergency Medical Services Systems: A Model for Expanded EMS Benchmarking: A Statement Developed by the 2007 Consortium U.S. Metropolitan Municipalities’ EMS Medical Directors (Appendix).” *Prehospital Emergency Care* 12, no. 2 (January 2008): 141–51. doi:10.1080/10903120801903793.

Reis, Eric. *The Lean Startup: How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*. New York: Crown Business, 2011.

Routley, J. Gordon, Michael D. Chiaramonte, Brian A. Crawford, Peter A. Piringer, Kevin M. Roche, and Timothy E. Sendelbach. “Firefighter Fatality Investigative Report: Super Sofa Store.” After-action report, City of Charleston, 2008. http://downloads.pennnet.com/fe/misc/20080515charlestonreport.pdf.

Schooley, Ben L., and Thomas A. Horan. “Towards End-to-End Government Performance Management: Case Study of Interorganizational Information Integration in Emergency Medical Services (EMS).” *Government Information Quarterly* 24, no. 4 (October 2007): 755–84. doi:10.1016/j.giq.2007.04.001.

Stone-Griffith, Suzanne, Jane D. Englebright, Dickson Cheung, Kimberly M. Korwek, Jonathan B. Perlin, James E. Bliffen, and Benjamin Rosenthal. “Data-Driven Process and Operational Improvement in the Emergency Department: The ED Dashboard and Reporting Application.” *Journal of Healthcare Management* 57, no. 3 (June 2012): 167–80.

Swersey, Arthur J. “A Markovian Decision Model for Deciding How Many Fire Companies to Dispatch.” *Management Science* 28 (1982): 352–65. doi:10.1287/mnsc.28.4.352.

United States General Accounting Office. *Performance Measurement and Evaluation*. GAO/GGD-98-26. Washington, DC: United States General Accounting Office, 1998.

Wang, Xiao Hu. “Perception and Reality in Developing an Outcome Performance Measurement System.” *International Journal of Public Administration* 25, no. 6 (January 2002): 805–29. doi:10.1081/PAD-120003819.

Wright, P. Daniel, Matthew J. Liberatore, and Robert L. Nydick. “A Survey of Operations Research Models and Applications in Homeland Security.” *Interfaces* 36, no. 6 (December 2006): 514–29. doi:10.1287/inte.1060.0253.

Yang, Lili, Guofeng Su, and Hongyong Yuan. “Design Principles of Integrated Information Platform for Emergency Responses: The Case of 2008 Beijing Olympic Games.” *Information Systems Research* 23, no. 3-part-1 (September 2012): 761–86. doi:10.1287/isre.1110.0387.

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