

THESIS

MULTI-MEASURE PERFORMANCE ASSESSMENT OF THE DIVISIONS OF THE
WYOMING HIGHWAY PATROL

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ABSTRACT

MULTI-MEASURE PERFORMANCE ASSESSMENT OF THE DIVISIONS OF THE WYOMING HIGHWAY PATROL

With many lives lost every year in traffic related crashes, traffic safety is a big concern all around the world. One way to advance traffic safety practices is to improve the overall organizational performance of agencies responsible for enforcing traffic safety. Internal benchmarking would be the first step to accomplish that goal, in order to compare the units of an organization, identify the best performing ones, and learn from their best practices so that other units within the organization can take advantage and improve their performance as well.

Wyoming Highway Patrol (WHP) is a data-driven organization which uses multiple measures to assess its performance. These measures can be used by WHP to perform comparisons between its 17 divisions. However, this process involves the utilization of a single performance measure at a time and may result in difficulties in identifying the overall performance. Therefore, there is a need to develop a performance assessment framework that can identify the overall performance of these divisions in the presence of multiple measures. This research presents a performance assessment system developed for WHP using Data Envelopment Analysis. This system can incorporate multiple measures, enabling WHP to identify its best-performing divisions to be able to use those as benchmarks.

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CHAPTER 1: INTRODUCTION

This chapter starts off with brief background information on highway traffic safety in the United States, performance measurement, more specifically benchmarking, and the Wyoming Highway Patrol as the points of departure for this research. Then, the problem statement and the research questions are discussed. The chapter, then, presents the overarching purpose of the research and concludes by discussing the scope and limitations of this research, as well as its contributions to the body of knowledge.

1.1 Highway Traffic Safety in the United States

According to the U.S. Department of Transportation (USDOT), highway fatalities account for nearly 93 percent of the total U.S. transportation related fatalities (USDOT, 2013). In the United States, travelling by motor vehicles is the primary mode of transportation (NHTSA, 2012a), yet despite all of its convenience and advantages, motor vehicle crashes are considered to be the leading cause of death for people up to age 34, specifically for teens and young adults with ages from 15 to 24 (AAA, 2013).

The National Highway Traffic Safety Administration (NHTSA), in its 2010 overview of motor vehicle crashes, documented that 2010, with 32,885 people killed and 2,239,000 people injured (NHTSA, 2012a) had the lowest number of fatalities since 1949, declining 2.9 percent since 2009 (NHTSA, 2012b). This declining trend continued with 32,367 people killed in motor vehicle crashes in 2011 (USDOT, 2013). It should be noted that although this number represents the fewest number of people killed in traffic crashes in a single year since 1950, it also indicates that an average of 89 lives per day were lost in traffic crashes (AAA, 2013)- one every 16

minutes (NHTSA, 2012a). Moreover, based on an estimated 34,080 fatalities during 2012, an increase of about 5.3 percent in the number of fatalities compared to that occurred in 2011 was predicted (NHTSA, 2013a). According to a report published by NHTSA in November 2013, the actual number of fatalities in 2012 was 33,561, which is still higher than that of 2011 (NHTSA, 2013b). This is the first year-to-year increase in traffic fatalities since 2005. Unfortunately, several indicators suggest that the number of traffic fatalities is likely to increase in the coming years (Sivak, 2012).

All of the facts presented above suggest the importance of highway traffic safety and the need to improve it. When talking about highway traffic safety, it is important to have the roadway, the vehicle, and the roadway user (e.g., drivers) in mind, as research indicates that they contribute to 33, 10 and 93 percent of the crashes, respectively (EOT, 2008). Motor vehicle crashes have multiple contributing factors; therefore to promote highway traffic safety, there needs to be a multidisciplinary approach that encompasses all stakeholders. The most common approach that includes the broad stakeholder communities responsible for making roads safer is known as the ‘4 Es’ of highway traffic safety (EOT, 2008; FHWA, 2013a), explained below:

- Engineering (e.g., roadway planning, design and traffic engineers, operation, and maintenance);
- Enforcement (city police, sheriff, state, and local law enforcement agencies);
- Education (e.g., driver education, state traffic safety offices, schools, citizen advocacy groups); and
- Emergency Medical Services (EMS) (e.g., first responders, paramedics, fire, and rescue).

Each of these four categories brings a unique viewpoint to improving highway traffic safety practices. For instance, engineers tackle safety issues from the roadway and vehicle perspective while law enforcement entities focus on road users' behaviors. These two, along with educational approaches, contribute to highway traffic safety from a preventive point of view rather than post collision care, which is mostly the focus of emergency groups (FHWA, 2013a).

While motor vehicle crashes have multiple contributing factors; the approach that has the potential to have the highest impact in improving highway traffic safety is the one that focuses on the roadway user; as driver (or more accurately driver behavior) is the largest source of causal factors related to crashes. An important outcome of this fact is that actions that can influence driver behavior are key to reducing the frequency (and severity) of crashes. As roadway users contribute to a large percentage of traffic crashes, highway patrol agencies enforce traffic laws in an attempt to catch violators who put their own safety and that of others at risk. Their ultimate goal is to make a positive change in undesirable roadway user behaviors.

1.2 Performance Measurement and Benchmarking

In order for agencies to improve their overall organizational performance in enforcing traffic laws to prevent the crashes, they need to be able to measure their performance in the first place. With a set of unified, consistent and effective performance measures in place, first step in the process of improving the overall organizational performance could be taken. This first step is internal benchmarking, in order to realize which units of the organization are the best performing ones so that they could be further set as benchmarks for the other units. Through the benchmarking process, other poor performing units could learn their peers' best practices and apply those in order to improve their own performance.

There are many definitions available on the topic of benchmarking. Construction Industry Institute defines it as “the systematic process of measuring one’s performance against recognized leaders for the purpose of determining best practices that lead to superior performance when adapted and utilized”(CII, 1995). Benchmarking process can be done either internally or externally. In the case of internal benchmarking, comparative analysis is made against organization’s own projects, while in the case of external benchmarking, projects are sought from other organizations as well; and ultimately the comparison is conducted among multiple organizations (NRC, 2005). Internal benchmarking, often considered to be the starting point of the quantitative process examination (NRC, 2005), would enable decision makers to compare the units of an organization, identify the best performing ones, and learn their best practices so that other units could take advantage and improve their performance as well. The same logic applies to external benchmarking of several organizations that follow the same goal, with the added value of comparing one organization against its competitors (NRC, 2005).

1.3 Background on the Wyoming Highway Patrol

Wyoming Highway Patrol (WHP) is the specific traffic law enforcement agency that is investigated in this research for which a multi-measure performance assessment and benchmarking framework is developed an attempt to improve their overall organizational performance. Therefore, a brief discussion on this agency relevant to its organizational structure and performance measures is warranted.

Wyoming is the 10th largest state and one of the least populous ones, making it the state with the second lowest population density after Alaska. The capital of the state, Cheyenne, with 60,000 residents, is Wyoming’s most populous city (U.S.CensusBureau, 2010).

Established in 1933, WHP defines its primary duty as “to keep the motoring public safe as they travel over 6,800 miles of highways in the state, including 900 miles of interstate” (WHP, 2011). WHP consists of two sections: Field Operations and Support Services (WHP, 2011), where civilian (with no arresting powers) and sworn officers (with arresting powers) are working. WHP is within the Wyoming Department of Transportation (WYDOT). The head of WHP, with the rank of colonel, reports directly to the director of WYDOT. WHP’s organizational structure is shown in Figure 1.1.



Figure 1.1: Organizational structure of WHP

Field officers, as the name suggests, are those who patrol out on the road. Wyoming is divided into five districts, which are further subdivided to make a total of 17 divisions throughout the state. Figure 1.2 shows a map indicating the boundaries of these divisions (WHP, 2011). The amount of available manpower differs from district to district depending on the number of enforcing officers required to meet the enforcement needs of each division. This is based on

division's characteristics, such as population, traffic volume, Commercial Motor Vehicle (CMV) traffic, terrain, typical weather conditions, mileage, and number of calls/complaints received over the course of a year, as well as trends and changing demographics. (For instance, Division T covers a region that has greatly developed the oil and gas rich resources, which has significantly changed the demographics within that division.) The main goal of field officers is to enforce uniform traffic codes on the state's highways.

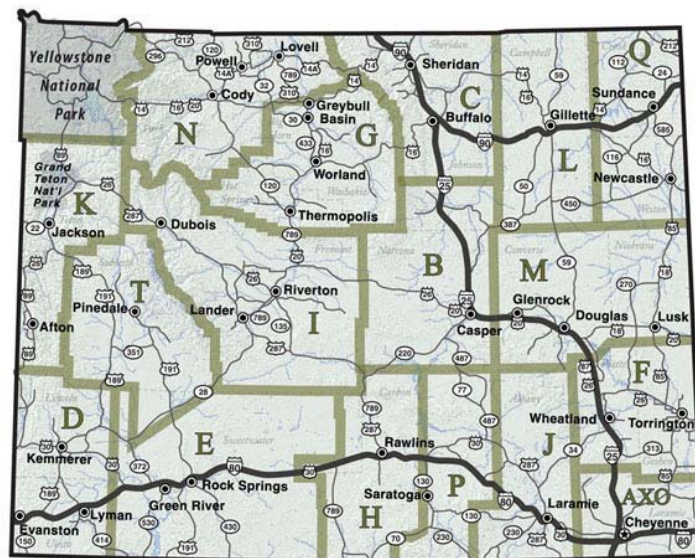


Figure 1.2: Boundaries of 17 divisions of WHP (WHP, 2011, p. 3)

Support services encompass four main areas:

- Safety, training and records (including both sworn and civilian officers to help with day to day administrative tasks, e.g., entering citations into a database);
- Evidence and equipment;
- Communication (IT); and
- Commercial motor care.

Civilian officers, who also work in Ports of Entry (POE), investigate the CMVs entering the state of Wyoming to check if they are in compliance with federal and state laws with respect to permits, size, weight, hours of service, mechanical characteristics, and oversize loads (e.g., they can issue permits with specific fees for CMVs with oversize loads, depending on how oversized the load is and how many miles it should be carried).

The Highway Patrol in Wyoming does not deal with non-traffic crimes (e.g., murders) in general (as opposed to State Patrols that exists in some other states), although it may sometimes deal with small thefts that involve vehicles. WHP is responsible for enforcement on all types of highways throughout Wyoming (as opposed to only interstates), dealing with approximately 70-75 percent of highway crashes in Wyoming. Contrary to the City Police, who only have enforcement power and authority within city limits, WHP has the charter and authority to perform patrol activities within the boundaries of cities as well.

During the years 2003-2004 for purposes of accountability, WHP was encouraged to take advantage of performance measures in their organization at the suggestion of the Governor's Office (Mickelson, 2012, Personal Communication). WHP, then, studied the Colorado State Patrol (CSP) that had been utilizing performance measures at that time and developed measures that were very similar to those of CSP's. The idea of implementing Balanced Scorecards to measure the performance of the various programs within the Wyoming Department of Transportation (WYDOT) came into the picture at this time. There was a natural fit between DOT's use of Balanced Scorecards, and the use of performance measures by WHP.

The Balanced Scorecard concept, developed by Kaplan and Norton, was introduced as a way to measure and improve organizational performance (Kaplan & Norton, 1996). The Balanced

Scorecard suggests four different perspectives that need to be considered in order to have a comprehensive performance measurement framework. These four categories are as follows:

- Financial;
- Customer;
- Internal business process; and
- Innovation and learning, later renamed as learning and growth (Piñero, 2003; Peter Rouse & Putterill, 2003).

As a result, WHP has considered the Balanced Scorecard perspectives and developed seven overall goals that are outlined in its Strategic Plan (WHP, 2011). These categories, as extracted from WHP's scorecard, are as follows:

1. Reduce highway fatalities, alcohol-related crashes, and injury crashes;
2. Maximize our enforcement, educational, and support efforts;
3. Develop and care for our employees;
4. Perform our duties and obligations without reservation;
5. Handle every call with a service-oriented response;
6. Develop and maintain an agency structure that prepares WHP for future growth and demands;
7. Operate within a balanced budget

Each of these categories has multiple performance measures. To help understand the specific measures that WHP uses in its strategic plan, the performance measures in the top two categories (i.e., “Reduce highway fatalities, alcohol-related crashes, and injury crashes” and “Maximize our

enforcement, educational, and support efforts”) are shown in Table 1.1. All measures are discussed in more detail in **Chapters 2** and **3**.

Table 1.1: WHP’s Measures in Their First Two Balanced Scorecard Categories (WHP, 2011)

Goal	Performance Measure
Reduce Highway Fatalities, Alcohol Related Crashes and Injury Crashes	# of Fatalities
	# of Fatal Crashes
	# of Impaired Driver Related Fatal Crashes
	# of CMV Fatalities
	# of Fatalities during Specially Recognized Holidays
	# of Injury Crashes
	# of CMV Crashes
Maximize our Enforcement, Educational and Support Efforts	% of Citations Issued per Investigated Crashes
	% of Seat Belt Usage
	# of Hours Dedicated to Targeted Enforcement Efforts
	# of Outreach Programs or Presentations

Fortunately, WHP’s early efforts in implementing Balanced Scorecards and performance measures were in line with directions encouraged by NHTSA and other federal agencies. According to a report published in August 2008, a minimum set of performance measures was decided by NHTSA and the Governors Highway Safety Association (GHSA) to be used by state and federal agencies in the preparation process of their highway safety plans (NHTSA, 2008). The report discusses that performance measures should be used to set goals and measures and furthermore, assess an organization’s progress on local, state, and federal levels. It goes on to categorize behavior traffic safety performance measures into three groups (NHTSA, 2008):

- Outcomes (crashes, injuries, and fatalities);
- Activities (media, education, and all other activities that may affect traffic safety);and
- Behavior itself (observed behaviors on the road and/or in surveys).

However, despite the fact that WHP has been using performance measures for quite some time now, Wyoming's fatality rates are still higher than the national average (NHTSA, 2011). Table 2.2 compares fatality rates in Wyoming with those in the USA national average and the Best State.

Table 1.2: Fatality Rates in Wyoming, USA National Average and the Best State

Year		Fatalities per 100 Million VMT
2007	Wyoming	1.60
	USA	1.36
	Best state*	0.79
2008	Wyoming	1.68
	USA	1.26
	Best state	0.67
2009	Wyoming	1.40
	USA	1.15
	Best state	0.62
2010	Wyoming	1.62
	USA	1.11
	Best state	0.64

* Note that the lowest rate in the Best State could be in a different state each year.

1.4 Problem Statement and Research Questions

It is clear from the discussion presented in the preceding sections that WHP has the potential to improve its organizational performance; and internal benchmarking is a viable starting point given WHP's existing focus on performance measures. Nevertheless, internal benchmarking becomes a challenging task, for large organizations like WHP with 17 divisions (as units) where each of them uses multiple measures and values specific ones more than the others (Mickelson, 2012, Personal Communication). To make matters more clear, consider the following questions:

- How should two divisions be compared when one of them gives heavy weight to the number of citations, while to another division the number of fatalities is more important?

Or

- Even for a given division, how can its overall performance be measured when it is doing better with regards to the number of issued citations but not so good when it comes to fatality rates?

Also it is important to note that in order to have a fair level of comparison, factors that are affecting the units' performance but are beyond decision makers' control need to be considered. For instance back to the WHP context, what if a division is constantly dealing with high volumes of highway traffic? Is it really fair to compare that division against another division that is patrolling smoothly under light traffic volumes for the majority of the year? Therefore, it is important to lay a level ground for reasonable comparison among the units. To take the challenges even one step further, the resource utilization should be taken into account as well, in order to say at what cost the overall performance is being attained, which is where efficiency comes into picture.

This research tries to tackle the abovementioned challenges by introducing a comprehensive framework that takes all of the issues into consideration and makes it possible to compare the 17 divisions of WHP in attempt to allow internal benchmarking and thus to improve the overall organizational performance. However, it should be noted that even though the comprehensive performance measurement framework was developed and best performing peers for each division were identified, the formal process of benchmarking was not completed in this research due to time constraints. The formal benchmarking process and its results will be the topic of future research.

Based on the current practices of WHP and how the agency wants to improve its performance in different areas according to their Strategic Plan (WHP, 2011), also considering the challenges and issues that need to be overcome as discussed above, the questions that are going to be addressed in this research are as follows:

- How can the performance of an organization be assessed in the presence of different performance measures?
- How can different units within an organization be compared to each other on a fair level? (In the context of this question, a unit is defined as any main point within the organization that is of importance to the decision makers).
- How can an organization improve its performance on the way to be both more efficient and more effective?

1.5 Purpose of the Study

The overarching purpose of this study is to develop a comprehensive framework that could be implemented by WHP in an attempt to improve their overall organizational performance while addressing the questions stated in the previous section. This study will use Data Envelopment Analysis (DEA) as a tool to develop a comprehensive framework that could measure the overall performance of WHP's divisions in the presence of multiple performance measures while also considering the external factors' effects on that overall performance. DEA is based on the concepts of linear programming and production theory and is equipped to deal with the presence of multiple measures as well as uncontrollable variables (those that could affect the performance of a unit but are beyond the control of the decision makers) (Ramanathan, 2003). DEA measures the efficiency of each unit and is not only capable of identifying the best performing and poor performing units, but it can also identify the appropriate benchmarks for poor performing units.

This will help recognize the best practices of 100 percent efficient units which can further be implemented in the poor performing units in an effort to benefit them and improve their performance (Ozbek, de la Garza, & Triantis, 2009).

The steps in getting to the final framework are as follows and will be discussed in detail in **Chapter 3: Methodology** and **Chapter 4: Results:**

- Developing consistent and effective performance measures that reflect the main purposes of WHP;
- Collecting data representing the variables that can be used in the defined performance measures;
- Identifying the uncontrollable variables and collecting the appropriate data;
- Analyzing the data and preparing them to be used in the DEA context;
- Selecting the best DEA framework and running the models;
- Post processing the results of the DEA analyses to identify the poor performing units and their respective efficient peers; and
- Holding benchmarking sessions in order to learn about the best performing units' best practices to be incorporated in the poor performing units. While this last step is necessary to complete the development of the framework, it should be mentioned again that due to time constraints, it was not performed in this research.

1.6 Project Scope and Limitations

Below is a list documenting the scope of this project:

- 1) Although the steps resulting in the final framework developed in this study can be replicated to be used in other highway patrol agencies in the similar context, the

framework is specifically tailored for WHP and thus, some variables identified based on the characteristics specific to Wyoming and WHP may not apply to other agencies.

- 2) This study will not address all of the problems and issues attributed to highway traffic safety. It only focuses on the enforcement practices of traffic agencies particularly addressing roadway users' behavior. Therefore, roadway and traffic design issues as well as the remaining three "Es" of highway traffic safety which were mentioned earlier (i.e., Engineering, Education and EMS) are excluded from this study.
- 3) This project only takes into account two years of data (2011 and 2012) from WHP's database to comply with the timeline of their Strategic Highway Safety Plan (WHP, 2011).

It is important to note that there are other limitations applicable to the data used for this study, which will be discussed later on in the relevant chapters.

1.7 Contributions to the Body of Knowledge

Discussed below are the specific contributions of this research to the body of knowledge:

- 1) There have been many examples of implementing DEA in several domains from hospitals to schools to transportation maintenance. However, literature review to date has not identified any specific application that investigates highway traffic safety and police forces concurrently (while a few studies investigate those concepts individually). Given the importance of highway traffic safety and the many benefits that come along with improved performance of highway patrol agencies, there is a great potential for research that considers a holistic approach to answer the question of improving overall organizational performance of highway patrol agencies, for which this research could be a starting point.

- 2) As a result of this study, several advantages could be gained; most important of which is saving lives. All of the crashes happening because of a faulty roadway user behavior are preventable. By implementing the best practices that are identified in this study to improve the performance of highway patrol agencies, the efforts of such agencies would be concentrated in the right direction that could essentially have an impact on improving roadway users' traffic behavior.
- 3) Another important outcome of this study is improving the overall efficiency of highway patrol organizations. This will allow for more effective utilization of available resources in order to produce more of the desired outcomes, which consequently, could lead to saving time, money and manpower throughout the organization.
- 4) As a part of the internal benchmarking process (which is the point of departure for the framework developed in this research), organizations would concentrate more on the right practices in the most effective areas that could have the highest influence in achieving their desired goals and spend less time in the areas that have no practical returns.
- 5) The results and processes introduced in this study could be implemented by other patrol agencies for internal and external benchmarking practices in an attempt to constantly improve organizational performance. The performance measures introduced in this study could also be replicated in other patrolling agencies with similar goals. Also the approach behind developing the proposed performance measures could be highly beneficial in defining a set of nationwide performance measures in the context of highway traffic safety to be implemented by enforcement agencies for the purposes of external benchmarking.

CHAPTER 2: LITERATURE REVIEW

This chapter aims at discussing several topics pertinent to the study of multi measure performance assessment and benchmarking of the divisions of the Wyoming Highway Patrol (WHP), starting with highway traffic safety in general in the United States and continuing with information on WHP's practices in particular. The chapter, further, discusses performance measurement in highway patrol from a general perspective, followed by a more in depth look at those measures in a few state patrols as well as WHP. The chapter continues with a discussion on efficiency and how efficiency tools and techniques could be used to improve highway patrol operations. The chapter is concluded with previously performed studies in the domains related to this research.

2.1 Highway Traffic Safety in the United States

According to Centers for Disease Control, motor vehicle crashes are the leading cause of death for people ages 15-24 as well as for children, teens and young adults up to 34 (CDC, 2014). Apart from crashes resulting in lost lives, they also result in hundreds of thousands of injured victims and billions of dollars in property damages every year (FARS, 2012). Since nearly 93 percent of total U.S. transportation fatalities occur on highways, the U.S. Department of Transportation (USDOT) rightfully dedicates its number one priority to the safety of the travelling public (USDOT, 2013). Although the initiatives taken by USDOT between 1990 and 2011 has helped reduce the highway fatalities by 28 percent (USDOT, 2013), the statistics still indicate 32,367 deaths in motor vehicle crashes in 2011 (NHTSA, 2012c), representing an average of 89 needlessly lost lives on an average day on U.S. roadways. In a report published by

NHTSA in November 2013, the number of highway fatalities in 2012 was reported to be a total of 33,561, representing the first year to year increase in traffic fatalities after six consecutive years of declining trend (NHTSA, 2013b).

With improving roadway safety as a continued priority of transportation agencies from local to state to federal levels, vital partnerships exist and continue to grow between different entities (TRB, 2011). Research centers at academic institutes as well as private partners continue to contribute to ideas on how roadways and traffic safety could be enhanced. The AAA foundation for Traffic Safety has been sponsoring research to create a “social climate in which traffic safety is highly valued and rigorously pursued” (Girasek, 2012), where a nationally representative survey using a web-enabled probability based panel depicting the United States population is conducted to recognize a few key indicators as to what extent traffic safety is valued and is being pursued (AAA, 2013). Similarly in early 2003, the Federal Motor Carrier Safety Administration (FMCSA) began a multi-year development process of new safety measurement initiatives, currently known as Compliance, Safety, Accountability (CSA), explicitly geared towards reducing Commercial Motor Vehicle (CMV) crashes, injuries and fatalities (FMCSA, 2014).

In similar attempts, approximately 30 states since 2001, have adopted a mission to reduce fatal traffic crashes to zero, followed by comprehensive formal programs to help them reach these set goal. These programs, under a wide variety of titles from Vision Zero, Target Zero and Toward Zero Deaths, are now being promoted as a national movement under the name “Toward Zero Deaths” (TZD) in an attempt to reduce roadway fatalities using a range of Engineering, Education, Enforcement and Emergency Medical Services (EMS) approaches (Munnich, Douma, Qin, Thorpe, & Wang, 2012), also known as the “4 Es” of traffic safety (EOT, 2008; FHWA, 2013a). The scope of each “E” was previously explained in **Chapter 1**. Taking into account the 4

Es of traffic safety, TZD strategies range from design to behavioral to policy and enforcement approaches that have a potential to help achieve significant reductions in traffic fatalities and serious injury crashes (Munnich, et al., 2012).

Additionally, Strategic Highway Research Program 2 (SHRP2), a \$232 million federally funded research program, is trying to address critical transportation challenges, in the following main categories (SHRP2, 2014):

- Making highways safer;
- Fixing deteriorating infrastructure;
- Reducing congestion;
- Collaborative planning for new roads.

This program is managed by Transportation Research Board (TRB) of the National Academies, in collaboration with Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) and was originally planned to operate from 2006 to 2013 but is now extended to March 2015. The main purpose of this program is to advance innovative ways to plan, renew, operate and improve Nation's highways' overall safety. The official four research areas of SHRP2 are as follows:

- Safety (i.e., Prevent or reduce the severity of highway crashes by understanding driving behavior);
- Renewal (i.e., Renew aging infrastructure through rapid design and construction methods that minimize disruption and produce long-lived facilities);
- Capacity (i.e., Integrate mobility, economic, environmental, and community needs into the planning and design of new highway capacity);

- Reliability (i.e., Provide reliable travel times by preventing and reducing non-recurring congestion).

Only focusing on the safety category (as far as its applicability to the project undertaken in this study is concerned), the objective of SHRP2's safety group was to "improve traffic safety by obtaining objective information on driver behavior and driver interaction with the vehicle and the roadway" (SHRP2, 2014). The Naturalistic Driving Study (NDS) was initiated to instrument volunteer drivers' vehicles and continuously gather data as they go about their normal daily activities. This is in an effort to monitor what is it that drivers really do, what were they doing right before they got involved in a crash and how do roadway, vehicle and environment can impact the driving behavior (Hallmark et al., 2013; TRB, 2014). It should be noted that similar studies, although in much smaller scales, have been done previous to SHRP2's NDS by Virginia Tech Transportation Institute (VTTI) (Dingus et al., 2006; VTTI, 2014) and University of Michigan Transportation Research Institute (UMTRI) (LeBlanc et al., 2006).

2.2 WHP Operations and Status

WHP is a traffic law enforcing agency to operate on all highways in the state of Wyoming. Wyoming is the 10th largest state and one of the least populous ones, making it the state with the second lowest population density after Alaska. The capital of the state, Cheyenne, with 60,000 residents, is Wyoming's most populous city (U.S.CensusBureau, 2010). Established in 1933, WHP defines its primary duty as "to keep the motoring public safe as they travel over 6,800 miles of highways in the state, including 900 miles of interstate" (WHP, 2011). WHP is within the Wyoming Department of Transportation (WYDOT). The head of WHP, with the rank of colonel, reports directly to the director of WYDOT. Wyoming is divided into five districts,

which are further subdivided to make a total of 17 divisions throughout the state. Figure 2.1 shows the jurisdictional borders of each of these divisions.

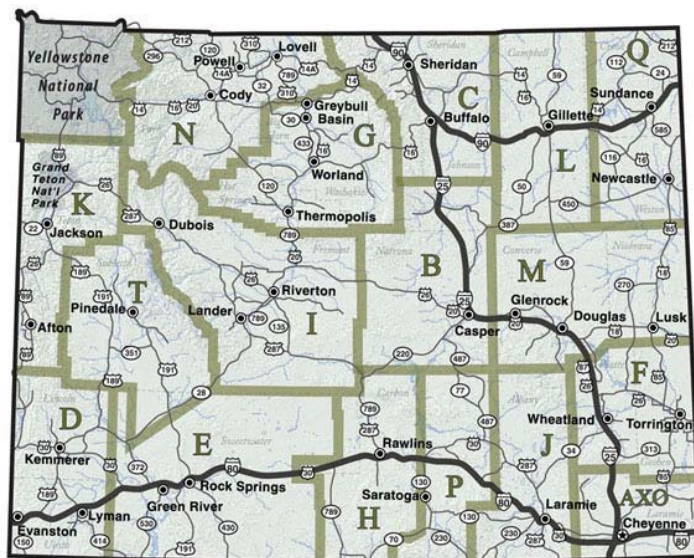


Figure 2.1: Boundaries of 17 divisions of WHP (WHP, 2011, p. 3)

The Highway Patrol in Wyoming does not deal with non-traffic crimes (e.g., murders) in general as opposed to State Patrols that exist in other states like Pennsylvania State Police (PSP, 2015; Torres, 1987). Although WHP may sometimes deal with small thefts that involve vehicles, it is important to note that contrary to other forms of state law enforcement such as state police, WHP is a state highway patrol agency (Shelly et al., 2013) and its primary area of focus is highway and traffic safety. WHP is responsible for enforcement on all types of highways throughout Wyoming (as opposed to only interstates), dealing with approximately 70-75 percent of highway crashes in Wyoming. Contrary to the City Police, who only have enforcement power and authority within city limits, WHP has the charter and authority to perform patrol activities within the boundaries of cities as well (Mickelson, 2012, Personal Communication).

According to Wyoming's comprehensive report on traffic crashes quick facts sheet for the year 2007, the most prevalent type of crash was motor vehicle vs. motor vehicle, where 149 people

were killed in fatal crashes, from which 49 were alcohol related. Natrona County had the highest number of crashes and Sweetwater County had the most fatal crashes during that year (WYHSP, 2007). Figure 2.2 shows a map of different counties in the State of Wyoming.

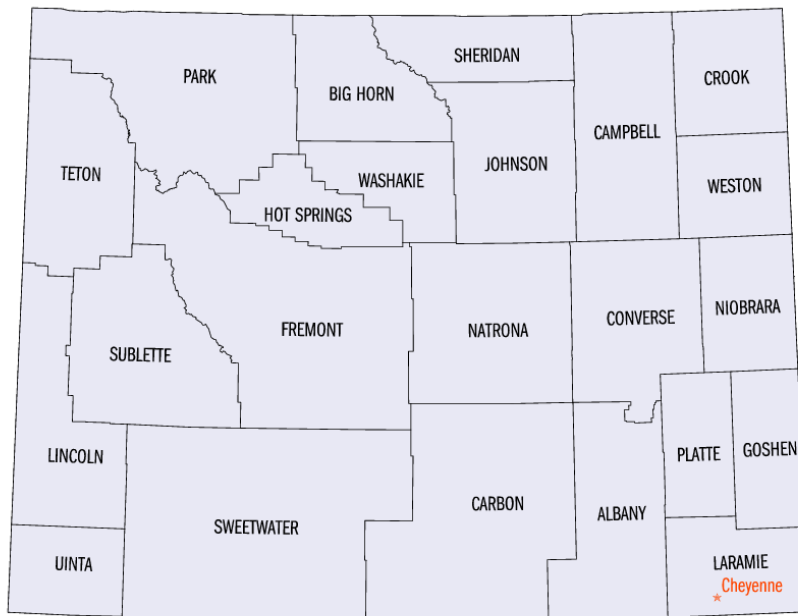


Figure 2.2: Wyoming counties (USCensus, 2014)

In the facts section of Wyoming Seat Belt Coalition, the number of fatalities in 2013 is reported to be 87, dropping down from a total of 119 fatalities in 2012, (WYSBC, 2014), which represents the lowest number in the state since 1945 (with 71 fatalities) (WHP, 2014). However, despite this improvement, Wyoming's fatality rates are still higher than the national average (NHTSA, 2011). NHTSA also has put together a report containing data from multiple resources such as Fatality Analysis Reporting System (FARS), Annual Report File Observed Safety Belt Data, FHWA and National Center for Statistics and Analysis National Occupant Protection Use Survey, presenting the traffic safety facts and trends in the state of Wyoming from 2007 to 2011. A summary of this report is shown in Table 2.1 and in Figure 2.3.

Table 2.1: Traffic Safety Facts for Wyoming (NHTSA, 2012d)

Measures		Year				
		2007	2008	2009	2010	2011
Traffic Fatalities	Rural	124	137	115	133	97
	Urban	26	22	19	22	38
	Total	150	159	134	155	135
Alcohol related driving fatalities (BAC [*] = .08+)		50	65	48	53	38
Speeding related fatalities		56	65	56	57	51
Pedestrian fatalities		2	7	2	3	6

*Blood Alcohol Content

As can be understood from Table 2.1, the fatality rate in Wyoming has been unstable (increase in 2008, reduction in 2009, followed by another increase and reduction over the course of two years in 2010 and 2011). Figure 2.3 shows the same trend, albeit in number of fatalities per 100 million Vehicle Miles Traveled (VMT), in both the state of Wyoming and Nationwide in the US.

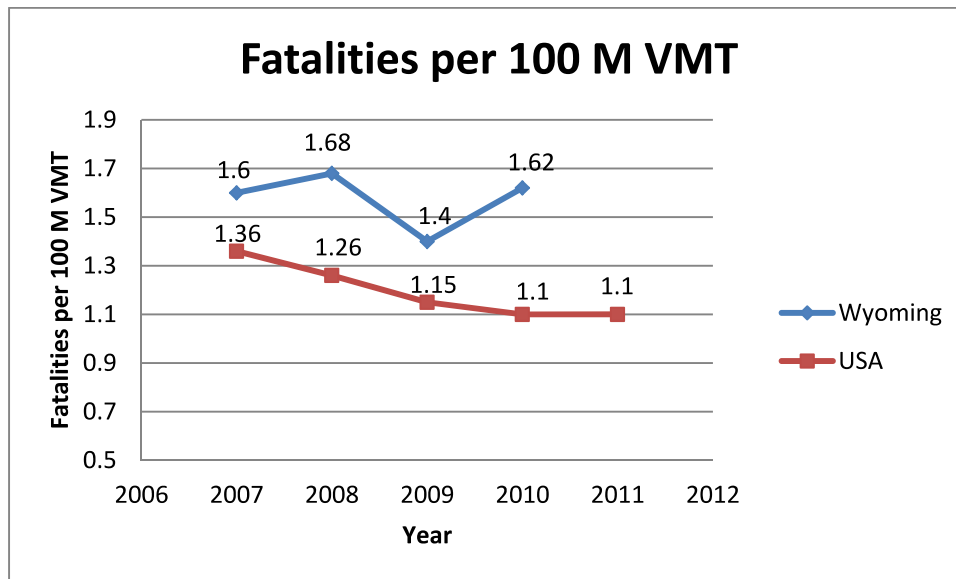


Figure 2.3: Fatalities per 100 million VMT (NHTSA, 2012d)

A similar trend could be seen for the alcohol-impaired driving fatalities per 100 million VMT as well (NHTSA, 2012d). Also it is important to note that as a state with secondary seat belt laws (where police can issue a seat belt citation only after stopping a motorist for another traffic violation), the average seat belt usage rate in Wyoming was below the national average of 83

percent in 2007, despite a statewide increase from 61 percent in 2006 to 72 percent in 2007 (NHTSA, 2009) which was achieved through a funded study by NHTSA and WYDOT's Highways Safety Program (WYDOT, 2009). The seat belt usage rate still remains below the national average, with the vehicle occupants in one in three fatal crashes not being properly restrained (WYSBC, 2014). Despite all the presented facts, based on the 2012 results of the biennially administered survey since 2002 to measure the customer satisfaction of residents of Wyoming and how they perceive the operations performed by WYDOT, a large majority (84 percent) agreed that WHP meets their expectations for highway patrol (WYSAC, 2012).

Given the information and trends presented above, six interviews were conducted in January 2013 with six of high ranking officers and executives in WHP, to investigate what their perceptions of the conditions in the state are, how they value their Strategic Plan and how they think the potential problematic areas need to be addressed. The overall seven categories of performance in WHP's 2011-2013 Strategic Plan is presented in **Chapter 1** of this research (what each of these categories entail is further discussed in **Section 2.4**) but is once again showed below (WHP, 2011):

1. Reduce highway fatalities, alcohol-related crashes, and injury crashes;
2. Maximize our enforcement, educational, and support efforts;
3. Develop and care for our employees;
4. Perform our duties and obligations without reservation;
5. Handle every call with a service-oriented response;
6. Develop and maintain an agency structure that prepares WHP for future growth and demands;
7. Operate within a balanced budget.

During the hour long interviews, it was discovered that almost all interviewees considered safety (i.e., Category 1) as number one priority of the agency- only one officer identified that employee care (i.e., Category 3) was the most important, with the rationale that no business in the world would put the job before their employees - and almost every officer put enforcement operations (i.e., Category 2) as the second- with the exception of one interviewee who put customer service (i.e., Category 5) in the 2nd rank. These two categories were consequently identified as the corner stones for this research and fortunately in line with the nationwide movement towards safer roadways.

Performance measurement in highway traffic safety nationwide from a general perspective as well as particularly pertinent to WHP will be discussed in more detail in the **Sections 2.3 and 2.4** of this chapter respectively. Also the procedure that was implemented to develop performance measures appropriate to the goals set by the recognized top two most important categories in WHP (i.e., safety and enforcement) will be discussed in the following chapters, which will be the starting point for the final models developed in this research.

2.3 Performance Measurement in Highway Traffic Safety

In a report that was created by then the vice-president of the United States, Al Gore, it is stated that agencies need to take proper actions to reduce costs, improve productivity and enhance their levels of service to American public (Gore, 1993). The process of measuring and assessing an organization's progress to achieve its set goals is the definition of performance measurement according to a report for the National Performance Review (NPR) and U.S. Army Corps of Engineers. This report was a follow up attempt after the original driving force from the Government Performance and Results Act (GPRA) and NPR in 1993 (Rodakowski, 1995). One

of the purposes of this report was to improve internal management of federal programs and systematically holding them accountable for results (USDOL, 2013). As a result, agencies and departments must (EPA, 2012):

- Describe their programs' goals and objectives clearly up front;
- Identify actions and resources needed to achieve those set goals and objectives;
- Develop a framework to measure and assess their progress;
- Regularly report on their accomplishments.

Along the lines of this effort, in August 2008, a minimum set of performance measures was introduced by NHTSA and the Governors Highway Safety Association (GHSA) to be used by States and federal agencies in the preparation process of their highway safety plans. These measures were developed by a panel of experts from NHTSA, State Highway Safety Offices, and academic and research organizations. The report discusses that performance measures should be used to set goals and measures and furthermore, assess an organization's progress on local, state, and federal levels (NHTSA, 2008). It goes on to categorize behavior traffic safety performance measures into of the following three groups (NHTSA, 2008):

- Outcomes (crashes, injuries, and fatalities);
- Activities (media, education, and all other activities that may affect traffic safety);and
- Behavior itself (observed behaviors on the road and/or in surveys),

For the following ten areas (NHTSA, 2008):

- Overall
- Seat belt use

- Child occupants
- Alcohol-impaired driving
- Speeding and aggressive driving
- Motorcyclists
- Young drivers
- Older drivers
- Pedestrians
- Bicyclists

The three main categories of performance measures (i.e., outcomes, activities and behavior) are used in different ways. For instance, the outcome measures are more geared towards setting goals on both State and national level (e.g., number of fatalities), while behavior and activity measures are used more for setting indicators of the effects of a specific strategy (e.g., if a state is seeking to educate teen drivers, they may set a goal for the number of hours they put into that effort) (NHTSA, 2008).

GHSA supports ten performance measures to be used as a minimum for State highway safety plans, which are outlined in a report entitled “Guidelines for State Highway Safety Plans” (GHSA, 2004). Of these ten measures, only one (i.e., observed seat belt usage rate) measure is a behavior measure and all the rest are outcome measures. These measures were obtained from FARS and/or State crash data files and are presented in the list below:

- Overall measures
 - Traffic fatalities
 - Fatalities/VMT

- Fatalities/population
- Traffic injuries (including fatalities)
- Injuries/VMT
- Injuries/population
- Seat belt measures
 - Observed seat belt usage rate
- Alcohol measures
 - Alcohol related fatalities
 - Alcohol related fatalities/VMT
 - Percent of all fatalities that involve alcohol

NHTSA reports on how different states were using the proposed performance measures in their highway traffic safety programs four years later after the publication of “Guidelines for State Highway Safety Plans” in 2004 (NHTSA, 2008):

- All States use performance measures, either implicitly or explicitly;
- No single measure is used by all states;
- Only two measures are used by more than half the states (i.e., observed seat belt usage and fatalities/VMT);
- Only four states use all ten proposed measures (NHTSA, 2008).

Additionally NHTSA identified ten of the most frequent State priorities in traffic behavioral areas. Table 2.2 shows these areas along with the number of states that are using them in their Strategic Highway Safety Plans (SHSP).

Table 2.2: Most Frequently Used Areas in States' SHSP (NHTSA, 2008)

Behavioral Focus Areas	Number of States
Occupant protection	48
Impaired driving	46
Young drivers	40
Aggressive drivers	35
Pedestrian safety	34
Motorcycle safety	30
Speeding	28
Bicycle safety	27
Older drivers	24
Distracted drivers	21

A milestone in implementing performance measures was certainly the Moving Ahead for Progress in the 21st Century Act (MAP-21), which was signed into law by President Obama on July 6, 2012 (USDOT, 2014a). MAP-21 focuses on performance-based transportation programs in different areas including Infrastructure, Safety, Freight, and Environment and Realty (USDOT, 2014a). Safety area, which is applicable to this research, includes the following areas identified as major FHWA activities to successfully implement MAP-21 (USDOT, 2014b):

- Highway safety improvement program eligibility and reporting;
- SHSP;
- High risk rural roads;
- State safety data systems;
- Older road users; and
- Best practices manual.

MAP-21 is designed to help transportation safety administrators reduce traffic crashes, injuries and fatalities. It also makes federal funding for transportation agencies and State Departments of Transportation (DOTs) available based on their performance (FMCSA, 2013). Moreover, the American Association of State Highways and Transportation Officials (AASHTO) Standing

Committee on Performance Management (SCOPM) task force on performance measure development reports that, based on the MAP-21, there is a need to develop a set of standard and consistent national performance measures (SCOPM, 2013).

All of the abovementioned emphases on performance measures have led to the utilization of different methods and frameworks by transportation agencies and highway traffic safety entities in an attempt to help them monitor and measure their performance. One of these frameworks is Balance Scorecards. It is important to note that having performance measures and Balanced Scorecards would present further opportunities for benchmarking processes in an attempt to identify and implement best practices within an organization or among different organizations with similar goals, which is also in line with one of FHWA's activities to address MAP-21 (USDOT, 2014b). Balanced Scorecards and benchmarking processes are discussed in the following sections.

2.3.1 Balanced scorecards and benchmarking

The Balanced Scorecard concept, developed by Kaplan and Norton, was introduced as a way to measure and improve organizational performance (Kaplan & Norton, 1996). The Balanced Scorecard suggests four different perspectives that need to be considered in order to have a comprehensive performance measurement framework. These four categories are as follows (Piñero, 2003; Peter Rouse & Putterill, 2003):

- Financial;
- Customer;
- Internal business process; and
- Innovation and learning, later renamed as learning and growth.

Each of the four dimensions of the Balanced Scorecard, which has been widely used since its development in many businesses including State highway traffic safety agencies (NHTSA, 2008; Peter Rouse & Putterill, 2003), focuses on different areas of interest to businesses. From Financial and Customer standpoint, profitability and customer satisfaction are taken into account, while the efficiency of internal processes is the main focus of the third dimension. Finally learning and growth takes into consideration the organization's ability to grow and improve to always be of value to stakeholders and customers (Ozbek, 2007). Many state and federal agencies started to take advantage of the level of comprehensiveness that Balanced Scorecards offer in the process of implementing performance measures in their organizations and aligning their strategies with Federal directives (CSP, 2011; Maryland, 2011; NHDOT, 2011; NorthDakota, 2011; Schumacher, 2012; SouthDakota, 2012; WSP, 2012).

Performance measurement and Balanced Scorecards work very well with the concepts of benchmarking. There are many definitions available on the topic of benchmarking. Construction Industry Institute defines it as "the systematic process of measuring one's performance against recognized leaders for the purpose of determining best practices that lead to superior performance when adapted and utilized"(CII, 1995). With a set of good performance measures, benchmarking can be done in every organization, one of the outcomes of which is to identify best practices within or among entities that will further benefit the organization with an overall improvement in operations and performance. Benchmarking processes can be done either internally or externally. In the case of internal benchmarking, comparative analysis is made against organization's own projects, while in the case of external benchmarking, projects are sought from other organizations as well; and ultimately the comparison is conducted among multiple organizations (NRC, 2005). Internal benchmarking, often considered to be the starting

point of the quantitative process examination (NRC, 2005), would enable decision makers to compare the units of an organization, identify the best performing ones, and learn their best practices so that other units could take advantage and improve their performance as well. The same logic applies to external benchmarking of several organizations that follow the same goal, with the added value of comparing one organization against its competitors (NRC, 2005).

2.3.2 Balanced scorecards and measures in other patrols

As mentioned in **Section 2.3.1**, many state and federal agencies utilize Balanced Scorecards in their organizations. While many of the performance measures in the state SHSPs are in line with Guidelines for State Highway Safety Plans and NHTSA's Traffic Safety Performance Measures for States and Federal Agencies (GHSA, 2004; NHTSA, 2008), details of which were presented in **Section 2.3**, the level of details and emphasis put on certain measures can be different from state to state. SHSPs and Balanced Scorecards of several states were studied in order to help gain perspectives on patrol operations as well as to develop the most applicable measures for WHP. The list below points out some of the more rudimentary measures used in other states:

- California Highway Patrol (CHP): California was among the states that have very comprehensive highway safety plans. One of the top main departmental goals in CHP, is to “prevent loss of life, injuries and property damage” (CHP, 2006, p. 4). This statement shows the importance of avoiding all crashes, whereas many states, including Wyoming, only focus on fatal and incapacitating injury crashes. Also California's Highway Safety Plan in 2012, divides the agency's focus in 13 specific program areas based on target population and behavioral categories. These program areas include, among others,

alcohol, drugs, distracted driving, occupant protection, pedestrian and bicycle safety, motorcycle safety and equipment (CAHSP, 2012).

- Maryland State Police (MSP): Similar to CHP, Maryland has also divided the performance measures in its highway safety plan and SHSP into different behavioral categories. These categories include aggressive driving, distracted driving, impaired driving, occupant protection, pedestrians and speed; and have targeted focus areas emphasizing on young and older drivers, as well as bicycles, motorcycles, buses and trucks (MHSP, 2013). Maryland's SHSP also recognizes different measures in hazardous locations such as intersections and work zones (MSP, 2011).
- Washington State Patrol (WSP): Similar to CHP and MSP, Washington has divided highway crashes into different categories. However, WSP only takes into account the fatalities and serious injury crashes in categories focusing on behaviors involving speed and DUIs (WSP, 2012).
- South Dakota Highway Patrol (SDHP): This neighbor state of Wyoming classifies its performance measures in three main categories of core outcome measures, behavior measures and activity measures. SDHP further breaks down the fatalities and serious injury crashes into speeding, unhelmeted motorcyclist, drivers age 20 or younger, and unrestrained passenger vehicle occupant in all seat positions (SDHP, 2012).
- Montana Department of Transportation (MDT): Montana has different categories of measures in its Comprehensive Highway Safety Plan, which include increasing safety belt usage, reducing statewide impaired driving, motorcycle, older driver, and young drivers under 21 years of age specifically in fatal and incapacitating injury crashes (MDT, 2010).

These measures were discussed in meeting with WHP staff to investigate their applicability and pertinence to WHP's patrolling practices. More discussions regarding the measures used in this research are presented in **Chapters 3 and 4**.

2.4 Performance Measurement in WHP

During the years 2003-2004 for purposes of accountability and with directives coming from the federal level, WHP was encouraged to take advantage of performance measures in their organization at the suggestion of the Governor's Office (Mickelson, 2012, Personal Communication). WHP studied the Colorado State Patrol (CSP) that had been utilizing performance measures at that time and developed measures that were very similar to those of CSP's. The idea of implementing Balanced Scorecards to measure the performance of the various programs WYDOT came into the picture at this time.

As mentioned in **Chapter 1** and earlier in this chapter, WHP developed seven categories for their overall Balanced Scorecard in the Strategic Plan for 2011-2013. Each of these categories contains goals accompanied by measures and targets values in most instances as well as appropriate strategies, all of which is presented in Table 2.3.

Table 2.3: WHP Balanced Scorecard (WHP, 2011)

Goal	Measure	Strategy
Reduce Highway Fatalities, Alcohol Related Crashes and Injury Crashes	# of Fatalities	Reduce the total number of fatalities annually
	# of Fatal Crashes	Reduce the number of fatal crashes by 5% annually
	# of Impaired Driver Related Fatal Crashes	Reduce the number of impaired driver related fatal crashes by 5% annually
	# of CMV Fatalities	Reduce the total number of CMV fatalities annually
	# of Fatalities during Specially Recognized Holidays	Reduce the number of fatalities during specially recognized holidays
	# of Injury Crashes	Reduce the number of incapacitating injury

		crashes by 5% annually
	# of CMV Crashes	Reduce the number of CMV crashes by 5% annually
Maximize our Enforcement, Educational and Support Efforts	% of Citations Issued per Investigated Crashes	Actively enforce legitimate traffic violations that result in a crash
	% of Seat Belt Usage	Increase seat belt use to equal the nationwide seat belt use rate for Wyoming residents
	# of Hours Dedicated to Targeted Enforcement Efforts	Identify and utilize effective targeted enforcement efforts with innovative methods, tactics, strategies, etc.
	# of Outreach Programs or Presentations	Increase efforts for outreach to the public by all areas within Patrol
Develop and Care for Our Employees	Turn Over-Rate	Reduce the turn-over rate for all areas in Patrol
	% of Employees Offered an Individual Development Plan (IDP)	Offer each employee an IDP annually
	Rating from Employee Survey	Increase the rating from Employee Survey
	# of Duty Related Employee Injuries	Decrease employee injuries by fostering a safe work environment
	% of Troopers Who Qualify for Incentive	Increase by 5% those troopers who qualify for incentive under the Fitness Program
	# of Employees Participating in the Wellness Program	Increase the number of employees who qualify for incentive under the Wellness Program
	Rating from Employee Survey- Employee Recognition	Foster an environment of employee recognition
		Develop an overall training program
Perform Our Duties and Obligations Without Reservation		Develop a recognition awards program for civilian personnel
	% of Employees	Increase the number of certified inspectors
	% of Out of Service Drivers Compared to Total # of Commercial Vehicle Safety Alliance (CVSA) Inspections	Place drivers out of service for established violations
	% of Out of Service Vehicles Compared to Total # of CVSA Inspections	Place vehicles out of service for established violations
	% of Short-Term Goals Obtained from FHWA Plan	Comply with short-term goals listed in the plan submitted to FHWA annually
Handle Every Call with a Service Oriented Response	% of Time Spent Patrolling	Increase % of total hours worked, actually spent, patrolling by 5%
	Rating from Customer Satisfaction Survey Cards-SWORN	Maintain a 98% or greater positive response rate
	Rating from Customer Satisfaction	Maintain a 98% or greater positive

	Survey Cards-Port of Entry (POE)	response rate
	% of Calls Responded to Within 20 minutes	Safely respond to all calls in 20 minutes or less
		Develop and implement a system that tracks response time using the Record Management System (RMS)
		Improve internal customer service
Develop and Maintain an Agency Structure that Prepares WHP for Future Growth and Demands		Conduct a statewide assessment of resources
		Assess the need for a new Patrol academy
		Obtain additional dispatch personnel to minimize overtime, employee burn-out, and to better serve our customers
		Obtain Patrol dedicated IT support for our technology needs
		Develop and implement e-Citations
		Develop and implement e-Permitting and self-issuing permit process
		Develop a comprehensive inventory system
		Effectively use RMS
		Develop a recruiting strategy
Operate Within a Balanced Budget	% of Expenditures to Budget	Stay within + or - 5% of budget
		Conduct annual budget review with Patrol staff

However, despite the fact that WHP has been using performance measures for quite some time now, Wyoming's fatality rates are still higher than the national average (NHTSA, 2011). Table 2.4 compares fatality rates in Wyoming with those in the USA national average and the Best State.

Table 2.4: Fatality rates in Wyoming, USA National Average and the Best State

Year		Fatalities per 100 Million VMT
2007	Wyoming	1.60
	USA	1.36
	Best state*	0.79
2008	Wyoming	1.68
	USA	1.26
	Best state	0.67
2009	Wyoming	1.40
	USA	1.15
	Best state	0.62
2010	Wyoming	1.62
	USA	1.11
	Best state	0.64

* Note that the lowest rate in the Best State could be in a different state each year.

It is clear from the discussion presented in prior sections of this chapter that WHP has the potential to improve its organizational performance; and internal benchmarking is a viable starting point given WHP's existing focus on performance measures. Nevertheless, it is important to note that internal benchmarking becomes a challenging task, especially for large organizations like WHP with 17 divisions (as units) and so many different measures (refer to Table 2.3). In the same context, it is important to understand the difference between effectiveness of strategies implemented by an organization versus its efficiency. Effectiveness measures the performance of an organization only with respect to the produced outcomes, while efficiency takes it one step further and looks at the ratio of those outcomes to the amount of resources used in the process of producing them. With the limited amount of budget and resources available for organizations, improving their overall efficiency would allow them to perform at their best and maximize the desired outputs while keeping their resources within the constrained amount. WHP is not currently looking at the efficiency of their operations from an overall point of view. This further emphasizes the need for a comprehensive framework that will

allow for an overall performance assessment of the efficiency of their organization. **Section 2.5** talks about methods and tools to perform such task.

2.5 Efficiency Measurement Methods

Given the need for the development of a comprehensive performance framework to be utilized in WHP to measure their overall efficiency as well as benchmarking their operations and identifying the best practices, it is critical to apply the most appropriate method considering the characteristics of this research.

Efficiency is defined as the ratio of outputs to inputs (Cooper, Seiford, & Tone, 1999) and there are several approaches that have been used for the measurement and comparison of the efficiencies of systems in the presence of multiple inputs and outputs. Three of these methods are briefly discussed below:

- **Partial Efficiency Measure Approach:** This approach takes into account the ratio of one output to one input, one at a time (Sexton, 1986), which understandably makes it very hard to investigate and measure the overall efficiency of the organization (Ozbek, 2007).
- **Parametric Approach:** In this approach the outputs are formulated as a mathematical function of the inputs which requires the use of a parametric specification to properly describe the processes. While by using this method, the drawback mentioned in the Partial Efficiency Measure Approach could be addressed, it would be very hard for big organizations with complicated processes to develop such relationships (Ozbek, 2007).
- **Total Factor Efficiency Measure Approach:** This approach overcomes the drawbacks identified in Partial Efficiency Measure Approach and Parametric Approach, however; it

introduces a large level of subjectivity by requiring the prescription of weights to be assigned to inputs and outputs (Cooper, et al., 1999).

All of the abovementioned approaches come with drawbacks that make them less than desirable to be utilized for this research. Data Envelopment Analysis (DEA), which was briefly introduced in **Chapter 1**, is a powerful methodology with features that make it suitable for this research, while overcoming the weaknesses of other efficiency measurement methods. DEA is equipped with tools to address the issues that were identified and discussed previously, both in **Chapter 1** and earlier in this chapter, in the context of difficulties with developing a comprehensive multi measure performance assessment framework for big organizations like WHP.

2.5.1 Data Envelopment Analysis (DEA)

DEA was originally proposed by Charnes, Cooper and Rhodes in 1978 as an approach that is capable of dealing with processes and systems with multiple measures while not having any of the major drawbacks of the other efficiency measurement methods (Charnes, Cooper, & Rhodes, 1978). DEA is a mathematical tool based on the concepts of linear programming and production theory that will enable the assessment of the efficiency of the operations undertaken by organizations in the presence of multiple measures (Ramanathan, 2003). DEA quantifies how efficiently a unit within an organization transforms inputs to desired outputs (Ramanathan, 2003). The units in the DEA context are referred to as Decision-Making Units (DMUs). The ultimate products of DEA are (Charnes, et al., 1978):

- An envelope (efficient frontier) consisting of 100 percent efficient DMUs
- Efficiency score assigned to a given DMU (i.e., the maximum of a ratio of the weighted outputs to the weighted inputs) subject to the following constraints:

- The mentioned ratio should be less than or equal to one for every DMU using the same weights; and
- The weights are non-negative
- Peers that are 100 percent efficient DMUs closest to the DMU under study, which can be used for benchmarking purposes to learn their best practices.

The original formulation of DEA (also known as CCR, using the initials of Charnes, Cooper and Rhodes) extends the single output to the single input approach used by Farrell in 1957 (Mason Jared Farrell, 1957) to optimize the multiple outputs to multiple inputs ratio. There are two perspectives to approach this optimization:

- I. From Inputs perspective: In this method the objective is to minimize the weighted inputs, subject to the weighted outputs being equal to one. This is also known as the input minimization approach.
- II. From Outputs perspective: Contrary to the input minimization approach, in this perspective the objective is to maximize the weighed outputs while the weighted inputs equal to unity (also known as the output maximization approach).

Each of these perspectives has dual formulations as well which help solve the equations easier from a mathematical standpoint. In this context, approach I (i.e., input minimization) would be the **output oriented** model and the second approach (i.e., output maximization) would be referred to as the **input oriented** model. It is important to note that the detailed DEA formulations on the selected models are presented in **Chapter 3: Methodology**.

In the CCR models, processes are considered to perform under **Constant Returns to Scale (CRS)**, which means that a proportionately equal increase (or decrease) in all inputs would lead

the same proportional increase (or decrease) in all outputs (Ozbek, 2007). As might be obvious, most systems and processes do not perform under CRS in reality. This means that CCR is a very conservative approach and not very applicable to real life processes. Therefore, new formulations were proposed by Banker, Charnes and Cooper in 1984 (Banker, Charnes, & Cooper, 1984) that introduced **Variable Returns to Scale (VRS)**, under which a proportionately equal increase (or decrease) in all inputs would lead to a proportionally greater or smaller increase (or decrease) in all outputs (Ozbek, 2007). This model is called BCC, named after its developers.

To better understand how DEA works, Figure 2.4 presents the application of DEA for a process with two outputs and one input. Let's assume that the so called process is a WHP operation. The input to perform this process is the number of patrol staff in WHP (x) and the outputs are two that are selected from WHP's Balanced Scorecard measures presented previously in Table 2.3, seat belt usage (y_1) and the percentage of time spent patrolling (y_2). The axes of the diagram are the normalized value of outputs (y_1 and y_2) by the utilized input (x) (i.e., $\frac{y_1}{x}$ and $\frac{y_2}{x}$). The dots plotted in the diagram are the six hypothetical DMUs of WHP (A through E). The efficient frontier, which is the solid bold line, has the 100 percent efficient DMUs on it identified as a result of the DEA process and by solving the mathematical formulations previously mentioned in this section and will be discussed in detail in **Chapter 3** (i.e., C, D and E). All the other DMUs are inefficient relative to C, D and E. The efficiency score of DMU B was calculated to be 87.7 percent (ratio of OB to OB'). B' is the projection of B on the efficient frontier on a line through origin that passes through B. This means that DMU B can improve its performance by 12.3 percent to achieve the hypothetical 100 percent efficient unit of B'. In this process DMU B can learn DMUs C and D's best practices and implement them to achieve to the complete efficiency. This is because B' is the linear combination of C and D and therefore, in the context of DEA,

those DMUs (C and D in this example) are known as **efficient peers** of an inefficient DMU (B in this case).

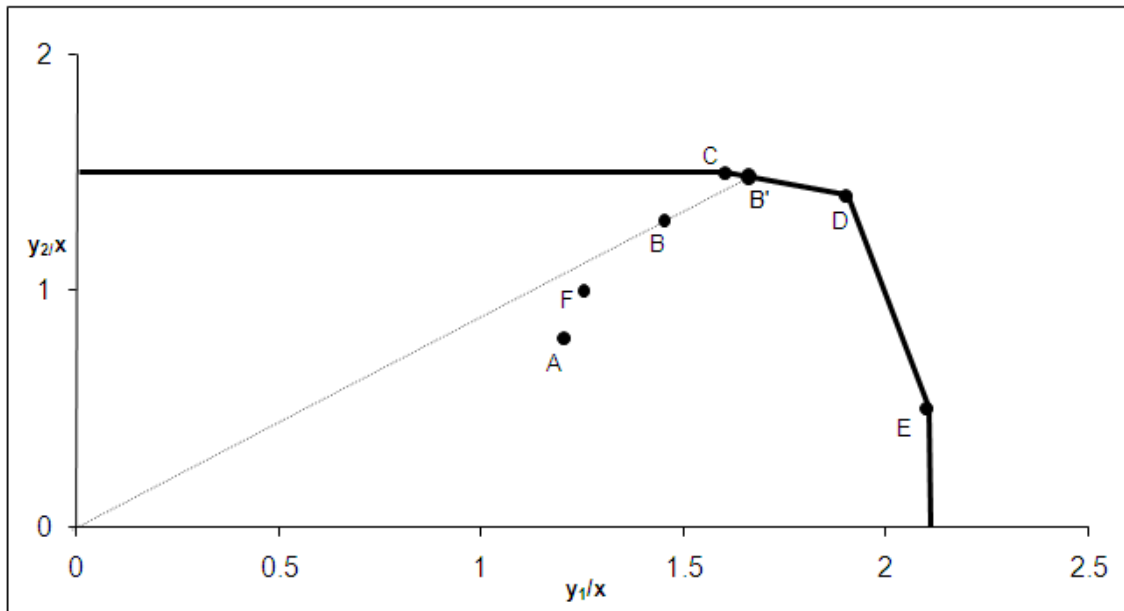


Figure 2.4: Hypothetical DEA model for the highway patrol process with a single input and two outputs (Ozbek, 2012, p. 3)

Some of the DEA characteristics/strengths are listed below (Charnes, Cooper, Lewin, & Seiford, 1994; Ozbek, et al., 2009; Ramanathan, 2003):

- Ability to simultaneously deal with multiple inputs and outputs;
- Ability to deal with uncontrollable variables (such as environmental factors). These factors can affect the processes of a unit but are beyond the decision makers' control and need to be considered in order to have a level ground of comparison between the units;
- No subjectivity in assigning the weights;
- Calculating the efficiency of processes from an overall perspective;
- No mathematical formulation describing the process is necessary;
- Identifying the peers in addition to calculation each DMUs' efficiency score;

- Ability to deal with variables with different natures and units;
- Ability to be extended beyond the original formulation to make the models appropriate for particular purposes.

On the other hand, DEA limitations include (Charnes, et al., 1994; Ozbek, et al., 2009; Ramanathan, 2003):

- The bigger the organization (and thus larger the number of variables and DMUs), the more complicated the mathematical computations get. This calls for utilization of specific software platforms that could handle the large amount of calculations. Fortunately there are many platforms and solvers available on the market today.
- It is difficult to explain the DEA formulations and how the models work to non-technical audience.
- Availability and accuracy of data itself. DEA, as its name suggests, is a data driven technique and is highly dependent on data. Therefore in case of human errors or erroneous data, the results of the models would be useless.
- Since DEA is a non-parametric approach (which is one of its strengths as well), it makes it hard to perform statistical analyses on the results.

Detailed DEA formulations are discussed in **Chapter 3**.

2.6 Studies Related to This Research

Although DEA has been utilized for organizational performance evaluations in multiple sectors such as banks, insurance companies, hospitals, industrialized manufactures, universities, hotels, military services in governments, transportation, and engineering (Avkiran, 2006; Ozbek, et al.,

2009), no studies have specifically incorporated DEA in the context of highway traffic safety from the patrol's perspective. **Section 2.6.1** discusses patrol studies related to the objectives of this research that were done without implementing DEA. **Sections 2.6.2** and **2.6.3** present studies pertinent to Highway Traffic Safety and Police Forces respectively that utilized DEA as their main methodology.

2.6.1 Non-DEA patrol studies

There are several studies that are geared towards identifying crash prone locations on highways as well as traffic safety practices based on different case studies. The paragraphs below provide a brief overview on some of the most recent studies, all of which have used methodologies other than DEA:

The Idaho Transportation Department has developed a data-driven method using the Highway Safety Manual (HSM) and Geographic Information Systems (GIS). This study was performed in an attempt to identify the high priority locations for safety improvements. HSM is nationally recognized and provides the basic information to estimate the potential reduction in the number and severity of crashes after applying the improvements in each stretch of the highway. The stretches of the highway were prioritized based on the potential crash cost savings and the cost to benefit ratio in each segment (Loudon, Schulte, Pilachowski, & Jennings, 2014). Another study in Maryland used data-driven approach to coordinate engineering, education and enforcement operations in order to create pedestrian's safety initiative. Similar to the study by Loudon et al. (2014), this study used GIS and data analysis of county wide pedestrian crashes to achieve its objectives (Dunckel, Haynes, Conklin, Sharp, & Cohen, 2014). In another study by Pande et al. (2014), the same objective as the previous two studies (i.e., identifying high crash risk highway

locations) was addressed by means of exploring naturalistic driving data. The data was collected through Global Positioning System (GPS) devices and linked the long-term crash frequencies to abrupt and/or abnormal driving maneuvers to the roadway characteristics data map (Pande, Dixit, Spansel, Wolshon, & Kent, 2014).

A study by Wu and Wemple (2014) proposes a sketch method in the absence of quantitative information. The sketch method is aimed to analyze the cost-effectiveness of safety investment decision making across the 4 Es of traffic safety and was applied by the North Carolina DOT. As a result of this method, investment projects would be prioritized by their relative cost-effectiveness, the definition of which was gathered from HSM (Wu & Wemple, 2014).

In a study targeted towards identifying safety practices, issues and needs pertinent to local transportation and law enforcement agencies in the state of Florida, online surveys were distributed among relevant audience. The questions focused on several areas such as high crash locations, standardization of crash analysis methods, traffic violations, and safety campaigns. The results from investigating Florida DOT suggest that speeding, failure to use safety belts and/or improperly using restraints systems for passengers, specifically children, and DUI related violations were the most common traffic violations. Also enforcement activities on DUI, speeding, running red light and restraining systems issues were perceived to be among the most effective measures to improve traffic safety, while following too closely, illegal parking and illegal turning turned out to be the least effective measures. The study concludes that similar surveys and studies should be adopted by other state DOTs to identify the issues with their local traffic safety and enforcement entities. (Haleem, Gan, Alluri, & Saha, 2014).

A case study was conducted in the State of Missouri, in an attempt to assess the safety effect of Missouri's SHSP (MSHSP). This study evaluates the changes in traffic and motor vehicles crashes that occurred on Missouri's highways after implementation of the state wide SHSP between 2004 and 2007. The main method in this study was the utilization of regression models for different crash categories and severities. Estimates suggest that there has been a ten percent reduction in the overall number of crashes and 30 percent reduction in the case of fatal crashes with the application of MSHSP. The study concludes that there is a need to analyze the particular effectiveness of specific focus areas in SHSPs with the addition of other measures that could affect the safety status of roadways (Mohammadi, Samaranayake, & Bham, 2014).

Other countries have performed similar studies, the goals of which were to evaluate the traffic safety conditions in local areas and to create action plans and/or holistic safety plans for safer roadways (Flores, Park, Gardiner, & Nyen, 2014; Sarhan, 2014; Vanderlei, Van, & Klok, 2014). In all of these studies, authors are reporting on investigations of current traffic conditions and issues and the need for future studies that can take into account multiple performance measures as well as other factors that can affect the performance of the entities in charge. This is where the importance of DEA studies becomes clear.

2.6.2 DEA and highway traffic safety

In a study by Odeck in 2006, a BCC model with a constant input was applied to measure productivity growth in the target achievements set by the operational units of the Norwegian Public Roads Administration charged with traffic safety services during a four year time frame. The authors conclude that more research needs to be done in an attempt to identify the specific

characteristics (i.e., uncontrollable variables) of the units under which they are operating (Odeck, 2006).

DEA was used by Cook et al. (2001) as their methodology to prioritize highway accident sites. DEA allowed them to include multiple inputs on the resource side (e.g., cost of repair, driver inconvenience) as well as to assign weights to different sections of the roads. As a result, the authors suggest that a more comprehensive study needs to be done to incorporate wider ranges of uncontrollable variables such as the age and gender of driver, extent of alcohol involvement, and presence of high speeds (Cook, Kazakov, & Persaud, 2001).

A study by Egilmez and McAvoy (2013) was performed in which a DEA based model was utilized to assess the productivity and relative efficiency of US states in decreasing the number of road fatalities in the period of 2003-2008. The methodology was mainly chosen because of the fact that each state had its own strategic plans to reduce road fatalities. The results of the study suggest that even though there is a declining trend observed in the fatality rates, the usage of societal and economical resources by the states is still not efficient. The main output in the models was the number of fatalities. The risk domains that affect the fatality rates were divided into seven groups such as the safety expenditures, number of registered vehicles, number of registered drivers, VMT, safety belt usage, total road length and road condition score (Egilmez & McAvoy, 2013).

Finally Hermans et al. (2009) attempted to prioritize policymakers' actions in 21 European countries as to which risk domain mostly contributes to roadway crashes. Risk domains in this study include alcohol and drugs, speed, proactive systems, vehicle, infrastructure and trauma

management that affect the road safety outcomes (i.e., crashes, fatalities) (Hermans, Brijs, Wets, & Vanhoof, 2009).

2.6.3 DEA and police forces

In a study by Sun (2002), DEA was used to measure the relative efficiency of 14 police precincts in Taipei city, Taiwan using police statistical data from 1994-1996. Several methods such as window analysis, slack variable analysis, and output oriented DEA models with both CRS and VRS were performed for this study. The results revealed that differences in operating environments (e.g., resident population, location factors) did not have significance influence on the police precincts' efficiency (Sun, 2002).

Nyhan and Martin (1999) conducted an exploratory study examining the potential implications of DEA in making comparative performance assessment among government service providers such as municipal police services. The study found that multijurisdictional comparisons using uncontrollable variables can better determine the relative performance. According to this study, DEA can specifically provide insights that other analytical techniques are incapable of (e.g., assessing the performance in the presence of multiple inputs and outputs, assigning optimum weights to variables without being subjective, identifying benchmarking opportunities, and estimating potential cost savings). In this study population, median income and geography were used as uncontrollable variables (Nyhan & Martin, 1999).

DEA along with another quantitative tool (i.e., Structural Equation Modeling) was used in a study by Goltz (2008) to explore the effects of the environment on police organization structure and performance. The author used population density, different age groups, crime rate per 100,000 of population, unemployment rate, poverty rate, percentage of sworn officers assigned

to non-patrol duties, size of the district, police vehicles, and mobile computers as uncontrollable variables. The results of the study suggest that the environment in which a police organization is operating significantly influences its resourcefulness and performance, which emphasizes the importance of uncontrollable variables (Goltz, 2008).

Gorman and Ruggiero (2008) performed Multiple-stage DEA models using multiple inputs and outputs in 49 states in the United States to characterize police services performance, technical and scale efficiency. The results of the paper indicate that most states are technically efficient but about half are operating at less than an optimal scale size, and about 30 percent of the state police forces are inefficient compared to their peers. Population, population per square mile, percentage of labor force, percentage of single mothers and percentage of poverty were used as uncontrollable variables in this study (Gorman & Ruggiero, 2008).

In 1995, Thanassoulis (1995) published a paper assessing the performance of police forces in England and Wales to further contribute to a study of crime management that was carried out in 1993. In this study the overall performance of forces was assessed by setting the clear up levels against the crime and manning level (Thanassoulis, 1995).

Carrington et al. (1997) used DEA to measure the efficiency of major government service providers (e.g., police, courts, hospitals) in New South Wales (NSW). The results suggest that NSW local police districts could reduce their input usage by 13.5 percent by better management. It also found that differences in operating environments (e.g., location and socioeconomic factors) do not have significant effects on the efficiency of police patrols. The study was designed in two phases. In the first phase DEA is used to compute technical efficiency scores for all police patrols, while in the second phase, Tobit regression was used to analyze the external

factors which could have potentially influenced patrol's technical efficiency. The external factors identified by NSW police services include certain age population, percentage of public housing and the area that needs to be served (Carrington, Puthucheary, Rose, & Yaisawarng, 1997).

It should be noted that although DEA has been used in both highway safety and police forces domains separately, no study was found to combine the two areas together. Given the importance of these two domains and DEA's potential to help improve traffic enforcement agencies' performance and efficiency, this research is believed to contribute to the body of knowledge by serving as a starting point for future similar studies.

CHAPTER 3: METHODOLOGY

This chapter discusses the methodology that was used in this research. As was mentioned in **Chapter 2**, the main methodology utilized in this study is Data Envelopment Analysis (DEA). There are several phases that need to be undertaken in order to conduct a thorough DEA study and develop a comprehensive framework for WHP in this research. These phases (along with any extra sub-phases required to complete the goal of each phase) are discussed in detail in this chapter. Overall, the purpose of this chapter is to talk about all the processes and steps that need to be taken to get to final results, which is further discussed in **Chapter 4: Results**. Therefore, there is a one on one match for each section between **Chapter 3** and **Chapter 4**.

3.1 Phases of a DEA Study

Ramanathan (2003) in his book “*An Introduction to Data Envelopment Analysis*” talks about several non-computational aspects in addition to performing the routine mathematical formulas, that need to be considered when conducting an efficiency study using DEA (Ramanathan, 2003). These aspects are discussed in separate phases in the following sections (Ramanathan, 2003; Sarkis, 2002):

3.1.1 Phase one: Selection of Decision Making Units (DMUs)

As discussed in **Section 2.5.1**, in the context of DEA, DMUs are units within an organization that utilize resources through certain processes to generate desired outputs. There are some characteristics that need to be taken into account when identifying the DMUs for an efficiency study. These characteristics are as follows (Dyson et al., 2001; Golany & Roll, 1989; Ramanathan, 2003):

- Homogeneity of DMUs: DMUs must be homogeneous units. This means that while DMUs are different units of an organization, they are performing the same tasks with similar objectives to one another, using the same set of inputs to generate the same set of outputs. It should be noted that obviously the amount or magnitude of the used inputs and produced outputs can be and often is different from DMU to DMU, but the overall process of DMUs can be described using the same set of inputs and outputs to achieve a set of objectives.
- Number of DMUs: Number of DMUs in each study is dependent upon the objective of the study. However, there are some rules of thumb that, if implemented (when possible depending on the characteristics of study), could help increase the discriminating power of DEA. Before moving on to these rules, the concept of discriminating power of DEA should be discussed. The discriminating power of DEA is the power by which a DEA model can distinguish efficient units from inefficient ones. If the number of DMUs is high, then it is more likely for the DEA model to identify higher numbers of DMUs as inefficient. However, it is not only the number of DMUs but rather the number of inputs and outputs (total number of variables) in comparison to the number of DMUs under study that affects the discriminating power of the DEA model. This is due to the fact that a DMU with a high ratio of a particular output to input, would assign all the weight to that ratio to be identified as 100 percent efficient (Ozbek, 2007). Running a DEA model with large number of variables would thus result in more DMUs with high efficiency scores. Below are some rules of thumb established in the DEA literature:
 - The number of DMUs should be larger than the product of the number inputs and outputs (Avkiran, 2001). For instance, in a model with three inputs and three

outputs, there would be at least nine efficient DMUs. Dyson et al. (2001) recommend that the number of DMUs be at least two times larger than the product of the number of inputs and outputs (Dyson, et al., 2001).

- The number of DMUs should be at least 2 or 3 times larger than the sum of the number inputs and outputs (Ramanathan, 2003).

However, despite the above mentioned rules of thumb, there are several DEA studies with rather small sample sizes (i.e., DMUs). It is always a trade-off to have bigger sample sizes. The higher the number of DMUs in a study, the more likely it is to risk their homogeneity. On the other hand, with a bigger sample size, there is more room to incorporate greater numbers of inputs and outputs (according to the rules of thumb explained above) while still being able to discriminate between inefficient and efficient DMUs.

- Condition of DMUs: DMUs should be performing under same conditions and circumstances. The reason for this characteristic is that the performance of DMUs could be greatly affected by the conditions and circumstances under which they are working. This criterion is very hard to meet and is in fact hardly ever met in DEA studies. Therefore, there are factors that are introduced in the DEA model that represent these conditions and DEA is capable of incorporating them into the analyses (Ozbek, 2007). These factors are discussed in **Section 3.1.3**.

The important point to keep in mind when conducting this step is to investigate the DMUs in compliance with criteria mentioned above and to have all the necessary units present that can characterize a comprehensive model, depicting the operations performed within the organization fully. The DMUs selected for the purposes of this study are discussed in **Section 4.1.1**.

3.1.2 Phase two: Selection of controllable variables (inputs and outputs)

As was discussed earlier in **Chapter 2**, inputs are defined as resources that are utilized by DMUs in the process of generating the outputs. The second phase in conducting a DEA study is to identify the controllable variables (i.e., inputs and outputs). The reason for insisting on calling these variables “controllable” is to distinguish them from the “uncontrollable” variables that will be discussed in detail in **Section 3.1.3**. Inputs and outputs are referred to as controllable variables because their magnitude can be altered as a result of the decisions made by the decision makers. For instance if the inputs in a study is the number of employees working in an organization, it is within the decision makers’ control to lay some people off or hire some more people depending on the needs of the organization. Also on the output side, it is again in the power of decision makers to make appropriate changes within the organization or processes that will influence the amount of produced outputs. Uncontrollable variables, on the other hand, are factors that cannot be controlled by decision makers. They can be any factor from environmental to operational and economy that can affect the processes of an organization; but there is nothing that decision makers can do to change them. These variables will be discussed in **Section 3.1.3**.

The process of selecting inputs and outputs to be used in a DEA study is often subjective; and thus it is rather difficult to come up with a general guideline that can be extended to every application. However, as recommended by Ramanathan (2003), after a thorough study to identify how DMUs perform within an organization and what the ultimate goals and objectives of those DMUs are, a long exhaustive list of inputs and outputs that can have even the smallest effect on the performance of DMUs can be created. This is a good start but as discussed in **Section 3.1.1**, these variables should be refined to a reasonable number in order for the DEA models to have

good discriminating power. As was mentioned briefly in Phase One, the greater the number of variables, the lower the discriminating power of DEA models would be.

In order to come up with the initial comprehensive list of inputs and outputs and further refine them to form the final set of variables to be used in the models for this research, following steps were taken:

3.1.2.1 Review of the Literature

This literature review mainly focused on the performance measures that were in use by different State and Highway Patrols, Highway Traffic Safety agencies and traffic enforcement entities nationwide in addition to studying WHP's most recent Strategic Highway Safety Plan (SHSP) (WHP, 2011). In addition to studying WHP's Balanced Scorecards both at the agency and district level (as was mentioned in **Section 1.3**, WHP has divided its jurisdiction into 5 districts, adding up to 17 divisions throughout the state of Wyoming), different enforcement agencies and entities from the neighboring states of Wyoming (i.e., Montana, Idaho, Utah, Colorado, Nebraska and South Dakota) as well as states with very comprehensive and detailed SHSPs like California, Washington, Florida and Maryland were studied.

Through this detailed and much focused literature review, areas of significance along with States' strategies to address those issues were identified. Most of the performance measures are in line with what NHTSA had suggested in its report published in 2008, entitled *Traffic Safety Performance Measures for States and Federal Agencies* (NHTSA, 2008). Details of this report along with summaries of different states' SHSPs were previously discussed in **Section 2.3**. This first step was critical for developing the next steps in the most efficient and comprehensive way.

3.1.2.2 Meeting with the Champion of the Research Project

After getting a good idea on what the areas of significance were, a list of questions was created to be discussed with the Champion of the research in WHP, Captain Derek Mickelson. A complete list of these questions is presented in Appendix A. The outcome of this meeting helped gain more elaborate perspective on the operations performed by different units within WHP. It also further helped create a list of questions to be used in the subsequent interviews that the researchers planned on conducting as discussed below.

3.1.2.3 Interviews with Decision Makers

As mentioned earlier in **Section 3.1.2**, there are no general guidelines on how to come up with the final set of inputs and outputs to be used in DEA models for different applications. For this reason, DEA literature suggests getting as much information as possible from the decision makers (in the area under study) in an attempt to model the operations of an organization as close as possible to what happens in reality. In this step, researchers may refine and reinvestigate the initial list of variables through judgmental process. Some of the helpful questions that could be asked to facilitate the filtering process are listed below (Golany & Roll, 1989; Ozbek, 2007):

- Does the input/output have any implications to achieve the objectives set for the DMUs?
- Can the variables suggested be measured? Is any data readily available and accessible if the variable were to be used?

Additionally, Ramanathan (2003) discussed the fact that since many inputs and outputs aim at similar concepts but are explained in different manners, it should be asked if an input/output explains an aspect of the process performed by the DMU that is not identified by other

inputs/outputs. Therefore, utmost care should be given to eliminate the variables with same purposes from the list (Ramanathan, 2003).

From the information provided to the researchers through the first interview with Captain Mickelson, a list of questions was prepared to be discussed with six of the high ranking executive officers in WHP. This initial list of questions was sent to Captain Mickelson to seek his opinion and feedback. After receiving his perspectives on the initial set of questions, the final list of interview questions was prepared and sent to the interviewees before the scheduled date for their interviews. This was in an effort to provide interviewees with sufficient time to gather their thoughts and think thoroughly about the questions. A complete list of the questions discussed in the interviews is provided in Appendix B.

In the process of preparing for the interviews, an Institutional Review Board (IRB) application was submitted through Colorado State University (CSU). The purpose of IRB is to make sure that the researchers know how to handle sensitive subjects, how to work with human subjects, how to keep the data confidential and safe and how to get subjects' consent if any publication is to be created as a result of the research. The IRB application for this research was approved by the IRB panel after reviewing all the required information provided to them (e.g., consent forms, permission to audio record the interviews and interview questions).

At the beginning of the interviews, all the necessary information was explained to the interviewees (i.e., how the results from their audio- recorded interviews was going to be used in the research and possibly for future publications) and their signatures on the consent forms were collected. All of the interviewees have allowed us to use their names along with the information provided to us through the interviews for the purposes of this research as well as thesis and

academic publications. Later on, after transcribing all the six interviews, the final transcripts were sent to the interviewees for their review and approval. The final recorded transcripts for the interviews are presented in Appendix C.

The questions asked in the hour long interviews were mainly focused on WHP's Balanced Scorecard that are represented in WHP's SHSP (WHP, 2011). The questions were tailored to get the perspectives of high rank executives working in WHP towards the Balanced Scorecards, the areas that need more focus and the factors, either controllable or uncontrollable by the decision makers, which can influence the patrol practices. Final interview transcripts were investigated to seek for common threads, both through a manual reading process and also using NVIVO, a qualitative data analysis software that can identify the common threads throughout the interviews.

3.1.2.4 Brainstorming Sessions

The results of the interviews in the areas pertinent to input and output measures were further investigated through brainstorming sessions to refine the initial list of controllable variables. The brainstorming sessions included wide variety of individuals:

- Researchers themselves.
- Two faculty members in the Civil Engineering and Sociology Departments in CSU with expertise in the area of highway traffic safety and patrol operations.
- Mr. Joe McCarthy, a researcher over at WHP who has been working on a study, entitled Data-Driven Enforcement. Data-Driven Enforcement study helps troopers decide more systematically on where and when they need to focus their time and presence to have higher impacts on keeping the highways safer. The study concentrates on utilizing

available historical patrol data (e.g., citations and crashes) to come up with those suggestions. Although this research mainly focuses on best practices (i.e., how WHP's operations could be more efficient), there are some overlapping areas between the Data-Driven Enforcement study and this research. This is the reason why the researchers decided to get in contact with Mr. McCarthy, who has extensive knowledge both about WHP's operations and the data available in WHP's database.

- Captain Mickelson, the Champion of this research and thus the main point of contact, Major Jones and Major Groeneweg. Captain Mickelson used to be a Lieutenant in one of WHP's divisions but currently serves as a Captain in Safety, Training and Records. Major Jones and Major Groeneweg are Support Services Commander and Field Operations Commander respectively.

3.1.2.5 Selection Process

At the conclusion of the brainstorming sessions, the selection process of the first set of controllable variables (i.e., inputs and outputs) commenced. The approach taken was to carefully scrutinize WHP's performance categories according to the Balanced Scorecards in the most recent SHSP (Refer to Table 2.3) and further investigate- based on the interviews- if they are applicable to this research. One important decision making piece that was heard loud and clear during the interviews and brainstorming sessions was the fact that the ultimate goal of WHP operations is to change roadway users' behaviors. Therefore, all the discussions presented in this section and decisions made on whether or not a specific performance measure has implications on this research are essentially driven by the idea of changing roadway users' behavior.

The first two performance categories (i.e., (i) "Reduce highway fatalities, alcohol related crashes and injury crashes" and (ii) "Maximize our enforcement, education and support efforts") make

up most of the variables to be used in this research. This is in line with these categories' attributed importance in highway patrol performance as was acknowledged by all the interviewees. Table 3.1 and Table 3.2 show the performance measures under those two performance categories and how each of those measures is applicable to the research scope. Detailed explanations can be found in **Chapter 4** in the corresponding sections mentioned in the tables shown below.

Table 3.1: Measures from the “Reduce Highway Fatalities, Alcohol Related Crashes and Injury Crashes” Performance Category

Measure	Included in the study?	Explanation Section
# of fatalities	Included (but not separately)	4.1.2.2.1.1
# of fatal crashes	Included	4.1.2.2.1.1
# of impaired driver related fatal crashes	Included	4.1.2.2.1.2
# of Commercial Motor Vehicle (CMV) fatalities	Included (but not separately)	4.1.2.2.1.1
# of fatalities during specially recognized holidays	Included (but not separately)	4.1.2.2.1.1
# of injury crashes	Included (all severity crashes)	4.1.2.2.1.1
# of CMV crashes	Included (but not separately)	4.1.2.2.1.1

Table 3.2: Measures from the “Maximize Our Enforcement, Education and Support Efforts” Performance Category

Measure	Included in the study?	Explanation Section
% of citations issued per investigated crashes	Included (but not separately)	4.1.2.2.1.1
% of seat belt usage	Included	4.1.2.2.1.4
# of hours dedicated to targeted enforcement efforts	Included (but not separately)	4.1.2.2.2
# of outreach programs or presentations	Included	4.1.2.2.2

Table 3.3 shows the measures under the performance category for “Develop and care for our employees”. None of the measures under this category will be included in this study. This decision was made due to the fact that there is not necessarily a direct causal link between these measures and how the divisional performances for this study have been defined. We

acknowledge that many of the measures in this category could have potential effects on divisional performances. For instance, employee care and recognition programs could possibly contribute to better performances since they can lead to motivated troopers. However, despite this potential effect on the performance of troopers in each division, these measures are not going to be used in the study as they represent a secondary influence on the divisional performance (and they do not have an immediate impact on changing the driver behavior, which is the ultimate goal of the research as mentioned previously).

Needless to say, “Number of duty related employee injuries” is a very important measure highlighting an important aspect of highway patrol operations. As a matter of fact, according to one of the interviewees, in no other job in the world, one puts other people’s safety before her/his own. However that measure is not going to be included in this study- as the scope of this research is to focus on the divisional performance from the external (i.e., travelling public) safety point of view as opposed to internal (the troopers) safety point of view.

Table 3.3: Measures from the “Develop and Care for Our Employees” Performance Category

Measure	Included in the study?
Turn over rate	Not included
% of employees offered an individual development plan	Not included
Rating from employee survey	Not included
# of duty related employee injuries	Not included
% of troopers who qualify for incentive	Not included
# of employees participating in the wellness program	Not included
Rating from employee survey – employee recognition	Not included

Table 3.4 lists the measures in the category of “Performing our duties and obligations without reservation”. Since this goal is presumably a given fact- as underlined by the interviewees as well- it is not included in the research. It is assumed that each officer in each division is already performing their duties without reservation with the ultimate goal of changing undesirable

behaviors of drivers. The last measure in this category is “percentage of time spent patrolling”. It is important to note that the hours that each trooper spends (dealing with any task other than being visible and proactive on the field) is taken into account in the study as an uncontrollable variable, which will be explained in this chapter later on in **Section 3.1.3**.

It should be noted that this study’s focus with respect to the performance of divisions is on **actual proactive enforcement activities initiated by patrol that change driver behavior**, i.e., being visible and proactive in the field. Therefore, any time that troopers have to spend away from proactive enforcement activities (e.g., administrative work, responding to a Call for Service (CFS), etc.) will be included in the study but as uncontrollable variables. Within this context, two terms have been defined:

- **Enforcement time:** Enforcement time includes the time dedicated to proactive enforcement activities including self-initiated (e.g., making traffic stops, enforcing violators) and uncommitted patrol (i.e., being visible on the field). As might be clear, this is the time that needs to be considered in our study.
- **Overall patrol time:** Overall patrol time, on the other hand, includes the abovementioned activities and the time spent on administrative activities and reactive mode (e.g., responding to calls for service).

It should be pointed out that these terminologies are not the same as what WHP is currently using. However, according to Major Groeneweg and Major Jones, it is reasonable to call the time of a trooper that essentially influences travelers’ behavior as enforcement time. There are several line items in a time log sheet used by WHP called P-26. Each item explains different activities that a trooper could spend time on. Each of these items was discussed with WHP staff in order to

categorize the hours that troopers spent over a course of the year in each division. Final decision along with explanations on why each item belong to which category and whether or not it should be included in the study is discussed in detail in Section 4.1.2.2.2.2. A copy of this form (P-26) is presented in Appendix D.

Table 3.4: Measures from the “Perform Our Duties and Obligations without Reservation” Performance Category

Measure	Included in the study?
% of employees	Not included
% of out of service drivers compared to total # of Commercial Vehicle Safety Alliance (CVSA) inspections	Not included
% of out of service vehicles compared to total # of CVSA inspections	Not included
% of short term goals obtained from FHWA plan	Not included
% of time spent patrolling	Included as uncontrollable variable

Table 3.5 shows the measures related to the goal of “Handling every call with a service oriented response”. Since the troopers who are assigned to respond to a CFS, cannot engage in any enforcement activities while travelling to the call, the number of CFSs could affect the enforcement hours of each division. For this reason, number of CFSs is going to be considered in the study as an uncontrollable variable that will keep the officers away from being proactive on the field. The dilemma to include CFSs as non-proactive time took some discussion. One may argue that since the troopers are being visible, even if they cannot make traffic stops, should result in CFS hours to be considered as enforcement time. However, a counter argument could be to include them as an uncontrollable variable that takes away from troopers’ proactive time, since they cannot make traffic stops while responding to CFSs and they just are visible while responding to the call. Regardless of the two arguments, it is important to note that troopers have to respond to CFSs when assigned to them, while they do not necessarily **make that decision**.

This was why it was decided to consider these hours as an uncontrollable variable eventually. More details on this discussion are provided in **Section 3.1.3**.

It is worth mentioning that the “20 minutes” allotted to respond to calls in the last performance measure in Table 3.5, was introduced in the 1990’s when WHP was using Personnel Allocation Model (PAM) in the agency. The idea behind it was to allocate the manpower throughout the state in a way that no matter where the caller is, even in the least busy parts of the state, help could be provided for them in 20 minutes. Another measure under this group is ratings from customer satisfaction survey (CSS) cards for both sworn and Port of Entry (POE) officers. The measure about POE is not within the scope of this study as the research is focused on the sworn side of WHP. For the sworn side, CSS cards are handed out to public when a traffic stop is made; asking questions with regards to the professionalism and courtesy of the troopers on how they have treated the violator. Since the ultimate goal of this study is to measure the performance of divisions on actual proactive enforcement activities that change driver behavior, it was decided that this measure is not necessarily directly relevant to the study. Furthermore, all other variables included in the research are directly related to changing driver behavior through proactive enforcement activities (either by visibility or activity as will be explained later) or through educational efforts. Therefore, including CSS ratings is not within the definition of patrol performance for the purposes of this research.

Table 3.5: Measures from the “Handle Every Call with a Service Oriented Response” Performance Category

Measure	Included in the study?
Rating from customer satisfaction survey cards- sworn	Not included
Rating from customer satisfaction survey cards- POE	Not included
% of calls responded to within 20 minutes	Included as uncontrollable variable

The last two remaining categories in WHP's Balanced Scorecards, "Develop and maintain an agency structure that prepares WHP for future growth and demands" and "Operate within a balanced budget" will not be included in this research at all. The reason behind this decision is that these measures are not as much parts of a divisional decision making process as they are of headquarters'. Since the focus of this study is on the divisional performance, the measures in these two categories are excluded.

The final decisions regarding what variables would be used in the DEA models as inputs and outputs are presented in **Section 4.1.2**.

3.1.3 Phase three: Selection of uncontrollable variables

As mentioned several times before, uncontrollable variables are mostly external factors that affect the production of a process but are beyond the controls of decision makers. Failure to account these factors may lead to unfair comparisons between the DMUs. As a result of disregarding these factors, a DMU may look inefficient because of the simple fact that it has the disadvantage of performing under harsh conditions. Whereas, if the uncontrollable variables (i.e., the harsh conditions) were to be taken into account, the efficiency score of the so called DMU could have been higher. One of the main strengths of DEA is its ability to take the uncontrollable variables into consideration. It should be noted that these factors are not unforeseeable factors. Decision makers know that these factors exist. They also know how they might affect the performance of their organization; they are just not able to control them. Therefore, to account for uncontrollable variables' influences, decisions with respect to resource allocation are made by the decision makers.

Also it should be mentioned that some of these factors are really hard and sometimes even impossible to quantify, either because of lack of reliable data or due to the fact that their influence on performance outcomes is not direct. Thus, there is always a trade off in considering these factors (i.e., how much value they add to a DEA model considering the cost, time, and effort required to quantify those). This section is intended to explain which uncontrollable variables were identified as applicable to this study. Similar to the process of selecting inputs and outputs (discussed in **Section 3.1.2**), this section is also prepared using the information gathered from multiple resources and individuals.

Uncontrollable variables can be categorized under two groups: environmental (e.g., climate, location) and operational (e.g., traffic, roadway design). Through the review of literature and discussing patrol operations with decision makers in WHP, initially three main categories of uncontrollable variables were chosen to be used in this study (i.e., difficulties in enforcement, crash proneness, and time away from proactivity). One category (crash proneness) is further divided into multiple sub-categories (discussed in detail in **Section 3.1.3.2**). Figure 3.1 shows these three main categories. However, as will be presented later on, through brainstorming sessions among the researchers and WHP decision makers, some of these categories were deemed not applicable to this research and therefore, were eliminated.

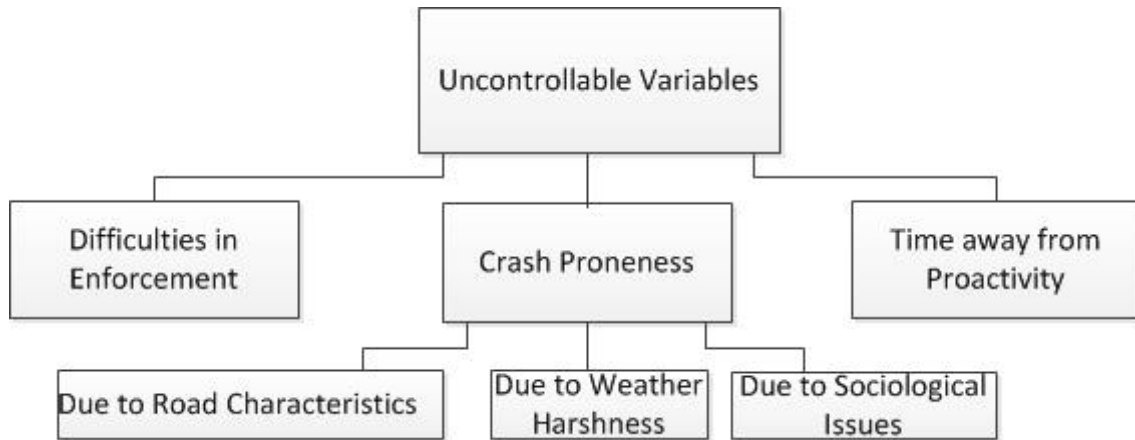


Figure 3.1: Initial uncontrollable variables classification for the study

It is very important to note that all of the factors in a category or sub-category should have the same direction on how they affect the outcomes with respect to performance. For instance, if one of the factors works to the advantage of patrol performance, it cannot be combined with another factor that has a negative effect on their desired performance. Another key concern in including or excluding uncontrollable variables is whether or not there is reliable and accurate data available to measure and quantify the impacts of these variables. The rest of this section presents discussions on each of the uncontrollable variables' categories under separate headings. It should be emphasized that although the processes to identify appropriate parameters for each category is discussed in this section, final decisions on whether or not these parameters should be included in the study, the reasons behind those decisions and how the included variables were quantified and used in the models is discussed in **Chapter 4**.

3.1.3.1 Difficulties in Enforcement

Under this main heading, the factors that could potentially make the enforcement harder for troopers are discussed.

3.1.3.1.1 Median-crossing difficulty

Highway median guardrails are safety features mandated by the federal government. In case of a motor vehicle contact, guardrails will stop the vehicle from running over onto the other side of the highway and cause a head-on collision. It is interesting to point out that although more property damage crashes may happen because of the guardrails, number of critical crashes (resulting in injury and/or death) would drastically drop down due to their presence. However, putting guardrails in place has made enforcement operations difficult especially with regards to certain violations. All of the interviewees mentioned that the presence of the median guardrail makes it hard for the troopers to quickly turn around and chase down a violator who is on the other side of the road. This is only one way that guardrails could influence the enforcement activities.

Another effect of guardrails which incidentally works to the benefit of divisional performance is further discussed in **Section 3.1.3.2.1.5**. It should be noted that wide medians also makes it difficult for troopers to enforce, because it is hard for them to cross the median regardless of whether there are guardrails or not. After a discussion with Mr. Joe McCarthy on the data available for median widths, it was decided that considering the width of a median is not a good indication of measuring the difficulties that patrol are facing. The reason is that there are other factors in addition to median width that could create barriers for patrol to be able to cross the median. Some of these factors are type of material in the median (grass, gravel, etc.), slope of the median and type of median among other things.

Additionally, there is not a consistent definition on what qualifies as a median, but in theory anything that could affect the ability of normal drivers to cross over is considered as median.

Therefore, anything ranging from curbs dividing the opposing traffic to grassy areas to concrete barriers and cable median guardrails classify as median. The reason why the width of a median is not a good measure to reflect the imposed difficulty for the Patrol, is that depending on the type of the median and other factors named above, it might not largely affect the enforcement activities by patrol. For instance, a four feet sloped median filled with gravel is not easy to cross over while a ten feet grassy median is.

Since such data about the characteristics of medians and guardrail locations are not readily available, a simplifying assumption was made. It was assumed that whether a highway is divided or not can be an indicator of median-crossing difficulty. It could be argued that certain medians are easy to cross (i.e., not wide, appropriate material, good slope on both sides, no guardrails, barriers, or curbs, stabilized and no rough areas to cross over) and/or in some stretches of a divided highway there are cross overs by design that could be used by patrol. However, as such data is not available, once again the mileage of divided versus undivided highways was used as an indication of potential difficulties for patrol. This assumption was discussed with all the interviewees and was deemed reasonable by all of them, emphasizing that the issue with median crossing difficulty is mainly if the highway is divided or not. It is important to note that highways 25, 47, 80 and 90 are all divided throughout the state and other highways are not (even though there might be short segments on the other highways that are divided); and those four highways are to be used for determining the mileage of divided highways falling under the jurisdiction of a division.

3.1.3.1.2 Road shoulders

One issue with road design is narrow shoulders. As one of the interviewees stated, it might not be obvious but troopers typically choose to go to the areas that have good roads, where there are wide shoulders that will allow them to make safe traffic stops. This would lead to areas with lack of traffic enforcement agents and could result in higher probabilities in fatal or injury crashes in those areas without sufficient shoulder widths. Therefore, when comparing two divisions where all the other components are similar, the division with more miles of road with narrow shoulders would be at a disadvantage. It was decided that a weighted average shoulder width (shoulder width weighted based on the mileage) calculated in the jurisdiction of each division is not a good measure to reflect the effect of shoulders on patrol operations. It would not matter for a trooper to make a traffic stop on a six foot shoulder or on a 40 foot one as long as it meets the minimum width to safely pull over a vehicle.

3.1.3.1.3 Road location

This measure is meant to take intersections and construction zones into account. Presence of construction areas and intersections would also contribute to difficulties to enforce. According to one of the interviewees, construction areas and intersections are difficult to work (e.g., these areas are difficult for patrol to turn around, there tends to not be a lot of area on the shoulder to make the stop, it is already confusing for the traffic); so trying to make a traffic stop in those areas makes everything worse. Thus, troopers tend to avoid these areas because it is difficult to work there. However, it must be pointed out that when troopers are assigned to construction zones, they are essentially contributing to safety and enforcement activities and thus should get credit for. This is already taken care of as the hours that are put into work zones as an item in

troopers' time log (i.e., P-26 form), which is discussed later in detail in **Chapter 4**. In case of intersections, it is important to note that intersections consist of city intersections (intersections located within the city limits) and high speed intersections (intersections located in high speed zones, like highways). Although city intersections are locations that are hard for patrol to work, it would not affect the study much, as WHP tends to focus more on highways rather than city limits. This is the reason why the number of intersections within the city limits is not of value to the study; and only the number of high speed intersections is taken into account. As will be discussed in Section 3.1.3.2.1.6, another effect of intersections is the role they play in crash prone areas.

3.1.3.1.4 Road type

During the interviews, it was revealed that some troopers are more comfortable enforcing on a certain set of roads (e.g., interstate vs. two lane highway or vice versa). However, since all the divisions have troopers that will cover different types of roads, it can be assumed that the effect of road type on the patrol performance is negligible. This factor is mainly a personal preference and does not necessarily mean that different road types make it harder for troopers to patrol.

3.1.3.1.5 Number of hours with lack of traffic or congested traffic

This factor was initially considered because of the fact that in either case of no traffic or bumper to bumper congested traffic, it would be impossible for the patrol to enforce traffic laws. In the first case, there are no vehicles out on the road and thus no way to be proactive; while in the latter case, there is simply too much traffic that making traffic stops would be impossible. However, with further research, it was realized that even in the most urban settings in Wyoming (i.e., Cheyenne and Casper), chances for bumper to bumper traffic are very slim.

Also lack of traffic would not have a separate negative effect on the performance of the patrol on the second thought. This was discovered through brainstorming sessions between the researchers, which further revealed that since the effects of lack of traffic could be captured in other variables (i.e., outputs or uncontrollable variables); it doesn't need to be a separate variable in the study. For instance, if a trooper is patrolling in an area with very low levels of traffic, he/she can decide to change his/her location to be visible in an area with more traffic. If this is the case, the trooper's visible hours would be captured in the P-26 form and would be used as an output. On the other hand, if the trooper decided to go to the office and engage in administrative work, this time would also be recorded in the P-26 form, but would be considered as an uncontrollable variable in the model. In either case, there is no need to define a new variable only to account for the number of hours with lack of traffic. More details on the troopers' hour log sheet (also known as P-26 form) are presented in **Section 4.1.2.2.2**.

3.1.3.2 Crash Proneness

Under this main category, the study will account for external factors (either environmental or operational) that contribute to the likelihood of crashes to happen (which will be referred to as crash proneness from here on). The identified factors that fall under this category can be further classified under three main sub-categories. Sub-category 1 looks at crash proneness from a road characteristics point of view. In Sub-category 2, weather related influences on crash proneness are discussed. Sub-category 3 takes crash prone people into account.

Some of the factors mentioned in this section may seem redundant as they were mentioned in previous sections. It should be noted that since some factors have dual effects on the performance of the patrol, they should be counted twice in a thorough efficiency and DEA study.

For instance, roads may have dual effects: i) Certain characteristics of roads may make it hard for troopers to enforce traffic laws as discussed in **Section 3.1.3.1.4** and ii) Certain characteristics of roads may increase the probability of crashes happening as discussed in **Section 3.1.3.2.1.3**.

3.1.3.2.1 Sub-category 1: Crash proneness due to road characteristics

3.1.3.2.1.1 Ice-Channels

According to one of the interviewees, there are some stretches of the road where there is a high likelihood to have a solid sheet of ice during winter and thus a better chance for severe crashes to happen.

3.1.3.2.1.2 Type of Terrain, Curvature and Superelevation

Different types of terrain (roads in flat areas vs. roads in mountainous areas) along with poor designs of the road (such as curvature and superelevation) would essentially contribute to more traffic crashes specifically in curves and ramps. The probability of these factors contributing to a fatal and/or incapacitating injury crash would be greater in higher speeds and under bad weather conditions especially where the surface of the road is slippery.

3.1.3.2.1.3 Road Type

It was indicated in one of the 31st Annual Lifesavers' workshops that only 14 percent of crashes happen on Interstates; while local roads have the highest number of crashes (Miller, 2013). Also according to available literature, the crashes that happen in rural roads could be more severe due to several reasons. There is a higher chance of head-on collisions, faster driving, drinking and driving and older drivers as well as lack of safety features like guardrails and police forces

around. Moreover in the case of crashes happening, there are fewer people to receive help from within a close distance which could ultimately change an injury crash into an incapacitating injury or fatal crash (PEW, 2012).

After further discussions, it was realized that different types of roads influence the crash prone characteristics of a roadway when they are undivided. Therefore, the important factor is whether or not a roadway is divided or not. It is not necessarily important what the type of the road is (e.g., interstate versus two lane highway versus rural or urban type). The only aspect that increases the probability of a crash is the fact that opposing traffic is not divided on the road. However, the issue with the vicinity of help accessible on a roadway still holds true on rural roads.

3.1.3.2.1.4 Road Shoulders

Road shoulders contribute to crashes that happen because of increased probability of sliding off the road. These types of crashes happen in the areas with narrow shoulders, especially in the mountainous areas.

3.1.3.2.1.5 Median Guardrails and Wide Crossings

One of the effects of guardrails from a “difficulty in enforcement” point of view was discussed earlier in **Section 3.1.3.1.1**. Guardrails are safety features that will essentially prevent vehicles from running over to the other side of the road and cause head-on collisions, which would further eliminate the chances for fatal and/or incapacitating injury crashes to happen. Therefore, a division with more mileages of guardrail would be at an advantage. The same logic applies to wide median crossings. As was mentioned in **Section 3.1.3.1.1**, there is no consistent definition on what qualifies for a median and median width is not a correct measure to reflect crash

prone. Based on the type of median, lack of the slope in the median and the material present in the median, it might be possible for a vehicle to cross over to the opposing side of the road in case of a high speed crash. Therefore, to simplify this case, it is assumed that the only aspect of medians to lower the probability of critical crashes happening on the highways is whether the roadway was divided or not.

3.1.3.2.1.6 Road Location

It was mentioned during one of the interviews that intersections and construction zones could potentially be two of the crash prone locations. This could be attributed to the fact that intersections and construction zones' different designs make them complex traffic encounters for the public traveler (FHWA, 2013b). This issue is mainly applicable to intersections on highways (also known as high speed intersections) and although intersections in the city limits have a high number of crashes, only a few of them are fatal or incapacitating injury crashes.

3.1.3.2.1.7 Annual Average Daily Traffic (AADT) and Annual Average Daily Truck Traffic (AADTT)

The most important reason as to why the amount of traffic will be incorporated into the study is the fact that clearly the more traffic in a division, the more likely for crashes to happen. Additionally, the more time and effort the troopers need to invest on the roads. A good measure that will show how much traffic a division is dealing with over the course of a year is AADT. Also truck volume is of importance in the performance of a division which is why AADTT is considered in the study as well. More details on the effects of trucks are provided in the section below.

3.1.3.2.1.8 Number of CMVs/Trucks versus Passenger Cars

As mentioned many times before, the purpose of this research is to improve the performance of the patrol; therefore different type of vehicles is not necessarily important. However, as was mentioned by a couple of the interviewees, enforcing trucks and CMVs could be different from passenger cars, mainly because their traffic violations differ. Given the fact that there is also a division that was specifically created just because of the large number of truck traffic that it has to deal with, researchers' understanding is that the troopers have adapted their operations with regards to enforcing CMVs. Another aspect in which trucks are actually different from smaller passenger cars is the fact that they have bigger surface area and thus are more vulnerable in windy situations. This emphasizes the fact that bad weather conditions could have more serious impacts on trucks. Also mechanical defects are more probable among Trucks and CMVs and because they are heavier in weight, their crashes are more likely to turn into a critical crash. This would put a division with higher volumes of trucks and CMVs at a disadvantage.

3.1.3.2.1.9 Holidays/Major Events and New Commuters

This factor was introduced to account for the amount of new commuters that travel through certain divisions during holidays and/or major events. Local residents are presumably more familiar with the roads and WHP's enforcement efforts and will potentially be better and safer drivers; while this is not the case for new commuters. Although it would be ideal to know how many drivers are actually local residents and how many are out of state commuters, there is no feasible way to collect this data. One potential way to quantify the number of new commuters is to look for driver plates that were involved in a crash, however; this way we are only accounting for those commuters who had a crash and not all the commuters. Interestingly, according to Mr.

Joe McCarthy, Wyoming commuters are likely to drive in their own counties; this does not apply to the commuters from out of state who are passing through Wyoming though.

3.1.3.2.2 Sub-category 2: Crash proneness due to weather harshness

A weather harshness index (inclusive of snow, wind, and other potential events) depicting its effect on crash proneness needs to be defined based on the trends found among the crash data. It should be noted that weather also makes it hard for the troopers to enforce traffic laws. However this effect is captured in time taken away from being proactive. As a result, troopers will go into the reactive mode (as opposed to proactive mode) when the weather conditions are harsh. This aspect of weather is included in the study as a different uncontrollable variable, discussed in **Section 3.1.3.3**. Specific devices capable of measuring different characteristics of the weather are located throughout the state. The location of such devices is specified in certain databases like National Oceanic and Atmospheric Administration and Road Weather Information System. The challenging part is to map their locations in order to account for the whole size of each division.

3.1.3.2.3 Sub-category 3: Crash proneness due to sociological issues

Several factors such as Socio Economic Status (SES), level of income, occupation, level of education, age, gender and other demographical information about roadway users were identified under this category. All of the above factors were introduced due to the fact that there are certain traffic violations pertinent to certain demographic groups. As mentioned in many existing literature, male drivers within the age group of 18-34 comprise both a very large group of traffic violators and victims of traffic crashes. Also distracted driving is more prevalent among teenage drivers; while drinking and driving is more common among certain other age groups (J. Smith,

2013). All of these have led the researchers to think that if there are significant differences in demographics of the drivers in different divisions, the study needs to account for them as uncontrollable variables. How to address and quantify these measures is not clear though.

It should also be mentioned that different types of vehicles could have an effect on probabilities for crashes to happen. According to WHP officers, pick-up trucks for instance, make up for more crashes. However, since it would not be easy to gather the information on what type of cars is used by drivers in a division (not to mention the fact that it is not even possible to figure out who drives in a division/county given that the drivers in a division do not necessarily live in that division/county), there is no way to consider type of vehicle involved in a crash.

3.1.3.3 Time away from Proactivity

3.1.3.3.1 Number of CFS hours and number of calls for help from outside

In both of the above mentioned cases, troopers will be assigned to travel to a call for service or to help the city police/sheriff with a crash investigation and they have an obligation to respond to them. Since troopers do not have active decision making power to make a choice in the cases of CFS or outside help, they ultimately cannot take credit for the services that they provide. For this reason, the hours put into these activities are not proactive enforcement time and they are actually taking away from the performance of a division. Therefore, a division with higher amount of calls received would be at greater disadvantage. (Refer to CFS discussion in **Section 3.1.2.5**).

3.1.3.3.2 Number of hours engaged in training for officers

Although the total number of hours away from the proactive enforcement due to these training sessions will be considered as an uncontrollable variable, we will not consider the reasons as to

why the troopers are being away. For example for this factor, we will not distinguish between number of hours put in attending sessions on new software or academy training or even driving to the location where the session is held. They all qualify as uncontrollable variables.

3.1.3.3.3 Number of hours dedicated to non-field operations

This measure would essentially account for the time that field troopers dedicate to administrative work instead of being visible and proactive on the road. These hours away from the field hours will be included in the study as an uncontrollable variable, representing the time that sworn officers are engaged in any non-field administrative activity.

As mentioned in **Section 3.1.3.2.2** and also stated by several of the interviewees, weather could be considered as an example that would shift patrol activities to a reactive mode. This could result in more travelling to respond to CFSs (as discussed in **Section 3.1.3.3.1**) or doing more administrative work (as discussed in **Section 3.1.3.3.3**) rather than being visible and proactive on the side of the road. Therefore, such effect of weather will be captured through the uncontrollable variables explained in **Section 3.1.3.3**.

3.1.3.4 Miscellaneous

As might be clear, there are many parameters that can affect the processes of an organization. Several other factors that could potentially influence patrol operations that could not be categorized under the previously discussed groups, are listed below:

- Experience of troopers: According to one of the interviewees, troopers' performances could be different in different ranges of troopers' experiences. However, since both being young but inexperienced, and being older but experienced has its own advantages and

disadvantages, their potential effects on patrol performance essentially even each other out.

- Number of construction zones: Perhaps a better term for this measure is number of troopers assigned to work zones, since it was discovered through the interviews that there are troopers assigned to every construction zone on Wyoming highways. These hours are captured in a specific line item in the P-26 form and need to be considered as part of troopers' proactive enforcement activity. This is further discussed in **Section 4.1.2.2.2.2**.
- Presence of other traffic enforcement entities: While seat belt usage in Wyoming is a secondary law, it is a primary law in some locations throughout the state where tribal communities live (J. Smith, 2013). This could result in higher percentages of seat belt usage in those areas which could potentially contribute to less fatal and/or incapacitating injury crashes. Therefore a division with tribal law enforcing entities may be at an advantage. However, this effect is presumed to be minimal since those entities and their jurisdictions are comparatively small. The only division that has tribal communities is Division I (See Figure 2.1), where according to WHP officers, even with the primary seat belt law; their number of critical crashes is still in the same range as Wyoming average.
- Serving area of divisions: The other factor that needs to be taken into account is the size of a division, i.e., the lane miles of roads under the jurisdiction of each division. One may argue that since multiple lanes are created to deal with traffic; and traffic volume is already considered in the study separately, traffic effects are being taken into account twice. However, it was further discovered that traffic is not the only thing affecting the creation of multiple lanes. Other factors for instance, include "climbing lanes" (mostly on uphill roads); where there would be multiple lanes to reduce the possible formation of

long chain of cars following a heavy truck, going very slowly up the hill. For this and other reasons that would influence having multiple lanes, the stated argument is not valid. Furthermore, it was mentioned that it is easier for troopers to work on one lane roads when compared to multi-lane roads (because of the fact that they need to watch multiple lanes and enforce in multiple lanes); further emphasizing that capturing lane mileage is important.

All of the factors discussed in this section are summarized in Table 3.6.

Table 3.6: Initial list of Uncontrollable Variables to be Considered in the Study

Main Category	Sub-Category	Variables
Difficulties in Enforcement	N/A	Median-crossing difficulty
		Road shoulders
		Road location
		Road type
		# of hours with lack of traffic or congested traffic
Crash Proneness	Due to road characteristics	Ice channels
		Type of terrain
		Curvature
		Super elevation
		Road type
		Road shoulders
		Median guardrails and wide crossings
		Road location
		AADT and AADTT
		# of CMVs/trucks vs. passenger cars
		Holidays/major event and new commuters
	Due to weather harshness	# of days with harsh weather conditions
	Due to sociological issues	SES
		Level of income
		Occupation
		Level of education
		Age and gender
		Other demographical

		information
Time away from Proactivity	N/A	# of CFS hours
		# of calls for help from outside
		# of hours engaged in training for officers
		# of hours dedicated to non-field operations
Miscellaneous	N/A	Experience of troopers
		# of construction zones
		Presence of other traffic enforcing entities
		Serving area of divisions

It is important to note that not all of the variables mentioned previously were considered in the study, details of which are presented in **Chapter 4**. Even after the refinement process (refer to **Chapter 4**) and with the final set of uncontrollable variables that are going to be considered in the study, it was discovered that the discriminating power of DEA model was too low. Therefore, several options were considered in order to reduce and refine the initial list of variables. DEA literature suggests that there are mathematical and judgmental tools and methods available that can help accomplish this task in an attempt to increase the discriminating power of DEA models. One of the methods that was identified to be suitable for the purposes of this research is Principal Component Analysis (PCA), which is explained in **Section 3.1.3.5** below.

3.1.3.5 Reducing the Number of Variables using PCA

As mentioned previously, after developing the rather large initial list of uncontrollable variables, it was discovered in the study that a variable reduction method is needed to achieve a reasonable level of discriminatory power through the DEA models. There are several methods that can be utilized to refine and reduce the number of variables and thus, increase the discriminating power of the DEA model. The first way to eliminate additional variables is through judgmental and

critical thinking process. Common reasons for excluding a variable from the initial list are listed below (Ozbek, 2007):

- Availability of the data: This could either mean that no data is available or the data that is somewhat available but is not readily accessible or is not from a reliable source and thus is not accurate.
- Value of the variables: Some variables add minimal values to the research while requiring incredible amounts of time and effort to be obtained.
- Some variables are not even measurable and/or quantifiable.
- The effects of a variable are already explained by other variables.
- Two (or sometimes multiple) variables could be combined in order to explain an effect on the process under study.
- The values of variables might not be very different between DMUs. This means that circumstances, under which DMUs perform, are rather similar with regards to that variable.

However, even after going through this filtering step, there might still be too many variables. PCA is a variable reduction method that was identified to be applicable and appropriate for the purposes of our study. PCA is a mathematical procedure, developed in 1901 by Karl Pearson (also independently developed in 1930s by Harold Hotelling) (Hess, 2013), that transforms a number of possible correlated variables into a smaller amount of variables that are uncorrelated, called Principal Components (PC). Every Principal Component Analysis would have the same number of PCs as the original number of variables in the data set. For instance, if PCA is being performed on a total number of eight variables, there will be eight PCs as the result of the analysis. From these eight PCs, two or three would explain the majority of the variability in the

original dataset (i.e., the extent of the information captured by the original eight variables). The first PC accounts for as much of the variability in the initial set of data as possible and each PC after that account for as much of the remaining variability in the data as possible. PCA extracts uncorrelated PCs through linear transformation of the original data set, which is why the first few PCs often explain 80-90 percent of the variability in the data. Therefore, by considering the first few PCs, the number of variables will be reduced, while at the same time, maintaining most of the variability in the original variables (Fernandez, 2010; Hess, 2013; Holland, 2008).

Statistical packages such as R, SAS, SPSS and Matlab are capable of performing PCA. Also Excel Add-ins (e.g., NumXL, XLSTAT, XLMiner) have made it easier to perform such analyses in the familiar setting of spreadsheets (Anderson, 2011; L. I. Smith, 2002). Interested reader is encouraged to refer to the literature for more details on the mathematical formulations of PCA (Chatfield & Collins, 1980; Jolliffe, 2002).

Depending on the nature of the original variables in the data set, Correlation or Covariance matrix can be used to run PCA. If the variables are of different units and vary significantly in size and scale, a correlation matrix need to be used, in which the variables will be first standardized. On the other hand, if none of the above conditions are present, a covariance matrix could be used (Hess, 2013; Holland, 2008). Regardless of the approach chosen for the PCA, two parameters are calculated: Component loadings and calculated PCs. Loadings are the weights that need to be assigned to the original set of variables (this may be the standardized values in case the correlation matrix has been used) to calculate the PCs. PCs are the summation of the loadings multiplied by the original variables, in case of the covariance matrix method is used; or the standardized variables, in case the correlation matrix method is used. Both of these parameters will be presented as final results after running the PCA calculations through most of

the software (Hess, 2013; L. I. Smith, 2002). How PCA was used in this research along with the final results are presented in **Section 4.1.5.3.1**.

3.1.4 Phase four: Selection of the appropriate DEA model

This section is organized and discussed in multiple sub headings. First, in order to introduce the reader to the details of DEA, the brief overview of DEA which was presented in **Section 2.5.1** is expanded upon. Second, a selection process is presented depicting the approach that was taken in an attempt to choose the right DEA model for the purposes of this research.

3.1.4.1 DEA Formulations

A brief overview of DEA was presented in **Chapter 2**, where the concepts of input and output orientation along with Constant and Variable Returns to Scale were discussed. In addition to the general information about DEA, the advantages and limitations of the approach was also discussed. In this section, the formulations of DEA are presented in detail.

3.1.4.1.1 Primal CCR models

In 1978, Charnes, Cooper and Rhodes proposed a mathematical framework that was capable of handling frontier analysis, the concepts of which was described by Farrell in 1957 (M J Farrell, 1957). Their framework uses linear programming to extend Farrell's efficiency measure, which was simply defined as the ratio of a single output to input. The primary way that the extension was described, was a Fractional Program (FP), taking into account the ratio of multiple outputs to multiple inputs. This ratio (efficiency score) should be maximized for the DMU under investigation (i.e., DMU_0) (Charnes, et al., 1978):

$$\text{Maximize} \quad Q_0 = \frac{\sum_{i=1}^n U_i Y_{i0}}{\sum_{j=1}^m V_j X_{j0}} \quad (\text{Formulation 3.1})$$

$$\text{Subject to} \quad \sum_{i=1}^n U_i Y_i \leq \sum_{j=1}^m V_j X_j \quad \text{for each DMU in the data set}$$

$$U_i, V_j \geq 0$$

Where

n : number of outputs (i is the output indicator)

m : number of inputs (j is the input indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

U_i, V_j : outputs' and inputs' weights, **non-negative** values as the result of solving this optimization problem.

Within the context of DEA, $U_i Y_i$ and $V_j X_j$ are called the weighted outputs and the weighted inputs respectively. This will allow for multiple inputs and outputs to be taken into account at once. Any FP problem can be replaced by an equivalent Linear Program (LP) problem, making it easier to be solved. The linear form of the fractional problem above is what DEA literature refers to as the Primal CCR model. Formulation 3.2 demonstrates the Primal CCR model for the DMU under investigation (i.e., DMU_0) (Charnes, et al., 1978):

$$\text{Maximize} \quad Q_0 = \sum_{i=1}^n U_i Y_{i0} \quad (\text{Formulation 3.2})$$

$$\text{Subject to} \quad \sum_{j=1}^m V_j X_{j0} = 1$$

$$\sum_{i=1}^n U_i Y_i \leq \sum_{j=1}^m V_j X_j \quad \text{for each DMU in the data set}$$

$$U_i, V_j \geq 0$$

Where

n : number of outputs (i is the output indicator)

m : number of inputs (j is the input indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

U_i, V_j : outputs' and inputs' weights, **non-negative** values as the result of solving this optimization problem.

To simplify what Formulation 3.2 is essentially doing: It seeks the weights (V_j) for each input and weights (U_i) for each output of the DMU under investigation in a way that maximizes the efficiency of that DMU. The selection process for these weights is such that when applied to each variable (i.e., inputs and outputs) in other DMUs, would result in an efficiency score (Q) of less than or equal to 1 for those DMUs, while satisfying the other constraints presented above. This unique approach in coming up with the weights for variables is how DEA overcomes the subjectivity of assigning weights set by individuals in other efficiency methods (See **Section 2.5**). As a final step after calculating each DMU's efficiency score, those with the score of 100 percent would form the efficient frontier (Refer to Figure 2.4).

What Formulation 3.2 is demonstrating is called an **Input Oriented** Primal CCR model. Therefore, as a result of solving the optimization problem and further obtaining the efficiency scores for each DMU, those scores need to be applied to the inputs, to reduce the utilized resources while maintaining a constant level of produced outputs. For instance, in an input oriented model where the efficiency score (also known as Q) is equal to 0.6, the DMU is

performing 60 percent efficient and in order to get to 100 percent efficiency, the input level should be reduced by 40 percent.

To change the perspective of models, DEA also has the **Output Oriented** approach which is discussed in Formulation 3.3 for the DMU under investigation (i.e., DMU₀) (Charnes, et al., 1978). As a result of utilizing this formulation, the inverse of the efficiency score would be applied to the outputs, to increase the amount of generated outputs while keeping the same amount of resources. For instance if Q equals 0.75 in an output oriented model, then the DMU is performing under 75 percent of efficiency and to be 100 percent efficient, it needs to increase the amount of outputs by 1.33 times ($\frac{1}{0.75} = 1.33$).

$$\text{Minimize} \quad Q_0 = \sum_{j=1}^m V_j X_{j0} \quad (\text{Formulation 3.3})$$

$$\text{Subject to} \quad \sum_{i=1}^n U_i Y_{i0} = 1$$

$$\sum_{i=1}^n U_i Y_i \leq \sum_{j=1}^m V_j X_j \quad \text{for each DMU in the data set}$$

$$U_i, V_j \geq 0$$

Where

n : number of outputs (i is the output indicator)

m : number of inputs (j is the input indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

U_i, V_j : outputs' and inputs' weights, **non-negative** values as the result of solving this optimization problem.

3.1.4.1.2 Dual CCR models

As the result of the Primal CCR formulations (regardless of the orientation of the model), efficiency scores will be calculated. These scores are certainly of interest to decision makers; as depending on the orientation of the model, they represent the amount by which inputs need to be reduced or outputs need to be increased. However, what might be more of an interest to the decision makers is how these modifications should be addressed. The best way to answer this question is to find the efficient peers of each DMU, the 100 percent efficient DMUs closest to the operations of the inefficient DMU. As was discussed in **Figure 2.4**, B's efficient peers are C and D, because the projection of DMU B on the efficient frontier (i.e., B') was located between these two DMUs (i.e., C and D). In this hypothetical scenario, it was possible to identify the efficient peers of inefficient DMUs, since it was possible to plot a graph including the efficient frontier. However, since plotting more than three variables is not possible on a two dimensional graph, it is not possible to identify the efficient peers of a DMU in instances with higher numbers of variables. Therefore, dual formulations of the Primal CCR models were developed, giving researchers the ability to identify the efficient peers of the inefficient DMUs.

Before continuing with dual formulations, two terms should be discussed: Target value and the projection of a DMU on the efficient frontier. The target value, depending on the orientation of the model, is the amount of reduced inputs or increased outputs that is needed to be achieved in order for the DMU to be 100 percent efficient. The target value is the same as the projection of the DMU on the efficient frontier but only in the absence of slacks. A slack means that even if the projection of a DMU is apparently located on the 100 percent efficient frontier, it is using some excessive inputs or is lacking a little on the output side, depending on the orientation of the model (Ozbek, 2007). The dual formulation is capable of calculating the slacks whereas the

primal formulation cannot. Figure 3.2 illustrates the concept of slack in a hypothetical case, with one input and one output. As shown in the figure, both of DMUs B and D are located on the efficient frontier. However, while both of them produce the same amount of outputs, DMU B is clearly more efficient since it is utilizing less amount of input ($X_B < X_D$) compared to DMU D. The difference between X_D and X_B is the amount of slack existent in DMU D.

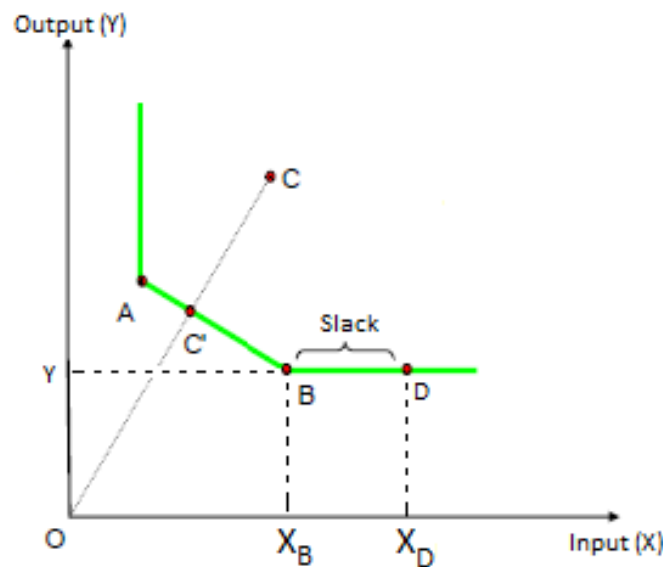


Figure 3.2: Concept of slack in a hypothetical case with one input and one output (Ozbek, 2007, p. 134)

Back to the Dual DEA formulations, every LP problem has a dual form associated with it; but it is important to note that the objective in the primal LP problem and its dual form are opposite. For instance, if the objective of a primal LP problem is to maximize, the objective of its dual LP problem would be to minimize. In the context of DEA, the differences between the primal and dual models could be listed as follows (Ozbek, 2007):

- The primal formulation identifies:
 - a) The efficiency scores
 - b) Weights of inputs and outputs

- c) Projection on the efficient frontier
- The dual formulation identifies:
 - a) The efficiency scores
 - b) Efficient peers of the DMU under study as well as weights of such peers
 - c) The target value for the DMU
 - d) Projection on the efficient frontier

With this introduction, the dual models for both orientations presented in the preceding section will be discussed now. The dual formulation for the input oriented primal CCR model (See Formulation 3.2) for the DMU under investigation (i.e., DMU₀) is presented in Formulation 3.4 below (Charnes, et al., 1978):

Minimize θ (Formulation 3.4)

Subject to $\sum_{k=1}^t Z_k X_{jk} \leq \theta X_{j0}$ $k=1,2,\dots,t$ $j=1,2,\dots,m$

$\sum_{k=1}^t Z_k Y_{ik} \geq Y_{i0}$ $k=1,2,\dots,t$ $i=1,2,\dots,n$

$Z_k \geq 0$

Where

t : number of DMUs in the data set (k is the DMU indicator)

m : number of inputs (j is the input indicator)

n : number of outputs (i is the output indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

Z_k : Weight of the efficient peers, **non-negative** values as the result of solving this optimization problem.

The dual formulation measures the efficiency of the DMU under study against a hypothetical DMU. The efficiency of this hypothetical DMU is θ and it is defined as the efficiency score that needs to be applied to the inputs of the DMU under study to maximize its efficiency. In this context, a DMU is not efficient in using its resources to produce a given amount of output if it can be proved that another DMU or a combination of DMUs (hence a hypothetical DMU) is able to produce the same amount of outputs for less amount of inputs (Ozbek, 2007).

To help understand Formulation 3.4, consider the following example. In an organization with three DMUs (A, B and C), there are two inputs (X_1 and X_2) as well as two outputs (Y_1 and Y_2). The formulation intends to minimize θ for the DMU under investigation (e.g., DMU A) subject to the constraints below:

- i. $Z_A X_{1A} + Z_B X_{1B} + Z_C X_{1C} \leq \theta X_{1A}$
- ii. $Z_A X_{2A} + Z_B X_{2B} + Z_C X_{2C} \leq \theta X_{2A}$
- iii. $Z_A Y_{1A} + Z_B Y_{1B} + Z_C Y_{1C} \geq Y_{1A}$
- iv. $Z_A Y_{2A} + Z_B Y_{2B} + Z_C Y_{2C} \geq Y_{2A}$

The left sides of the equations displayed above essentially represent the hypothetical (and theoretically 100 percent efficient) DMU, to which the DMU under study (i.e., DMU A) is being compared against, formed by the real amounts of given variables (X_1 in the first equation, X_2 in the second, Y_1 in the third and Y_2 in the fourth one) in that same DMU. The right sides of first and second equations demonstrate the input usage for that DMU to be efficient (note that this is an input oriented model).

The output oriented dual CCR model for the DMU under investigation (i.e., DMU₀) is shown in Formulation 3.5 (Charnes, et al., 1978).

Maximize θ (Formulation 3.5)

Subject to $\sum_{k=1}^t Z_k X_{jk} \leq X_{j0}$ $k=1,2,\dots,t$ $j=1,2,\dots,m$

$\sum_{k=1}^t Z_k Y_{ik} \geq \theta Y_{i0}$ $k=1,2,\dots,t$ $i=1,2,\dots,n$

$Z_k \geq 0$

Where

t : number of DMUs in the data set (k is the DMU indicator)

m : number of inputs (j is the input indicator)

n : number of outputs (i is the output indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

Z_k : Weight of the efficient peers, **non-negative** values as the result of solving this optimization problem.

3.1.4.1.3 BCC models

As discussed briefly in **Chapter 2**, CCR models operate under the Constant Returns to Scale (CRS), meaning that a proportionately equal increase (or decrease) in all inputs would lead the same proportional increase (or decrease) in all outputs. All DEA formulations presented up until now are designed to measure the **technical efficiency**, which means that the operations are assuming CRS. However, since the assumptions of CRS are not always realistic and there are

scale inefficiencies present in real world processes, there is a need to adjust the formulations to account for Variable Returns to Scale (VRS) to deal with such inefficiencies. Under the assumptions of VRS, a proportionately equal increase (or decrease) in all inputs would equal to a proportionally greater or smaller increase (or decrease) in all outputs.

Figure 3.3 depicts the efficient frontier for six hypothetical DMUs with arbitrary amount of inputs and outputs assigned to them operating under CRS assumptions, while in Figure 3.4, the efficient frontier for the same DMUs with the same amount of variables is shown working under VRS.

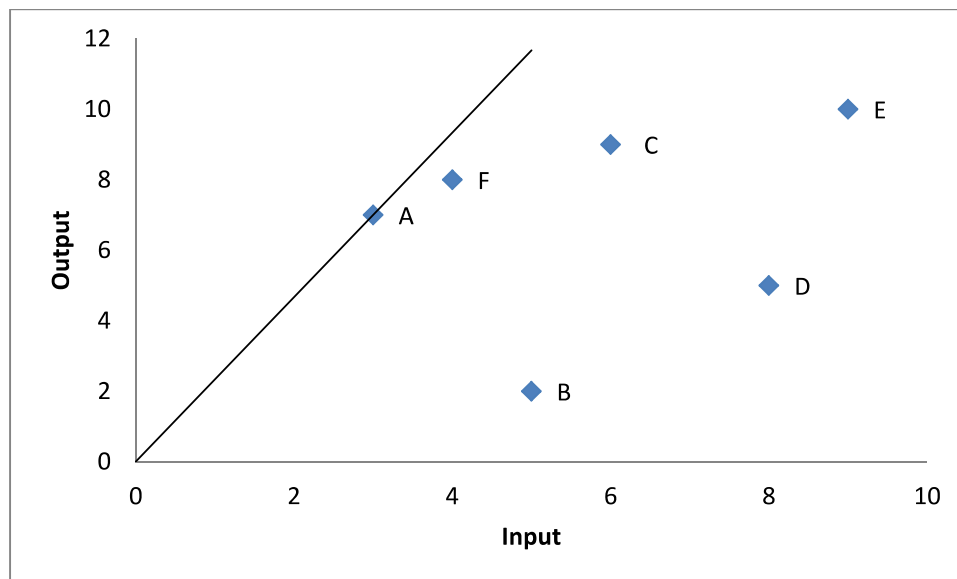


Figure 3.3: Efficient Frontier for DMUs Operating under CRS (Ozbek, 2007, p. 61)

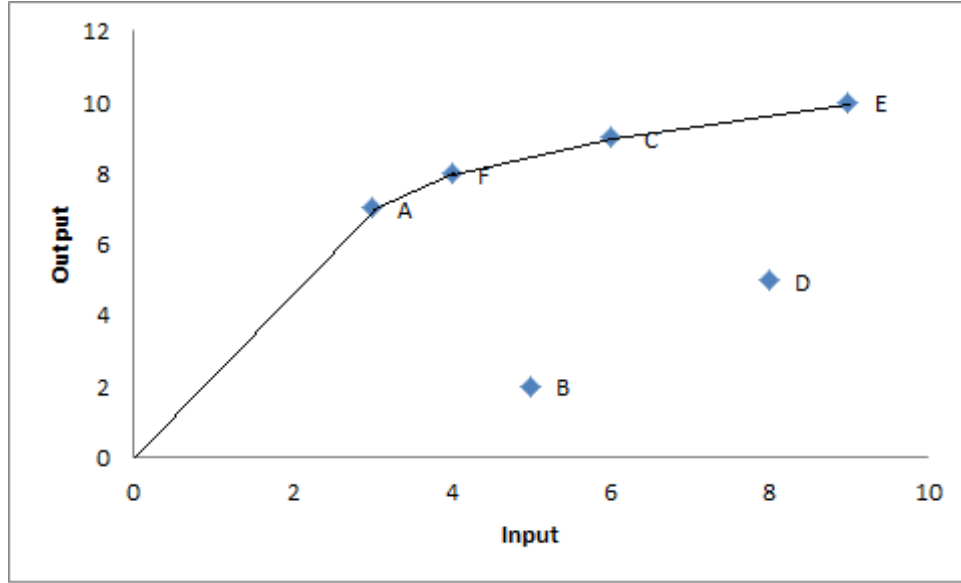


Figure 3.4: Efficient Frontier for DMUs operating under VRS (Ozbek, 2007, p. 62)

As can be seen in the figures, DMUs F, C and E have resulted in full efficiency under VRS assumptions. To account for scale inefficiencies and processes working under VRS assumptions, new formulations were proposed by Banker, Charnes and Cooper (BCC) in 1984. Formulation 3.6 shows an input oriented dual BCC formula for the DMU under investigation (i.e., DMU₀) (Banker, et al., 1984).

Minimize θ (Formulation 3.6)

Subject to $\sum_{k=1}^t Z_k X_{jk} \leq \theta X_{j0} \quad k=1,2,\dots,t \quad j=1,2,\dots,m$

$\sum_{k=1}^t Z_k Y_{ik} \geq Y_{i0} \quad k=1,2,\dots,t \quad i=1,2,\dots,n$

$\sum_{k=1}^t Z_k = 1$

$Z_k \geq 0$

Where

t : number of DMUs in the data set (k is the DMU indicator)

m : number of inputs (j is the input indicator)

n : number of outputs (i is the output indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

Z_k : Weight of the efficient peers, **non-negative** values as the result of solving this optimization problem.

BCC formulations only introduce an additional constraint to the dual CCR formula that restricts the sum of weights for hypothetical DMUs to be equal to 1. The point of this constraint is to take care of the scale inefficiency. By setting the summation of peer weights (Z) to 1, it is ensured that the hypothetical DMU is operating under the same scale size as the DMU under investigation (Ozbek, 2007). This extra constraint restricts the peer comparison set of the DMU under investigation to DMUs with comparable size or volume (P Rouse, 1997).

Similarly, the output oriented BCC model is shown for the DMU under investigation (i.e., DMU_0) in Formulation 3.7 (Banker, et al., 1984).

Maximize θ (Formulation 3.7)

Subject to $\sum_{k=1}^t Z_k X_{jk} \leq X_{j0} \quad k=1,2,\dots,t \quad j=1,2,\dots,m$

$\sum_{k=1}^t Z_k Y_{ik} \geq \theta Y_{i0} \quad k=1,2,\dots,t \quad i=1,2,\dots,n$

$$\sum_{k=1}^t Z_k = 1$$

$$Z_k \geq 0$$

Where

t : number of DMUs in the data set (k is the DMU indicator)

m : number of inputs (j is the input indicator)

n : number of outputs (i is the output indicator)

Y_i, X_j : known outputs and inputs for a given DMU, all **positive**.

Z_k : Weight of the efficient peers, **non-negative** values as the result of solving this optimization problem.

3.1.4.1.4 DEA models dealing with uncontrollable variables

Although one might argue that uncontrollable variables can be included in DEA models simply as inputs, there is a major drawback to this approach. Uncontrollable variables are fixed values (i.e., they are not controlled by the decision-makers), the amounts of which cannot be altered in order to increase the efficiency of a DMU. Therefore, new constraints need to be incorporated in the formulations that will enable the decision makers to estimate the extent to which controllable variables can be modified (reduction in the case of inputs and increasing in the case of outputs) while maintaining the amount of uncontrollable variables within their existing levels (Banker & Morey, 1986; Ozbek, 2007). In order to deal with uncontrollable variables in DEA and to create a fair level of comparison for the DMUs, Banker and Morey (1986) introduced a modification to the traditional DEA formulations. Formulation 3.8 demonstrates the input oriented dual BCC model for the DMU under investigation (i.e., DMU_0) with additional constraints to account for uncontrollable variables (Muniz, Paradi, Ruggiero, & Yang, 2006):

Minimize θ (Formulation 3.8)

$$\text{Subject to} \quad \sum_{k=1}^t Z_k X_{jk} \leq \theta X_{j0} \quad k=1,2,\dots,t \quad j=1,2,\dots,m$$

$$\sum_{k=1}^t Z_k W_{rk} \leq W_{r0} \quad k=1,2,\dots,t \quad r=1,2,\dots,p$$

$$\sum_{k=1}^t Z_k Y_{ik} \geq Y_{i0} \quad k=1,2,\dots,t \quad i=1,2,\dots,n$$

$$\sum_{k=1}^t Z_k = 1$$

$$Z_k \geq 0$$

Where

t : number of DMUs in the data set (k is the DMU indicator)

m : number of controllable inputs (j is the input indicator)

p : number of uncontrollable inputs (r is the uncontrollable input indicator)

n : number of output, controllable or uncontrollable (i is the output indicator)

Y_i , X_j , W_r : known outputs, inputs and uncontrollable variables for a given DMU, all **positive**.

Z_k : Weight of the efficient peers, **non-negative** values as the result of solving this optimization problem.

As can be seen, θ is not multiplied by the amount of the uncontrollable inputs; and as a result, the magnitude of uncontrollable inputs would not be changed. However, uncontrollable inputs can affect the results of the model through their presence in the additional constraint (Cooper, et al., 1999). Essentially, what this formulation implies is the answer to the question of “what would be the efficiency of a DMU given the uncontrollable variables it faces?” (Banker &

Morey, 1986). However, it should be noted that the analyzer needs to know the effects of the uncontrollable variable on the processes under study beforehand. This is due to the fact that in the proposed new formulation, uncontrollable variables could be on either the input or output side. Therefore, it is necessary to know how they will affect the process.

There are other but less desirable methods to include the uncontrollable variables into the DEA models. The interested reader is encouraged to refer to other related literature (Ozbek, 2007).

3.1.4.2 Selecting the Appropriate DEA Model

In order to choose the most appropriate DEA model that will suit the purposes of the process under investigation, the researcher needs to answer the question of orientation and the scale under which the processes are operating.

- Orientation: It should be asked where the area of flexibility is that can be modified by the decision makers in order to improve the efficiency. For instance, if the decision makers have more flexibility to alter the amount of resources that are being utilized in the process of generating outputs, then the appropriate model is the input oriented model. On the other hand, if there is more flexibility in working with the outputs, then an output oriented model should be considered.
- Scale: It should be investigated whether or not the processes undertaken by DMUs are performing under assumptions of CRS or VRS. If a proportionately equal increase (or decrease) in all inputs is leading to the same proportional increase (or decrease) in all outputs, then the process is working under CRS and a CCR model is appropriate. Otherwise, the process is being performed under VRS and thus, BCC is appropriate.

3.1.5 Phase five: Collecting and preparing the data and running the models

After getting a good idea on what was needed to develop the models, the next step was to gather the appropriate data. Working with different departments within the Wyoming Department of Transportation (WYDOT), needed data was gathered in Excel spreadsheets. After receiving the data, a good amount of time was spent on preparing them in the right format that could be used in the DEA models.

A big portion of what the preparation process entailed was to break down the state level bulk information presented in the original databases into the 17 divisions of WHP. For this reason, first the jurisdiction of each division along with the highways and roads within those boundaries was identified. For all the other databases, the characteristic under study (e.g., AADT, citation data) was broken down to fall under the jurisdiction of each division and was then transferred into the appropriate division. During these procedures, certain assumptions were made to deal with existing issues and problems in the data sets (e.g., missing data points and discrepancies). Complete procedures and assumptions for the final variables, which will be incorporated in the model, are presented in **Section 4.1.5.2**.

After finalizing the preparation of the data on the divisional level as well as choosing the appropriate models, selected through the processes explained in **Section 3.1.4.2**, models were run using the software entitled Frontier Analyst. There are several software platforms available on the market that are capable of running DEA calculations (some are independent software while others are Excel Add-ins). A handful of these platforms were studied before deciding to utilize Frontier Analyst due to its user interface and ability to generate outputs and reports in a spreadsheet format. Model descriptions and iterations are described in detail in **Section 4.1.5.3**.

3.1.6 Phase six: Post processing and presenting the DEA results

Since DEA is highly dependent on the data, even the smallest error in the data can lead to inaccurate results. Also as DEA is a non-parametric approach, the conventional statistical methods to estimate the confidence level of the results are not applicable. For these reasons, utmost care should be taken in preparing the data and importing them into the models. Also sensitivity analyses are highly encouraged to put some level of confidence on the results. These analyses could range from removing efficient DMUs from the data set to removing one variable from the list of variables and studying the results (Ramanathan, 2003).

To present the DEA results in the most sensible fashion that is comprehensible by the non-technical audience, it is important to run different iterations of models. The results of these iterations can be used for comparison purposes to make a point on the importance of uncontrollable variables or the discriminating power of the models. The final results of several iterations of the DEA models performed for this research are presented in Section 4.1.5.

3.2 Benchmarking

As mentioned previously, the objective of a DEA study is to not only identify the best and poor performing units in an organization, but more importantly to assign meaning to the existent efficiency differences. Therefore, benchmarking constitutes a significant phase in a comprehensive DEA framework, in an attempt to investigate the changes that poor performing DMUs need to undergo to achieve their maximum efficiency. Identifying the efficient peers for each inefficient DMU, DEA facilitates the benchmarking process in the sense that the best practices of the peers need to be examined and implemented to improve inefficient DMUs' performances (Charnes, et al., 1994). However, due to time constraints, the benchmarking

workshops could not be performed during the time frame of this research. For this reason, only the methods to effectively perform benchmarking are discussed in this section and no results are reported in Chapter 4.

Benchmarking concept was developed by Xerox in 1979 when they were facing a competitive crisis (Zairi & Hutton, 1995). “Benchmarking” is a measurement tool used for comparison, which depicts the continuous process of identifying problematic areas, understanding the process and adapting practices that will lead to better performance (Auluck, 2002). Benchmarking consists of four critical elements (Longbottom, 2000):

- Planning
- Analysis
- Implementation
- Review

Each of these elements requires understanding the process as well as senior management support and working in teams (Grayson, 1992). There are several approaches to conduct benchmarking. Section 2.3.1 briefly discusses internal and external benchmarking. Other types of benchmarking include competitive, industry, generic, process, performance and strategic benchmarking (Ahmed & Rafiq, 1998); however, all of them appear to value the importance of adopting and implementing a structured approach in the learning process (Cox & Thompson, 1998). Difference between these methods depends on whether the comparison is being performed on the outputs or the processes, either against other units, organizations, peers or set standards (Auluck, 2002). The process of benchmarking involves answering the “what, who and how” should be benchmarked? (Ahmed & Rafiq, 1998; Watson, 1993).

Ahmed and Rafiq (1998) and Zairi and Whymark (2000) have provided several frameworks on how benchmarking is done in some industries based on case studies (Ahmed & Rafiq, 1998); however, this is not a general framework; rather a guideline. The following list is the essential elements of the benchmarking process (Blaschke & Morrow, 2013):

- Well defined and structured
- Provides value to the participants
- Flexible in participation, metrics and comparisons
- Focused on best practices
- Understanding what is the critical success factors and what is important to the organization
- Measurement and comparison against the peers/leaders

It is important to note that with the help of senior management and the organization's leadership, each organization would be able to find the approach that best serves them in conducting benchmarking workshops. Figure 3.5 presents a flow chart to better understand the benchmarking process. This roadmap could be a starting point to help decision makers develop the necessary steps to conduct benchmarking workshops.

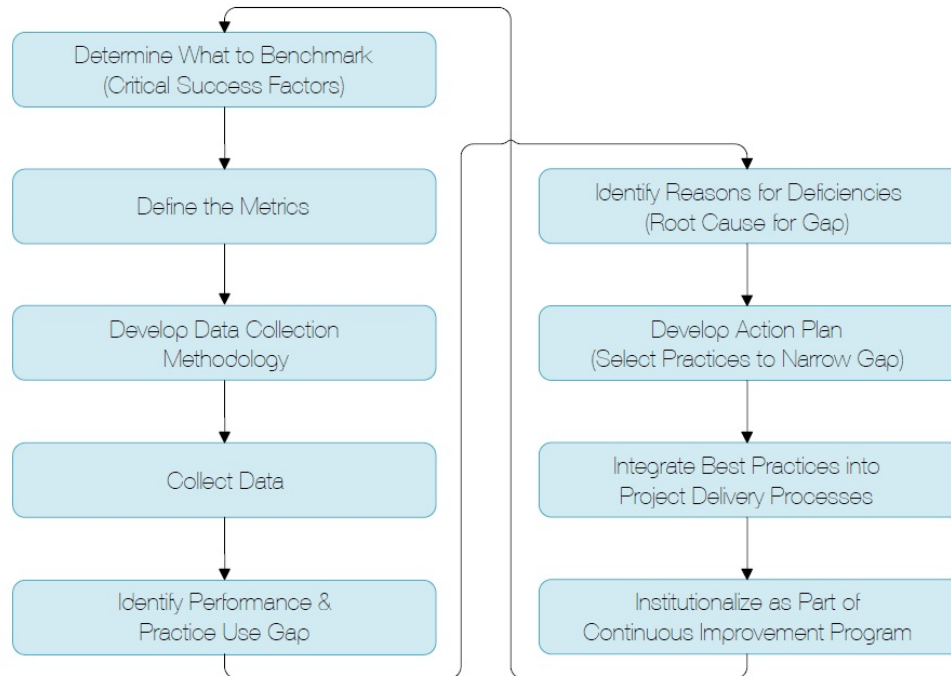


Figure 3.5: A roadmap for the benchmarking process (Blaschke & Morrow, 2013)

In performing benchmarking as a part of the DEA framework, it is important to fully understand the potential challenges of the process. One challenge would be the skepticism towards the DEA results for the non-technical audience (Ramanathan, 2003; P Rouse, 1997) and therefore, reluctance to accept those results. This could be addressed by having a facilitator who is familiar with the DEA concepts to communicate the results of the DEA model effectively through proper means of visual graphs and charts (Ozbek, 2012). Another complication could be resistance to change for the poor performing units; while for the efficient units the issue would be to get them to share their successful (best) practices. With the former issue, it could be argued that in DEA, results are expressed in a “relative” way, and thus when a DMU is identified as poor performing, it means that it is not performing as good as its counterparts and that there is still room for it to change and improve their practices. The issue with efficient units not willing to share their best practices is not as significant in internal benchmarking processes as it is in competitive or external benchmarking, since the units that are being compared against each other are all parts of

the same organization. Regardless of the type of challenge, the role of senior management is critical in overcoming such challenge. All of these challenges could be addressed by having the support of the leadership to remind that the objective of benchmarking process is to improve the overall organizational efficiency and not to award or penalize units (Auluck, 2002; Ozbek, 2012).

CHAPTER 4: RESULTS

This chapter presents the results of the study obtained as a result of implementing the framework that was previously discussed in Chapter 3. This chapter, in essence, revisits the phases necessary to conduct a DEA study as were discussed in Chapter 3. Different from Chapter 3, under each phase, the results are demonstrated and screen shots of the data are presented where appropriate.

4.1 Results of the DEA Framework

The results of each phase of the DEA framework that was introduced in Chapter 3 are presented in the appropriate section of this chapter.

4.1.1 Phase one: Selecting Decision Making Units (DMUs)

Several characteristics were introduced as part of the selection process for appropriate DMUs in a DEA study. The DMUs in this research are the divisions of WHP. As discussed in Chapters 1 and 2, WHP consists of five districts and 17 divisions. These divisions perform patrol operations in an attempt to achieve the goals set by the agency. Although the magnitude of the used inputs and generated outputs might be different in each DMU (i.e., each division), it does not contradict with the concept of homogeneity- as discussed in **Section 2.5.1**. However, it should be noted that the conditions and circumstances under which each DMU performs differs. This issue is considered by incorporation of Uncontrollable variables in the model, a concept that is discussed in detail in **Section 4.1.3**. The number of DMUs could not be increased since the research needs to take into account the entirety of the WHP agency with all of its divisions. Therefore, the issue with discriminating power of the DEA model, as discussed in **Section 2.5.1**, will be addressed by

reducing the number of variables in the model through mathematical approaches. **Section 4.1.5.3.1** explains this process. Figure 4.1 shows the 17 divisions of WHP that are considered as the 17 DMUs to be utilized in the DEA models. O, R, S and X are other divisions in WHP; however, none of them represent geographical locations. For example, Division S represents all of the supervisors in the organization.

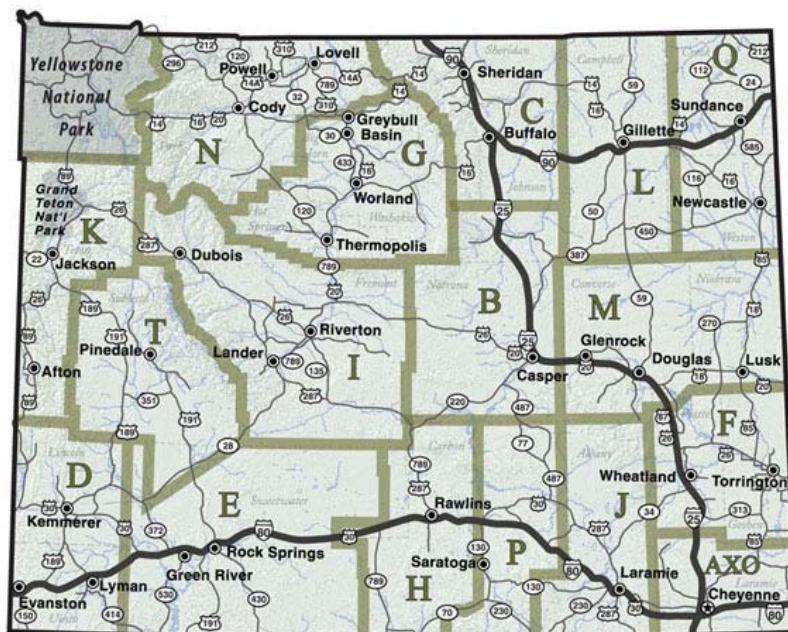


Figure 4.1: Boundaries of 17 divisions of WHP (WHP, 2011, p. 3)

4.1.2 Phase two: Selection of controllable variables (inputs and outputs)

The selection process of controllable variables (i.e., inputs and outputs) was previously discussed in **Section 3.1.2**. After going through the available literature and conducting interviews with WHP's executive staff and the Champion of the research, the variables that were decided to be considered in the model are as described in the following sections:

4.1.2.1 Inputs

During the process of gathering information for the initial set of variables (as discussed in **Section 3.1.2**), it became clear that the only resource varying from division to division is the number of troopers. This is the single most important factor contributing to the divisional performance, however; there are several issues that need to be taken into consideration:

- Utilizing the number of troopers as the only input in the model comes with the assumption that all divisions have access to the needed equipment and cars to perform the patrol operations. This is a valid assumption according to WHP officers.
- Despite the fact that it was discovered during a meeting with Captain Mickelson that supervisors of divisions do not contribute significantly to the traffic stops (i.e., issued tickets and citations), the number of troopers for each division includes the number of supervisors in that division as well. In order to make this decision, a simple comparison was performed on the proactive time (i.e., enforcement hours plus the time dedicated to public outreach programs) between troopers and division supervisors (a detailed discussion on these hours and what items they consist of are presented in **Section 4.1.2.2.2**) for each division. The information was collected from WHP's hour log datasheet (aka P-26) for 2011 and 2012. Table 4.1 summarizes the results from comparing the hours of a division without including the supervisor (troopers only), the hours recorded by the supervisors and the difference that it makes over the total divisional time.

Table 4.1: Troopers' and Supervisors' Time Contribution Comparison

Divisions	A. Division's total trooper time in 2011 (hours)	B. Division's supervisor time in 2011 (hours)	Percentage difference $(\frac{B}{A+B})$ (%)	C. Division's total trooper time in 2012 (hours)	D. Division's supervisor time in 2012 (hours)	Percentage difference $(\frac{D}{C+D})$ (%)
A	9191.3	346.5	3.77	9495	448	4.51
B	11425.5	289	2.47	9468.6	256	2.63
C	10903	452	3.98	9920.2	487.5	4.68
D	7948.5	614.5	7.18	8192.5	641	7.26
E	8266.5	389.5	4.5	8201	456.5	5.27
F	6424.5	334.5	4.95	7139.8	375	4.99
G	7814	624	7.4	7431.5	567	7.09
H	10015	96.5	0.95	8671.6	94	1.07
I	10395.5	220.5	2.08	10742	265	2.41
J	12781.4	470	3.55	11821.5	483.5	3.93
K	11290.4	270.8	2.34	11372.9	585.6	4.90
L	8092.8	472	5.51	7814.5	427	5.18
M	10167.6	299	2.86	9912.1	386.7	3.75
N	9852	559.5	5.37	9434.5	695	6.86
P	8259.5	211	2.49	5432	396	6.79
Q	4819.1	401.5	7.69	6485.4	407.5	5.91
T	10104.5	501.3	4.73	10672.3	406	3.66

As Table 4.1 shows, although supervisors' contribution is rather negligible, there is a rather significant deviation between different divisions (maximum of roughly 6.74 percent in 2011 and 6.2 percent in 2012). This is the reason why it was decided to include the supervisors in the trooper count for each division. Since DEA is a relative approach and it compares different units of a system, the deviation between one variable among DMUs would play an important role in the results. Also the decision is in line with the inclusion of the citations issued by supervisors (in spite of its rather small number) for the sake of consistency in the models.

- The number of troopers used for the input only accounts for the sworn officers who operate on the field. The number of civilian officers that could help the sworn forces with the administrative work is a contributing factor to how much time sworn officers could

actually dedicate to proactive enforcement activities on the field. If there is definitive help coming from other resources, which is called support services from here on, and is available on a divisional level, then this needs to be taken into account in the model. However, during a meeting with one of the Majors in WHP (Support Services Commander), it was discovered that support services are not available on a divisional level. They are present wherever there is a WYDOT office (e.g., Cheyenne, Casper, etc.) and could be used by all the divisions. This means that all the divisions are similar to each other with regards to having access to support services. Though to take this discussion one step further, in some cases, the divisions that are located closer to a WYDOT office are at an advantage of getting the service that they need more quickly. To better understand, consider the following example:

In case of equipment break down (e.g., laptop to write citations), a trooper needs to wait for the appropriate support service to address the problem which could take longer for divisions that are located farther from a WYDOT office. However, it could be argued that in that situation, it is still the trooper's choice to stay in the office and engage in administrative work, or go on the field and be visible. In either case, the time will be taken into account, either as time taken away from being proactive or as their visible time. In other cases, where a patrol car needs service and thus a trooper cannot go out on the field and be proactive, he/she may subsequently end up in the office, engaging in administrative work, which again is considered as time taken away from proactivity as an uncontrollable variable in the models (See **Sections 4.1.2.2.2** and **4.1.3.3**).

- It was discovered that in some divisions, the troopers need to drive many miles to get to an evidence center to drop the evidence documents for certain arrests (e.g., DUI). Therefore, divisions that are located farther to evidence centers will be at a disadvantage.

However, there is no need to have a separate measure only for to reflect this issue, since the time spent on the road driving to an evidence center could be considered as visible hours, which is already captured in one of the outputs (i.e., Number of enforcement hours, See **Section 4.1.2.2.2**).

- Number of troopers in a division is assigned not only based on how big the division is, but also based on the traffic volume that the division has, its population, and also different types of activities that troopers need to work on during their patrol time. This could be very different from division to division. For instance, Division A (Cheyenne) has more population and has to deal with more Call for Services (CFSs) compared to a less populous division and thus may need to have more troopers. It should be noted that the factors that affect the proactive time of troopers in each division is taken into account in the models, with an output for number of enforcement hours and an uncontrollable variable for times away from proactivity. These variables are discussed in **Sections 4.1.2.2.2** and **4.1.3.3** respectively.
- The factors that could demand more activity from the troopers (e.g., traffic, population, size of the division) could result in the need for more troopers in a division. These factors are also considered in the models. Most of these parameters are already captured in the models by including proper variables. For instance to account for the amount of traffic, Annual Average Daily Traffic (AADT) and Annual Average Daily Truck Traffic (AADTT) are utilized in the models. However there are no variables to account for the population of a division (e.g., number of drivers). This is mainly due to the fact that the driving population of a division is not confined to that division and there is no way to quantify what percentage of that is always in the division. Regardless, traffic counts

captured through AADT and AADTT is a good indication of the amount of drivers in a given division.

- It should be noted that patrolling is significantly different depending on the characteristics of divisions, which can essentially affect the number of troopers in a division. For instance in Cheyenne, because of the high numbers of CFSs, troopers do not get a lot of chance to work proactively. To make up for this, they spend most of the time when they are free in the easier areas and not necessarily where enforcement is needed. This issue is addressed with the approach taken to define meaningful activities as outputs used in the models as well as the inclusion of number of hours spent for CFSs in the list of uncontrollable variables (See **Sections 4.1.2.2** and **4.1.3.3**).

Information on the number of manpower (i.e., troopers) for each division in 2011 and 2012 on a monthly basis was collected from WHP and is presented in Table 4.2. Based on the table, it is clear that the number of troopers could fluctuate over the course of the year. To account for this issue, the average of the trooper count was calculated. Although the outcome could be a non-integer number, since the DEA model treats this number as an input to represent the available resources in each DMU, it does not matter that the ultimate number is not round despite the fact that intuitively it does not make sense to have 9.5 troopers in a division.

Table 4.2: Divisional Monthly Trooper Count

Division	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
A	2011	11	11	11	10	11	11	11	11	11	11	11	11	10.91
	2012	11	11	12	12	12	12	12	12	12	12	12	12	11.83
B	2011	12	12	12	11	11	12	12	11	12	12	11	11	11.58
	2012	11	11	11	11	11	11	11	11	11	12	11	11	11.08
C	2011	9	9	9	9	9	9	9	9	8	8	8	8	8.66
	2012	8	8	8	8	8	8	8	8	8	8	8	8	8
D	2011	8	8	8	8	8	8	8	8	8	8	8	8	8
	2012	8	8	8	8	8	8	8	8	7	9	9	9	8.16
E	2011	8	8	8	8	8	8	8	8	8	8	8	8	8
	2012	8	7	9	9	8	8	8	8	9	9	9	9	8.41
F	2011	6	6	5	5	6	6	6	6	6	7	6	6	5.91
	2012	6	6	6	6	6	6	6	6	6	7	7	7	6.25
G	2011	7	7	7	7	7	6	6	6	6	6	6	5	6.33
	2012	6	6	6	6	6	6	6	5	6	7	7	7	6.16
H	2011	10	10	10	8	9	7	7	7	7	7	7	7	8.16
	2012	7	9	9	8	7	7	8	8	8	8	8	8	7.91
I	2011	9	9	9	9	11	10	10	10	10	10	9	9	9.58
	2012	10	10	10	10	10	9	10	10	10	10	10	10	9.91
J	2011	10	10	10	10	10	10	11	11	11	11	11	11	10.5
	2012	11	11	10	11	11	11	11	11	11	10	10	10	10.66
K	2011	9	8	8	8	9	9	9	9	9	9	9	9	8.75
	2012	9	9	9	9	9	9	9	9	9	9	9	9	9
L	2011	8	8	8	8	6	6	6	6	6	6	6	7	6.75
	2012	7	7	8	8	8	8	8	7	7	6	7	5	7.16
M	2011	9	9	9	9	9	10	9	10	10	10	10	10	9.5
	2012	10	10	10	10	10	10	10	10	10	10	10	10	10
N	2011	7	7	7	6	7	8	8	8	8	8	8	8	7.5
	2012	8	7	7	7	7	7	7	7	8	8	8	8	7.41
P	2011	8	8	8	8	8	8	9	9	8	8	8	8	8.16
	2012	8	7	8	6	6	6	6	6	5	5	5	5	6.08
Q	2011	4	4	4	4	4	4	3	3	3	3	3	4	3.58
	2012	5	5	5	5	5	5	5	5	5	5	5	4	4.91
T	2011	8	8	8	8	8	8	8	8	7	8	8	8	7.91
	2012	8	8	8	8	8	8	8	8	9	9	9	9	8.33

Also to consider the supervisors in each division, one unit was added to the trooper yearly average count. This is due to the fact that each division has one supervisor over the course of the year. The final input values for both 2011 and 2012 are presented in Table 4.3.

Table 4.3: Divisional Final Input Count

Division	Manpower count (i.e., input) in 2011	Manpower count (i.e., input) in 2012
A	11.91	12.83
B	12.58	12.08
C	9.66	9
D	9	9.16
E	9	9.41
F	6.91	7.25
G	7.33	7.16
H	9.16	8.91
I	10.58	10.91
J	11.5	11.66
K	9.75	10
L	7.75	8.16
M	10.5	11
N	8.5	8.41
P	9.16	7.08
Q	4.58	5.91
T	8.91	9.33

4.1.2.2 Outputs

The outputs in this research are defined in a way that will signify two characteristics of patrol operations that are considered valuable to WHP: **visibility** and **activity**. These two concepts were underlined on several occasions in interviews with WHP executive staff and through brainstorming sessions and is further in line with WHP's ultimate goal of changing roadway users' behavior in an attempt to save lives (See **Section 3.1.2.5**). For this reason, some of the outputs specifically focus on the activity side of troopers' patrol operations; while others mainly represent their visibility and effort for educational programs. It is worth mentioning that time spent for educating the public is included as part of patrol's activity, maybe not in the most straightforward way but it definitely helps change behaviors and save lives, which is the ultimate goal of WHP.

According to DEA literature and in an effort to increase the discriminating power of DEA models, inclusion of redundant variables should be avoided. An indication of redundancy is how strongly two (or more) variables are correlated. Correlation values are given on a scale from negative unity to positive unity, where the sign indicates the direction of the relation between values and the magnitude demonstrates how strong of a relation exists between them. Strong positive correlation suggests that the information possessed in one variable is already represented by the other variable and therefore, one of the variables is redundant (Ozbek, 2007). As appealing as it sounds to simply remove the correlated variable, such action should be avoided solely on the basis of the outcome of a correlation study (Dyson, et al., 2001; Golany & Roll, 1989). Instead, the correlation results should be utilized as basis for more elaborate examination of variables (Golany & Roll, 1989).

While some amount of interdependence between visibility and activity measures (i.e., number of enforcement hours and number of issued citations) could be identified, there is not necessarily a direct or measurable link that could affect the independent status of each of the outputs. For instance, the fact that a trooper spends hours on the roadside being visible, does not necessarily imply that traffic stops are made and citations are being issued by that trooper. Therefore, it cannot be inferred that the more visible hours in a division, the more the number of issued citations within that division. To verify the validity of such statement, a correlation analysis was conducted for 2012 data using R. Figure 4.2 demonstrates a diagram plotting the enforcement time per division in 2012 (independent variable, x-this includes both the troopers' and the supervisors' enforcement time) against the total number of citations (dependent variable, y) issued by each division. The correlation value (R^2) came out as 0.4262 which suggests that 42.62% of the variance in the number of issued citations can be explained by the changes in the

number of enforcement hours. The remaining 57.38% of the variation in number of issued citations is presumably due to random variables. This means that while there is a relationship between number of enforcement hours and number of issued citations, neither one of the variables can be explained fully by the other one. The significance level of this linear correlation (p-value) is equal to 0.0044, which explains the level of statistically significant association between the variables. While concluding if a p-value is significant enough is highly subjective and varies among different discipline areas (e.g., behavioral sciences versus medical sciences), in behavioral sciences a correlation is deemed significant at the 0.01 level (Cohen, 1988) , which is not met in the case of this correlation and thus, verifying the abovementioned statement. This observation also holds true for 2011 data.

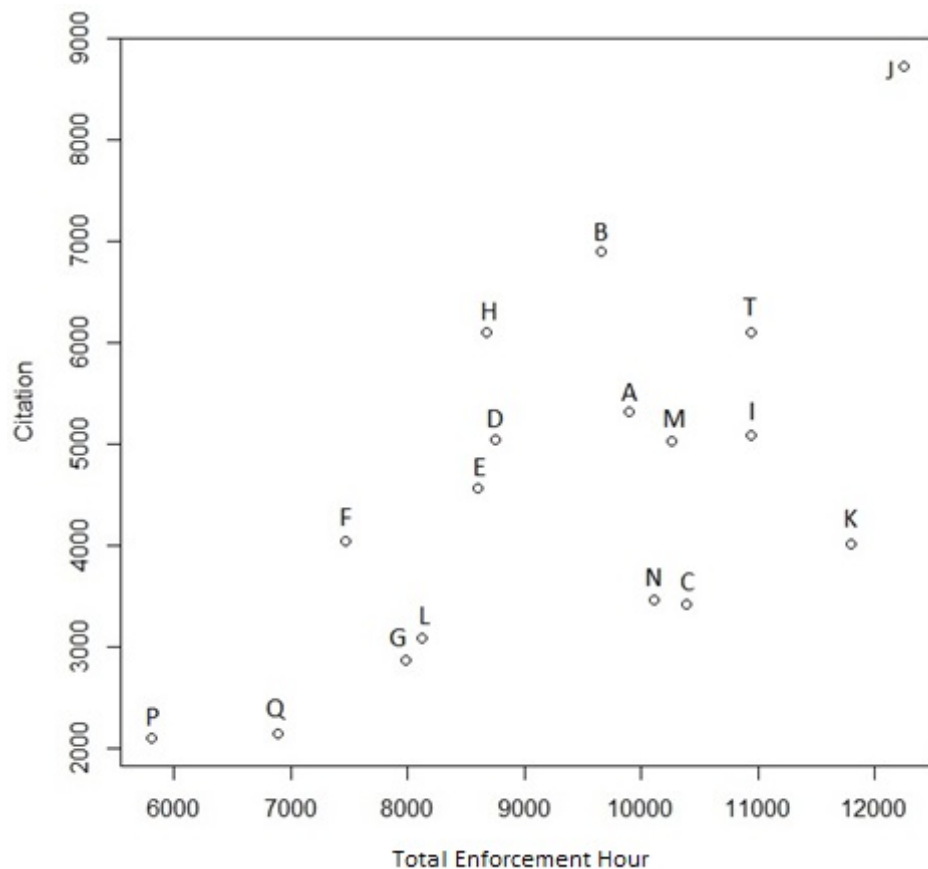


Figure 4.2: Enforcement time versus citations issued in 2012 per division

To capture the meaning of the two main concepts valuable to WHP (i.e., visibility and activity) in the outputs, two main categories of outputs have been defined: **Citations and behaviors** category to reflect the activity side of patrol, while **Hours category** is used to represent the visibility side. The details on these two categories are explained in the following sections:

4.1.2.2.1 Citations and behaviors

As mentioned in **Section 3.1.2.5**, not all the categories in WHP’s Balanced Scorecard are included in this research. The first two performance categories (i.e., (i) “Reduce highway fatalities, alcohol related crashes and injury crashes” and (ii) “Maximize our enforcement, education and support efforts”) make up most of the variables to be used in this research. This is in line with these categories’ attributed importance in highway patrol performance as was acknowledged by all the interviewees. Table 4.4 and Table 4.5 show the performance measures under these two performance categories and how each of the measures is applicable to the research scope. More detailed explanation is presented in the corresponding sections of this chapter as presented in Table 4.4 and 4.5.

Table 4.4: Reduce Highway Fatalities, Alcohol Related Crashes and Injury Crashes (WHP, 2011)

Measure	Included in the study?	Explanation Section
# of fatalities	Included (but not separately)	4.1.2.2.1.1
# of fatal crashes	Included	4.1.2.2.1.1
# of impaired driver related fatal crashes	Included	4.1.2.2.1.2
# of Commercial Motor Vehicle (CMV) fatalities	Included (but not separately)	4.1.2.2.1.1
# of fatalities during specially recognized holidays	Included (but not separately)	4.1.2.2.1.1
# of injury crashes	Included (all severity crashes)	4.1.2.2.1.1
# of CMV crashes	Included (but not separately)	4.1.2.2.1.1

Table 4.5: Maximize Our Enforcement, Education and Support Efforts (WHP, 2011)

Measure	Included in the study?	Explanation Section
% of citations issued per investigated crashes	Included (but not separately)	4.1.2.2.1.1
% of seatbelt usage	Included	4.1.2.2.1.4
# of hours dedicated to targeted enforcement efforts	Included (but not separately)	4.1.2.2.2
# of outreach programs or presentations	Included	4.1.2.2.2

One of the important metrics in measuring patrol performance is citations. However, utilizing only the number of citations issued is not a good reflection of the patrol performance. An officer could make many traffic stops to issue speeding tickets only because it is very easy to have/catch drivers overspeed in a specific stretch of a highway; notwithstanding the fact that there are no crashes happening because of overspeeding in that same stretch

The first and foremost responsibility of any Patrol agency is to save lives. Therefore, keeping the number of fatalities and incapacitating injury crashes (both are classified as “critical crashes”) at a minimum level possible is an essential measure to evaluate enforcement agencies’ activities. WHP’s Balanced Scorecard currently has measures that focus on critical crashes (See Table 4.4 above). Additionally reducing the number of critical crashes was identified as an important focus area during the interviews with WHP executive staff. However, it was also mentioned by all of the interviewees that changing drivers’ behavior is the most important overarching goal of WHP that would result in the reduction in all kinds of crashes. In other words, while critical crashes are important to acknowledge and address (i.e., reduce), what WHP is charged with is to address and reduce the bad behaviors exhibited by the drivers resulting in any type of crash. Progress toward this goal can only be measured by concurrently considering the number of issued citations aimed at changing bad driver behavior and the number of bad behaviors that have resulted in crashes (i.e., the measure of interest is not the number of crashes but the number of bad behaviors

exhibited by drivers that have resulted in those crashes), regardless of the crash severity, making it important to take all severity level crashes into account.

Given the discussion above, it was decided to modify the initial “number of citations” measure and make it more meaningful for the performance of the patrol. To do this, the number of issued citations for bad driver behaviors (different categories of ‘bad’ driver behaviors are explained later in this section) was normalized by the number of bad behaviors exhibited by the drivers that have resulted in crashes. This way of defining outputs helps factor in **meaningful patrol activities** that will essentially change a bad behavior, accomplishing the ultimate goal of traffic enforcement.

Once again it is important to note that different from WHP’s current performance measures that only focus on critical (fatal and incapacitating injury crashes), this research takes into account all severity level crashes (from property damage only to fatal crashes). This is mainly because as discussed above, the ultimate goal of WHP is to change drivers’ behavior, which is independent from the severity of the crash; e.g., a driver exhibiting the bad behavior of drunk driving could result in a crash that can be property damage only or fatal. Regardless of the severity of the crash, the driver is exhibiting bad behavior that needs to be changed.

Also as mentioned above, the outputs take into account the number of bad behaviors exhibited by drivers involved in crashes as opposed to number of crashes or number of drivers involved in crashes. This is mainly due to the fact that patrol’s activities are targeted to impact drivers’ behaviors that are the causes of those crashes. It should be noted that driver’s behavior is the most important reason contributing to crashes. As discussed previously in the introduction and

the literature review chapters, 93% of crashes are driver related (EOT, 2008). Thus it is very important to change the driver behavior in order to be able to prevent crashes.

The abovementioned way of concurrently considering the citations aimed at changing bad driver behavior and the number of bad behaviors resulting in crashes depicts meaningful activity by patrol that contribute to a desirable outcome (i.e., citations issued to reduce crashes resulting from bad driver behaviors) as opposed to independently investigating citations which would only depict activity by patrol. An important implication of introducing this performance measure (concurrently considering citations aimed at changing bad driver behavior and the number of bad behaviors resulting in crashes) would be to help push the idea of issuing meaningful citations, those that focus on bad behaviors that actually result in crashes. This requires a cultural shift in troopers' mindset with respect to how, when, and where to issue citations. With the proposed way of defining measures, a trooper will look better if his/her enforcement activities result in one less bad driver behavior resulting in a crash as opposed to 100 more citations. This way, troopers will value where to invest their time and efforts to be more effective and efficient. It could be argued that this approach might convey a message of 'working less' to the troopers, but this is not the case. The results of this new performance measure will teach troopers how to be more effective in achieving their ultimate goal of changing behavior. Working more is always good; however working more in a more logical and effective way is even better. DEA will identify those divisions which are working in more logical and effective ways so that other divisions can learn from what they do through the benchmarking sessions.

It was mentioned above that with the proposed way of defining measures, a trooper will look better if his/her enforcement activities result in one less bad driver behavior resulting in a crash as opposed to 100 more citations. This is due to the typical disparity in the order of magnitudes

of the numbers that will go into the numerator vs. denominator in the proposed measure. Since in general, and certainly in the case of WHP, the number of crashes (and thus the number of bad behaviors that have resulted in crashes) is significantly lower than the number of citations in terms of order of magnitude, a change in denominator tends to affect the overall measure more so than a similar amount of change in numerator. This can be illustrated by actual data from one of WHP's divisions for Calendar Year 2011: In that calendar year, a particular division had issued a total of 5099 (i.e., the value of the numerator in the proposed measure) speeding citations. In the same time period, there were 18 (i.e., the value of the denominator in the proposed measure) speeding-related bad behaviors exhibited by the drivers (e.g., exceeding the speed limit, going too fast for conditions, racing) that have resulted in crashes. This results in a performance score of $\frac{5099}{18} = 283$ for this division for the proposed performance measure. If, say, for the same time period, the troopers issued 100 more citations without being able to reduce the number of bad driver behavior-related crashes, the division's score would yield to $\frac{5199}{18} = 289$. On the other hand, if some of the 5099 speeding citations they issued were issued in more crash-prone areas and crash-prone times; thereby resulting in a change in driver behavior in those areas and times; even reducing the number of speeding-related bad behaviors exhibited by the drivers that have resulted in a crash by just 1, this division's performance score would significantly increase, to $\frac{5099}{17} = 300$. The main point of this discussion is that while more activity by the troopers will be rewarded based on the proposed performance measure (e.g., performance score going from 283 to 289), meaningful activity will be much more rewarding (e.g., performance score going from 283 to 300).

The abovementioned way of defining outputs has been implemented to five different categories of ‘bad’ driver behaviors as recognized by WHP:

- i. Alcohol and drug,
- ii. Speeding,
- iii. Distracted driving,
- iv. Lack of proper restraint systems, and
- v. All other factors

It should be noted that the first four categories of bad driver behaviors were recognized as main contributing factors to critical crashes as a result of a data-driven enforcement study conducted for WHP (by Mr. Joe McCarthy) and was mentioned by all interviewees. These categories are individually and equally important and valuable to the agency and thus are incorporated into the proposed performance measures separately.

Even though the first three categories were identified as contributing factors to critical crashes, they represent bad driver behaviors that can result in any kind of crash, critical or otherwise. However, this point of view brings up one question: Does improper restraining systems contribute to crashes? All other categories could be considered as factors that could result in a crash but improper restraining systems could only change a crash to a critical crash. Therefore the question is: should this category be utilized in the proposed performance measures or not. Given that the seatbelt usage in the state of Wyoming is below the national average, there was a strong resistance by the researchers not to omit this category from the list of main contributing factors. Also using proper restraining systems by road users is a good behavior that deserves credit and getting road users to buckle up and use proper restraint systems was identified as a

valuable outcome for WHP. For these reasons, lack of proper restraint systems is included in this study as a contributing factor even though it does not fit the general logic to define the output measures. Furthermore, in this same category, not only the drivers with lack of proper restraint systems were considered, but also the passengers who exhibited the behavior were included. This is due to the fact that it is essentially drivers' responsibility to make sure that everybody in the vehicle is being safe.

Although the first three categories of behaviors (and the fourth one by extension as per the discussion above) are the ones that most contribute to crashes, there are still other reasons for crashes, which are mostly relevant to improper lane usage and following too close as indicated by WHP staff. Since limiting the performance measures to the abovementioned four categories could result in troopers concentrating solely on them, it is important to introduce a fifth performance measure that includes all other behaviors. This performance measure would ensure that the troopers get credit for issuing other citations (other than the citations issued for the abovementioned first four categories) and ultimately preventing crashes resulting from other bad behaviors. The fifth category which contains all other bad behaviors that could contribute to crashes (e.g., following too close, lane departures, not using signals, etc.) is added to the list to accommodate the fact that all severity level crashes are taken into account in this study. It should be noted that one crash can have multiple reasons, the same way that one traffic stop could lead to multiple citations, therefore it is important to have a comprehensive list of contributing factors taken into consideration.

The main reason for implementing the five main contributing factors to highway crashes separately in the model as opposed to adding them all up and coming up with only one measure for all citations, is that different divisions may be better with regards to one specific type of

citation and/or due to special needs of the division (and thus concentrating on one citation type). Defining citations separately brings out the strongest point of DEA. DEA assigns weights to the variables in a way that will be to the DMU's advantage. With this in mind, if a division is still not 100% efficient, it means that they are truly inefficient, even considering their main operational strengths and in spite of giving them several chances to be efficient. Also as previously mentioned, one crash can have multiple reasons, the same way that one traffic stop could lead to multiple citations. Defining separate outputs for each behavior would also provide the option to capture these multiple effects in the measures. The following sections discuss the measures related to the abovementioned five main factors in more detail, starting with general notes on the activity measures.

4.1.2.2.1.1 General Notes

Some general notes on the definition of the activity measures (i.e., citations normalized by bad behaviors exhibited in crashes), are provided below:

- Number of fatal crashes and number of fatalities are two measures currently in use in WHP's Balanced Scorecards. Many factors are involved in changing the status of a crash to a fatal crash (e.g., the position of the passengers or the quality of the vehicle involved in the crash). Also number of fatalities is a matter of luck depending on how many people were in a vehicle that was involved in a fatal crash. For all these reasons, this research considers bad behaviors exhibited in all severity crashes. Clearly if all bad behaviors could be eliminated, all fatal crashes would also be eliminated since they are a subset of all severity crashes. Additionally number of fatalities will go down. This point was made

by one of the interviewees and is further in line with the ultimate goal of changing behavior.

- All bad behaviors exhibited in crashes (and similarly all fatal crashes) need to be reduced, no matter what kind of vehicle was involved. This is the reason why the number of bad behaviors exhibited in CMV crashes is not separated from the rest of the data points. However, since CMV and other vehicle type crashes are combined together, it is important to make sure that the behaviors contributing to passenger car crashes (i.e., alcohol, drug, speeding, distracted driving and improper restraint system usage) are the same behaviors that are contributing to CMV crashes. That is generally the case; and furthermore all other behaviors for crashes and citations are taken into account in this study, which will take care of any other behaviors contributing to CMV or other vehicles' crashes. However, it should be acknowledged that WHP needs to report the number of CMV fatal and injury crashes to the federal government for funding purposes. Nevertheless, the agency can still do that with its own data. For the purposes of this research and the DEA models, separating bad behaviors exhibited in CMV crashes from the rest of the vehicle types is not justified. According to this research, a bad driver behavior should not have happened regardless of the type of the vehicle involved.
- Number of bad behaviors exhibited in crashes (and subsequently number of bad behaviors exhibited in fatal crashes) needs to be reduced regardless of the time of occurrence. This is why the number of exhibited bad behaviors during specially recognized holidays will not be considered separately. This point was highlighted by a few of the interviewees.

- Impaired drivers are charged with DUI tickets, which account for both alcohol and drugs. The specific reasons identified in driver's impaired behavior are indicated on the citations. Therefore, it is valid to combine drugs and alcohol related citations (and behaviors) into one output measure and not divide them into two measures (i.e., one for alcohol and one for drugs).
- The models do not have a separate measure only to consider the citations that are issued after the crash has happened (i.e., percentage of citations issued per investigated crashes). The reason behind this decision is that this is somewhat expected, as underlined by one of our interviewees. If a crash has already happened, there must be citations associated with it and although it is not proactive, it can still contribute to a change of behavior. Therefore, instead of having a separate measure to account for the number of citations issued per investigated crash, these citations are combined with all other citations, regardless of the time of issuance (i.e., whether associated with a crash or not).

4.1.2.2.1.2 Measure for DUI Citations and Behaviors

As mentioned before, one of the measures in WHP's Balanced Scorecard under their goal to "Reduce highway fatalities, alcohol related crashes and injury crashes" is the number of impaired driver related injury and fatal crashes. Knowing that the main contributing factors to an impaired driver are drugs and alcohol, one measure for this behavior is the number of DUI citations. As discussed above, the output is defined in a way that it not only counts DUI citations (activity by patrol) but also contributes to a desirable outcome (meaningful activity by patrol), which is to reduce the number of alcohol and drug related bad behaviors that have resulted in crashes. Equation 4.1 demonstrates how this output is used in the model:

DUI Measure=

$$\frac{\text{Number of Driving Under the Influence (DUI) citations issued}}{\text{Number of alcohol and drug-related bad behaviors exhibited by the drivers that have resulted in crashes}}$$

(Equation 4.1)

4.1.2.2.1.3 Measures for Speeding and Distracted Driving Citations and Behaviors

The same approach as discussed in the previous section applies to speeding and distracted driving related citations and crashes as well. Speeding citations both include over speeding and going too fast for condition, both of which are considered in the model. Going too fast for condition citations indicate that a driver was travelling faster than the safe speed under certain circumstances, although she/he could still be below the posted speed limit. Similarly, these citations are normalized by the number of bad behaviors exhibited by drivers involved in those types of crashes. Equations 4.2 and 4.3 show how these two contributing factors are addressed in the DEA models.

Speeding Measure =

$$\frac{\text{Number of speeding citations issued}}{\text{Number of speeding-related bad behaviors exhibited by the drivers that have resulted in crashes}}$$

(Equation 4.2)

Distracted driving Measure =

$$\frac{\text{Number of distracted driving citations issued}}{\text{Number of distracted driving-related bad behaviors exhibited by the drivers that have resulted in crashes}}$$

(Equation 4.3)

Given that texting and driving is actually banned in the state of Wyoming, it is assumed that there is data available on distracted driving citations. However, it should be acknowledged that because of difficulties in proving distracted driving in courts, troopers may choose not to enforce distracted driving. This will result in distracted driving citations being under reported. Moreover, those distracted driving citations that are reported may not be as reliable as other types of citations, simply due to the fact that a trooper could never be sure that a driver was actually distracted. It is important to note that despite having weaknesses in the data, since everything is relative in DEA, even if the data for all counties/divisions are a little bit inaccurate; it will not create a huge issue.

4.1.2.2.1.4 Measure for Restraint Citations and Behaviors

Restraint citations account for both seatbelts and proper occupant restraining systems (e.g., child booster seats). As seatbelts are enforced in Wyoming as a secondary law, officers are not able to make traffic stops only because the driver is not wearing seatbelts. At the same time, seatbelt usage in Wyoming is under national average and was considered as a very valuable measure by all our interviewees as well as a result of the “Data-Driven Enforcement” study.

It should be restated that the approach taken in this research in defining the output variables is to incorporate not only the output measures that will eventually contribute to a change in behavior, but also the desirable outcome resulting from that. To take this discussion one step further, not only the seatbelt citations for drivers are considered, but also all the occupant protection tickets (e.g., child boosters and passenger seatbelts) are taken into account. It should be noted that in all other output measures, only the drivers involved in a crash are considered, while in the case of occupant restraint citations, all of the passengers in a vehicle are considered. This is mainly

because of the fact the driver is responsible for proper restraint systems of all the passengers in the vehicle. Besides, even if a kid in the back seat was not properly seated in a restraint system, the citation will be issued to the driver. It should also be mentioned that since helmets are not enforced in Wyoming, this variable (both in citations and crashes) does not include motorcyclists. However, if a motorcyclist was speeding, he/she would be ticketed for that and if he/she was involved in a crash due to speeding, he/she would be reported as a driver involved in a speeding related crash. Equation 4.4 shows the measure for this behavior.

Restraint Measure =

$$\frac{\text{Number of lack of proper restraint system citations issued}}{\text{Number of } \textit{restraint-related bad behaviors exhibited by the drivers} \text{ of vehicles involved in crashes}}$$

(Equation 4.4)

4.1.2.2.1.5 Measure for All Other Citations and Behaviors

Although the reasons mentioned in previous sections are the top most contributing factors (alcohol, drug, speeding, distracted driving and by extension seat belt) to highway crashes, there are other reasons for crashes as well, mostly represented by improper lane usage, vehicle deficiencies, and following too close. Focusing only on the previously mentioned four factors could have an effect on patrol operations in that the troopers will only concentrate on them; while this is not what WHP intends. Troopers need to be credited for issuing other citations, too and ultimately reducing bad behaviors other than the previously mentioned four. This further underlines the importance of including the Equation 4.5 as one of the outputs in the model.

Other Behaviors Measure =

$$\frac{\text{Number of other citations issued}}{\text{Number of other bad behaviors exhibited by the drivers that have resulted in crashes}}$$

(Equation 4.5)

The problem is that some of the troopers in some divisions have stopped issuing those “other” citations due to difficulties in proving the charge (similar to the issue with proving the distracted driving in courts). Therefore, most of the lane usage or other moving violations citations (e.g., improper lane use, failing to yield, following too close) come from crashes, meaning that these kind of citations are mostly issued after the fact that the crash has already happened. This may lead to a rather small number of citations for corresponding crashes in this category.

As might have been realized, there are no warnings in any of the output measures. The reason why warnings are not included in any of the measures is quite simple. First of all, according to WHP Staff, the effect of a warning is not as strong as a citation. Secondly, there should not be any warnings for the main categories of reasons contributing to crashes anyway (with the exception of speeding). Although there are still some troopers that believe otherwise and thus would issue warnings to violators, due to the reasons discussed, the measures only focus on citations; and warnings were excluded.

4.1.2.2.2 Hours

As a general note, it should be pointed out that number of hours is considered as an output for the DEA model, since they are **produced** in the process of enforcement operations by the input variable in a DMU (i.e., number of troopers in a division). This output represents the **visibility** performance of the patrol. The hours included as output take into account only the **enforcement time**, which includes the number of hours that a trooper is out on the field, being visible and proactive; and thereby potentially changing bad driver behaviors through that visibility. Thus, it should be noted that the remainder of the overall patrol time during which officers could be engaged in administrative work (e.g., entering citations and crash information into relevant

databases, recording evidence, making a court appearance, meeting with the district attorney, etc.) or responding to a CFS or responding to a call for outside help (from sheriff or city police) or attending a training session (for troopers; not for the public) instead of being in the field, visible and proactive is excluded from the output.

According to the approach taken to define different types of time, number of hours dedicated to targeted enforcement efforts (as a measure in WHP's Balanced Scorecard) is also considered as a subset of enforcement time which is already addressed in the output and hence is not going to be a separate measure in the models. This statement was emphasized by several of the interviewees who underlined that the number of hours that officers are out on the field being visible and proactive is as important as targeted enforcement hours.

The recorded hour log data at WHP (also known as P-26 form) accounts for the overall patrol time. This form has many line items that breaks down the time spent by troopers, engaged in different patrolling activities. In collecting the data for this output and defining it in a way that reflects the meaningful patrol activities, each line item in the P-26 form was carefully examined (See Appendix D for a complete copy of P-26 and WHP's instructions). Table 4.6 shows the line items as demonstrated in the form P-26. Meaning of each line item and what it entails as well as different categories are explained in **Section 4.1.2.2.2.2**. For more information on decisions about specific line items, refer to the corresponding explanation sections showed in the table.

Table 4.6: WHP's Time Log Sheet (also known as Form P-26)

Line Item	Name of Activity	Category	Notes/Explanation Section
1	Patrolling all highways	VA	Included as output, 4.1.2.2.2.1
2	Patrolling target highways	VA	Included as output, 4.1.2.2.2.1
5, 7, 8, 9, 10	DUI arrests	NVNA	Included as uncontrollable variable, 4.1.2.2.2.2
15	Size and weight and cv arrests	VNA	Included as output, 4.1.2.2.2.3
18	Assists	VNA	Included as output, 4.1.2.2.2.4
20	Permits	VNA	Included as output, 4.1.2.2.2.3
21	Trucks	VNA	Included as output, 4.1.2.2.2.3
22	CVSA inspections	VNA	Included as output, 4.1.2.2.2.3
25	Passenger crash investigated/scene	VNA	Included as uncontrollable variable for troopers but output for supervisors, 4.1.2.2.2.5
26	CMV crash	VNA	Included as uncontrollable variable for troopers but output for supervisors, 4.1.2.2.2.5
27	Crash- follow up investigation	NVNA	Included as uncontrollable variable, 4.1.2.2.2.6
29	Court/county visits	NVNA	Included as uncontrollable variable, 4.1.2.2.2.2
30	Bonds taken	VNA	Included as output, 4.1.2.2.2.7
31	Abandoned/unattended vehicle	VNA	Included as output, 4.1.2.2.2.8
32	Meetings	NVNA	Included as uncontrollable variable, 4.1.2.2.2.9
33	Training	NVNA	Included as uncontrollable variable, 4.1.2.2.2.9
34	Vehicle searches	VNA	Included as output, 4.1.2.2.2.2
35	Livestock inspection	VNA	Included as output, 4.1.2.2.2.8
36	Stolen cars recovered	VNA	Included as output, 4.1.2.2.2.8
38	ICOP/DVD/Evidence/Copying	NVNA	Included as uncontrollable variable, 4.1.2.2.2.2
39	Equipment care	NVNA	Included as uncontrollable variable, 4.1.2.2.2.10
40	Restricted D.L. investigations	VNA	Included as output, 4.1.2.2.2.8
41	Office detail-reports	NVNA	Included as uncontrollable variable, 4.1.2.2.2.11
42	Special detail	NVNA	Included as uncontrollable variable, 4.1.2.2.2.12
43	Assist other officer/agency	VNA	Included as uncontrollable variable for troopers but output for supervisors, 4.1.2.2.2.1, 4.1.2.2.2.13
44	Reddi reports/public service calls	VNA	Included as uncontrollable variable for troopers but output for supervisors, 4.1.2.2.2.1, 4.1.2.2.2.14
45	Public relations/safety talks	Outreach	Included as output, 4.1.2.2.2.1
46-53	Executive items	NVNA	Included as uncontrollable variable, 4.1.2.2.2.15

4.1.2.2.2.1 General Notes

In essence, the hours that must be included in the enforcement time output are:

- i. Troopers' visible hours in the field
- ii. Troopers' active enforcement hours, being proactive in the field, issuing citations and making traffic stops
- iii. Number of hours that troopers are assigned to construction zones
- iv. Number of hours that troopers are engaged in public outreach programs

While items i and ii are obvious times that need to be considered in this output, number of hours that troopers are assigned to construction zones (item iii in the list above, a part of line item 2 on the P-26 form) must be taken into account as enforcement hours as well. The reason is simply because these hours count towards troopers' performance in being visible by the roadside in a work zone and also because the troopers can make their own decisions to proactively enforce (write citations) in construction zones, which would thereby minimize the potential work zone crashes.

Number of hours dedicated to outreach programs for the public is also added to this output measure. This is because of the fact that outreach programs are activities performed by the patrol on the educational side. Although they may not be considered as conventional enforcement activities, they will eventually contribute to a change of behavior and safer traffic manners; the importance of such activities was highlighted by many of the interviewees. Therefore, a division that decides to invest more on outreach programs is more likely to have less traffic crashes, which means that it is performing better compared to its counterparts. However, number of hours that officers themselves are engaged in any kind of training (e.g., for the utilization of new software or academy training) would be considered as an uncontrollable variable. This is because these trainings consume the hours that the officers are supposed to be visible and proactive on the field. While we acknowledge that the time spent in these trainings have the potential to result

in some kind of desirable outcome that will increase divisional performance, this increase is likely to happen in the long run (and training the troopers does not have an immediate impact on changing the driver behavior, which is the ultimate goal of this research). Thus for the purposes of the models, such time will be treated as an uncontrollable variable that take away from the time of the officers as opposed to an output improving the divisional performance.

On the other hand, as mentioned before in **Section 3.1.2.5**, the amount of time that troopers spend travelling to respond to a CFS or call for outside help from sheriff or other agencies should be excluded from the hours in the enforcement time measure. This is due to:

- If an officer is responding to a CFS, it is because he/she has to and thus being visible during that trip was not his/her decision and,
- While travelling to the call, a trooper cannot stop to deal with traffic violators on the way and thus cannot be proactive (the officer would not have the flexibility to do anything enforcement related by his/her own choice).

However, one may argue that the times when troopers are on the road for whatever reason (e.g., travelling to a CFS or outside help or a training session) should be counted as their visible hours and thus need to be included in the output. In response, it could be counter argued that those hours on the field did not happen as a result of a decision that a trooper made. In other words, when a trooper is assigned to travel to a CFS for example, he/she does not have any choice or flexibility in choosing not to go. Therefore, they cannot really take credit for those hours. The immediate question that may arise is: Should CFSs be treated as uncontrollable variables that divisions do not have any control over in their decision making process or should they be completely disregarded when counting troopers' enforcement hours? In debating to answer this

question, it was decided to count those hours as uncontrollable variables rather than completely excluding them from the models. To better understand the rationale behind this decision, consider the following extreme hypothetical comparison:

Consider two divisions (A and B) where everything else is the same. Division A is constantly dealing with CFSs and thus its troopers cannot be proactive and visible on the field while under different circumstances, they would have chosen to go out and proactively enforce traffic laws. Division B, on the other hand, has no CFSs but the troopers would choose to stay in the office and engage in administrative and office work instead of choosing to go out on the field and be proactive. If we were to completely disregard CFSs, both divisions A and B may be recognized as having the same amount of efficiency, while it is clear that this is not the right conclusion. Division A is doing its best under the given circumstances and it is not its fault if they are receiving many CFSs. As a result, number of hours dedicated to responding CFSs (and other similar items) should be considered in the models as uncontrollable variables. In short, while **visibility credit** is not given to divisions for responding to CFSs (and other similar items), uncontrollable variable credit is given to divisions for having to deal with those issues.

It is important to note the hidden assumption in all the scenarios featuring uncontrollable variables. DEA is giving the divisions the **benefit of the doubt** by including uncontrollable variables in the models. It is assumed that in the absence of uncontrollable variables (number of CFSs for instance) the troopers would go out and proactively patrol. In other words, if the troopers were given the chance they would work. This is the fundamental basis for the concept of uncontrollable variables and the reason why credit is due to divisions and troopers for having to deal with uncontrollable variables; for essentially these factors are the reason why troopers are not able to work proactively. This is a valid assumption since:

- Firstly, the assumption is presumed for all the divisions and therefore, the conditions for all DMUs are the same, and
- Secondly, there is no way any comparisons could be conducted if it were to be assumed otherwise.

On the same note, it should be mentioned that similar to CFSs, responding to an outside help request (e.g., city police or sheriff) should be excluded from troopers' enforcement time. Troopers who are assigned to respond to an outside help are not available through the trip (and it is not their decision to provide response-they just have to do that). As importantly, according to the citation and crash data that is being used for the models, only those crash and citation counts are included in the database that have happened in the jurisdiction of a given division. When troopers are assigned to engage to an outside help for the city police, those areas are essentially not within their limits of authority and thus, the crash data and citation counts are automatically not included in the database for the models. This is yet another reason why these hours should be excluded from the enforcement time.

4.1.2.2.2 Time Log Sheet (Also Known as Form P-26)

WHP troopers have to record their hours spent on different tasks in different line items in a form called P-26. A copy of this form along with the guidelines describing what each line item means and what hours need to be captured in them are presented in Appendix D. There are two main columns in this form representing the counts and the hours spent on each activity. Since only the number of hours is needed to define the enforcement time output, only the line items that have hours associated with them are discussed in detail.

There are 14 items out of the total of 53 items in the P-26 form that only have counts associated with them. These items are not even included in Table 4.6 (i.e., line items 3, 4, 6, 11, 12, 13, 14, 16, 17, 19, 23, 24, 28, 37, See Appendix D). This is because of the fact that the minimum time duration to put on P-26 line items is 30 minutes. Since these line items take less than 30 minutes; the time associated with them is added to other activities that are reported under line items 1 and 2 (i.e., patrolling) in P-26 form. Each trooper needs to fill the form out in a way that it adds up to eight hours per day. Although there might be some troopers that would randomly generate numbers to put in as hours for line items for which they do not have the exact time (or think was not large enough), it is mostly safe to assume that they fill the form out accurately to the best of their assessment. This is another instance reiterating the benefit of the doubt assumption that was discussed in **Section 4.1.2.2.2.1**.

Typically, the troopers who try to make the P-26 hours add to eight hours tend to put more hours in non-activity, non-visibility related line items, so that the low number of citations or the low patrol time on the field would not be questioned. However, ultimately when the results of the DEA models are out and the poor performing divisions are identified, this issue could be discovered and further investigated in benchmarking sessions. Nonetheless, it is assumed that the troopers have recorded their hours correctly; which is a safe assumption to make according to Captain Mickelson.

According to the discussion in a meeting with Captain Derek Mickelson and Mr. Joe McCarthy, the line items on P-26 were categorized under the groups presented below:

- Visible Available (VA)
- Visible, Not Available (VNA)

- Not Visible, Not Available (NVNA)
- Outreach

The category column in Table 4.6 demonstrates the classification of each line item. These classifications reflect the opinions of Captain Derek Mickelson. It should also be mentioned that setting a definite category for some of the activities was a rather difficult task, since they could fall under a couple of groups depending on the specific characteristics of a given case. However, based on the majority of the time and Captain Mickelson's experience, the most appropriate category is assigned to each item. Brief descriptions along with the number of the corresponding section in which the items are discussed in detail are listed under the column Notes/Explanation section. Also the inclusion of the items as outputs or uncontrollable variables is indicated under the same column.

As discussed in **Section 4.1.2.2.2.1** as to what needs to be considered in the enforcement time output measure, all of the VA items (line items 1 and 2) and most of the VNA items were used, mainly because those activities are performed by troopers who decide to make traffic stops and further engage in meaningful patrol activity. However, exceptions include outside help and CFSs (e.g., line item 43 and 44 respectively) as discussed earlier in **Section 4.1.2.2.2.1**, which are going to be considered as uncontrollable variables. Outreach hours are also included as part of our output variable. NVNA hours are captured as uncontrollable variables.

It is important to note that since supervisors are also included as inputs in the models, some items are treated differently in case of troopers and supervisors. This is mainly because the definition of uncontrollable variables for troopers and supervisors are different, since their primary job description is not the same (supervisors' job description is primarily administrative and executive

work as opposed to being visible and proactive out on the road, which is the troopers' main job description). As a general rule, uncontrollable variables for troopers are the ones that are taking them away from being on the field. With this rule, all of the uncontrollable variables identified for troopers were disregarded when it came to supervisors because those tasks are a part of their job.

An exception to this rule is the fact that sometimes troopers are assigned to a task (CFS, outside help, crash investigation) that they have to go out and address (i.e., line items 25, 26, 43, 44). Therefore, even though they are being visible, since they had no decision making power in the process, these four VNA line items are included as uncontrollable variables in case of troopers. Supervisors, on the other hand can choose to be outside to address those tasks and thus those hours are counted towards their enforcement time, essentially because they do have a choice and they chose to address the issue themselves rather than assigning it to one of their troopers.

Revisiting the general rule, in case of the follow up tasks that come up after field operations (e.g., attorney visits after a DUI arrest), supervisors will not get any credit for those hours as uncontrollable variable. This is because of their primary job description (administrative duties) and the fact that if supervisors were not dealing with those follow up tasks, they would have been doing their main job description and be in the office rather than patrolling the highways. It is important to remember that there is no way to determine for sure what the supervisors would be doing had they not have to deal with the follow up uncontrollable variable tasks. However, since the overarching benefit of the doubt assumption has been applied to troopers activities- meaning if they did not have to deal with the follow up tasks that come after an arrest, they would be patrolling on the field- for the sake of consistency, this same assumption has been applied to the supervisor level as well (i.e., if they were not dealing with the follow up uncontrollable variables

after an arrest, they would be doing their main job description, which is administrative tasks in the office). Again this is why there is no uncontrollable variable time for the supervisors.

Further detailed discussions for each line item in Form P-26 are presented in the sections below:

4.1.2.2.2.1 Line items 1 and 2

Patrolling all highways and patrolling target highways respectively. Both considered VA and were included in the output as time engaged in visible proactive patrolling activities.

4.1.2.2.2.2 Line items 5, 7, 8, 9, 10, 29, 34, 38

DUI arrests. After a DUI arrest, there are certain tasks that are imposed on the troopers, where they cannot return to their posts and patrol while they are dealing with them (e.g., searching the vehicle, field tests, preparing the appropriate reports and affidavits and logging the evidence). Some of these extra items are done on the side of the road where the traffic stop was made and thus would count towards the visibility hours of the troopers (i.e., 34).

The hours logged in line items 5, 7, 8, 9 and 10 are truly representing the time imposed on the troopers after a DUI arrest where they are neither visible, nor available. These arrests normally take up to four hours, one hour of which would be on the side of the road where could be counted towards troopers' VNA time. However, since the hours of VNA and NVNA are combined together under one line item (for items 5, 7, 8, 9, 10) and the majority of it is NVNA, these line items are treated as NVNAs. Also the time spent in preparing and copying the DVDs are recorded in line item 38. According to Captain Mickelson, some of the troopers sometimes feel annoyed, having to deal with the extra paper work that comes along with a DUI arrest but as Captain Mickelson stated "It is something that comes along with a good arrest and the troopers should not feel bad if they have to stay in their offices and deal with paperwork". With that, these

hours are counted as uncontrollable variables in our models because they are essentially taking away from troopers' time to be visible and proactive on the field (e.g., a division with higher number of DUI arrests would be at a disadvantage. This is because it has to deal with greater amounts of paper work and consequently, would not be able to spend as much visible and proactive time as a division with lower numbers of DUI arrests). Also the considerable amount of time that a trooper needs to spend in the court for a DUI arrest that he/she has made is counted as NVNA time and is logged under line item 29.

4.1.2.2.2.3 Line items 15, 20, 21, 22

Size, weight and commercial vehicle issues. Despite the name "arrests", these items are citations. The activities are mainly part of Port of Entry (POE) officers' responsibilities, but occasionally there are traffic stops made by sworn officers, enforcing oversized and overweight trucks and engaging in Commercial Vehicle Safety Alliance (CVSA) inspections. These hours are recorded separately mainly due to the fact that they are associated with longer amounts of time spent, where in some instances the trucks are accompanied by the troopers to POE locations. These hours are used as part of the enforcement hours (i.e., being visible) in the models.

4.1.2.2.2.4 Line item 18

Assists. This item accounts for assisting non-operating vehicles on the side of the road as they come across to troopers' attention while they are patrolling on the field. According to Captain Mickelson, troopers can still engage in chasing violators if they happen to identify them even when they are assisting a vehicle on the side of the road. If a trooper decides to leave the assist in order to chase a violator, it would be captured in other line items (e.g., 1 and 2). So it is safe to assume that the hours presented here, are truly those hours when the trooper was talking to the

driver and not really paying attention to what is happening on the road. This is why it is categorized as VNA and it was used as part of visible hours in the enforcement time.

4.1.2.2.2.5 Line items 25, 26

Passenger and CMV crash investigation. These items represent further investigation after a crash. As discussed previously, although troopers are visible at the scene, the action was not conducted upon their own discretion as they were assigned to these particular tasks. These two line items are similar to CFSs (See **Section 4.1.2.2.2.1**) and thus, while categorized as VNA, they were treated as uncontrollable variables in the models in troopers' case. Supervisors, however, take credit for these hours as part of their enforcement time; simply due to the fact that they have decision making power and that they have chosen to be out in the scene, addressing the issue themselves.

4.1.2.2.2.6 Line item 27

Crash follow-up investigation. Historically, this item falls under the category of NVNA, as the troopers needed to stay in their offices and write the required reports as part of the follow up process to a crash. But, nowadays they can do it on their laptops from the side of the road and thus they can be visible. This is the reason why this activity could swing either way (NVNA or VNA) and is considered 50-50. However, according to Captain Mickelson referring to the official description for this line item, it was decided to keep it as NVNA. For instance, troopers in a division that is more crash prone due to deficient road design, would probably put more time into following up and investigating the crashes that occur. This would further put them in a disadvantage of not being able to be visible and proactive on the field as much as they could otherwise.

4.1.2.2.2.7 Line item 30

Bonds taken. Occasionally when a traffic stop involves travelers from certain states that are not a part of Non- Resident Violator Compact (NRVC). There are a few states that are not a part of this act (e.g., Michigan, Wisconsin, and California). Under this act, when a motorist is cited in another state other than the driver's home state and chooses not to respond to the fine, the other state can communicate with driver's home state and notifies them to take proper action (NRVC, 1994). This is why the drivers from the non-member states have to pay for the ticket in cash right away. In some instances, if the driver does not have the required cash readily available, it is the responsibility of the trooper to escort the violator to the nearest ATM. This item counts for these hours and is categorized as VNA, which is going to be used in the model as part of the visibility hour in the enforcement time.

4.1.2.2.2.8 Line items 31, 35, 36, 40

These line items respectively account for those hours that were spent by the officer to recover abandoned/unattended vehicles; livestock inspections or livestock removals from the right of the road; recovered stolen cars; and restricted driver license investigation. The last item (i.e., line item 40) takes those hours into account where the officer is investigating the records on the violator's driver license on the side of the road. In all of the mentioned cases, the officers would be visible on the side of the road but not available to enforce traffic laws to other commuters (i.e., VNA).

4.1.2.2.2.9 Line items 32, 33

Meeting and training. These hours only account for the time that the troopers are in a meeting or training session. They do not include the time travelling to the location where the meeting or

training session is being held. Therefore, these two hours are categorized as NVNA and were used in the models as uncontrollable variables that take away from troopers' time.

4.1.2.2.2.10 Line item 39

Equipment care. This item focuses on the time that troopers spend on taking care and cleaning up their own cars and equipment. It is categorized as NVNA and is treated as an uncontrollable variable.

4.1.2.2.2.11 Line item 41

Office detail reports. This item accounts for the time that troopers are dealing with administrative work in their offices. This factor was categorized as NVNA and was considered an uncontrollable variable taking away from troopers' proactive and visible time.

4.1.2.2.2.12 Line item 42

Special detail. This task was identified as one of those activities that could swing either way (NVNA or VNA) depending on the unique characteristics of each case, however; it was ultimately categorized under NVNA and was included as an uncontrollable variable in the model. Per Captain Mickelson, hours reported in this line item do not include targeted or special enforcement activities (such hours are recorded under line item 1 and 2). According to WHP's official instruction on P-26, the special detail line item is for such activities as squad deployments, security details, bus inspections, etc. It is important to note that bus inspections are different from CMV inspections classified as VNA. Bus inspections are done in parking garages and not on highways, therefore, it truly falls under NVNA.

4.1.2.2.2.13 Line item 43

Assist other officer/agency. According to Captain Mickelson, this item is also one of those activities that encompasses variety of things and thus is hard to say confidently under which classification it would fall. However, since most of the time the troopers are called to provide back-up services, this line item could be considered as VNA. Given the discussion presented earlier in **Section 4.1.2.2.2.1** about outside help, these hours were treated as uncontrollable variables in the models. In case of supervisors, similar to line items 25 and 26 (See **Section 4.1.2.2.2.5**), assisting other officer/agency is included as output.

4.1.2.2.2.14 Line item 44

Reddi reports/public service calls. This line item essentially represents CFSs. The time spent by troopers to respond to CFSs is considered as time contributed to uncontrollable variable (See **Section 4.1.2.2.2.1**). However, in case of supervisors, similar to line items 25, 26 and 43 (See **sections 4.1.2.2.2.5 and 4.1.2.2.2.13**) the time is captured as output measure.

4.1.2.2.2.15 Line items 46 through 53

Line item numbers 46 through 50 are for Division O, representing Capitol Police and Dignitary Protection. Line items 51 through 53 are exclusively for high ranking Staff. All of these line items represent administrative time in the office, dealing with executive issues and problems and therefore, are included as uncontrollable variables in the model in case they are carried out by troopers.

4.1.3 Phase three: Selection of uncontrollable variables

A complete description of the initial uncontrollable variables that were identified to have an effect on the patrol performance is discussed in **Section 3.1.3** of Chapter 3. Final decisions and results as to which ones to include in this research are presented in this section. For the ease of referring to these variables, the information in **Table 3.6** is presented again in Table 4.7. The sections indicated in the “Explanation Section” column provide more detail on the rationale behind each decision. As mentioned earlier, decisions on which uncontrollable variables to include in DEA models often come with a trade-off. This is due to the fact that some of the variables identified as uncontrollable variables are very hard to measure and/or quantify. Furthermore, data availability is another issue. In some cases the data that demonstrates a given variable is very difficult to access. Therefore, it is important to investigate the value that each uncontrollable variable brings in a study and compare it to the level of effort that is required to collect and prepare the necessary supporting data.

Table 4.7: Initial list of Uncontrollable Variables to be Considered in the Study

Main Category	Sub-Category	Variables	Explanation Section for Final Decisions
Difficulties in Enforcement	N/A	Median-crossing difficulty	4.1.3.1
		Road shoulders	
		Road location	
		Road type	
		# of hours with lack of traffic or congested traffic	
Crash Proneness	Due to road characteristics	Ice channels	Excluded from the models, 4.1.3.2
		Type of terrain	
		Curvature	
		Super elevation	
		Road type	
		Road shoulders	
		Median guardrails and wide crossings	
		Road location	
		AADT and AADTT	
		# of CMVs/trucks vs. passenger cars	
		Holidays/major event and new commuters	
	Due to weather harshness	# of days with harsh weather conditions	
	Due to sociological issues	SES	
		Level of income	
		Occupation	
		Level of education	
		Age and gender	
		Other demographical information	
Time away from Proactivity	N/A	# of CFS hours	4.1.2.2.2.2, 4.1.3.3
		# of calls for help from outside	
		# of hours engaged in training for officers	
		# of hours dedicated to non-field operations	
Miscellaneous	N/A	Experience of troopers	4.1.3.4
		# of construction zones	
		Presence of other traffic enforcing entities	
		Serving area of divisions	

After carefully examining the effects of each of the uncontrollable variables in the initial list, they were refined and reduced to the final list of uncontrollable variables that were included in the models. This process of refinement is explained in the sections below.

4.1.3.1 Difficulties in Enforcement

As can be seen in Table 4.7, five factors were identified in this category. All of these factors were discussed in detail in **Section 3.1.3.1**. These factors and final decisions with respect to them are discussed below. The means to calculate each variable in order to properly represent their effects in the models is further discussed in **Section 4.1.5.2**.

- Median-crossing difficulty: The main problem with median crossing is the fact that troopers are not able to cross the median easily and quickly enough to chase down a traffic violator. With this in mind, an equivalent variable of divided mileage of highway is introduced as a good surrogate uncontrollable variable representing the difficulty in enforcement. Number of mileage in a division with divided highway considers median crossing difficulty without actually gathering information on the characteristics of the median itself.
- Road shoulders: There are places that the troopers would not work just because there is not enough shoulder width to make a safe traffic stop. Troopers need enough of shoulder width in order to be able to make a safe traffic stop, but that is not the only factor that goes into that decision and the shoulder width is not the only parameter. For instance, amount of traffic also plays a role. A trooper would make a traffic stop on a given segment of the road where there is no shoulder when there is not high volumes of traffic, while they will not take the same action when there is high traffic volumes. Other factors include curves, the visibility status of the trooper and terrain (i.e., reasonable slope) to name a few. These factors are difficult to quantify and are secondary factors in determining whether to make a traffic stop or not. Except for the amount of traffic that is

considered in the models (See **Section 4.1.3.1**), none of the additional factors mentioned above are included in the study.

The proper value for shoulder width was assumed based on the standard shoulder width of secondary roads, which is six feet. Six feet is the standard shoulder width for medium traffic volumes (measured in vehicle per day) in Arterial corridors and standard shoulder width for high volumes in Collector corridors. Given this, the length of highways meeting or exceeding this shoulder width is calculated for each division as an uncontrollable variable representing the difficulty in enforcement. It is important to note that sections on highways can have shoulders on both right and left side of the way. However, since pulling over a vehicle on the left shoulder is often associated with higher safety risks and rarely happens, only the right shoulder width is considered in the models.

- Road location: This factor takes crash prone locations such as construction zones and intersections into account. Since the time that troopers are assigned to patrol on a construction zone is reported in troopers' time log sheet (i.e., line item 2 in the form P-26), there is no need to define a separate variable to account for the effects of construction zones. Additionally, as discussed in **Section 3.1.3.1.3**, since intersections in the city limits do not make up much of WHP's focus, only the number of high speed intersections is taken into account in the models.
- Road type: As mentioned in **Section 3.1.3.1.4**, patrolling different road types are more a matter of personal preference and how comfortable each individual trooper feels to patrol on different road types. Therefore, this variable is not considered in the models.
- Number of hours with lack of traffic or congested traffic: Number of hours with congested traffic is not a big issue in a state like Wyoming while on the other hand;

number of hours with lack of traffic could be. It was discovered through meetings and brainstorming sessions that in the event of lack of traffic, a trooper could choose to patrol elsewhere or engage in other kinds of patrolling activities. Since troopers' time spent on different items is broken down and recorded in P-26 (See **Section 4.1.2.2.2**), no additional variable was introduced in the model to account for the effects of this variable.

4.1.3.2 Crash Proneness

Despite the initial identification of 18 different variables that were categorized under the concept of crash proneness due to different reasons (i.e., road characteristics, weather harshness, and sociological issues), none of these variables were used in the models due to the reasons explained below.

The crashes that are taken into consideration in this research can be categorized in six different categories, the first five categories are discussed in **Section 4.1.2.2.1** and are as follows:

- DUI
- No or improper restraint system usage
- Distracted driving
- Speeding
- All other factors

These categories address a citable driver behavior, however, there is a sixth category that takes into account all of the crashes where there is no human factor involved. Instances of this category could be acts of god type accidents (e.g., an eagle flying into a car through the open window) or purely attributable to poor road design or very harsh weather conditions. Since the crash data is collected through a query that filters the original crash database based on the five

categories listed above, those crashes that are in the sixth category and thus that have no driver related poor behavior associated with them are automatically left out of the models. Therefore, there is no need to include the initially identified uncontrollable variables in the models (as the crashes included in the models are not caused by them but by poor driver behavior). The real concern in this scenario is when a crash has multiple contributing factors, which is the case in majority of the time. Multiple causes of a crash could be a driver related behavior and another contributing factor truly weather/road related. For those cases, the question is: Should the model account for uncontrollable variables that influence the crash proneness of the situation (e.g., weather, road design, etc.)? Does WHP care about those factors and would want to measure its performance in the presence of such conditions? The answer to these questions helped deal with the crash proneness category of uncontrollable variables.

Before continuing with this discussion, it should once again be emphasized that everything within the DEA context is a process which will produce an outcome. This research studies the process of patrolling in WHP (e.g., their operations and performance) with regards to certain measures that are of value to the agency (i.e., number of crashes, citations, visible and proactive patrolling time, public outreach programs). Certain types of uncontrollable variables influence the process of patrolling while others affect the outcome. Those uncontrollable variables which have implications on the enforcement process are already taken into account under “difficulties in enforcement” category of uncontrollable variables as discussed earlier. The discussion presented here only applies to the uncontrollable variables affecting the outcomes from the perspective of “crash proneness” category of uncontrollable variables.

Based on discussions with WHP staff and Mr. Joe McCarthy, it was concluded that the second category of uncontrollable variables (i.e., crash proneness) should be excluded from the study,

since they have no implications on the way that the outputs were defined. According to WHP, in almost all crashes (with the exception of truly acts of god accidents which are not included in the models anyway), there is a poor driver behavior that has resulted in the crash. Furthermore, according to WHP, such behavior could have been prevented had the troopers done a good job of enforcing.

In conclusion, to recap the abovementioned discussion in justifying the exclusion of crash proneness category from the models, two points need to be reiterated:

- Only poor human behavior factors contributing to a crash should be considered in this research since the process of patrolling is only concerned about those and is required to take action based on those.
- There is always a poor human behavior factor contributing to a crash, even when combined with other external factors.

4.1.3.3 Time away from Proactivity

Four variables are identified under the category of time away from proactivity. Whatever the reason might be that is holding troopers back from being visible and proactive in the field, it needs to be taken into account in this uncontrollable factor category. Section **4.1.2.2.2** and Table 4.6 provide information on the items that need to be considered as hours representing the time away from proactivity.

4.1.3.4 Miscellaneous

As discussed at the end of **Section 3.1.3**, the experience of troopers is quite similar in all divisions, since young and inexperienced troopers are blended with older and more experienced peers. Number of construction zones and more importantly the number of troopers assigned to

these zones is already taken care of in the models by incorporating the time that troopers spend on patrolling construction zones (See Section 4.1.2.2.2.1). Presence of other traffic enforcement entities within the jurisdiction of divisions also was mentioned to have a potential effect on the performance of divisions. However, the effect of such entities was deemed minimal and thus, was disregarded from the list of uncontrollable variables. The only factor under this category that requires the inclusion of a separate variable is the serving area of divisions.

It is important to define the limits under the jurisdiction of each division and the activity limit of such division with precision. This is due to the fact that the size of each division needs to clearly indicate the amount of roads that the troopers need to patrol. For instance, county roads are examples of roads that WHP troopers do not patrol. Inclusion of city streets and city limits need to be carefully investigated as the types of violations and WHP involvement are different in these areas compared to highways outside of the city limits. Certain areas have certain traffic violations associated with them. For example, DUI citations and intersection related crashes happen more often in the city, while speeding related fatal and injury crashes happen on highways more frequently, explaining why speeding is not really enforced within the city limits. Many troopers write their DUI tickets within city limits and since those citations are included in WHP's database, those roadways are included in the model as well. Although the main focus of WHP as an agency is on the highways outside of the city limits, they can technically be held responsible for the crashes within the city limits too.

To represent the area served by each division, the roadway mileage under the jurisdiction of each division is considered. In the process of defining a proper variable to represent the serving area of each division, three measures were identified:

- Centerline miles: Roadway miles.
- Lane miles: Roadway miles multiplied by the number of lanes.
- Directional miles: Equals roadway miles in one way roads and double the roadway mileage for stretches of the way with two directions.

To come up with an accurate answer to the question of area served by each division, in a meeting with WHP executive staff, Figure 4.3 was shown in an attempt to have them distinguish the differences in patrolling operation in each case with the following description:

- One lane highway
- Bi-directional, two lane highway
- Bi-directional, two plus lane highway (mostly seen in urban settings)
- Divided highway (rural or urban setting), regardless of the number of lanes.

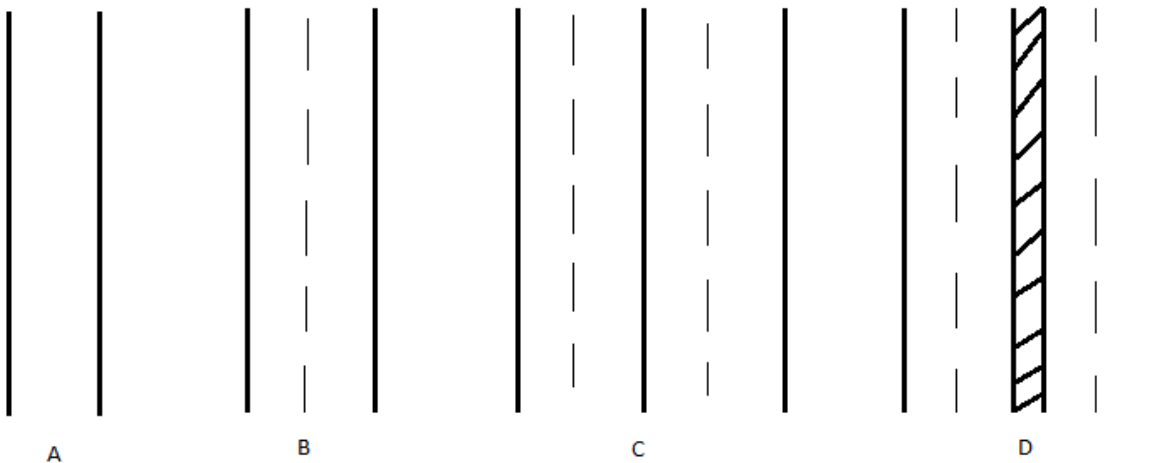


Figure 4.3: Possible highway settings

WHP staff unanimously stated that the troopers' visibility would be the same in all four cases depicted above regardless of the number of lanes. Also, it was stated that with the exception of divided highways (i.e., case D), the troopers would be able to enforce all lanes regardless of the number of lanes. Therefore, for the area that each division has to cover/serve, centerline mileage

is appropriate as long as the divided mileage of highway is taken into account separately in the models (divided mileage is already taken into account as was discussed under “Difficulties in Enforcement” category). WHP executive staff also stated that the amount of traffic should be included to represent the area served, therefore it was decided to include AADT and AADTT in the models.

The list below shows the final list of uncontrollable variables that are incorporated in the models based on all of the discussion presented in this section with respect to refinement and elimination of the initial list of uncontrollable variables:

- Divided mileage of highways in each division
- Roadway mileage with shoulder width more than or equal to six feet in each division
- Number of high speed intersections in each division
- Number of hours away from visibility and proactivity in each division
- Centerline mileage of highways under the jurisdiction of each division
- AADT and AADTT in each division

How each of these variables are quantified and further implemented in the models are discussed in **Sections 4.1.5.2.3.**

4.1.4 Phase four: Selection of the appropriate DEA model

As discussed in **Section 3.1.4.1**, there are several DEA formulations that can be used in a DEA study. To decide on which one to use, two questions need to be answered:

- Which of the controllable variables (i.e., inputs or outputs) could be modified to increase the efficiency of DMUs?

- Under which scale do the processes perform (i.e., Constant Return to Scale (CRS) or Variable Returns to Scale (VRS)?

The concepts in the abovementioned list are discussed in Sections 2.5.1 and 3.1.4.1. Since the inputs in this research (i.e., number of troopers in each division) are fixed and cannot be modified, an output oriented model is selected. Therefore, as an outcome of the models, inefficient DMUs will need to increase their outputs, while the amount of inputs remains the same. Also the BCC model is appropriate for the purposes of this research, since WHP's patrolling processes are not performed under the concepts of CRS. This means that a proportionately equal increase in the number of troopers (i.e., input), will not lead to the same proportional increase in the number of enforcement time (i.e., output). Therefore, the output oriented BCC model was selected for the purposes of this research.

Additionally, to account for the impact of uncontrollable variables, such variables are treated as fixed value inputs in the DEA models (See Section 3.1.4.1.4). After selecting the main DEA model, several iterations were performed to identify the best way to incorporate the selected variables into the model. These iterations along with extra steps that were needed to be performed in order to get to the best possible results are discussed in the sections of phase five.

It is important to note that there are several software platforms available on the market, which are capable of performing the computations of a DEA model. After examining several of the available platforms, Frontier Analyst software was chosen to best fit the purposes of this research. Frontier Analyst provides user friendly yet professional interface, visual display options and detailed reports that can be imported to Microsoft Excel after running analyses.

4.1.5 Phase five: Collecting and preparing the data and running the models

In this phase, the steps taken to collect the data for the variables that are used in the models are described. After finalizing the data, several DEA models were run in an attempt to find the best means to incorporate the variables.

4.1.5.1 Sources of Data

The databases required for the variables in this research were provided to the researchers from different departments in the Wyoming Department of Transportation. Captain Mickelson and Mr. McCarthy were the primary points of contacts for getting the necessary data and resolving the issues that came up in the process of preparing the data. More details on the data preparation process are presented in Section 4.1.5.2.

4.1.5.2 Data Preparation Process and Data Assumptions

These processes are explained in three different sections to delineate between different variables (i.e., inputs, outputs and uncontrollable variables). Screenshots of data are presented as necessary to better illustrate the procedures that were performed on the data.

4.1.5.2.1 Inputs

The number of troopers in each division was provided on a monthly basis to account for the inputs in the model (See Table 4.2). The average of monthly manpower counts was calculated in each division. It was decided that supervisors should be considered in each divisions as well. Since every division has one supervisor at any time over the course of the year, one unit was added to the yearly manpower count (See Table 4.3). The final numbers are not rounded. This is

because these numbers are to represent the amount of resources available in each DMU in a continuous data format. More information on inputs is presented in Section 4.1.2.1.

4.1.5.2.2 Outputs

As discussed previously in this chapter, there are two main categories of outputs defined to measure the WHP's patrol performance: activity and visibility. Citations and crashes are needed to calculate the activity outputs (See Section 4.1.2.2.1), while for the visibility measure, only the yearly P-26 forms (See Section 4.1.2.2.2) for both troopers and supervisors in each divisions was needed.

4.1.5.2.2.1 Citations

A complete database of issued citations for both 2011 and 2012 were provided, containing citations' statute numbers, a brief description of the charge, the name of the trooper who issued the citation, and the division to which the trooper issuing the citation belonged, among other information. It is important to note that the databases did not contain any identifying information on the violators due to privacy issues. The description of the charge was used to classify the citations into different behavioral categories. These categories are listed below:

- DUI
- Distracted driving (DIS)
- Improper of lack of restraint system (RES)
- Speeding (SPD)
- Other

At the end of this process, the number of citations in each category in each division was counted.

There were two main problems that were identified during the preparation of citation data:

- The division letters were not correctly associated with the troopers that had issued the ticket. A separate database that WHP had provided to the researchers, listed the troopers' names and which division within WHP they belonged to during the course of 2012. A quick comparison between the two databases made it clear that the citation database had numerous errors. After discussing the issue with WHP staff over a phone meeting, it was discovered that the citation database had not been fully updated and therefore, it did not reflect the changes in troopers' status (as to which division they are assigned to), but the second database containing the name and divisions of troopers was up to date. To resolve this issue, each record in the citation database was mapped with the updated troopers' status file to generate the accurate division assignment associated with each trooper. When this issue with 2012 database was communicated to WHP, an updated and accurate citation database was received for 2011.
- Some of the descriptions for issued tickets were too brief or non-existent. Therefore, a lookup table containing every statute number and a complete description of the charge was provided to the researchers. Also the web address to Wyoming Legislative Service Office was provided in case very detailed and complete descriptions of charges were needed. Both of these resources were used in deciding on what citations needed to be included in the study and moreover, the categorization of such citations. These decisions were also discussed with WHP staff in a meeting in order to get their feedback and opinion as well.

The general guideline in including a citation in the study was whether it had anything to do with i) the driver and ii) traffic related behavior. This decision was made due to the fact that the research focuses on the performance of WHP divisions with respect to changing the **driver**

behavior for traffic related items. Furthermore, as far as the model goes, the defined ratios as the output variables (i.e., the ratio of citations to crashes) should be consistent. Therefore, the citations that need to be included in the model are the ones that a driver could get cited for as a reason for causing a crash (See Section 4.1.5.2.2.2). It is important to note that while the focus of this research is on WHP's ability to change driver behaviors and even though highways are mostly concerned with drivers, there are a handful of instances of pedestrian citations and pedestrian-caused crashes that will be taken into consideration in the models as well (as WHP has the responsibility to change poor pedestrian behavior and the authority to issue citations to pedestrians too).

The far left number in any citation is a one or two digit number that represents the general title that it belongs to. The middle section number indicates the subcategory of the general title and the remaining numbers refer to the number of the article in each subcategory. For instance, a citation with the statute number of 12-6-101 refers to the Title 12 - Alcoholic Beverages, Chapter 6 - Minors and article 101 in that chapter. Table 4.8 lists the citations that are present in the citation database but are not included in the study as they did not meet the criteria discussed above.

Table 4.8: List of Citations that Are Not Included in the Study

Title Number and Name	Notes
6 – Crimes and offenses	All chapters excluded, except 6-2-106. See Section 4.1.5.2.2.1.1
7- Criminal procedure	All chapters excluded
11 – Agriculture, livestock and other animals	All chapters excluded
12 – Alcoholic beverages	Chapter 6, Article 1 excluded (i.e., sale or possession by minors)
14 – Children	Chapter 3, Article 3 excluded (i.e., possession or use of tobacco products by minors)
23 – Game and fish	All chapters excluded
24 - Highways	All chapters excluded, except three articles. See Section 4.1.5.2.2.1.2
30 – Mines and minerals	All chapters excluded
31 – Motor vehicles	All/some articles in Chapters 2, 4, 5, 7, 8, 9, 11, 13, 16, 18 excluded. See Section 4.1.5.2.2.1.3
35 – Public health and safety	Only one article included. See Section 4.1.5.2.2.1.4
39 – Taxation and revenue	All chapters excluded

4.1.5.2.2.1.1 Title 6: Crimes and offenses

All of the chapters under this title are excluded, except for statute number 6-2-106 (i.e., homicide by vehicle, aggravated homicide by vehicle). This decision is based on the fact that there is a human fatality involved due to driver behavior in these kinds of citations.

4.1.5.2.2.1.2 Title 24: Highways

From this entire chapter, there is only three different statute numbers existent in the citation database provided by WHP. These citations are 24-1-109 (i.e., fail to observe traffic signs), 24-6-110 (i.e., prohibited traffic acts) and 24-1-110 (i.e., acceleration or speeding on the highways). The first two categories are included under the Other, while the last one is included as the SPD category.

4.1.5.2.2.1.3 Title 31: Motor vehicles

This general title makes up most of the citations that are used in the study, since it specifically focuses on the motor vehicles. However, some of the citations under this title have been

excluded after careful investigation of the charge in addition to discussions with WHP staff. As mentioned previously, the general rationale behind the exclusion of some citations is the fact that they do not have anything to do with either driver behavior or traffic related instances. The chapters that are excluded from the general title of motor vehicles are listed below:

- Chapter 2- Title and registration
- Chapter 4- general offense and penalties (e.g., registration, license plates)
- Chapter 5- Regulation of traffic on highways. Not all the articles under this chapter are excluded. A list of the citations that were included under this chapter is presented in Table 4.9.

Table 4.9: List of Citations under Chapter 5 that Are Included in the Study

Statute Number	Description	Category
31-5-104	Obedience to authorized persons directing traffic	Other
31-5-106	Authorized emergency vehicles	Other
31-5-1104	Colliding with unattended vehicle or property	Other
31-5-115	Operation of motorcycle	Other
31-5-116	Obstruction of driver's view or driving mechanism	Other
31-5-120	Driving upon sidewalks	Other
31-5-1303	Child safety restraint system	RES
31-5-1402	Safety belts required to be used	RES
31-5-201 to 230 (with the exception of 224 (ai) and (a ii))	General operations of vehicles (e.g., lane change, stopping, yielding, signals, right of way)	Other
31-5-224 (ai) and (a ii)	Operation of vehicle upon approach of authorized emergency vehicles	SPD
31-5-233, 234 and 235	Operating the vehicle under influence of alcohol or drugs, possession of opened alcoholic beverages containers	DUI
31-5-236	Careless driving	Other
31-5-237	Use of handheld electronic wireless communication devices for electronic messages.	DIS
31-5-301, 304, 305	Maximum speed limits (including too fast for conditions)	SPD
31-5-402 to 405, and 501-512	Traffic control devices, stopping and parking	Other
31-5-602 and 605	Pedestrian rights and duties	Other
31-5-612	Pedestrian under the influence	DUI
31-5-901 to 970	Equipment	Other

- Chapter 7- Driver's license. All the articles under this chapter are excluded except for 31-7-404 (i.e., driving without interlock device), which is classified under the Other category.
- Chapter 8- Identification cards
- Chapter 9- Motor vehicle safety responsibility (e.g., insurance, liability coverage)
- Chapter 11- Identification of vehicles and prevention of theft

- Chapter 13- Abandoned vehicles
- Chapter 16- Motor vehicle franchises
- Chapter 18- Commercial vehicles. Some of the articles under this chapter are included in the study, most of which are with respect to equipment and inspection. These instances are grouped under the Other category. Some extensions to the statute number 31-18-701 referred to driving under the influence (i.e., 382.201, 392.4 and 392.5), lack of or improper usage of restraint systems (i.e., 392.16 and 393.93) and distracted driving (i.e., 392.82). These citations were categorized respectively under DUI, RES and DIS.

4.1.5.2.2.1.4 Title 35: Public health and safety

All the chapters and articles under this title refer to delivering and/or manufacturing controlled substances, which do not necessarily have any implication on the scope of this research and thus are excluded. There is only one exception for the statute number 35-7-1039 (i.e., using or under the influence of controlled substance), which is included under the DUI category.

Table 4.10 shows the citation counts divided by each category of behavior in each division for years 2011 and 2012. As can be seen in the table, the number of DIS citations is very small compared to the other categories. This is mainly because troopers rarely issue this type of citations due to the fact that they are hard to prove in court.

Table 4.10: Final Citation Counts per Division in each Behavioral Category

Division	Year	DUI	DIS	RES	SPD	Other
A	2011	164	2	441	3,689	852
	2012	178	4	629	3,661	854
B	2011	149	1	1,294	5,202	964
	2012	230	11	1,124	4,556	982
C	2011	85	8	358	2,858	287
	2012	71	4	308	2,823	220
D	2011	92	2	589	4,123	863
	2012	80	9	570	3,799	597
E	2011	97	1	413	2,955	575
	2012	108	5	411	3,368	673
F	2011	81	2	260	2,367	184
	2012	39	5	396	3,363	248
G	2011	32	0	280	2,583	161
	2012	36	1	359	2,304	174
H	2011	57	2	651	6,187	891
	2012	64	16	624	4,742	661
I	2011	41	1	236	4,053	397
	2012	46	2	621	4,062	357
J	2011	91	1	693	6,672	721
	2012	102	1	768	7,249	617
K	2011	99	6	738	2,680	567
	2012	81	10	560	2,680	687
L	2011	115	2	267	1,857	206
	2012	85	2	454	2,287	264
M	2011	74	1	705	3,831	306
	2012	92	6	597	3,856	485
N	2011	39	0	637	1,974	292
	2012	52	3	729	2,299	394
P	2011	37	1	355	2,418	642
	2012	38	1	248	1,520	297
Q	2011	55	0	51	989	185
	2012	58	1	165	1,680	245
T	2011	124	3	666	5,364	478
	2012	119	6	698	4,911	374

4.1.5.2.2.2 Bad Behaviors

As the outputs defined for this research use both the number of citations and the number of exhibited bad behaviors, the criteria for including citations and bad behaviors need to be consistent. Similar to the citations, the general guiding principle in including a crash in this study is whether it is attributable to the driver (as opposed to, for example, poor road design). This is

due to the fact that the study focuses on the performance of WHP divisions with respect to changing the **driver behavior** for **traffic related items** (therefore, registration or driver's license violations would not be counted for instance).

In the majority of the time, there are multiple factors that contribute to a crash. All of these factors are listed in WHP's crash form (See Appendix E). The information required for collecting the bad behavior data was pulled from the crash report through a written query prepared by Mr. McCarthy. The sections included are:

- Safety equipment usage as well as person type under the vehicle occupant information. This is used to gather information for crashes under the RES category.
- Driver's action, alcohol and drug suspicion, driver's distraction and citations issued under the driver's information portion.

Figure 4.4 and 4.5 show the driver information and safety equipment usage and the person type portions of the crash form respectively. In order to come up with the number of **active** enforceable bad driver behaviors (as opposed to a **passive** behavior that WHP is not charged with enforcing) resulting in a crash and to avoid any double counting, all the different options pulled from the crash form were reported in separate column headings.

Driver's Action (choose up to 4) 01 - No Improper Driving 02 - Ran Off Road 03 - Failed to Yield ROW 04 - Disregarded Traffic Signs 05 - Ran Red Light 06 - Disregarded Other Road Marking 07 - Speeding 08 - Drove too Fast for Conditions 09 - Improper Turn or No Signal 10 - Improper Backing 11 - Improper Passing 12 - Improper Parking 13 - Wrong Side/Wrong Way 14 - Following too Close 15 - Failed to Keep Proper Lane 16 - Erratic/Reckless/Careless/Aggressive 17 - Avoiding an Object on Road 18 - Avoiding Animal 19 - Avoiding Non-Motorist 20 - Avoiding MV 21 - Swerve Due to Wind/Slippery Surface 22 - Over Corrected/Over Steered 23 - Evading Law Enforcement 24 - Other Improper Action 99 - Unknown	1st choice <input type="text"/> 2nd choice <input type="text"/> 3rd choice <input type="text"/> 4th choice <input type="text"/>	Driver's Condition (choose up to 2) 01 - Apparently Normal 02 - Emotional (depressed, angry, disturbed...) 03 - ill (Sick) 04 - Fell Asleep, Fainted 05 - Fatigued 06 - Under Influence of Meds 07 - Physical Disability 08 - Suspected Drug Use 09 - Suspected Alcohol Use 10 - Other 11 - Driver Inattention 99 - Unknown	1st choice <input type="text"/> 2nd choice <input type="text"/>	Citations Issued choose up to 5 01 - None 02 - DWUI 03 - Drinking - (i.e., open container) 04 - Exceeding Speed Limit 05 - Speed too Fast 06 - Following too Close 07 - Wrong Side of Road 08 - Improper or No Signal 09 - Improper Lane Use 10 - Improper Turn 11 - Improper Passing 12 - Improper Starting Out 13 - Failed to Grant ROW to Ped 14 - Failed to Grant ROW to MV 15 - Disregard Officer 16 - Disregard Stop Light 17 - Disregard Stop Sign 18 - Disregard Other 19 - Improper Parking 20 - Reckless Driving 21 - Vehicular Homicide 22 - Driver's License Violation 23 - Improper Backing 24 - No Insurance 25 - Hit & Run 26 - Registration Violation 27 - Failure to Use Seat Belt 28 - Charges Pending 29 - Fed R & R Driver 30 - Fed R & R Vehicle 31 - Racing 32 - Careless 33 - Other (explain in narrative)	1st choice <input type="text"/> 2nd choice <input type="text"/> 3rd choice <input type="text"/> 4th choice <input type="text"/> 5th choice <input type="text"/>		
Suspect Alcohol <input type="text"/> 01 - Yes 02 - No 99 - Unknown <small>If Alcohol Test performed other than Breath then form 902E will be required with results at a later date.</small>		Alcohol Test Type <input type="text"/> 01 - No Test Performed 02 - Test Refused 03 - Blood 04 - Serum 05 - Breath 06 - Urine 07 - Other 99 - Unknown		Suspect Drugs <input type="text"/> 01 - Yes 02 - No 99 - Unknown <small>If Drug Test performed then form 902E will be required with results at a later date.</small>		Drug Test Type <input type="text"/> 01 - No Test Performed 02 - Test Refused 03 - Blood 04 - Serum 05 - Urine 06 - Other 99 - Unknown	
Alcohol Test Result <input type="text"/>		Driver's Distraction (choose one) <input type="text"/> 01 - Not Distracted 02 - Electronic Communication Device (cell, pager...) 03 - Other Electronic Device (palm, TV, computer...) 04 - Other Distraction Inside MV (passenger, pet...) 05 - Other Distraction Outside MV 99 - Unknown		DL Investigation <input type="text"/> 01 - Yes 02 - No 99 - Unknown			

Figure 4.4: Different categories of contributing factors to a crash for drivers involved in a crash

MV # 01 02	Person Type 01 - Driver 02 - Passenger 99 - Unknown <small>If non-motorist, complete supplemental form</small>	Safety Equipment Usage 01-None Used 02-Not Available 03-Shoulder & Lap belt 04-Shoulder Belt Only 05-Lap Belt Only 06-Passive Restraint Only 07-Restraint used-Type Unk. 08-Forward Facing Child 09-Rear Facing Child Restraint 10-Booster Seat 11-Child Restraint-Type Unk. 12-Helmet Used 13-Other 99-Unknown
MV #	Person Type Seat Position Seat Belt Usage	

Figure 4.5: Safety equipment usage and the person type involved in a crash

General notes about what each of the less obvious factors mean is provided in Section 4.1.5.2.2.2.1. Section 4.1.5.2.2.2.2 talks about factors under each category of behavior (i.e., DUI,

DIS, RES, SPD and Other) and how the final exhibited bad behavior count was calculated in each category.

4.1.5.2.2.2.1 General notes

In this section, some general notes on the crash form are presented:

- “24-Other Improper Action” in driver’s action and “33-other” in citations issued: There should be enough evidence available on the scene of the crash so that the trooper is able to check a box either on the Driver’s Action or Citation Issued section in the crash form rather than only checking the “24-Other Improper Action” in Driver’s Action box or “33-Other” in the Citations Issued and explaining it in the narrative (this is all based on WHP’s experience in that a crash in almost all the cases has a human factor involved which could be essentially tied to one of the reasons in the crash form). Nevertheless, if only “other improper action” or “other citation” is checked, that “other” reason will be a reason that can truly cause a crash and thus included in the behavior counts.
- “01-No Improper Driving” in the driver’s action box is associated with incidents that did not have anything to do with a reportable driver behavior. For instance, when evidence suggests that there was a front tire blowout that contributed to the crash. “01-None” in the citations issued box also happens in cases when several vehicles were involved in a crash where for instance a drunk driver crashed into their vehicles. Essentially the other drivers were not at fault and were not exhibiting a citable bad behavior.

Going through the actual crash forms, there was a case where three vehicles were involved in an incapacitating injury crash. According to the officer’s judgment only one of the drivers was trying to avoid colliding with a deer that was passing the highway and exhibited an

inexperienced behavior (locking the tires by braking hard instead of slowing down and maneuver) and essentially caused the crash. In this case, the crash forms filed for the other two drivers had “01- No Improper Driving” in the driver’s action box and “01-None” in the citations issued box. For the third driver however, it indicated “18-Avoiding Animal” as the driver’s action but still no citations issued. Again it should be noted that in such cases, there is nothing that WHP could do to prevent the occurrence of such crashes (such a crash is not necessarily caused by a driver behavior that WHP is responsible for changing) and thus the troopers should not be charged with changing those behaviors. Also it is important to point out that since January 2008 (the earliest date that the crash data could be accessed through the database) until September 2013; there were only 1,284 driver counts for “01-No Improper Driving”. This is pretty minimal given the time period of over five and a half years.

Based on the discussion above, some of the factors listed under driver’s actions box would be excluded for they are not really behaviors that WHP needs to be concerned about changing.

Instances falling under this note include:

- 02- Ran off road
- 17- Avoiding an object on road
- 18- Avoiding animal
- 19- Avoiding non-motorist
- 20- Avoiding MV
- 21- Swerve due to wind/slippery surface
- 22-Over corrected/over steered

4.1.5.2.2.2.2 Final behavior counts

The crash database that was provided to the researchers contained several columns, each with values of one (presence of a behavior) or zero (absence of a behavior). The headings under each category of behavior along with the rationale to come up with the final count in that category is explained below:

- DUI: This category consists of Drinking (i.e., open container), DWUI in citations issued, Suspect Alcohol and Suspect Drug in the additional boxes provided in the driver information section of the crash form. To explain how the DUI crash counts were calculated, let's treat DWUI as A, Suspect Alcohol as B and Suspect Drug as C. The following rules apply:

A, B, C = 1 → Behavior count = 2

A, B = 1 → Behavior count = 1

A, C = 1 → Behavior count = 1

B, C = 1 → Behavior count = 2

To further explain what these rules mean, consider the first line (i.e., A, B, C = 1 → Behavior count = 2). In case DWUI is selected in the citations issued box in addition to positive results to alcohol and drug tests (i.e., Suspect Alcohol and Suspect Drugs), the crash count is not equal to three. It will be counted as two instead. This is because the number of behaviors is important in the crash count, which in this case is the usage of alcohol and drugs. In any of the abovementioned rules, the "Drinking" column (i.e., open container) is added to the end result after applying the rules to the remaining three columns.

- RES: Four behaviors are included in this category. Driver misuse, passenger misuse, passenger none and other restraint issues (e.g., child restraint systems, driver none usage). No special rules are applied here. The results of each of these four factors are summed up and reported as the crash count under the RES category.
- SPD: Racing, over the posted speed limit and too fast for condition are the three columns under this category. Similar to RES, all of these factors are summed up to form the final crash count for the SPD group.
- DIS: This category of driver behavior contains electronic devices for communication and other distractions. Since regardless of the origin of distraction, driver distraction is only one bad behavior, in case any of the columns presented the behavior, the behavior count was one. In case both of the columns indicated the existence of behavior, the end result would still be equal to one, although this instance never happened in the 2012 crash database for example.
- Other: For this category, several items were included, some of which were treated with a logic. All of the factors are included in the crash count under this category with no special logic except for the following:
 - Right of Way (ROW): Failure to grant ROW to pedestrian (A) and failure to grant ROW to motor vehicles (B) are factors under citations issued, while failure to yield ROW (C) is under the driver's action box. The following rules apply:

A, B, C = 1 → Behavior count = 2

A, B = 1 → Behavior count = 2

A, C = 1 → Behavior count = 1

B, C = 1 → Behavior count = 1

- Signal/turn: Improper or no signal (A), improper turn (B) both in the citations issued box in addition to improper turn or no signal (C) in driver's action section of the crash form. The following logic apply:

A, B, C = 1 → Behavior count = 2

A, B = 1 → Behavior count = 2

A, C = 1 → Behavior count = 1

B, C = 1 → Behavior count = 1

- Careless and reckless driving: Careless driving (A) and reckless driving (B) are listed in the citation issued box, while erratic/reckless/careless/aggressive driving (C) is a part of driver's action box. The following apply:

A, B, C = 1 → Behavior count = 2

A, B = 1 → Behavior count = 2

A, C = 1 → Behavior count = 1

B, C = 1 → Behavior count = 1

Table 4.11 shows the number of final behavior counts in years 2011 and 2012 per each division.

Table 4.11: Final Behavior Counts per Division in each Category

Division	Year	DUI	DIS	RES	SPD	Other
A	2011	46	8	51	126	465
	2012	47	9	40	153	408
B	2011	58	4	49	128	364
	2012	56	11	50	113	375
C	2011	33	1	34	79	142
	2012	24	3	30	82	104
D	2011	18	2	23	126	206
	2012	18	4	18	67	170
E	2011	31	3	31	178	239
	2012	31	3	26	129	235
F	2011	14	3	23	53	117
	2012	7	3	24	30	118
G	2011	22	2	20	30	73
	2012	13	3	21	21	69
H	2011	6	2	23	169	221
	2012	17	3	24	100	221
I	2011	20	8	31	52	130
	2012	31	8	33	39	147
J	2011	17	4	31	210	471
	2012	18	4	16	124	339
K	2011	22	3	24	43	176
	2012	25	1	19	40	188
L	2011	20	4	35	57	120
	2012	28	2	22	47	106
M	2011	18	2	22	112	188
	2012	21	5	24	89	187
N	2011	8	3	20	34	81
	2012	21	3	19	31	125
P	2011	8	3	11	122	218
	2012	15	2	12	73	217
Q	2011	26	2	32	55	114
	2012	25	2	29	43	106
T	2011	10	3	10	18	70
	2012	8	3	6	11	50

4.1.5.2.2.3 Hours

The detailed description of what items are included in the enforcement hour measure as an output in the model is presented in Section 4.1.2.2.2.2. It is important to note that the enforcement time (i.e., being visible and proactive in the field) is combined with the number of hours dedicated to outreach programs to define the hour output (See Section 4.1.2.2.2.1). Table

4.12 shows the enforcement time combined with the outreach time per division in years 2011 and 2012.

Table 4.12: Enforcement time plus Outreach Time per Division

Division	Enforcement time plus outreach time in 2011 (hours)	Enforcement time plus outreach time in 2012 (hours)
A	9,537.8	9,943
B	11,714.5	9,724.6
C	11,355	10,407.7
D	8,563	8,833.5
E	8,656	8,657.5
F	6,759	7,514.8
G	8,438	7,998.5
H	10,111.5	8,765.6
I	10,616	11,007
J	13,251.4	12,305
K	11,561.2	11,958.5
L	8,564.8	8,241.5
M	10,466.6	10,298.8
N	10,411.5	10,129.5
P	8,470.5	5,828
Q	5,220.6	6,892.9
T	10,605.8	11,078.3

4.1.5.2.3 Uncontrollable variables

The selection process of uncontrollable was fully described in Section 4.1.3, at the end of which the final list of uncontrollable variables to be used in the study was listed. As a reminder, the list is shown below.

- Divided mileage of highways in each division
- Roadway mileage with shoulder width more than or equal to six feet in each division
- Number of high speed intersections in each division
- Number of hours away from visibility and proactivity in each division
- Centerline mileage of highways under the jurisdiction of each division

- AADT and AADTT in each division

In this section, the processes and assumptions in preparing the data for uncontrollable variables at a divisional level are explained.

4.1.5.2.3.1 Divided Mileage of Highways

All the routes included in the jurisdiction of each division were investigated in an attempt to identify whether or not they are divided. Based on the directions provided by WHP, it was assumed that the routes ML25, ML80, ML 90 and ML 47 were the only routes which are completely divided. In addition to these routes, ML23 was also considered as a divided highway for approximately 16 miles all going through Division J.

Routes are labelled as I, D or B in WHP's databases. I (for increasing) means that the mile posts are increasing along the way, while D (stands for decreasing) indicates a reduction in the mile posts. These letters are used when a roadway is divided. The last letter is B (for bidirectional), which means that the roadway is not divided but is a two way road. Results computed for divided mileage considering all of this information are presented in Table 4.13.

4.1.5.2.3.2 Roadway Mileage with Shoulder Width More Than or Equal to Six Feet

As discussed in **Section 4.1.3.1** for the shoulder widths, some divided roads can have both right and left shoulders. Since pulling traffic over on the left shoulder can be dangerous and since it is more common among troopers to make traffic stops on the right shoulder, only the information with respect to right shoulders with a width more than or equal to six feet was included as an uncontrollable variable. Therefore, for B routes, the length of right and left shoulders meeting

this criterion are added up (since the left shoulder in one way is the right shoulder on the opposite way). However, for the roadways indicating I and D in the shoulder width database, only the right shoulder was considered. With this assumption, the miles in each division with shoulder widths greater than or equal to six feet were summed up as the total amount and results are presented in Table 4.13.

For the missing shoulder widths in some routes (where no shoulder information was provided for some segments of roads), the following assumptions were made:

- If the missing segment was a middle portion of a route, it was assumed that the missing shoulder width was equal to the shoulder width of the longest segment before or after the missing segment. For instance, if the shoulder width of ML25 was missing somewhere in between the route in the jurisdiction of one division and the route had 12 miles of five feet shoulder width before the missing point and 4 miles of seven feet shoulder feet, it was assumed that the missing part had shoulder width equal to five feet.
- If the missing segment was at the very beginning or the end of a route, the information on the previous section of the route was extended.
- If there was no information available for the shoulder width in the entire length of a route, the records were taken out of the database completely.

4.1.5.2.3.3 Number of High Speed Intersections

Number of high speed intersections was provided by Mr. McCarthy per division as shown in Table 4.13.

4.1.5.2.3.4 Number of Hours away from Visibility and Proactivity

This measure equals to the uncontrollable variable hours that were discussed in detail in **Section 4.1.2.2.2.2**. Table 4.13 lists these values for both years 2011 and 2012.

4.1.5.2.3.5 Centerline Mileage of Highway (i.e., Area Served)

The name of every route in the state of Wyoming as well as the mile markers were provided by WHP. The purpose of mile markers is to show the stretch of the route that belongs to each division. This database was sorted by the route name and then by mile markers to facilitate the preparation of each divisional jurisdictional area. The centerline mileage of all the routes in each division was then summed up and results are presented in Table 4.13.

4.1.5.2.3.6 AADT and AADTT

AADT and AADTT in each route under the jurisdiction of each division are considered for the whole section of the B or I/D highways. The AADT in each segment of the road was multiplied by the length of that segment. The summation of AADT multiplied by the length of the routes was then divided by the total length of the routes in that division. This is done in order to get a weighted AADT for the whole division. The same process was applied to the truck traffic (AADTT). The missing AADT or AADTT information in some stretches of the routes was calculated as per the following assumptions:

- If the missing value was in the middle of a segment, an average of the values before and after was calculated.
- If the missing portion was at the beginning or at the end of a route, the immediate value after of before was extended.

- If no information was available for the complete length of a route, the route was completely disregarded.

AADT and AADTT were combined to form one measure representing the combined traffic level in each division. Table 4.13 shows the final traffic counts for each division in years 2011 and 2012.

Table 4.13: Uncontrollable Variables in each Division for Years 2011 and 2012

Division	Divided mileage (miles)	Shoulder width \geq 6 ft (miles)	High-speed Intersections (count)	Hours away in 2011 (hours)	Hours away in 2012 (hours)	Area Served (miles)	Traffic in 2011 (count)	Traffic in 2012 (count)
A	113.32	390.21	58	12,368.5	13,148	415.18	4,439.85	4,575.34
B	89.39	557.13	17	10,657.1	12,333.5	431.13	3,168.04	3,278.99
C	152.26	453.63	25	6,012.5	5,661.1	547.17	1,831.48	1,821.59
D	57.04	540.56	20	7,989	8,268.5	453.42	3,343.28	3,103.54
E	106.74	390.60	19	7,748.5	8,443.9	490.36	4,961.11	4,603.29
F	63.60	338.55	56	4,519.5	4,697.3	477.50	1,735.53	1,775.81
G	0	297.92	26	4,390.9	4,457.6	362.58	1,196.64	1,257.35
H	70.90	337.28	5	5,562.7	6,158.9	271.85	4,848.10	4,768.00
I	0	621.45	22	7,856	7,942.5	504.69	2,071.22	2,179.59
J	71.88	275.55	8	7,585.2	8,504.8	310.56	3,716.76	3,621.31
K	0	249.99	19	5,779.5	6,276.4	247.23	4,688.78	4,117.92
L	51.47	378.40	16	5,973.7	5,919.7	336.43	2,812.17	3,003.19
M	48.92	367.58	22	7,882.5	8,571.9	409.61	1,903.97	2,164.86
N	0	519.73	42	4,288.5	4,552.8	546.33	1,685.45	1,689.29
P	46.19	229.70	9	7,196.8	5,314.6	288.35	2,536.55	2,471.46
Q	59.70	359.61	19	2,345.2	3,033.5	495.87	1,389.30	1,422.60
T	0	181.31	16	4,775.7	5,891	260.83	2,207.46	1,851.45

It should be noted that some portions of certain routes had length equations associated with them. This means that the difference between the start and finish mile post of the route did not equal the length of the stretch. For instance, if the start and end mile post of a route was at 12 and 20 miles respectively, it is clear that the length of that stretch of the roadway is equal to eight miles (i.e., 20 minus 12). However, if that stretch of the road had length equation associated with it, depending on the equation type, the true length can be more or less than eight miles. The length

equations on roads happen because of the development of roads over time (e.g., tunnels, shortcuts, curves). With the implementation of length equations, there is no need to redo the mile posts. There are two types of length equations: gaps and overlaps. If there is a gap present in a section of a road, the gap amount should be added to the length of the road, while in case of an overlap, the amount should be taken out of the segment length.

A list of existing equations in Wyoming routes was provided by Mr. McCarthy. The equations were applied to the correct segments of the routes in the traffic and shoulder width data to help get to the closest route length. After application of equations, the final route length was compared against the true length of each route specified in Wyoming highways database. If the application of equations resulted in a closer length of the route to the true length of it, it was kept. On the other hand, if the application of the equation got the length of route farther away from its correct value, it was disregarded.

4.1.5.3 Iterations of DEA Models

Several iterations of the selected DEA model (See Section 4.1.4) were run in order to identify the best way of incorporating the variables into the models. Before continuing with these iterations, it is important to explain the isotonicity concept in DEA. In DEA context, the inputs and outputs need to be isotonic. This means that an increase in the input level should result in an increase (not a decrease) in the output level (Thanassoulis, 2001). Therefore, the effects of every variable that goes into the DEA model need to be carefully investigated. If the isotonicity concept is not satisfied, one might redefine the variables in a way that they meet the isotonicity criterion. If this is not possible either, inversion of variables (i.e., variables' values' multiplicative inverse is calculated) can be used. Through this transformation, a direct proportion between input and

output variables can be satisfied (Athanasopoulos, 1998; Athanasopoulos & Thanassoulis, 1995; Golany & Roll, 1989).

In the list of the uncontrollable variables included in this research, it is clear that some do not satisfy the isotonicity principle. “Divided mileage of highways” variable works to the disadvantage of a division and therefore, results in less of the output in case there is more mileage of divided highways. To resolve this issue, this variable was redefined to meet the isotonicity principle and thus converted to “undivided mileage of highways” to be used in the models. This conversion was performed by subtracting the divided mileage from the total mileage of highway in a division. The variable “roadway mileage with shoulder width more than or equal to six feet” does not need any change, since it already works to the advantage of a division. All the remaining four uncontrollable variables are inverted in order to meet the isotonicity principle of DEA models.

The iterations of the DEA models are described below:

- Baseline 1: The model has the input (i.e., number of troopers). The citation/poor behavior ratios of all five behavioral categories (i.e., DUI, DIS, RES, SPD and Other) were calculated and included in the model as well as the enforcement hours as outputs. All the six uncontrollable variables, albeit in the converted format as discussed above (i.e., mileage of undivided highway, roadway mileage with shoulder width more than or equal to six feet, $\frac{1}{\text{high speed intersections}}$, $\frac{1}{\text{hours away}}$, $\frac{1}{\text{area served}}$, and $\frac{1}{\text{traffic}}$) were included in the model. The results indicated that all of the divisions were 100 percent efficient. This means that there are too many variables present in the models and therefore, the model does not have enough discriminating power to identify the poor performing DMUs.

- Baseline 2: The inputs and outputs are the same as Baseline 1. Uncontrollable variables were modified in an attempt to reduce the number of variables.
 - Traffic was combined with area served (i.e., centerline mileage) to form a concept called Vehicle Miles Travelled (VMT). VMT is a prevalent concept in transportation domain, which is also applicable to this research. However, VMT is not isotonic, meaning that the more the VMT in a division, the harder it gets to patrol that division. Therefore, $\frac{1}{\text{traffic} \times \text{area served}} = \frac{1}{\text{VMT}}$ was considered in the second baseline model.
 - Mileage with shoulder width greater than or equal to six feet was also added to the mileage of undivided highway. This is a valid modification, since both of those variables have implication to the concept of difficulty in enforcement. Also since they both work to the advantage of a division, no inversion is required.

In spite of reducing the number of uncontrollable variables from six to four, the results of running the model still indicate that most of the divisions (all but one) are 100 percent efficient. Therefore, as a next step to reduce the number of variables, a statistical approach called the Principal Component Analysis (PCA) was utilized as discussed in the next section.

4.1.5.3.1 Utilization of PCA to reduce the number of variables

To reduce the number of variables, PCA was performed on the six isotonic uncontrollable variables (i.e., mileage of undivided highway, roadway mileage with shoulder width more than or equal to six feet, $\frac{1}{\text{high speed intersections}}$, $\frac{1}{\text{hours away}}$, $\frac{1}{\text{area served}}$, and $\frac{1}{\text{traffic}}$). PCA analysis was done through a Microsoft Excel add-in called XLMiner with the selection of Correlation Matrix method to account for the large variance and different data units in the variables (See

Section 3.1.3.5). Table 4.14 shows the loadings associated with each of the six original variables for both 2011 and 2012. Loadings of variables in the PCA context mean the weights that are assigned to each of the variables to make up the final principal component values (i.e., PCA score). Table 4.15 demonstrates the final principal components' (PC) values for each division. As a result of the PCA analysis, it was calculated that 81.51 percent of the variability in the original dataset is explained by using only two principal components (i.e., PC1 and PC2) for 2011 data and 83.07 percent of the variability in the original dataset is explained by using only two principal components (i.e., PC1 and PC2) for 2012 data . For both years, two principal components explain a large variability in the original data set. Therefore, from here on PC1 and PC2 are used in place of the six uncontrollable variables (i.e., the first two columns of Table 4.15). However, it should be noted that since some of the PC1 and PC2 values are negative, a relatively large positive number for each year (larger than the absolute value of the smallest negative value in the data set) was added to them so that all the values would become positive; as DEA requires all variables to be strictly positive as was discussed in Chapter 3 In the case of this research, such transformation would not affect the results as BCC output-oriented model (the model used in this research) is input translation invariant (i.e., an affine transformation of data on the input variables can be performed with no impact in the DEA efficiency results) (Adler & Golany, 2001; Pastor, 1996).

Table 4.14: Principal Component Loadings for the Uncontrollable Variables

Original Variable	Year	PC1 load	PC2 load	PC3 load	PC4 load	PC5 load	PC6 load
UNDIVIDED	2011	0.965368	-0.034299	0.099107	-0.039482	0.093969	0.216044
	2012	0.540240	-0.026664	0.136520	-0.013077	0.277137	-0.782186
SHOULDER	2011	0.683260	-0.611862	0.328148	0.025474	0.183459	-0.129585
	2012	0.378083	-0.466010	0.406616	0.274006	0.403586	0.486404
1/INTERSECTION	2011	-0.742031	0.016621	0.648952	0.139868	-0.067565	0.062010
	2012	-0.417209	0.011799	0.828320	0.150125	-0.249074	-0.234748
1/HOURS AWAY	2011	0.298039	0.861528	0.274569	-0.298123	0.030871	-0.061000
	2012	0.163980	0.661560	0.332454	-0.512278	0.3038102	0.264939
1/AREA	2011	-0.911105	0.236927	-0.105805	0.029196	0.317205	0.032949
	2012	-0.506262	0.188661	-0.137923	0.363428	0.735684	-0.125584
1/TRAFFIC	2011	0.622320	0.679075	-0.026634	0.385572	0.021862	-0.041470
	2012	0.328539	0.555634	-0.019014	0.712532	-0.254447	0.102590

Table 4.15: Final Principal Component Values

Division	Year	PC1	PC2	PC3	PC4	PC5	PC6
A	2011	-0.215448	-1.487662	-1.207572	-0.367624	-0.346627	-0.262027
	2012	-0.253444	-1.652305	-1.254355	-0.342136	-0.236022	0.193258
B	2011	0.412372	-1.805472	0.261211	0.194647	0.196084	-0.505533
	2012	0.331924	-1.987080	0.148961	0.421248	0.011227	0.403646
C	2011	1.494011	-0.237928	-0.003451	0.346397	-0.419780	-0.225610
	2012	1.517845	0.035240	0.113829	0.0620233	-0.440758	0.293451
D	2011	0.868936	-1.559818	0.277105	-0.227331	0.203602	-0.120781
	2012	0.880861	-1.492617	0.242291	0.031692	0.218589	0.142744
E	2011	0.237340	-1.243315	-0.146592	-0.706614	-0.653537	0.426993
	2012	0.238234	-1.313884	-0.195484	-0.770611	-0.353162	-0.404756
F	2011	1.430620	0.849102	-0.599345	-0.127779	-0.370655	0.139849
	2012	1.412670	0.958598	-0.502506	-0.382566	-0.221363	-0.082997
G	2011	0.851516	2.009291	-0.566112	1.095166	0.097134	-0.145809
	2012	0.815153	2.143023	-0.419289	0.756173	-0.229924	0.132016
H	2011	-3.381214	-0.053928	2.098426	0.105056	0.000826	-0.011737
	2012	-3.316056	-0.161454	1.996701	0.034455	-0.008485	-0.002579
I	2011	2.289717	-1.425984	0.635489	0.409738	0.626976	0.249743
	2012	2.190815	-1.411058	0.633006	0.574943	0.426606	-0.248516
J	2011	-2.324896	-0.195549	0.391482	0.165747	-0.403224	0.174866
	2012	-2.289027	-0.344679	0.312611	0.051824	-0.459422	-0.237679
K	2011	-2.275389	0.295394	-0.994063	-0.779851	0.772452	0.038667
	2012	-2.167614	0.282199	-1.009635	-0.318613	0.948506	-0.013521
L	2011	-0.738087	-0.142935	-0.164743	-0.153520	0.156237	-0.388063
	2012	-0.730622	-0.103952	-0.109742	-0.250707	0.279088	0.414246
M	2011	0.420653	-0.128393	-0.535000	0.635672	-0.219691	0.094083
	2012	0.275358	-0.379921	-0.545373	0.341940	-0.412098	-0.209508
N	2011	2.945832	0.171355	0.418282	-0.164729	0.386708	0.469879
	2012	2.903318	0.330520	0.474588	-0.046758	0.449691	-0.373069
P	2011	-2.245139	0.470821	-0.059633	0.536820	-0.192735	0.232862
	2012	-2.030396	1.037781	0.229667	-0.046531	-0.115102	-0.042778
Q	2011	2.062568	2.958991	1.066022	-0.895066	-0.198838	-0.306593
	2012	1.898651	2.538795	0.858749	-0.668173	0.015704	0.231952

T	2011	-1.833394	1.526029	-0.871503	-0.066729	0.365068	0.139210
	2012	-1.677675	1.520793	-0.974022	0.551792	0.126921	-0.195912

PCA was not performed on the outputs. This is because of the fact that the interpretability of the data will be lost after using PCA. Even for the uncontrollable variables side, it is very hard to explain to the non-technical audience what a component means. This task is even harder when it comes to outputs, since modifying the generated output level of DMUs is the ultimate goal of the study. Without knowing what category of citations needs to be concentrated on or what types of crashes need to be reduced, there is no practical means of improving the efficiency and performance of a division. Moreover, one of the strengths of DEA is to assign weights to each variable in an objective way that will make the DMU look at its best performance. Combining all the output categories in one large ratio for the purposes of reducing variables, will deprive the divisions of that chance. The DEA model with all the outputs considered separately gives each DMU a chance to be at its best state. For these two reasons, it was decided not to perform variable reduction (through PCA or combining the variables) on the output side.

- Baseline 3: The model with one input (same as Baseline 1 and Baseline 2), two components as uncontrollable variables (PC1 and PC2) and six outputs (i.e., DUI, DIS, RES, SPD, Other and enforcement hours) was the third baseline in this study, which was the first time that some inefficient DMUs were identified. The result of this model is presented in Table 4.15 under the column for Baseline 3.
- Baseline 4: To reduce the number of variables even one step further, the distracted driving citations and behaviors were added to those of the “Other” category to come up with a combined citation/poor behavior ratio. This is because the number of DIS related citations and crashes are comparatively significantly lower than the other behavioral categories. Also distracted driving behavior is not of much focus in WHP, which might

be due to the associated difficulties in proving those charges in the court as was discussed earlier. This model is the same as Baseline 3 with the exception of one less variable. Comparing the results between Baseline 3 and Baseline 4 indicates the fact that the DIS category was not an important variable in the models as combining it with the “Other” category only resulted in a minor (and negligible) change in efficiency scores. Therefore, the distracted driving was decided to be kept as an individual variable category (DIS) for the sake of consistency.

4.1.5.4 Final Selected DEA Models

Model results from baselines 1, 2, 3, and 4 were reported so far in an attempt to show how the number of variables influences the discriminating power of the DEA models. Baseline 3 is the final selected model to report the results on and is further compared against two other models:

- i. Comparison 1: No uncontrollable variables are included in this model. Inputs and outputs are the same as Baseline 3, which means that all the six original output categories are considered separately. A comparison between Baseline 3 and this model shows the effects of including uncontrollable variables and reducing the number of variables. Table 4.16 demonstrates this result.
- ii. Comparison 2: All of the citations and all of the behaviors were combined together to form one large ratio of citation/poor behavior. Therefore, this model only has two outputs (i.e., one output for the entire citations to behaviors and one output for the enforcement hours). PC1 and PC2 are the uncontrollable variables in this model and there is one input (i.e., number of troopers). This model is compared against Baseline 3 model to illustrate the impact of including different behavioral categories in the model as separately as opposed to combining them.

**Table 4.16: DEA Efficiency Scores resulting from Baseline 3, Comparison 1, and Comparison 2
DEA Models**

Division	Year	Baseline 3	Comparison 1	Comparison 2
A	2011	90.89	74.58	83.56
	2012	99.59	81.73	99.59
B	2011	100	93.02	100
	2012	100	80.87	100
C	2011	100	100	100
	2012	99.40	96.36	99.40
D	2011	100	79.58	100
	2012	100	80.53	100
E	2011	97.37	79.57	97.37
	2012	95.60	76.82	95.60
F	2011	100	83.21	93.88
	2012	100	93.63	100
G	2011	96.65	95.90	96.65
	2012	94.75	94.41	94.75
H	2011	100	92.82	100
	2012	100	82.60	100
I	2011	100	86.62	100
	2012	100	91.37	100
J	2011	100	100	100
	2012	100	100	100
K	2011	100	100	100
	2012	100	100	100
L	2011	100	92.10	100
	2012	100	84.27	100
M	2011	90.26	85.53	86.27
	2012	88.08	85.36	86.50
N	2011	100	100	100
	2012	100	100	100
P	2011	80.33	77.18	79.56
	2012	100	69.61	100
Q	2011	100	100	100
	2012	100	100	100
T	2011	100	100	100
	2012	100	100	100

Looking at the results from Baseline 3 and Comparison 1 shows the significance of uncontrollable variables. For example for 2012, as can be seen in Table 4.16, without the inclusion of uncontrollable variables, twelve DMUs were inefficient according to the model. However, once uncontrollable variables were included and the comparison between the DMUs

was levelled, only five inefficient DMUs remained, all of which faced increased efficiency scores.

Finally, a simple comparison between Baseline 3 and Comparison 2 reveals that minor differences exist when all the behavioral categories are combined together, significantly reducing the number of variables. These minor differences point out the fact that the large number of efficient DMUs (and relatively high efficiency scores of inefficient DMUs) do not result from the large number of variables used in the model (and thus potentially reduced discriminating power of the DEA models) as even when only 2 output variables were used (in Comparison 2) as opposed to 6 (in Baseline 3), the results are very similar, indicating that efficient DMUs did not end up being efficient due to problems with discriminating power. Another important conclusion is that even when a few DMUs are provided with every chance to look at their best (by having separate variable categories), they still are not completely efficient. Thus, divisions A, C, E, G, M and P are truly inefficient. However, it is important to note that the efficiency scores are not that low, which means that relatively speaking; the 17 divisions in WHP are similar in their enforcement efficiency.

4.1.6 Phase six: Post processing and presenting the model results

One of the most important outcomes of a DEA study aside from the fact that each DMU gets to know at what percentage it is performing, is to represent the efficient peers of the inefficient DMUs. This phase allows for benchmarking, where divisions could identify the differences between practices that is responsible for better efficiency scores in those DMUs labeled as peers. Figure 4.6 and 4.7 show the peers in WHP with relation to poor performing divisions, respectively for years 2011 and 2012.

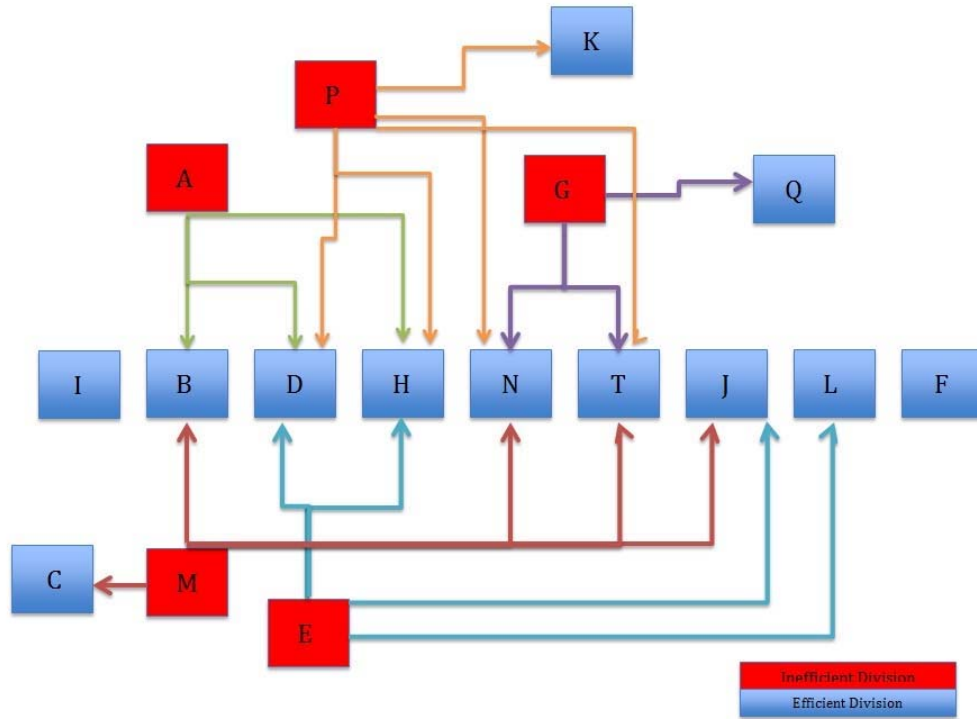


Figure 4.6: Peer relationships for inefficient divisions for year 2011

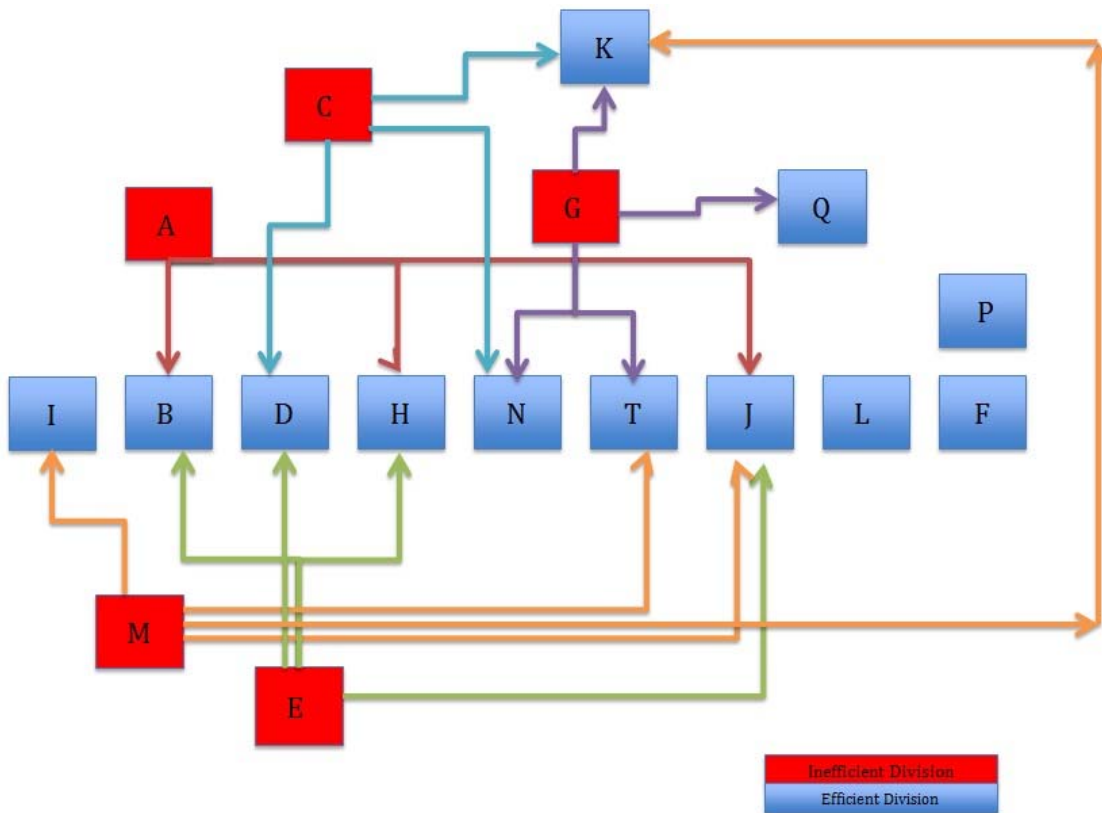


Figure 4.7: Peer relationships for inefficient divisions for year 2012

Table 4.17 and 4.18 illustrate the complete results from the Baseline 3 model along with output variables' values as incorporated into the model, for inefficient divisions respectively for years 2011 and 2012. The target values represent the amount of outputs that need to be generated in order for the inefficient DMU to be completely efficient. Peers and their associated weights as discussed in Chapter 3 are also given for each inefficient DMU. Efficient divisions are not shown in these tables as the target values and the actual values for their output variables are the same (as they are 100% efficient) and they do not have any peers (again as they are 100% efficient).

CHAPTER 5: CONCLUSION

This chapter presents an overall summary of the research. Within this context, after a brief introduction of the research, specific findings of the study are discussed. The chapter then proceeds to discuss limitations of the study and contributions of the research to the body of knowledge and ends with recommendations for future research.

5.1 Summary of the Research

In the United States, 93 percent of all transportation related fatalities occur on highways (USDOT, 2013). Motor vehicle crashes are the leading cause of death for people up to 34, specifically for teens and young adults, between the ages of 15 to 24 (AAA, 2013). The National Highway Traffic Safety Administration (NHTSA), released an overview of motor vehicle crashes in 2010, documenting that 32,885 people were killed and 2,239,000 people were injured (NHTSA, 2012a) in that year, yet the number represents the lowest number of fatalities since 1949, with a 2.9 percent decline since 2009 (NHTSA, 2012b). This declining trend continued with 32,367 people killed in motor vehicle crashes in 2011 (USDOT, 2013). It is important to realize that even though this number represents the fewest number of people killed in traffic crashes in a single year since 1950, it also indicates that an average of 89 lives per day were lost in traffic crashes (AAA, 2013)- one every 16 minutes (NHTSA, 2012a). Moreover, an estimated 34,080 fatalities during 2012 suggests an increase of about 5.3 percent in the number of fatalities compared to what had occurred in 2011 (NHTSA, 2013a). The actual number of fatalities in 2012 was 33,561, which is still higher than that of 2011 (NHTSA, 2013b). This is the first year-

to-year increase in traffic fatalities since 2005. Unfortunately, several indicators suggest that the number of traffic fatalities is likely to increase in the coming years (Sivak, 2012).

The statistics mentioned above suggest the importance of highway traffic safety and the critical need to improve it. While motor vehicle crashes have multiple contributing factors; the approach that has the potential to have the highest impact in improving highway traffic safety is the one that focuses on the roadway user; as driver (or more accurately driver behavior) with 93 percent contribution to the total number of crashes, is the largest source of causal factors related to crashes (EOT, 2008). An important outcome of this fact is that actions that can influence driver behavior are key to reducing the frequency (and severity) of crashes. As roadway users (i.e., drivers) contribute to a large percentage of traffic crashes, highway patrol agencies enforce traffic laws in an attempt to catch violators who put their own safety and that of others at risk. Their ultimate goal is to make a positive change in undesirable roadway user behaviors.

With this overarching strategy in mind, it is important for highway patrol agencies to have quantifiable metrics in place to be able to measure their performance with regards to different outcomes that are valuable to their organization. However, while many highway patrol agencies have performance measures in place (refer to **Section 2.3**), they are not performing efficiently in incorporating practices that will result in a positive change in undesirable roadway user behaviors. Wyoming Highway Patrol (WHP) that is specifically investigated in this research, has been utilizing several performance measures in their balanced scorecards since 2003, details of which are discussed briefly in **Section 1.3** and more in depth in **Section 2.4**. However, Wyoming's fatality rates are still higher than the national average (NHTSA, 2011), suggesting that the agency can benefit from improvements in their organizational performance (See **Section 2.4**).

After studying several efficiency measurement methods (see **Section 2.5**) and evaluating their pros and cons, this research utilized Data Envelopment Analysis (DEA) as a tool to develop a comprehensive framework that makes it possible to compare the 17 divisions of WHP with their unique characteristics on a fair level in an attempt to identify and ultimately improve their overall performance. As a reminder, the steps in getting to the final framework are listed below which are discussed in detail in **Chapter 3: Methodology** and **Chapter 4: Results**:

- Developing consistent and effective performance measures that reflect the main purposes of WHP;
- Collecting data representing the variables that can be used in the defined performance measures;
- Identifying the uncontrollable variables and collecting the appropriate data;
- Analyzing the data and preparing them to be used in the DEA context;
- Selecting the best DEA framework and running the models;
- Post processing the results of the DEA analyses to identify the poor performing units and their respective efficient peers; and
- Holding benchmarking sessions in order to learn about the best performing units' best practices to be incorporated in the poor performing units. While this last step is necessary to complete the development of the framework, it should be mentioned again that due to time constraints, it was not performed in this research.

Section 1.4 talks about the challenges of developing a comprehensive framework and **Section 2.5.1** presents the general DEA approach more in detail. The methodology chapter introduces the generic and comprehensive DEA framework which focuses on the efficiency measurement as applicable to highway patrol operations and traffic safety. Chapter 4 presents the results of

applying the established framework to real data collected from WHP belonging to years 2011 and 2012, in an effort to:

- i. Show the implementation of the framework and challenges associated with it,
- ii. Provide answers to the problem statement and research questions (see **Section 1.4**), and
- iii. Satisfy the purpose of the study (**Section 1.5**), and ultimately provide WHP with important information about the efficiency of its 17 highway patrol divisions and their practices; which could then be used for benchmarking.

However, it should be noted that even though the comprehensive performance measurement framework was developed and best performing peers for each division were identified, the formal process of benchmarking was not completed in this research due to time constraints. The formal benchmarking process and its results will be the topic of future research, which is discussed in **Section 5.5**.

5.2 Findings of the Research

As discussed in the previous section, after developing a generic framework for highway patrol efficiency measurement, the framework was applied to real data collected from WHP databases during the years 2011 and 2012. The DEA model runs for both years 2011 and 2012 identified efficiency differences between the 17 divisions of WHP. Table 5.1 presents the overall efficiency scores for both years for each of these 17 divisions.

Table 5.1: Overall Efficiency Scores for Each WHP Division

Division	Year	Overall Efficiency Score of the Division (%)	Division	Year	Overall Efficiency Score of the Division (%)
A	2011	90.89	J	2011	100
	2012	99.59		2012	100
B	2011	100	K	2011	100
	2012	100		2012	100
C	2011	100	L	2011	100
	2012	99.40		2012	100
D	2011	100	M	2011	90.26
	2012	100		2012	88.08
E	2011	97.37	N	2011	100
	2012	95.60		2012	100
F	2011	100	P	2011	80.33
	2012	100		2012	100
G	2011	96.65	Q	2011	100
	2012	94.75		2012	100
H	2011	100	T	2011	100
	2012	100		2012	100
I	2011	100			
	2012	100			

Table 5.1 clearly shows the efficiency differences that exist between the divisions of WHP and moreover, suggests that there are 100 percent efficient divisions that can be further set as benchmarks for the inefficient divisions for them to learn from those benchmarks' best practices and improve their own patrolling operations in order to achieve 100 percent efficiency.

Table 5.2 presents the results of the DEA model runs with and without uncontrollable variables for both years of the collected data. Uncontrollable variables are the factors that are beyond decision makers' control, yet can affect the outcomes of the processes under investigation (See **Sections 3.1.3** and **4.1.3** for more detailed discussion on uncontrollable variables). The results presented in Table 5.2 show the significance of acknowledging uncontrollable variables in affecting the performance of the divisions. For example in 2012, 12 divisions out of the 17 total divisions were inefficient according to the DEA model without the inclusion of uncontrollable variables. However, once uncontrollable variables were included and the comparison between

the divisions was levelled, only five inefficient divisions remained, all of which faced increased efficiency scores.

Table 5.2: Overall Efficiency Scores for Each WHP Division with and without the Inclusion of Uncontrollable Variables

Division	Year	Overall Efficiency Score of the Division with Uncontrollable Variables (%)	Overall Efficiency Score of the Division without Uncontrollable Variables (%)
A	2011	90.89	74.58
	2012	99.59	81.73
B	2011	100	93.02
	2012	100	80.87
C	2011	100	100
	2012	99.40	96.36
D	2011	100	79.58
	2012	100	80.53
E	2011	97.37	79.57
	2012	95.60	76.82
F	2011	100	83.21
	2012	100	93.63
G	2011	96.65	95.90
	2012	94.75	94.41
H	2011	100	92.82
	2012	100	82.60
I	2011	100	86.62
	2012	100	91.37
J	2011	100	100
	2012	100	100
K	2011	100	100
	2012	100	100
L	2011	100	92.10
	2012	100	84.27
M	2011	90.26	85.53
	2012	88.08	85.36
N	2011	100	100
	2012	100	100
P	2011	80.33	77.18
	2012	100	69.61
Q	2011	100	100
	2012	100	100
T	2011	100	100
	2012	100	100

Another comparison was also performed that reflects the significance of defining performance measures (i.e., outputs) the way they were developed in this research (see **Sections 3.1.2** and **4.1.2**), specifically categorizing different types of citations and bad behaviors resulting in crashes. An easier approach would be to combine all the categories of citations and normalize them by the total number of drivers' bad behaviors that were exhibited in each crash. However, this approach results in one of the most important aspects of DEA to be neglected. As fully described in the methodology chapter through the mathematical formulations of DEA, DEA assigns weights to each variable included in the model in such a way to maximize the efficiency score of the decision making unit. Table 5.3 presents the efficiency scores of the DEA model runs with all categories of outputs considered separately and combined in the models. In the DEA model where all categories of outputs are acknowledged separately, six outputs exist in the model for each behavioral category (i.e., DUI, distracted, speeding, restraint systems, others and the enforcement hours), while in the other model there are only two outputs present (i.e., one big category for all citations normalized by all bad behaviors exhibited in all crashes, in addition to enforcement hours). Inputs and uncontrollable variables are all the same between these two models (Refer to **Section 4.1.2.2** for detailed explanation on how the outputs were defined).

The differences between efficiency scores presented in Table 5.3 show that even when a few divisions are provided with every chance to look at their best (by having separate variable categories), they still are not completely efficient, and thus, identifying divisions A, C, E, G, M and P as truly inefficient divisions. However, it is important to note that the efficiency scores are not that low, which means that relatively speaking; the 17 divisions in WHP are similar in their enforcement efficiency.

Moreover, a simple comparison between the two columns of Table 5.3 reveals that minor differences exist when all the behavioral categories are combined together, which significantly reduces the number of variables. These minor differences point out the fact that the large number of efficient divisions (and relatively high efficiency scores of inefficient divisions) do not result from the large number of variables used in the model, which is associated with reduced discriminating power of the DEA models. It can be seen that even when only two output variables are used as opposed to six, the results are very similar, which indicates that efficient divisions did not end up being efficient due to problems with lack of discriminating power of the DEA model (refer to **Section 3.1.1** for explanation of discriminating power of DEA models).

Table 5.3: Overall Efficiency Scores for Each WHP Division with all Outputs Separately Considered and Combined

Division	Year	Overall Efficiency Score of the Division with Outputs considered separately (%)	Overall Efficiency Score of the Division with Outputs considered combined (%)
A	2011	90.89	83.56
	2012	99.59	99.59
B	2011	100	100
	2012	100	100
C	2011	100	100
	2012	99.40	99.40
D	2011	100	100
	2012	100	100
E	2011	97.37	97.37
	2012	95.60	95.60
F	2011	100	93.88
	2012	100	100
G	2011	96.65	96.65
	2012	94.75	94.75
H	2011	100	100
	2012	100	100
I	2011	100	100
	2012	100	100
J	2011	100	100
	2012	100	100
K	2011	100	100
	2012	100	100
L	2011	100	100
	2012	100	100
M	2011	90.26	86.27
	2012	88.08	86.50
N	2011	100	100
	2012	100	100
P	2011	80.33	79.56
	2012	100	100
Q	2011	100	100
	2012	100	100
T	2011	100	100
	2012	100	100

The important findings obtained from the DEA models are discussed below:

- i. Divisions A, E, G and M were inefficient in both 2011 and 2012. Even though the overall efficiency scores are not generally very low, these divisions can benefit from working closely with their efficient peers (as identified through the DEA model) in order to learn from those peers' best practices and improve their own operations accordingly.
- ii. Divisions C, E, G and M have worsen their efficiency scores from 2011 to 2012. This along with the finding listed above, should raise a red flag for the upper management to observe and investigate the practices of these divisions more closely.
- iii. Division A with 8.7 percent and Division P with almost 20 percent improvement in their overall efficiency scores should be studied closely by the upper management in order to identify the changes that have resulted in such efficiency improvements. Such findings in addition to the findings of benchmarking sessions can be utilized in enhancing the overall performance of the overall organization and its divisions.

5.3 Limitations of the Research

Even though the steps resulting in the final framework developed in this research can be replicated to be used in other highway patrol agencies in the similar context, the framework is specifically tailored for WHP and some variables were identified based on the unique characteristics of Wyoming and WHP, and thus may not be applicable to other agencies. As mentioned in the literature review chapter, this research focuses on WHP, a state highway patrol agency, which is not charged with enforcing laws and regulations in other areas of crime, as opposed to other state patrol and state police agencies. This makes WHP and the scope of this research more restrictive; however, the overall concepts for developing the performance assessment framework still apply.

It is also important to note that this research is not attempting to address all the problems and issues attributed to highway traffic safety. It only focuses on the enforcement practices of traffic agencies particularly addressing roadway users' behavior. Therefore other factors contributing to highway traffic safety (i.e., roadway and traffic design and engineering issues, motor vehicles, education and emergency medical services) are excluded from this study. Moreover, the research only takes into account two years worth of data falling under the same timeline as WHP's most recent strategic plan, which was used as a general guideline to define the performance measures implemented in the DEA model.

Similar to any quantitative research, the limitations of the research mostly are due to limitations of data. The limitations of the data were more apparent in some areas compared to others, and it is important to remember that some variables are harder to quantify. For instance, the databases for uncontrollable variables were less complete and accurate compared to the citations database, which again can be attributed to the fact that it is harder to quantify these variables. To overcome the problems with data, different approaches from extending the range of data points to averaging the data points were taken, which is explained in detail in the appropriate sections of Chapter 4.

Moreover, specifically in the context of highway patrol enforcement practices; there are certain issues that may affect the troopers or highway patrol officers' course of action. For instance, data points for certain behavioral categories (e.g., distracted driving, lane change, following too closely, etc.) are very small compared to the other categories like DUI or speeding, due to the fact that officers do not enforce those as frequently since they cannot be easily proven in courts. However, since DEA is a relative approach and all the divisions are treated equally in this sense, this would not have a major negative effect on the accuracy of the DEA model results.

Additionally, in order to access the data points, different queries need to be written and performed. While the general ideas behind each variable and the overarching logical methods to obtain those variables can be easily explained, developing the right computerized query that reflects those concepts can be very difficult. This challenge often results in some data points to be neglected. At this point, it becomes critical to be able to predict which data points are being left out and to what extent this can influence the overall accuracy of the models. Instances of this challenge were faced when collecting the number of bad behaviors exhibited in a crash, which is explained in **Section 4.1.5.2.2.2**.

Lastly, all the findings of this research are based on the results of DEA models. While various powerful aspects of DEA models were discussed and compared to other efficiency measurement methods, it is important to realize that DEA is essentially a model, which runs on a set of variables defined by the model developers, and all its outcomes are relative in nature. Therefore, it is important that the results of a DEA model be perceived and treated as such, and not as an absolute conclusion, specifically in the context of how the variables were defined.

5.4 Contributions to the Body of Knowledge

Discussed below are the specific contributions of this research to the body of knowledge:

- 1) There have been many examples of implementing DEA in several domains from hospitals to schools to transportation maintenance. However, literature review to date has not identified any specific application that investigates highway traffic safety and police forces concurrently (while a few studies investigate those concepts individually). Given the importance of highway traffic safety and the many benefits that come along with improved performance of highway patrol agencies, there is a great potential for research

that considers a holistic approach to answer the question of improving overall organizational performance of highway patrol agencies, for which this research could be a starting point.

- 2) As a result of this study, several advantages could be gained; most important of which is saving lives. All of the crashes happening because of a faulty roadway user behavior are preventable. By implementing the best practices that are identified in this study to improve the performance of highway patrol agencies, the efforts of such agencies would be concentrated in the right direction that could essentially have an impact on improving roadway users' traffic behavior.
- 3) Another important outcome of this study is improving the overall efficiency of highway patrol organizations. This will allow for more effective utilization of available resources in order to produce more of the desired outcomes, which consequently, could lead to saving time, money and manpower throughout the organization.
- 4) As a part of the internal benchmarking process (which is the point of departure for the framework developed in this research), organizations would concentrate more on the right practices in the most effective areas that could have the highest influence in achieving their desired goals and spend less time in the areas that have no practical returns.
- 5) The results and processes introduced in this study could be implemented by other patrol agencies for internal and external benchmarking practices in an attempt to constantly improve organizational performance. The performance measures introduced in this study could also be replicated in other patrolling agencies with similar goals. Also the approach behind developing the proposed performance measures could be highly beneficial in

defining a set of nationwide performance measures in the context of highway traffic safety to be implemented by enforcement agencies for the purposes of external benchmarking.

5.5 Recommendations for Future Research

DEA alone is not capable of identifying the reasons for inefficiencies in DMUs; rather it helps decision makers realize which DMUs are efficient while which DMUs are not performing to the best of their efficiency (Ozbek, 2007). Since assigning meaning to the organizational differences between efficient and inefficient DMUs is the overall objective of an efficiency study, it is important for decision makers to be able to determine what changes need to happen on an organizational level in an effort to enhance the efficiencies of poor performing DMUs to make them 100 percent efficient. This step requires benchmarking sessions in order for decision makers to familiarize themselves with what practices are being implemented in each DMU, choose the successful practices in efficient DMUs, decide to implement them in less efficient DMUs and undertake associated changes that need to happen in order for those practices to be successfully incorporated in poor performing DMUs. Although efficient peers were identified through DEA models, the benchmarking sessions could not be performed due to the time constraints of the research. This presents a great future research opportunity.

Other recommendations for future research include exploring other approaches to deal with uncontrollable variables. This can be i) the inclusion of other uncontrollable variables that can affect the processes under study, but were decided not to be utilized in the models in this research due to lack of quantifiable and/or reliable databases, and ii) other statistical approaches that can be used to reduce the number of uncontrollable variables (PCA was used in this research as discussed in **Section 3.1.3.5**).

Moreover, it is important to note that even though DEA is a mathematical framework based on the concepts of optimization and linear programming, it is not a statistical approach. This means that unlike statistical approaches where a level of confidence can be assigned to the results, DEA produces estimates with no measure of error or uncertainty associated with the outcome of the models (Ozbek, 2007). Yet DEA models can be subject to uncertainty, which needs to be calculated through appropriate statistical methods (Simar & Wilson, 2000, 2001). Simar and Wilson (2000 and 2001) suggest a bootstrap approach that can be applied to deterministic and non-parametric efficiency methods, such as DEA in order to assign confidence intervals to their calculated efficiency scores (Simar & Wilson, 2000, 2001). This can be a big potential area for future researchers to implement in efficiency studies for highway patrol and traffic safety operations.

Lastly, it should be mentioned that a new area of behavioral research emerges from this study and its results from the benchmarking processes. The existing culture of each unit within an organization can influence the performance of new hires that are newly joining the team. The underlying behavioral culture that is different from unit to unit determines the acceptable level of individual performance, which affects the overall performance and efficiency of the unit. This phenomenon can be further studied to measure how and to what extent the culture of a unit can influence the performance of the individuals within that unit.

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APPENDICES

APPENDIX A: QUESTIONS FOR THE INTERVIEW WITH THE RESEARCH CHAMPION

List of clarifying questions/ notes

Organizational Structure

1. Could you talk a little bit about organizational structure of WHP? Is there an organizational chart you can share with us? Branches, Divisions, Dispatch, Uniform vs. Non-uniform Personnel, Staff, etc.
2. What, if any, is the difference between a state patrol and a highway patrol?
3. Does highway patrol only focus on highway related issues e.g. safety or it also deals with theft, fire, robbery, murder that may be relevant to highway or vehicles?
4. Does highway patrol deal with general crime outside of the highway system?
5. Are there any other organizations in addition to WHP that investigate traffic crashes and deal with highway safety? (e.g., Colorado State Patrol approximately investigates 30% of traffic crashes in CO)
6. What areas/activities of WHP do you exactly want this study to focus on?

Strategic Plan and Performance Measures

7. Who came up with the performance measures/balanced scorecard for WHP? Based on what? Can we arrange meetings with them in order to talk about the measures and discuss issues, e.g., how they established the measures and the numbers associated with them and whether some of them can be combined. Does it make sense to categorize them into i.

activity measures e.g. impaired driving citations, speeding; ii. Behavior measures e.g. seat belt usage; iii. Core measures e.g. number of injuries and fatalities?

8. Do the performing officers/troopers know about the performance measures and their objectives in general?
9. Do we have data for all of the measures? Are there specific measures that WHP would like to focus on more than others?
10. Do we need to separate the possible causes of crash e.g. improper left turn, lane violation, animal causes, spilling of load, wrong way driving, etc. like some DOTs have done? Do you have such broken-down data readily available?
11. Is there any requirement as to how many citations should an officer issue per month? How do you measure the individual performance of your officers e.g. by considering how many citations he/she has issued (the more- or less- the better) versus number of speeding/crashes that was reported in the area under his supervision (the less the better)?
12. How are the hotspots identified, e.g. the places where you could issue most speeding tickets but not many crashes actually happen or the spots with the most probability of crashes?
13. Are there any measures affecting the behavior of the troopers e.g. his/her own safety? Do you think this should also be implemented into WHP's plan and/ or our research?

Additional Questions

14. Discuss paper work in office (or maybe in the car) by officers versus patrolling on the field. How do you think it may influence the efficient hours of patrolling? How do you think this effect can be measured?

15. Discuss Patrolling vs. Travelling to a call. How do you think it may influence the efficient hours of patrolling? How do you think this effect can be measured?
16. Are there currently classes or activities offered through WHP to help educate general public, teenage and young drivers, motorcyclists, CMV driver, etc. with respect to highway safety?
17. Is there any way for people to communicate with WHP in order to place their input on WHP's performance? Has there ever been a survey or community engagement activity to help WHP realize what areas may need improvement/more focus?
18. Based on our literature review, we have created the following list of questions to discuss with WHP staff. Could you please provide us with your inputs/ suggestions?

Interview Questions

Wyoming Highway Patrol (WHP) Balanced Scorecard

- 1- WHP uses multiple measures to assess its organizational performance. These performance measures are grouped under seven different areas as follows:
 - Safety (reduce highway fatalities, alcohol related crashes and injury crashes)
 - Enforcement (maximize enforcement, educational and support efforts)
 - Employee care (develop and care for employees)
 - Performing duties (perform duties and obligations without reservation)
 - Customer service (handle every call with a service oriented response)
 - Future growth (develop and maintain an agency structure that prepares WHP for future growth and demands)
 - Fiscal responsibility (operate within a balanced budget)

- a) Please rank these 7 categories in order of importance that you think they should have in WHP.
 - b) Is the order that you defined in previous question, the same as what it currently is in WHP? If not, please explain the reasons.
 - c) Can the top 2 categories in previous question significantly contribute to highway safety? Please explain how.
 - d) Can you think of any particular unnecessary area in WHP's current balanced scorecard? Please explain.
 - e) Are there any other areas and measures that are missing in WHP's current scorecard which need to be added? Please explain.
- 2- In general, do you think the performance measures defined in each area are representative of the goals that they are designed for? If not, please explain.

Performance Measures, Goals and Strategies

Safety

WHP uses the following measures in order to determine their performance to achieve safety:

- Number of fatalities
- Number of fatal crashes
- Number of impaired driver related fatal crashes
- Number of CMV fatalities
- Number of fatalities during specially recognized holidays
- Number of injury crashes
- Number of CMV crashes

- 3- Which performance measures in this category are the most important ones in your opinion that should be focused on more in Wyoming?
- a) Which ones, if any, are unnecessary?
 - b) What others, if any, could be added?
 - c) Can some of these measures be combined?
- 4- Do you think the measures well reflect the goal that they were designed for i.e., reducing highway fatalities, alcohol related crashes and injury crashes? Please explain.
- 5- Do you think it is appropriate to divide the crashes with respect to driver's age (older and high risk drivers 21-34), vehicle type, impaired/ aggressive driving, pedestrian/ pedalcyclist? Please explain.

Enforcement

WHP uses the following measures in order to determine their performance to achieve maximized enforcement:

- Percentage of citations issued per investigated crashes
 - Percentage of seat belt usage
 - Number of hours dedicated to targeted enforcement efforts
 - Number of outreach programs or presentations
- 6- Which performance measures in this category are the most important ones in your opinion that should be focused on more in Wyoming?
- a) Which ones, if any, are unnecessary?
 - b) What others, if any, could be added?
 - c) Can any of these measures be combined?

- 7- Do you think the measures well reflect the goal that they were designed for i.e. maximize enforcement, educational and support efforts? Please explain.
- 8- What other activities besides warning/ citation could be implemented to enforce traffic violations resulting in a crash?
- 9- Do you see any conflict with respect to citation and how it's a measure of patrolling performance?
- 10- What other strategies, if any, could be implemented to improve public behavior and/ or targeted audience e.g. teen drivers with respect to safety on highways?

Performance Measures in General

- 11- What are the top 5 performance measures that are currently emphasized on in WHP?
 - a) Are these measures in accordance with what is needed in Wyoming based on its characteristics?
 - b) Are these measures in accordance with what you personally think is important in Wyoming?
 - c) Why do you think the difference in **a** and **b**, if any, could be attributed to?
- 12- Are there any particular performance measures/ strategies that you may know of that have been utilized in other states and not in Wyoming?
 - a) Do you think they can help improve Wyoming's highway safety and thus should be adopted?
 - b) Are there any measures, that you are aware of, that are unique to Wyoming?
- 13- What are some of the measures, if any, that you think are missing on a national level?

Patrolling

14- Do you think patrol performance can be affected by external factors, e.g. climate, time of the day, area type, etc.?

- a) How do you think **climate** may affect patrolling? Please explain how and to what extent.
- b) How do you think **the amount of (daily) traffic** may affect patrolling? Please explain how and to what extent.
- c) How do you think **special occasions/ public holidays/ time of the day** may affect patrolling? Please explain how and to what extent.
- d) How do you think **types of vehicles** may affect patrolling? Please explain how and to what extent.
- e) How do you think **road surface condition** may affect patrolling? Please explain how and to what extent.
- f) How do you think **road type** e.g. local roads, interstates **and area type** e.g. rural or urban may affect patrolling? Please explain how and to what extent.
- g) How do you think **location** e.g. work zones, intersections may affect patrolling? Please explain how and to what extent.
- h) Are there any other factors that you could think of that may affect patrolling in addition to the ones listed above? If yes, please explain how and to what extent.

15- What is the minimum/ average amount of time in which an officer is engaged with paper work and not patrolling on the field?

16- What are some of the other cases where the officers may be available but could not engage in patrolling e.g. travelling to a call?

- a) Do you think these issues could negatively affect patrol performance?
- b) Is there a way to measure these issues and/ or address them in existing performance measures?

Additional Questions

- 17- What are of the most popular measures affecting behaviors of troopers in WHP?
- 18- What are some of the factors that contribute to **officers' safety** that you think should be reflected in highway safety measures as well, e.g. the location of the officer and the highway patrol car?

APPENDIX B: QUESTIONS FOR THE INTERVIEW WITH WHP STAFF

Wyoming Highway Patrol (WHP) Balanced Scorecard

1- WHP uses multiple measures to assess its organizational performance. These performance measures are grouped under seven different areas as follows:

- Safety (reduce highway fatalities, alcohol related crashes and injury crashes)
- Enforcement (maximize enforcement, educational and support efforts)
- Employee care (develop and care for employees)
- Performing duties (perform duties and obligations without reservation)
- Customer service (handle every call with a service oriented response)
- Future growth (develop and maintain an agency structure that prepares WHP for future growth and demands)
- Fiscal responsibility (operate within a balanced budget)

- a) Please rank these 7 categories in order of importance that you think they should have in WHP.
- b) Is the order that you defined in previous question, the same as what it currently is in WHP? If not, please explain the reasons.
- c) Can the top 2 categories in previous question significantly contribute to highway safety? Please explain how.
- d) Can you think of any particular unnecessary area/measure in WHP's current balanced scorecard? Please explain.

e) Are there any areas and measures that are missing in WHP's current scorecard which need to be added? Please explain.

2- In general, do you think the performance measures defined in each area are representative of the goals that they are designed for? If not, please explain.

Performance Measures, Goals and Strategies

WHP uses the following measures in order to determine their performance to achieve SAFETY:

- Number of fatalities
- Number of fatal crashes
- Number of impaired driver related fatal crashes
- Number of CMV fatalities
- Number of fatalities during specially recognized holidays
- Number of injury crashes
- Number of CMV crashes

3- Which performance measures in this category are the most important ones in your opinion that should be focused on more in Wyoming?

d) Which ones, if any, are unnecessary?

e) What others, if any, could be added?

f) Can some of these measures be combined?

4- Do you think the measures well reflect the goal that they were designed for, i.e., reducing highway fatalities, alcohol related crashes and injury crashes? Please explain.

5- Do you think it is appropriate to divide the crashes with respect to driver's age (older and high risk drivers 21-34), vehicle type, impaired/ aggressive driving, pedestrian/ pedalcyclist? Please explain.

WHP uses the following measures in order to determine their performance to achieve maximized ENFORCEMENT:

- Percentage of citations issued per investigated crashes
- Percentage of seat belt usage
- Number of hours dedicated to targeted enforcement efforts
- Number of outreach programs or presentations

6- Which performance measures in this category are the most important ones in your opinion that should be focused on more in Wyoming?

d) Which ones, if any, are unnecessary?

e) What others, if any, could be added?

f) Can any of these measures be combined?

7- Do you think the measures well reflect the goal that they were designed for i.e. maximize enforcement, educational and support efforts? Please explain.

8- What other activities besides warning/ citation could be implemented for enforcement efforts addressing traffic violations resulting in a crash?

9- Do you see any conflict with respect to citation and how it's a measure of patrolling performance?

10- What other strategies, if any, could be implemented to improve public behavior and/ or targeted audience, e.g., teen drivers, with respect to safety on highways?

Performance Measures in General

11- What are the top 5 performance measures that are currently emphasized on in WHP?

- d) Are these measures in accordance with what is needed in Wyoming based on its characteristics?
 - e) Are these measures in accordance with what you personally think is important in Wyoming?
 - f) What do you think the difference in **a** and **b**, if any, could be attributed to?
- 12- Are there any particular performance measures/ strategies that you may know of that have been utilized in other states and not in Wyoming?
- c) Do you think they can help improve Wyoming's highway safety and thus should be adopted?
 - d) Are there any measures, that you are aware of, that are unique to Wyoming?
- 13- What are some of the measures, if any, that you think are missing on a national level?

Patrolling

- 14- Do you think patrol performance can be affected by external factors, e.g. climate, time of the day, area type, etc.?
- i) How do you think **climate** may affect patrolling? Please explain how and to what extent.
 - j) How do you think **the amount of (daily) traffic** may affect patrolling? Please explain how and to what extent.
 - k) How do you think **special occasions/ public holidays/ time of the day** may affect patrolling? Please explain how and to what extent.
 - l) How do you think **types of vehicles (car vs. trucks)** may affect patrolling? Please explain how and to what extent.

- m) How do you think **road surface condition** may affect patrolling? Please explain how and to what extent.
 - n) How do you think **road type**, e.g., local roads or interstates, **and area type**, e.g., rural or urban, may affect patrolling? Please explain how and to what extent.
 - o) How do you think **location**, e.g., work zones, intersections, may affect patrolling? Please explain how and to what extent.
 - p) Are there any other factors that you could think of that may affect patrolling in addition to the ones listed above? If yes, please explain how and to what extent.
- 15- What is the minimum/ average amount of time in which an officer is engaged with paper work and not patrolling on the field?
- 16- What are some of the other cases where the officers may be available but could not engage in patrolling, e.g., travelling to a call?
- c) Do you think these issues could negatively affect patrol performance?
 - d) Is there a way to measure these issues and/ or address them in existing performance measures?

Additional Questions

- 17- What are the most popular measures affecting behaviors of troopers in WHP?
- 18- What are some of the factors that contribute to **officers' safety** that you think should be reflected in highway safety measures as well, e.g. the location of the officer and the highway patrol car?

APPENDIX C: INTERVIEW TRANSCRIPTS

Interview #1 Transcription, with Major Keith Groeneweg

**Note: MJ is Maral Jalili, MO is Mehmet Ozbek and K is Keith Groeneweg*

MO- Just to put this whole interview in context, as you know what we're trying to do is to perform some research to figure out the performance of different divisions of the Wyoming Highway Patrol (WHP). So to be able to do that, we need to identify the performance measures that you guys use frequently and we have a fairly good idea, as we went through your Balanced Scorecard (BSC). We know you have different categories and all that but we really want to make sure that this whole performance measurement system that we're going to develop will actually focus on the measures that you do really care about as there are quite a few measures and I suspect that some of them are not as important as the others, so that's one thing that we want to figure out. The other thing that we want to figure out is there could be some measures for which you're not even collecting data and in those cases obviously it's not even worth trying to incorporate those measures into the whole performance measurement system. The last thing that we want to figure out as a result of this interview is what kind of uncontrollable factors affect the troopers' performance. We realize that they operate in very different conditions in terms of climate, traffic, the profile of the drivers let's say and many other things so we want to get an idea of what uncontrollable factors might be affecting your troopers' behaviors, as well their performance so that when we make comparisons between different divisions, we take those into account to be fair to every single division and every single trooper. So that's the overarching

purpose of this interview I guess and we have developed some questions and I'll let Maral take it over from there.

MJ- so to start with, can I know your position. I know you are a Major, but I don't know if you're a field officer or you work in support services?

K- Field Operations Commander. I am just recently in this position and I was a support services commander up until October 1st, 2012

MJ- So I'm going to start with WHP's BSC in general. There are 7 categories there: safety, enforcement, employee care, performing duties, customer services, future growth and fiscal responsibility. I would like to know which of these 7 performance categories you think are the most important?

MO- So I guess would you be able to rank these from 1 to 7 in terms of importance?

K- performing duties and obligations without reservation, is that how that's worded in BSC?

K- you're going to make me give you 1 through 7, aren't you?

MO- if you can and again if you feel that these all have the same importance or maybe safety is a definite first but the others are all equal, that's all fine. Again it's all based on your opinion.

MJ- yes, just as many categories as you want based on what you think.

K- Ok, safety and enforcement are 1 and 2. And they're close 1 and 2, they could be number 1, because I think they go hand in hand. But I'll do it that way for sure. After that customer service, and then future growth and fiscal responsibility are both important and I think have to go hand in hand. We want to, we need to grow as an agency. Numbers with troopers and support services

are both sides of the house as we call it, but we have to be fiscally responsible in doing so and then I'll go 6 employee care and then 7 performing our duties. again I'm doing that because you're making me. They're all significant and important to us.

MO- We realize that and this is again, it's a tough question to begin with, so sorry about that but again that's just to put things in perspective for us.

MJ- do you think the first ones that you picked, safety and enforcement, do you think those are ranked as important in WHP as you think personally?

K- Yes, I'm certain that as you interview everybody today and if you ask the troopers on the road today, what our top priorities are, what our top goals are in our BSC or in our mission, it would be those 2 things.

MJ- Do you think any of these performance measures, any of these measures in BSC are unnecessary probably? That you'll need to change or modify in any sort of way?

MO- or you don't use at all?

K- Yeah, I think. we've talked about perhaps getting rid of performing duties and obligations portion of BSC. We put that in there, we used it, we came up with that mainly because of the formatting of the BSC, but quite honestly in my opinion these measures and strategies could fall under the safety and enforcement aspect already.

MJ- is there any category or any performance measure in the BSC that is missing and should be there?

MO- or that you thought about last year and said oh we wish actually we added this to our BSC as well?

K- What's in the strategic plan and isn't in the BSC is, and that's why I asked to look at this "perform our duties", is that how we do it. In our vision statement it says we're committed to serve and protect all people in Wyoming with courtesy, professionalism and integrity, but we have no way to measure that. The enforcement is important, absolutely, but at the same time we talk about integrity and professionalism and the only place that we really evaluate that is in our customer service and all we do there is measure how many positive comment cards come in versus negative complaints, but there's more to it than that. I think we need to concentrate also on how we do it as in the character of our people and now that I'm on the field side of getting much more involved in personnel investigations and those kinds of things and in Derek's group, they've done a great job of raising the bar so to speak of the caliber of the people we hire, because they improved the background investigation. I think we need to continue that beyond the academy training and make sure that we are holding our people accountable and keeping those expectations very high for our people so we can minimize our personnel investigation but make sure that we truly have men and women of integrity and professionalism.

MJ- well actually I was reading through this survey which was conducted in 2012, recently in November and December, and it was about the overall performance of WYDoT, and it was saying that 77% of the people who were actually interviewed, they said that they were highly satisfied with the Patrol personnel that they treated people with courtesy.

K- well, again in the customer service one , that's probably where that will come together, tie together, because we have comment cards that we hand out on every traffic stop and at ports of entry and that comment card gives them a contact, either an email or online, a way to give us feedback on how our employees are doing and 99% of those are positive and we have some that come in as complaints but most of them are unfounded complaints so we don't count them as

negative because they're just complaining about getting a ticket for speeding more than the officer's conduct. So that is a good parameter for how they perceive us, I think what's important though is that we make sure that we are doing everything internally to evaluate our people and hold ourselves to higher standards.

MJ- So I'm going to go on with more detailed questions about safety. So you have all sorts of measures in those BSC with respect to safety: number of fatalities, fatal crashes, impaired driver related fatal crashes and all those things, my question is which of these performance measures do you think are most important that should be focused on in Wyoming based on its special characteristics, demographics and anything that you may think of?

K- Most important thing obviously is the number of fatalities, and then obviously the number of injury crashes as well. Those are the top 2: fatal and injury crashes. Now what we've done obviously is split those out into several different categories and we have discussed and I wonder if that is really necessary. I think sometimes we do the commercial vehicle fatalities because of the expectations of the federal government. We are part the federal motor carrier program and because of that, we have to keep track of how many fatalities happen in commercial motor vehicles, so that's why that requirement is there, both fatalities and the number of crashes. However, having said that I don't know that it needs to be one of our main strategies. The one on the holidays, I don't think that's as important because I think it's important to reduce fatalities every day of the year not just on holidays. Are the holidays a better opportunity for picking up drunk drivers? Absolutely, but we can focus on that without having to make an enforcement strategy.

MJ- can you think of anything that is probably not in there that you think it should be added?

K- No. The reason I hesitate, is I was double checking, I wonder if in enforcement we have, as one of the measures “safety, education or outreach to the public with safety, education, etc” and to me, I’m wondering if that would be better place under safety rather than under enforcement we’re breaking it down by these categories as we do, to me it makes better sense for it to be under safety, cause it’s the safety, education, presentation that we’re up making is safety topic rather than enforcement.

MJ- well I’m going to skip question number 4, because I think we have enough information about that, but do you think it is appropriate to divide crashes with respect to specific demographic or need throughout the state of Wyoming? Like maybe you have a lot of teen drivers, or maybe you have a lot of heavy truck drivers, do you think it should be divided into those?

MO- so once you’re reporting those crashes and you might be, this we don’t know, as you’re creating a report for those crashes, I guess the question is do the troopers get all kinds of information such as “this was a teen driver, older driver, truck driver, etc.”?

K- absolutely, however, maybe here’s where I ask you a question, the purpose of this is to help us perhaps work on our BSC and strategic plan to be better refined at it? correct? Or you’re just doing more of an evaluation?

MO- more of an evaluation. It may be a by product and it would make a great research topic. So we’re not really here to criticize or improve or change your BSC. Nevertheless, this is a 2.5 year long study so hopefully we’ll be in a position in 2.5 years where we’ll say we learned a lot during these 2.5 years, so maybe it’s also time for you to reconsider your BSC because there are some measures that nobody cares about, there are some measures for which you don’t ever

collect data, so maybe it's time for you to look at your BSC but we'll stop there, we won't suggest this is what you need to do and that sort of stuff.

K- the reason I asked that my philosophy is that less is better, because currently if I take this out to the field or when you do and you ask the troopers, without looking at this, just like I did, without looking at this, what are your priorities, what's your BSC, what does your strategic plan say is important to you, they'll give you those 2, safety and enforcement. The others are nice to have, they know customer service is important, that's why we do the comment cards at every traffic stop, because of that physical activity they know that's important to us to get that feedback, is it important to them? Are they focusing say this is really important to me as a trooper, as a member of the WHP? If you're having to think about it, no. The ones that do it naturally, do it because they're good people and that's what I was talking about before. They are people of character, they do it because it's the right thing to do and they want to treat people with respect and fairness and courtesy and professionalism, but they're not doing it because it's on here. Likewise, the safety and education as we go through this, they're going to be less important to them, less is better in my opinion, so getting back to your question, we already tracked that information, I don't think it's appropriate to put it in our BSC strategic plan. We collect that data, accident records does that for us, because the way the accident (crash) report is done, it has all those categories in it so we can pull reports with demographics for ages, and pedestrians versus bicycles versus 2 vehicle crash, we can get all that data from them, critical and important data and what Joe McCarthy is doing, in fact I was in a division meeting yesterday where he did, starting it with another division, that data driven enforcement. He's showing them where their crashes are taking place and pertaining to the 5 categories that are important to us in our BSC, is to speed, distracted driving, seat belt, alcohol, and one more. He's showing those

statistics and where those types of crashes are happening and comparing that to the data we have for the enforcement and they're using that to be more intentional now in how they go out and enforce the highway each and every day. So that's a long way to answer your question, that data's important but I don't think it's needs to be in the scorecard.

MO- By the way I think you made a good point, please don't be bashful in coming up with long ways to answer a question. We have these very rigid questions, but we call this a semi-structured interview, so there's a structure but we're really here to learn more about you guys. That's the whole purpose, so by any means, thank you.

MJ- moving on to the second category which is enforcement, I'm going to ask you the same question that I asked about safety. So there are different measures here under enforcement, can you rank them? Do you think any of them are more important than the others? Any of them is unnecessary? Anything's missing that needs to be added?

K- well, as I said earlier, that number of outreach programs and presentations, I don't think should be under enforcement. It should be under safety, if we're going to measure that. Of the remaining 3, I think the number of hours dedicated to targeted enforcement would be the top priority. I believe, if we are out on the highway, being visible and doing and taking enforcement actions, that is both the deterrent as well as an opportunity for education and making a difference in people's behavior on the highway. If we're not out there, not visible, the less we're out there, the less visible we are, I think encourages people to violate the law and drive less safe. Seat belt usage would be number 2, I think that is critically important, we have to both through enforcement and education; we need to raise that percentage, till where we get everybody to drive with seat belts. Actively enforce legitimate traffic violations that result in a crash... I don't

know if that's still something that we need to measure, I think that's another of those statistics that are important to look at as the division supervisor or in my position as I'm looking at the enforcement action of the field personnel. I don't know that it's important to say to the people of Wyoming and that's one of the reasons we put it in there, so people knew that we expected our troopers to write tickets on crashes. But at the same time, that's not as important as being visible and seatbelt usage.

MJ- I see that here in these measures, you don't have anything specifically for speeding. Does that go under the same category of number of citations issued per investigated crashes?

K- This is one of those that we did a better job of streamlining those measures, we tried to get away from measuring speeding to how many tickets people write, we wanted it to be more outcome based, the goal is reduction of fatalities, reduction of injuries, reduction of alcohol related crashes, and that's our outcome, we're less concerned about how many tickets outputs that we have. We used to have a requirement in our performance appraisal system, where one of the categories was quantity, we had a measure of you had to have one contact per hour which seems ridiculously low, but you'd be amazed that how many struggle to get there but what they would do is they manipulate their paper work, cause that contact could be a ticket of warning a motorcyclist, a level 3 truck inspection, any type of contact would count and on one traffic stop, I could get a citation for speeding, a warning for no insurance, a level 3 inspection on a truck. It's just ridiculous, I could get 5 contacts easily out of every traffic stop, so I can make one traffic stop or 2 traffic stops in the morning and be done and we had people focusing on the standard rather than focusing on being out there, being visible, being productive in their work. That's why we got away from numerical standards in our measures.

MJ- You made a great point, which actually goes to question number 9, because we were curious about this conflict, with respect to number of citations and how it can actually reflect how important it is, as you mentioned you can just go to hotspots and get a lot of citations and warning and be done, but how effective that is?

MO- or how is that a measure of patrol performance is a question that we had. Again it was a naive question in our mind, we said maybe we don't see the point or we don't get it. At some point I think, and this could be based on literature or based on conversation with Derek, I don't know, so you do keep track of number of citations per division, per officer? I don't know and I guess the question is whether is that a good measure of performance or not?

K- so how we were measuring that performance? Each division has its own BSC and within that most of them have an expectation of what is expected of each employee to perform. Also in our performance appraisal system, we have at the beginning of that appraisal process, goal setting opportunities for the lieutenant to be with their troopers. Also during that time, that's when they'll say the expectations for our division for each person to do these kinds of things, some of them have specific numbers, like how many tickets per month, or how many DUIs per year and those kind of things some do not, but they all know within their divisions what is expected as far as the minimum of productivity but we've tried to really stay away from the numbers and focus on just being out on the highway, because my philosophy is you go out on the highway and you drive up and down the interstate or up and down a 2 lane highway and you can't help but come across violations,. If you're out there, doing that, actively patrolling, it'll come to you. We have job security forever, because of the human nature. That's kind of what I tell my guys when I'm in the division, just be out there, be visible and you will be productive.

MO- as you said it'll be a direct outcome measuring, in that if you're out there you'll be issuing citation, you'll be helping motorists.

K- at the end of the year when we're doing our evaluations, I have to pull up their statistics as a part of that evaluation, and I got 2 troopers and I got one guy that's written 700 tickets, yet another guy wrote 200 tickets. Is there a performance measure there? Absolutely! But I can bet that those same employees will have the same percentage difference in patrolling time.

MO- let me just diverge a little bit, this is just about how you operate. So I think we heard this from Derek earlier, but just want to maybe confirm, so these 2 troopers that you just mentioned with 2 very different performance and you said probably that's because that they have the same ratio, the number of hours that they were out there, do they have true flexibility in well, I won't be going out today or I won't be spending as much time as my colleague does. Isn't there a directive coming from the division lieutenant who will tell them "hey guys you need to be out there, you'll be over there, you'll be over there and you'll be patrolling all day long." Do the troopers have that flexibility so that it may result in a trooper patrolling 1000 hours and another one just patrolling 200 hours?

K- yes and no. Your statement, that is our directive to the field, be out there on the highway. The problem is we are not efficient as an organization, by that I mean we have taken a lot of new technologies and those technologies, instead of helping them being efficient, have caused them to be less efficient. For example, in just the few months that I've been in this position, and attending division meetings, I've heard loud and clear how much that's the case. For example, for just a simple arrest, for a warrant, or make a traffic stop, they were going to write the guy for speeding but they run his driver's license and then wanting for his warrant arrest. They'd take

him to jail, they have to run report, do an affidavit for the judge and the sheriff's office, download the video, all those things, it takes him 2 hours for a simple arrest, to take him to jail, now we have 2 hours of work to do in that case. If it's a DUI, it's even more because of the extra paper work and the extra reporting that you have to do and it has just become more and more cumbersome. If it's a criminal interdiction drug stopper made, that's something we need to talk about too. If it's a criminal interdiction stop, you can multiply that by 4 or 5 or it might take the whole shift. So then the percentage of the patrolling time is going to go down, so the supervisor's looking at all of those things. Another thing that will hinder their patrolling time is how much they're involved in other activities. Are they instructors in the academy? Are they field training officer? Did they have another officer riding with them so it's not really their patrolling time, they're teaching another officer? Are they involved in another detail elsewhere in the state because of different things that they're involved in on behalf of the agency? Are they doing safety education presentations and if so, there will be less percentage of patrolling time, so there's lots of things. Crash investigations, if they're doing crash investigations which is an important part of our job, it's going to take away from that patrolling time. Having said that, we still have human nature and we have those who know how to stretch those activities out much longer than they need to and they're in their office much more than they need to be simply because that's their character.

MJ- so how do you think these problems that come across with the technology that you just mentioned can be addressed? you can have another person (a civilian officer) to take care of certain activities and the trooper just continues on the field patrolling?

MO- I guess the question is whether there would be support services available to help with downloading the video, for example?

K- the answer is yes, that would be nice to be able to do but we don't have the personnel to accomplish that. That's what I'm talking about, we are not efficient as an agency, as you talk to different folks from the support services here today, and coming from that side of the house just a few months ago, we are in dire need of more people in support services right now, you're absolutely correct, we have troopers doing clerical work that a civilian could do that would be more cost efficient and better for our enforcement efforts. We have lieutenants doing so much administrative work that they're no longer supervisors, they're just paper managers and they're evidence managers and they're report managers and video managers and they never get on the highway, they can't work and they can't ride with their people to develop them. They can't be leaders or supervisors, they're just like I said office managers. Headquarters is the same way, in our history, in the last 13 years, we have increased in over 50 trooper positions across the state and have had no increase in support services so we've got data entry downstairs who enter citations and warnings into the system that are over a year behind because we've increased that many people so we've got 50 more troopers and no more people to put their citations into the system. That's just one example of many, same thing increased by 50 troopers, no increase in support help to take care of their equipment, their cars, their technology issues and we've taken on this records management project which is huge in electronic citation, all of which is supposed to make them more efficient but because it's not running correctly, because there are so many technology challenges there, we have a captain where we just said oh you're not busy right now, that's now your project without giving him any more people or support. So to have people to do things for troopers that are clerical in nature, absolutely, but we can't even do that here in headquarters and we are in a culture now in Wyoming government where they're looking

everywhere they can to cut positions and reduce government rather than increase it. That's the challenges we face.

MJ- Do you think there would be any other activities besides warning and citations that can be done by the troopers on the field that can enhance highway safety in general? Maybe on the educational side? Or maybe working on people? Trying to make them more aware of the situation to cut their unsafe behaviors?

K- the outreach programs and presentations, those encompasses many different things, we have Alive at 25 program, that is a safety education program that targets specifically 25 year old and younger drivers, we got the idea from Colorado, we partnered with them and actually they've helped us get that off the ground, but we have yet to have somebody who's gone through that class being involved in a fatal crash, that is an outcome that is really significant to us, that's really huge because that's one of the highest age groups of fatalities, so that's another example of success and again it's something that we measure but we can only catch on it here on increased safety presentations because that's just one aspect of it. We also have troopers that do a great job of going into trucking companies and doing safety education things with them to what we look for when we're doing inspection on a vehicle to the importance of seatbelts and winter driving with a semi vehicle, semi tractor trailer through the different summits and mountain passes and those kinds of things. So we do various safety education like that but again we don't measure all those specifically in here. One thing and I do think as I touched on earlier, I'm not sure where it would fit but I think enforcement makes the most sense is, we are being more intentional about our criminal interdiction program. It's kind of mentioned later in the measure but I'm not sure... our philosophy used to be under the previous administration, that we would go out and do traffic safety activity and high volume of that and as we do that, if we come across criminal activity, we

will act on it. Now, this Colonel and we are all behind it, because it's a long time and coming, is that criminal interdiction is just as much a part of what we do as this is, that is highway safety. There are drugs coming through our state, into our state that are having an effect on our highways, on our children and on our people and we want to be actively involved and putting a stop to that, so I think we need to make sure that that's a specific measure in enforcement so that the troopers, they just don't say it, but they see it on paper, just like these are important to us, it's a part of what we do and who we are.

MJ- now if you want to look at all the performance measures, all of them altogether in general, can you pick the top five?

MO- if you were to rank intra-category wise? Any insight on that?

K- reduce the number of fatalities, reduce the number of injury crashes, increase the percentage of seatbelt usage, and the number of hours targeted for enforcement efforts. The thing is as I said before, all of these is important to us as I look through it. Everything else that is in here supports those. We have to have the people to do, our employee care's important, if we a high turnover rate and we're not hiring high quality people, then we can't do this.

MO- I guess the first part of the interview which was supposed to take the most amount of time, for at least my purpose is done, the second part is as I told you we want to get an idea of what you think might be affecting your troopers performance but which are not really within their control, just going through the literature and really thinking about it, we came up with a list of items if you go to question number 14 and we just want to confirm that you believe that yes, it does affect patrol performance in this way, no it doesn't, it may or may not, I don't know... so we can go through that list and if you feel that there is anything that we missed, you can even add

that as a part of the conversation, but let's start with the climate, how do you think it might affect patrolling? To what extent?

K- climate can have a significant effect on the amount of patrolling, if it's a winter storm, they're not patrolling, they're working crashes and that's true of any inclement weather, if it's significant inclement weather, they're not going to be able to patrol, where it can be difficult and discourage them from patrolling is high wind, when it takes everything you can to get out of your patrol car to open the door, last thing you want to do is mess with some paper out in the highway but usually when it's that high of a wind, the vehicle speed is down anyway but then at the same time, sometimes that's when they take advantage of office time because it's not good fishing weather and so why not take advantage of that weather to get caught up and do reports and these kind of things if they're truly being conscientious about that, others if it's bad weather, they just rather not be out here just like everybody else but that's pretty minimal, I really believe our folks that want to be out there, are going to be out there no matter what the weather is but as far as their enforcement action while they're out there patrolling, it will definitely have an impact.

MJ- so in your experience, do you have a lot of difference between when there are bad climate conditions like high winds, the number of citations for example that you have in your records, is dramatically less than what you have in better conditions?

K- I don't know that we've ever collected statistical data, as far as measuring in the different types of weather how many tickets are being read, I'm sure we don't have that.

MJ- so the other external factor would be the amount of traffic, does that really have anything to do with Patrolling?

MO- we know it's a mostly rural state that you're dealing with here so this question may not even be applicable but I suppose there is some traffic difference between Cheyenne and Casper and other places, so do you think that would affect patrol performance?

K- the amount of traffic, not so much, there are times yes, however I80 has much more traffic than any other state and that has a much more enforcement activity, it also has many more crashes, that has much more of everything. As far as affecting patrolling... maybe I need to clarify, are we talking about patrolling or enforcement actions or both? Because they might be out there patrolling but that doesn't mean they're out there actually taking enforcement action.

MO- so division #1 and division #7, division number 1, very pleasant in terms of climate, no major winds, no major snow storms, division number 7 pretty bad climate, so I suspect that if we were to go with any of these measures, let's say number of hours dedicated to targeted enforcement efforts, might be different not because there are slackers in division number 7 for lack of a better term, but because they cannot really do much targeted enforcement because of all the crazy weather that's happening. So you take the question from that point of view that we want to make sure that we are really leveling the comparison by incorporating the so called uncontrollable factors so that we don't really penalize division number 7 because of the harsh climate that they're dealing with, so whether enforcement whether patrolling, whichever you want to look at it, but we just want to understand how this different stuff might affect their ultimate performance because it's not really within their control.

K- then the amount of traffic affecting patrolling would be minimal, we have some heavy traffic areas but even in those heavy traffic areas, they are being intentional about being in the area patrolling it and enforcing it when and where they can.

MO- next one would be special occasions, public holidays, time of the day,?

K- I think it has a positive effect because we are very intentional about scheduling more officers around special event activities and holidays, we do that, we actually have days around the state where, it's small in comparison to Colorado, but in Wyoming they are big events, Cheyenne Frontier Days for example, so we have concentrated enforcement efforts in those times so it's always a positive effect.

MJ- types of vehicle, do you think that would be important?

MO- I assume there are certain parts of the interstate or highway where there's heavy truck traffic versus just passenger cars, so would that have any effect on patrol you think?

K- No, other than again, when that is taking place, we spend extra time with special enforcement in those areas. For example on Tuesday, I drove up to Kemmerer which is clear on the west side of the state, so I go across I80 and there's troopers everywhere enforcing all the big truck traffic but there's also 2 lane highway, highway 30, that's all it is, it's big trucks and a few cars in between and so there's a lot of potential for a lots of crashes, because of that ratio and in that short stretch of 30 miles, there's 2 troopers and that's because they're specific about their enforcement actions for that reason.

MJ- the road surface conditions, or road type, or area type do you think any of those may affect?

MO- we're mainly on highways so the road surface would probably be the same, you might have highway sections that are in terrible shape, with respect to the surface of the road, in terms of pavement, but do you think that might have an effect on patrolling? Would troopers prefer not to drive or patrol in those sections of the highway that are not as well maintained as other sections?

K- one road condition, one thing that affects their patrolling and enforcement efforts is the median cable guardrail. It's been proven nationwide and in Wyoming as well, the number of serious injury and fatal crashes has gone down because of that, but the number of crashes has gone up because what used to be minor slide offs in the winter time into the median where they get stuck, have now turn into vehicle damage crashes, but the other negative side of that is there's no breaks in that guardrail for miles at times and so a trooper can be patrolling the highway and they're going 90 miles/hr in that direction and by the time I get to a cross over to go back and get them, they're 5 miles ahead of me, now I got to go at 130 miles/hr for 5 or 6 or 7 miles and now what's the greater hazard? I'm talking about that with my troopers, don't jeopardize your safety and the safety of the others for the sake of one who might be a hazard more to themselves than anything else, but it's because of that guardrail and we're hearing that significantly on all the interstates where that's been implemented. Construction zones, again we're usually pretty intentional about being in at work in those. Work zones again we're usually intentional about putting people in those areas to help with the enforcement actions but it's not a negative effect at all. There are some highways throughout the state that are narrow and don't have much shoulder to work with to make traffic stops, so it'll discourage them from getting involved there because of those, but those are becoming less and less as WYDoT continues to improve the roads.

MJ- so a lot of these factors can have an effect but seems like you know about them and you assign more troopers so they're not really affecting the highway safety anymore.

K- the cable median guardrail, Joe's actually helping us actually with our data with that, to take the engineers and say wait a minute we're trying to make things safer on the highway just like you are but by taking away our enforcement efforts, it's becoming common knowledge that we

can't turn around and they're zipping away in there for example between Grand Avenue and the next exit is almost all cable guardrail and so the people from Laramie know they can get on the interstate and literally fly to the next exit and have a greater chance of not being caught than being caught.

MO- anything else that we haven't covered that jumps to your mind, "oh by the way this is something that I'm always hearing from my troopers that this is something that's affecting their patrolling or enforcement efforts but we cannot control that because it's beyond their control?" Anything that we might have missed?

K- another thing that I've heard loud and clear as I travel to different divisions is the technology challenges that we have, that we have covered that already. That is our biggest frustration. I have one guy almost literally in tears, who says just give me back my paper tickets and let me go to work, he loves the job, he just can't stand the technology and the challenges that have come with it.

MO- just out of curiosity do you have any training implemented to train all these troopers to go from paper base to computers?

K- yes, every time we implement something we give them training but again because of the lack of support personnel, it's hard to provide that training statewide. What we'd like to do now that it's implemented is make sure there's ongoing trainings to address these challenges and difficulties. What we've done is training with our RMS programs, we've trained one trooper in every division to be their division expert but he's not really an expert, he's just the division go to guy to find out the answers to our questions, but it's coming to a point where all he's doing is calling us down here to get the help that he needs to go back and answer their questions.

Interview #2 Transcription, with Captain Derek Mickelson

**Note: MJ is Maral Jalili, MO is Mehmet Ozbek and D is Derek Mickelson.*

MJ- Do you currently work in field or support services?

D- support services.

MJ- I'm going to start with the general Balanced Scorecard (BSC), you have 7 different categories in there, from safety to fiscal responsibility. I would like for you to rank these 7 categories based on the importance that you think should be focused in WY?

D- I think the way they're listed is probably really close to the correct order of importance, definitely the safety and enforcement go hand in hand and employee care, probably customer service up there as well. My issue with this is, and no one has really explained this to me so I just got to go with how it's identified in this book, is performing duties and obligation without reservation. I think that goes without being said in the current law enforcement, if you're not performing your duties without reservation, then I think you're derelict quite frankly in your duties. At a minimum you're lazy, and the reason why they have it's just expected, so I don't know how important that is.

MJ- Do you think there's anything that's missing in that BSC that needs to be added with respect to highway safety or WHP's vision?

D- maybe it could go along with future growth, but I think there needs to be something identified there with developing our employees and that can be under employee/ development care. I suppose it depends on how you look at that but I think we need to be doing a better job of really developing our employees into future leaders.

MJ- I'm going to continue with more detailed questions in safety first of all, so there are different measures: number of fatalities, number of injury crashes, number of impaired driver fatal crashes. I want you to think of all these measures and rank them in order of their importance.

MO- and again some of them could be pretty close, you know where we are headed to with this, we want to get a feel of which ones you think are really important so we could include those in our models.

D- number of fatalities obviously I think is the most important, right along with that is the number of fatal crashes and I would probably after that put the number of fatal crashes involving alcohol. I guess that's kind of how they have it listed too, CMV fatalities and the holidays, that's important but in reality we would really want to narrow down the scope of what is the problem here in WY and really what hits home to us so I think the number of fatalities, fatal crashes and the number of fatal crashes involving alcohol... cause we're seeing them really stick out recently: the number of fatal crashes involving alcohol, along with that I would say, along with Joe and our little data driven enforcement project that we're doing, we identify not only fatalities, quite a lot of data in fatalities, but incapacitating injuries. So I know it says injury crashes, but I think it needs to be classified as incapacitating because that's how it's classified in our report form because you have possible injury or no injury or incapacitating means basically there's a serious injury that resulted in a transport into a hospital so I think that is locked into that group as well.

MO- and you think that's actually an important measure?

D- yes, serious crashes.

MJ- so from what I realize, you don't really think that CMV really applies to the characteristics of WY? You don't really have to have different separate measures for just the CMVs?

MO- what you care is fatalities and crashes, not necessarily CMVs for instance?

D- yes, and again that's just my take that they're important and because of the property damages associated and the amount of money involved with CMVs it's important, but just based upon current trends, I don't see that should be the main focus of our agency.

MJ- so do you think based on different demographics or different characteristics' of people driving in WY throughout the whole state, should you be focusing on one of them in particular probably and come up with measures for them?

D- probably the number of fatal crashes involving alcohol, just because that really stuck out last year, we in WY have an issue with impaired drivers.

MO- can you think of any measures that could be added, that is missing from this list when it comes to safety?

D- no I can't. Just because I'm on the safety side, with respect to safety programs offered, we offered that Alive at 25 program which is a driver program for youths and we do keep track of how many of those that had been through the training have been involved in any type of serious crashes and obviously it's very low, so this kind of the statistic of how many people, how many young drivers receive some type of education with respect to driving and then how many subsequently are involved in any type of crash and my guess is that people that are obviously received any form of training, class or structure, the significance of them being in a crash is lower .

MJ- under the enforcement category there are 4 different measures, do you think any of them have more importance over the others.

D- seatbelt usage is probably the most important one, and again I can just go back to the project that Joe and I are doing, we have identified the 5 main factors involved in either fatal crashes or incapacitating and injury crashes, and that is speed, alcohol, distracted, seatbelt and drug impaired driving. So when you start examining crashes when there is a fatal injury or an incapacitating injury one of those 5 factors seem to show up, so I think in result to that what are we doing with respect to enforcement education in those 5 categories and to me above all of them seat belt because you could have someone that's impaired either by alcohol or drugs or speeding that gets in a serious crash but there's not a fatality and it's because they wore a seatbelt, so I think seatbelt usage is the most important one. Well, based upon what's here, the number of citations issued per investigated crashes would be number 2 because along with the education comes the enforcement.

MJ- do you have different citations for speeding, warnings, seatbelt because you don't have any measures for the number of citations specifically for speeding for example?

D- no we don't, and that's why I was looking. Because you know this is the agency BSC and then each division forms its own strategic plan, certainly under those divisional strategic plan, I'm sure would be the number of seat belt citations issued, number of child restraint citations issued, speeding citations issued, and that's what we looked at in these study is how many of those citations were issued in relationship to the number of crashes depending on a geographic area, type of day and those type of things, so when you seem to see that ratio really low, for instance currently I think as an agency we're at like 22 citations per crash when it deals with speed, so we issued 22 speeding citations for every one crash involving speed whereas seatbelt is like 4 to 1 and maybe alcohol is like 2 to 1, so I think those ratios are very important to look at especially considering the fact that seatbelts are the most prevalent factor resulting in

incapacitating injuries and fatal injuries so yes, it's not listed here but I can guarantee you especially when you speak to one of the division lieutenants later today, he'll say that within his strategic plan, he is looking at the number of citations issued per division for these individual areas.

MJ-so you don't think anything is necessary to be added in the overall measures for enforcement?

D- I'm a big supporter of patrol time, I believe that when troopers increase the amount of time spent patrolling, they're visible and thus are more proactive in their duties, so the lower the percentage time is, obviously their activities are sometimes lower as well, so I think the more we as an agency have our troopers visible and out actively enforcing, the better we are in handling, in being proactive and maybe stopping some of these things from happening. And I know for a fact that's probably going to be... "performing duties and obligation without reservation, percent of time spent patrolling"

MO- so under maximizing the enforcement, they have another measure which is "number of hours dedicated to targeted enforcement efforts", is it what you're talking about?

D- there are 2 separate lines in our activity report, one is patrol hours and the other is patrol hours in targeted area, what we try to do strategically was say ok, in your area what is the problem, what is the target area, what is the problem that seem to always arise, so let's just say this section of roadway between the hours of 9pm at night and midnight, we tend to have a higher whatever, experience with either speed or DUIs or etc., what that activity report is saying is that ok you as a trooper went out there and made a concentrated effort to go out and spend a couple of hours in that targeted area so on the line on your activity report you put 2 hours under

the target area, so one is a little bit different than the other. So each area identifying a weakness for lack of a better word and they need to really focus their efforts on that specific target area and then they're asking ok how much time do you spend per week in that just little target area versus overall patrol. I'm saying yeah that's important but overall patrol time is more important and that's along the lines of the project Joe and I are doing, we want to identify those areas that are red where the crash occurrence is higher, well the ratio of crashes occurring is higher than the number of citations that are issued for that area, identify that target area roadway so that troopers if they have more time, that's not saying take away from what you have been doing and focus it here because then this area might become red, that's just saying if you had extra few hours to target that area, go to that area.

MJ- do you think there are any other activities that can be done by the troopers or probably educational purposes that you can make public travelers aware of all the unsafe behaviors they can do?

D- I think Public Safety Announcements (PSA) over the radio, if they're local radio stations, I think having a good rapport with your local media and using them as an access to anytime there is a serious crash involved, and it doesn't have to be a negative story, it can be a good story, it can be something where there was a serious crash and someone walked away from it, emphasizing the importance of using seatbelts, so using media to get our message more, I don't think we do a good enough job with that, also along the line and I know we are doing a better job now but I am a strong supporter of safety education in the communities, whether it's any type of safety presentation, demonstrations to schools, using our resources to just get out our message locally in the community so I think education go along side but I don't think we do a good enough job with our media relations.

MJ- but you think warning and citations would be the thing to go with violators not any other activities that you can think of that can be added to issuing warning or citations that can improve troopers' performance and highway safety?

D- I'm more of a citation guy, than I am a warning guy. Think it has more of a lasting impact than a warning especially if the warning is for something significant, say you're going over 12 miles/hr of the speed limit which by our policy is you should be getting citation, then you get a warning, that really has a negative impact because they're going to think they can drive 10 miles/hr above the speed limit, but that's what we do, I mean we're in traffic enforcement so our actions are either warnings or citations and then again I think customer service is very important, so when we talk about our feedback, our rating, our positive to negative rating, from our customers, I think that's also important, so not only are we handling our business in a professional manner, are we responding to calls in a timely manner, are we providing a service oriented response, are we presenting ourselves as trustworthy and professional people, so that feedback that we get on customer comment cards and the positive feedback, that goes a long way to our credibility especially when we get to put out messages.

MJ- just a quick question for my own knowledge, does a trooper decide who would get a warning or a citation? Is it at his/her discretion pretty much?

D- absolutely! Obviously for most things, if you stopped someone and they're impaired, you cannot warn them for alcohol, but certainly the routine traffic violation, the officer has the discretion to either issue a citation of a warning.

MJ- so the performance measures in general, can you pick the top 5 that you need to focus on?

D- considering what our mission is as an agency, providing a safe transportation system, I think the number of fatal crashes, number of fatal crashes involving alcohol, seatbelt usage and reducing the number of impaired drivers, alcohol related violations and then I think speed is always, with state patrols, nationwide, speed is our bread and butter, that's what everyone is associated with in enforcement, speed limits.

MO- do you have the data tracking the comment cards?

D- yes, we track, so anytime they write in to that address or email address, a tracking sheet is identified by whom, time and date, officer identified, positive negative, what the positive what the negative was, complaint is investigated.

MO- I'm not concerned about per person basis, but per division basis?

D- yes, it's tracked.

MJ- do you think those 5 areas that you mentioned earlier, contribute to all of the crashes in WY? Which one is the most important?

D- seatbelts. let me just say that we don't have a preliminary seatbelt enforcement law, meaning that just because you drive by and I see you without your seatbelt on, I can't stop you. But if you drive by when you don't have your seatbelt on and you're speeding, I stop you for the speeding, I can write you the seatbelt citation so that has been a part of the problem I think with the lower numbers however typically, people who don't wear their seatbelts typically tend to be a little bit less disciplined with other areas of the driving, so I think generally you'll find a reason to stop that vehicle, so they drive by you see them without the seatbelt on, I think generally you can

potentially find a violation to stop them so you can write the ticket, but I know that does deter people the fact that they have to stop them for something else.

MJ- do you know of any particular performance measures that are happening in other states, probably the neighbor states of WY that are not in action here in WY and should be added? Because surrounding states have some measures for pedestrians, for aggressive drivers and trucks, but there's no such thing in your BSC.

D- I just don't know the strategic plans for the surrounding states. We're not going to have issues with pedestrians because we don't have metropolitan areas, this is the biggest it gets, and the number of pedestrians is really low.

MO- so you said this is an overarching BSC for the whole patrol but each division will come up with their own BSC and they will update it every year or so, one thing that we may need to think about as we're moving to the next stage of the research, obviously if we're going to compare these 18 divisions, we need to compare those on the same measures, we need to find a way to figure out the common measures, I'm hoping that they are not way off, maybe one of them uses the total number of citations whereas the other one divides it by speeding, etc, but I am hoping that they are common to a certain extent so that we can develop these common measures that we can compare them against each other

D- and I can certainly assist you in doing that, I think you need to get each division's strategic plan and BSC and I don't think it's any surprise that those that are not performing as well as others, there's probably because their plan is lacking a clear plan of vision, no expectations of goals, clearly identified goals, so that I think that's something that you need to find and look at.

MJ- since they update it every year, is there a big difference do you think?

D- I don't know. I can just go up with what I did and I may have added on one thing or taken one thing off, but pretty much what I did was I had this plan and then modified goals and the numbers.

MO- so the goals may change but the actual measures are likely to stay the same

D- yes, the measures for the most part were always the same, we identified what's most important to us and what we want to measure, and so the measures may stay the same, the goals might change

MO- what's each division's reporting process to the central office here? I assume they do reports either yearly or quarterly and they report based on their measures saying that "we met this measure, we didn't quite meet this measure" and all that, so then the main office here 1- try to individually work with the divisions and say "well what happened here, you didn't meet this" and 2- does the main office look at the overarching performance or BSC and say "well why did you even use this measure because its way off when compared to our overall BSC".

D- from my understanding, it would be upon the district captain overseeing the district and get divisions' individual scorecards to compile a district BSC to ensure that it's reasonable, that it's evident, thought went into it and then if someone's not doing something hold them accountable and ensure that they are setting measures and goals for the division. Whether or not it is done across the boards consistently, I don't know. I do know that all the data from each section goes to a final report that's disseminated to WYDoT and then WYDoT puts on an overall strategic BSC as far as what each section within WYDoT did collectively as a group, so that information's there, but certainly you would think someone would look at it and say they didn't do this, this, this and this and they didn't meet this, there's something wrong, maybe we need to get together

and rethink this or re-plan it, whether or not that's happening I don't know, in other words holding people accountable.

MJ- with respect to patrol performance and operations, do you foresee any external factor that can be accountable for patrol performance on the field?

MO- through literature review and naively thinking about this, we thought there are some things that are beyond troopers' control, which may have effects on the performance of the troopers, that we should account for when we want to run the comparisons.

D- climate is obviously naturally the most important one of the external factors that could affect just because you can't effectively go out and be proactive in enforcement if the weather conditions prevent you from effectively doing so, with that said however I was a lieutenant in Laramie, where we had this summit, you climb from Cheyenne a 5000 feet to a summit of 8500 feet in 40 miles, 35 miles, and the design of the roadway is always the windiest, gets the most snow and typically has the highest number of crashes, the most crashes along the stretch of I80, can be very treacherous and it's typically 10-12 degrees always cooler over there in that area than it is over in Cheyenne if not more, in fact I was there yesterday, snow on the ground everywhere in the city streets, you come over here and there's nothing on the ground, so that's a difference but I say we kick Cheyenne's butt flat out in our enforcement activities over there and we had an excuse every single year to point to so yes, I think a lot of people psychologically and mentally use that as an excuse not to go out and do their work, in reality I think the mindset they got over there is that when the weather is good, they really make use of their time really well when the conditions are good, cause they know there's going to be times that they just can't do that whereas here, in summer when the weather's good always, it seems like I can get done a

little bit every single day because I don't have to worry about it so I think mentally, maybe over time they'll get lazy, so yes, climate is probably the biggest external factor, you just can't control that will affect obviously. Deeper than that though I firmly believe in this agency is leadership, what type of leaderships/ leaders do we have in these divisions leading the group of people, motivating them, encouraging them, holding them accountable, setting expectations, what are they doing as far as planning, individual develop plans, instead of just typical supervisor go out and do it, it's really a part of the team and really motivating them to be the best that they can be so I think when you have that kind of leader, you overcome a lot of these external factors.

MO- I agree, these should not be used as excuses, however if you had 30 days in winter time in Laramie, that you can't go out period because of what's happening out there, then we need to take that into consideration when we are actually comparing Laramie's performance against here, acknowledging that they had 30 less days to go out and actually do patrolling yet they were able to put in more hours. So we won't take that as an excuse but we would take that into consideration in order to come to much better conclusions.

D- the amount of daily traffic I don't think it affects, at least not in WY, obviously driving between here and Fort Collins and Denver at times, there's just no way you can get out and pull someone over, I mean I see them park there sometimes in Colorado, south of Fort Collins, Loveland, some times of the day the traffic is so heavy there is no way they could get out and enforce, it just wouldn't be safe. I don't see that here, well even if the traffic's heavy they can get out and enforce, so I don't see an amount of decent traffic, so it might have an effect but not in WY. Obviously we're not out in the middle of the night, we usually step on public enforcement in public holidays we don't have a lot of special occasions here where we happen to provide manpower for that special occasion, even we're pulling resources from an area to help, but that

doesn't happen often enough and quite frankly it's not big enough. On I80 sometimes with the volume of CMV traffic out there, it's hard to turn around and catch up to a violator, because what happens is that they catch a violator, they turn around, the truck traffic is so heavy that they're blocking the lanes, they can't get around. So that sometimes is going to have an effect. To go back to the amount of traffic though, and to think about it in the reverse, there are areas in WY where past 7 pm or when it gets dark, there's no traffic so if we're talking about the amount of traffic in that respect, it certainly can have an effect because they just can't do anything, there's no one out there, there is nothing to stop.

MO- exactly, we said well traffic may affect negatively, that there's so much traffic going on you cannot do patrolling, but also with more traffic, there's more likelihood to issue citations and do enforcement compared to a case when there's nothing going on.

D- so then when it comes to that, you tend to look at what are they doing during the hours where there's traffic instead of overall, what are they doing in that targeted time. Road surface condition, again that goes back to weather, if it's icy or snowy, but as far as the actual pavement and concrete, WY has one of the best highway condition in US, the roads are very well maintained and kept up, I personally have never experienced that situation where the conditions of the roadway was bad, that I just said "No I don't want to enforce vehicles" because in WY when it's a heavily travelled highway when its routinely used, the upkeep is very good, I will say there are some older highways where it doesn't get a lot of traffic but there is some traffic usually between local communities where the width i.e. very limited shoulder space to safely pull over, I have seen that and certainly I would say that troopers then would probably not do much enforcement there, because there's nowhere to pull off and safely conduct a traffic stop, but when you're talking about our main highways in WY where I would say 90% of traffic occurs,

roadway conditions are very sufficient to conduct a traffic stop and obviously because of our mountainous terrain and elevation certainly, there's not like I80 Nebraska, where it's all straight and visibility is for 20 miles, so there are a lot of curves and a lot of hills, there's a lot of no passing zones, so troopers typically stay away of those areas because it's hard to enforce in those areas. It also a lot depends on how the towns and cities and their jurisdictions are over that, for instance like Cheyenne or Casper are the 2 larger areas, they have a lot of state highways running through the city and it depends on whether or not the city has said we got this jurisdiction, but I will tell you in Casper there are a lot of state highways within the city limits so in Casper we ended up having to enforce. I was in Casper 8 years, to get out and enforce the laws outside of town was difficult, in other words you get sucked back into the city limits to do enforcement because it has the population and the traffic volume inside the city limits on those roadways, inevitably leading to something bad happening and so we had to come back and handle that call, handle that crash, so a lot of times the state highway outside Casper, and that is 60 miles on highway 20, 60 miles on highway 220, lot of area is not covered because the troopers are sucked back into the city. I think that happens here in Cheyenne as well.

MO- if you get sucked into the city because they need help, anything that you do over there i.e. writing citations, wouldn't that also be recorded and reported towards your performance?

D- yes, it counts, in fact I found a lot of people, cherry picked the city limits, because it's so much easier, because you're just talking about 40 miles/hr speed limit, easier to get turned around, easier to get someone stopped. In fact most of your alcohol involved crashes up in Natrona County where Casper is, occurred in the highway system within city limits, people travelling to and from the bars. The crashes in the city limits also count towards a division's performance.

Construction zones, you got areas where a lot of highway miles is under construction, that certainly does affect, you can work the construction zone but usually what ends up happening is troopers who work construction zones have to sit stationary and monitor, and it drives the troopers nuts to stay stationary and wait, they want to be out there riding and doing stuff, but yeah especially if the construction zone is long, there's nowhere to pull people over safely, it can affect but troopers are typically smart enough that unless there's a specific request to have visibility or enforcement area, they just kind of safely stay away from it and go work in another area where they can accomplish what they want to. Road design will go along with geography as well, so if you're having areas where it's virtually impossible to pull people over because of the terrain, the elevations, and the curves, that type of things. I guess what I'm trying to say is that any area or location that can adversely affect the troopers safety, is going to have an impact, but certainly medians and the inability to cross the median cable barriers. But what we have found, through Joe's and my study, is that the crash rate in those areas is higher than the citation rate, partly because of some of those external factors, so now we want to try also as a result of the study to develop a business case to what can we do to help control those external factors, but what we end up seeing is that troopers say I'm not going to go here because I can't really do anything about it there. You know how many people in the divisions have extra-curricular activities/ duties? So we utilize our own people as academy instructors, either at our own academy, or up at the law enforcement academy, so if you have a division that has a lot of people which in the past has been a negative thing, in my mindset has always been a positive thing and I think that's the mindset of the direction agency now, because that's a good thing, we want people to be well rounded and well diverse and involved in many different avenues where as in the past it was viewed as negative thing because it meant they were off the road a few more days of the

year and it means someone else was having to pick up the slack, they weren't writing as many citations, so certainly that can have an effect, how many days a trooper is gone off the road doing something else, some other clerical duties within the patrol outside of enforcement and I just think leadership, qualities of their supervisors and I don't know how we're going to measure that.

MO- I think as a result of the study that (leadership within the division) will come up, so when we have poor performing divisions, who is responsible for this? Most likely the supervisor of that division. Yes, the troopers may be lazy and they may be slacking but a supervisor should not allow that to happen, so we are comparing not only divisions, but the "decision making units" which are units at which decisions are made and decision maker in a division is the supervisor of that division.

MJ- so you have data broken down based on climate? How many crashes do you have when there's a high wind, etc?

D- That would be on the crashes form, there would be a box, weather related stuff, we can identify snow, or ice, or wind and do a search as far as how many crashes occurred with this element.

MO- anything you want to add?

D-taking care of our employees, and I don't know if this is going to have any sort of bearing or not but there will be 5 years in a row where we have not seen a pay raise, we used to get legislative approved pay raises every year 4%, this is the 5th year in a row we don't have pay raise, we never had to pay into our retirement, state always picked up employee contribution, so starting last year about 1.8% started coming out of our pay check. Work schedules, we have

some district commanders, one in particular, that oversees 3 divisions, he does not allow them to work a modified schedule, he forces them to work the old 6 and 2 schedule, 6 days on, 2 days off, do that for 5 weeks and you'll get 4 days off whereas a lot of divisions have been working a 5, 2, 5, 3 days on and off (5 days on, 2 days off, 5 days on, 3 days off) so I think morale in general has an effect on performance.

Interview #3 Transcription, with Lieutenant Josh Walther

**Note: MJ is Maral Jalili, MO is Mehmet Ozbek and J is Josh Walther*

MJ- thanks for your time again, you are a lieutenant in what division?

J- Division A, which is the Cheyenne division here in town.

MJ- I'm going to start with some general question with the overall agency Balanced Scorecard (BSC). There are 7 different categories in there. I want to ask you to rank these 7 categories in order of their importance that you think should be given in WY?

J- I understand, I always struggle with these, and the one that I struggle with the most is the employee care, I got into law enforcement and everyone said you're here for everyone else and not for yourself but no other business in the world puts the job before their employees, it's always you're here for your employees and you care for your people first and then you go out and save the world kind of thing, that one I struggle with and I don't know where I'd rank it if I replace something at number 1 or I put it with something at number 1 but I think that should be of utmost if not shared importance with something else. They're all very important but when I kind of read through this earlier that's the one that stands out to me that should be up there, I can debate with myself which ones should be 2, 3, 4, 5, 6 or 7.

MO- Thanks for the comment, you said it would rise to the top and probably share top with another one and I'm not too concerned about an exact ranking here but would you say safety and enforcement would be also towards the top?

J- you know if I rank them, it would be just an ambiguous ranking, it's like I have 5 kids, which one would I rank as number 1... if I rank them, what am I ranking them on. They're all very

important and of course safety is a no brainer and should be on the top, operating within a balanced budget, is very important but really in the grand scheme of things maybe not quite as important. So I think if they had to be ranked, I don't think they're too far off other than employee care.

MJ- do you think there's any specific category that should be added there and it's not there now?

J- there's probably dozens that could be added but I think they did a pretty good job in minimizing it, so I think they got the most important ones.

MJ- do you think any of them are unnecessary at all?

J- no because again even though I think fiscal responsibility and operating within a balanced budget is really in the grand scheme of things. Is it important to me today? Obviously, it's something that we need to do in the long run otherwise we won't exist, so I think everything is on there and then again you could probably add a dozens more that I would think are important but we need to keep it kind of clean and simple too, so I think its fine.

MJ- I'm going to ask more detailed questions about safety, there are different measures underneath that category, from the number of fatalities to the number of CMV crashes. I just want you to rank them based on their importance when you think about safety.

J- you're going to have a hard time with me doing that.

MO- what this helps us with is that you have too many measures which is good and bad at the same time, sometimes it really becomes an issue of keeping track of everything when you have so many measures, but we want to get a feel of which measures are really very important when compared to others, so that maybe our research should focus more on those as opposed to the

other ones, but if you think that all these measures have equal importance that's fine, I'm not too much worried about the ranking part, I'm concerned about those that will rise to the top.

J- to me they're all the same thing, you're talking about people that are either injured or killed in a crash, so kind of an anomaly here when I started in this position, we had a bunch of fatalities right away, every single one of them we examined and we were like, you know if a trooper was here or if we had done more of this or if we had done this differently here or we educated here, what would have made the difference and none of them were really like if we were out, it would have made a difference, so I guess what I'm trying to say is to be able to say this year that our fatalities are down (they are, our fatalities have been down for a while), but is it attributed to us, being on the road, writing speeding tickets or the education we're doing at schools or what's it actually attributed to, probably none of those, I don't know or maybe all of them, who knows but I mean all these that we've talked about, all these that we've had in our district are really, I'm not going to say unpreventable, everything is preventable but looking at fatalities and saying this year we had 10 fatalities in District 1, last year we had 9, what the heck are we doing wrong, we have one more, it's just not a fair assessment, because we could be doing a lot more work but maybe there was a car that had 5 people in it and it's one crash and we have 5 fatalities. So to me these are all the same thing: number of fatalities, number of fatal crashes, number of impaired driving related fatal crashes, number of CMV fatalities, I mean these are all were you injured or killed in a crash? and how many numbers were there? Obviously the one with alcohol, it would be nice to know, these are things that we've been asking ourselves since day 1 that I've been here and I've been here only 10 years and I'm sure decades before I've been here, we've been all trying to solve the mystery of what should we be getting on the road and doing; and if we knew that answer, we would be very successful, but we're not, we don't know those answers, so I

don't know which of this is more important than the other. Obviously no brainer to say drinking and driving and fatal crashes, we can't delete that, it has to have some impacts somewhere, but I mean this whole thing we're kind of asking for some time that I'm not sure if any of us knows the answer. But I guess the number of fatalities we have in a year is some sort of an indicator of something, let's not forget too that cars are built different today, I mean the same crashes today that would happen 20 years ago on different vehicles could have a totally different outcome, so not all of it is what we're doing.

MJ- do you think any measures is missing in there? That can enhance the safety based on what's actually going on in WY highways?

J- maybe instead of counting deaths and counting injuries, find out how many people are changing behaviors, maybe figure out a way to calculate how many people are actually changing their behavior before this happens. When we have one death and we focus on that, but what about the 100 people who we change and are wearing their seatbelt and are not speeding and are not drinking and driving, and there's really no way to find that data but if there was, then that would certainly be fantastic.

MJ- do you think it is appropriate to divide the crashes with respect to driver's age or specific demographics or characteristics that might be going on in WY?

J- yeah I think it's helpful or it can be, obviously if there's a certain age group and they're all alcohol related, then there's something to focus on there so I think that can be of importance.

MJ- do you have any idea what age group is more prone to accidents?

J- all crashes, I'm not certain, alcohol is a younger crowd, but I certainly don't know the specifics and the numbers.

MJ- so I'm going to ask the exact set of questions that we discussed under safety, this time for enforcement?

J- here's what I do in my own division and I think it may be a little different from what's going on in the state, is that I never tell the guys I need you to go out and do 10 of this and write 5 of these every day and do 1 of these and find this and get that, I don't do that. I try to promote them to do, if all 3 of us were cops, we'd all have different strengths, she [pointing to Maral] would go out and do something that's her strength, then maybe yours [pointing to Mehmet] is education of whatever, so we'll all have different things we are strong in and I'll try to promote them to do that and do it for the right reasons and be energized to go out and do that because they want to, so for me to say the percentage of the citations issued per investigated crash might be totally different with 2 different troopers, one trooper might be better at sitting in his car and having the guys sitting next to him and educating him as opposed to another guy who says 5 words and writes a ticket, which one had a better impact? I don't know it depends on the trooper and how they relate that information; so to say that percentage of citations for crashes is a good performance measure for everyone I think is false, as are all these. I've always been a big proponent of when we make a traffic stop, we want to leave there changing behavior if it came from writing a citation or giving a warning or giving a little education or handing in a pamphlet of moving violations, whatever it is, that's what we want to do, that's our purpose here, it's not to write tickets or there are no codes or that type of thing, that doesn't exist, it's different with every person and it should be handled that way.

MJ- so I realize that every division has its own BSC and something like a strategic plan for itself, so how do you come up with measures for them?

J- we essentially have 4 and they're relatively ambiguous and to write the strategic plan was easy but it was very difficult to come up with the BSC and do the end product of it, say for instance the "attitude", we call it "the happy one", I'm happier with my job this year than I was last year, that's great and that's easy to say but then the hard part comes in, tell me what that means to you, what you did over the year to do that and it's different for 12 different people that are in my division. So that's how I do that, it's very ambiguous and easy to write but very difficult at the end, because I don't have "I wrote 100 speeding tickets, I wrote 100 seatbelt tickets, I wrote 50% of my crashes". I don't have that, but if someone interprets that way, one trooper is a speeding ticket guy and that's how I want to do and that's what I want to do, then perfect, then he establishes a number for it. I feel like a lot of people think that's the way it has to be, to have a BSC like at the state level, and I just did what I thought was the right thing to do and everyone seem to be on board with it, but I don't have numbers. I do use our P26 which is our activity sheets, we all sit down and someone tells me to me "what was important this year was writing seatbelt tickets, I really went on and hit that hard", then ok well let's see, then I can use numbers and I don't mind looking at the numbers for something but that's up to them however they want to interpret that goal.

MO- we recently realized that every division has its own BSC, and you need to report what you do at some point, so with your different approach, do you run into any problems with the central office? Do they come and say well we need some numbers, some solid measures that you can get immediate numbers from and then you can report to us so that we can run our own report to WYDoT leadership, do you have any of that thing going on?

J- I haven't yet. However, even though my strategic plan is what it is, I can still have one say "how many fatalities have you had in your division?" and that's an easy question to ask, but I haven't had anything yet to worry, "well we can't have this, this needs to be number based, what are we doing here", I haven't had that yet.

MJ- how many troopers do you have working in your division?

J- there are 13 of us, 12 plus myself

MO- we have covered the first section of the interview which was to get an idea of which performance measures you think are important, now we want to ask some questions about the uncontrollable factors that may be affecting the performance of the troopers.

J- It's just what's my definition of performance, does a trooper making a traffic stop have more of an impact or just a trooper being there? Does going over one car and talking to one person have a greater impact than him being seen by 100 cars? But performance, I assume everybody's definition is going to be their trooper's output and how much they're actually doing, which we can't really decide for a trooper sitting in the median doing paperwork and being visible, how much impact does that have? We have no idea, cause there's no way we can really measure that, but the way I think you want it to be answered, based on the way you wrote the questions, of course climate can, we're in a very windy area sometimes and quite frankly when the wind is blowing 60 miles/h, if we're not having crashes (it is another thing that we are on the defensive for), then a trooper may just not want to make a traffic stop for someone's doing 10 miles/hr over, certainly climate has an effect. Unfortunately, lately a lot of times, we're on the defensive rather than the offensive specially on a snow day, we're just responding from call to call to call, it's not like a trooper gets into his car which he should be, where am I going to go today is going to have

the greatest impact and I'm going to make the best change, it's not that, it's the minimum hour which is kind of a shame especially in snow storms and whatnot, it's just we're going from crash to crash to crash, how much impact are you having? Probably none, because you're just responding to where the problems have already occurred, so climate has a huge impact.

Daily traffic, again between heavy traffic, well most of the guys work traffic moving they're not doing a lot of stationary, (stationary by sitting in a median, flicking a button for when someone's speeding) most of them are moving, the cable barriers that we have now, hindered that quite a bit, especially in the busy areas through town, those cable barriers, they're in both interstates, where the medians too narrow and that's a federal requirement, to receive federal funds, we had to put those up so obviously for doing most of the patrolling moving, and we're going this way and the car's going this way and they're speeding and the cable barrier's there, it's difficult to turn around, so that and the traffic volume do affect that, if you can't pull out in the traffic to catch someone, you're not going to risk your life and go chase the speeders.

MO- so WY is a rural state, and probably this area is the most crowded area in relation to the rest, do you think traffic here will make a huge impact here and generally in WY? Even in this area when you have the most crowded time, if you had stationary patrol, would they have trouble getting on the highway and patrol as they need to do?

J- what you guys need to know as well as I do, is that when you see a trooper on the side of the road parked, people are going to give that away by flashing their light. People are pretty quick to react when they see breaks coming on, so it's difficult to do stationary but Cheyenne's the only place that I've ever lived in WY, I'm not from WY, it's the only place that I lived since I moved and the only place that I've worked as a cop, so that's the only thing that I know, but from

talking to other friends or troopers in other places, conversely the lack of traffic affects them, they want to close shop and go home at 10 at night because there's just not any cars so like I said, this is the busy area in WY, there are many areas where there just isn't traffic periods sometimes, so that's the opposite effect. There are a lot of summer holidays where folks from CO will come up to our lake, so obviously traffic's increased then so that affects violations and may affect patrolling. We certainly have increased the troopers on holidays, we never got to the point where we had a gridlock where we can't just physically turn around and catch a speeder or something, but it does affect especially through this area where guys will see a violation and just blow it off just because the risk is not worth, but that's not very typical here, it gets busy but it's not that busy. I don't really see a big effect there, if we have more cars versus trucks, they both can violate the law, we have guys that just do motor carriers so they might be more prone to go to areas with more trucks but I don't see anything large that stands out there. Road surface might be having an effect but we're pretty fortunate in WY, we have pretty good roads system right now, especially in this county, we don't have that issue where we have a really poor road where we want to avoid patrolling.

MO- We're trying to figure out the jurisdiction of the WHP, which is mainly highways I assume, but being a state patrol you can go into the cities, we've been told that in certain cases the city police may say no we can take care of this area so don't worry about it, but in certain cases they'll actually call you and say you know I don't have enough forces here, so would you come here and respond to an accident or etc, so how does it work here? Given that it's here in Cheyenne, it's the largest city here.

J- we probably do the majority of the work outside the city limit and that's because we try not to step on toes and assume that Cheyenne's police department handling things in the city but

certainly when guys are looking for drunks, they're allowed to go where they want to go, they're state troopers so they're welcome in the city, we have a pretty good relationship with the police department and sheriff's office here, so it's never like we're downtown and a police officer goes by and flips us off or anything and they appreciate it when we back them up or vice versa. The one thing you really want to stick to is the boundaries during the crashes, if there's a crash within the city limits, we try to let PD take care of it, if it's on the highway system, just outside the city, they try to let us take it. We've both worked each other's crashes if they're too busy or we're too busy, we call each other for help so we kind of have that relationship. As far as actual road type as in 2 lane roads and interstates, there are troopers that are more comfortable working in 2 lane roads as opposed to an interstate, just because when you're on an interstate you have the median, you're going the other way 75 miles/hr, if you get a violation you need to turn around and go the other way, there's a catch up time and it's a little higher speed, so it's a little bit more going on there as opposed to a 2 lane road, you just turn around and you're there and it's done so it's pretty clear that some troopers are more comfortable with that 2 lane road deal, and again some are more comfortable with the interstate. One trooper came from a pretty tiny little town, and she's really not afraid of anything, and she has no problem working in the interstate, but she can tell "where am I going to go today? I think I'm going to go with the 2 lane road", and it's pretty frequent and you can tell it's because she has a comfort level which isn't a bad thing, again we need that type troopers to do different things but they're comfortable with, it works out but it's pretty clear that that has an effect on their patrolling.

MO- as a division leader what kind of daily decisions do you make? What if you end in a situation where 10 troopers say "our comfort zone is from this mile marker to this mile marker so we all want to be stationed here." I assume at that point you would say no we have to cover 50

different areas. So what's your influence in their day to day operations? Where they go, how they patrol?

J- I try not to be micro manager and try to just educate, they have a pretty good hand on what's needed. I'm basically the guardrail of the division, they can go anywhere on the road they want, if they hit a guardrail, then I'd say hey, we need to do this and I very rarely have to do that. I make it pretty clear, we just had a division meeting yesterday, of what I expect and again it's not specific what I expect, here's what we're trying to do, here's why we're here, you guys interpret that and go to achieve what you need to do, but very rarely do I ever have to intervene and say hey you've been sitting at this thing for 2 miles on I25 for 3 days, now go do something else, our call volume here is probably from what I understand, is amongst the highest in the state, so a guy may go make 2 traffic stops (something that he wanted to do offensive), then spend 3 hours responding to calls, going over to counties, so we don't really have a lot of that "you guys spent a whole shift just doing whatever you wanted to do and haven't had responded to anything in here", it's a little unique in here and Laramie and Casper is pretty similar in that respect. I still don't think that Laramie gets quite the call volume we get but we spend ridiculous amount of time responding to calls, and some of them are valid and you're glad they called and that's not the point, the validity of the calls, just that we have a crazy high call volume, sometimes guys would literally come out and spend the entire shift just responding to calls and then you may get a shift where they don't have a single call which is rare now so call volume here is pretty crazy.

MJ- do you have an idea of an average amount of the time that your troopers probably spend on doing office work and not patrolling on the field?

J- funny you should ask that, because I was talking to a person, she works in motor carrier and she writes their grants and stuff, but she told me that the state average is 30% patrolling which is horrible. I assume ours is not far off that, I mean its gotten worse every year and with technology, you hope that it'll help things in the long run but increases that patrolling time, but it hasn't and one thing is obviously this is our headquarters, I'm in Cheyenne and our divisions in Cheyenne so when we get new equipment and whatever it is, we're always getting picked so they typically try it out and that's what we're doing right now. Half the division's trying that e-citation which is pretty troublesome but it's really the 7 guys that are on, and that's really cut their stuff in half so we have a lot of that, a lot of technology issues and things to handle there but yeah so that's the real number apparently, it's 30%. I would not have guessed it was that poor, I would have guessed still poor at maybe 50% or something but 30% is crazy.

MJ- so you mentioned technology is affecting patrolling time, can you think of any other thing that may be affecting that?

J- yeah, legal issues, even just since I've started, arresting someone driving under the influence of alcohol and the paper work that was required to what's required now, plus all the technology on top of that, you really have to pay attention and make everything perfect and do additional paperwork and more steps, and burning videos and submitting that to evidence and just really being very careful what you're doing just because of lawsuit. Attorneys are now asking from us, so there's now a lot that's expected from every arrest that wasn't even 10 years ago, even 5 years ago, so that's increased quite a bit. A crash report went from a single page report to 8 page report which is a federal mandate, so it's asked required from all agencies apparently and all those little things that's just isn't really that bad as it sounds? No maybe an extra 5 or 10 minutes, but those

things keep adding up, if I spent 10 minutes here and all these things take 10 minutes longer and that takes half an hour, it's been compiling now for years.

MO- we didn't talk about construction zones, if for instance a part of I25 goes under construction and they close 1 lane every day, how would that affect patrolling?

J- we don't think we have it this year, we have in the past that federal grants for working traffic into construction zones, so certainly increase patrol in there even if we don't have grants, we often have folks from WYDoT saying hey people need to slow down for our work and construction zones, so if you can send a couple of guys out, so we try to keep those construction zones in mind and try to patrol as more heavily simply because you have people standing on in the interstate. And the more time we're there, the less time we have to patrol in other areas, one of the things within interstate as opposed to some of these rural occasions that just have a couple state highways, if we're working on I80, the chances of seeing the same car again and again, probably it's not going to happen, I80 is a major corridor for all the way across the country, so the idea of having an impact on I80 and stopping a car and having him like ok, I better slow down for this area and he tells his buddies to slow down, that just doesn't happen on an interstate because it could be someone from New York, as opposed to a rural area where you have a 2 lane road where I could stop you 4 times and eventually you figure out "I guess I better slow down in this town, this is crazy", and you tell your friends. I was just going back to comparing interstates to 2 lane roads; I think your enforcement may have more of an impact long term as opposed to interstates.

MO- all these performance measures is with the goal of safety for the travelling public, but you put your life on the line on a daily basis, but in this overall BSC there's nothing that talks about trooper's safety? So any input on measures that could put in place to promote that?

J- this agency does a great job with supplying us with the equipment, graphics packages and lights that are very visible on the road side, but that technology thing again, is just, when someone makes a traffic stop I want them in and out as quick as possible and balance that line between being courageous and professional and brevity, I just want you guys in and out, just make the point and educate and go, but with technology like these e-citations are turning a 7-8 minute stop into sometimes half an hour, and causing computers to crash and things like that and I went from being vulnerable for 8 minutes to being vulnerable for 30 and not only that, and I'm not saying we need to go back to hand written, entire country except for us is there, but instead of doing one of these and looking in the mirror to see what's coming up behind you, it's this and the guys have no clue what's going on behind them, a car hitting them, but I mean someone walking up with a gun, so the guys are really being sucked into the technology and I think that's huge for officer's safety. Crash scenes, we're pretty fortunate around here to have these variable message signs, just like they have in CO, they're controlled from a terminal down by our dispatch so we can call down there and say put that message on that sign and they put it up pretty quickly so that's been a huge help, "crash ahead slow down" but we don't have a lot of those, we have a handful and they're not everywhere throughout the state, so the more of those the better, some sort of advanced warning would be beneficial but then again if it's 3 miles away people forget by the time they get to the crash scene. I'm fairly lenient on officer's approach whether they go up to drivers side or passenger side just simply because every stop is different, if a car happens to pull over against the guardrail you're going to have the trooper going that side

because he doesn't like to be on the highway side, it's up to them, however they feel most safe, they're all pretty good about positioning their patrol car so if it goes, where it would hit first and hopefully save them, I think they're pretty good at doing what they can do for safety, I think they're all pretty well educated in that respect.

MJ- what is the average years of experience of the troopers in your division? I'm trying to figure out if experience contributes to patrolling? Is there such a big difference between someone who'd been patrolling for 30 years and someone who has been hired last year in terms of how they perform and/or anything that's related to patrol?

J- one thing that I've noticed, when you think someone fresh out of the academy, they had all the training, they're probably the most cautious on the road, they're putting their thumb print on the car, turn around every second and look, everything that they learned in academy is fresh in their head, so if you look at that as a curve, as far as the officer safety goes, they would probably be on the top when they come out of the academy, they do some stupid things just because they don't have the experience, maybe they have been almost hit by a car, but what they learned is fresh in their head, and I think then they drop, the curve goes down, I'm getting used to this, this isn't not bad, they're getting a little lackadaisical and I think that curve drops and their safety goes down a little bit, maybe the lieutenant reminds them of hey, you got to do this but they still have that 3 or 5 year I got this figured out kind of thing and there's another scare, where someone scares them or they see something, they've been around long enough to experience some scary issues so then it kind of goes back up again. I think the guys that have been on for a long time kind of get that, still getting a little lackadaisical, sort of outlook on things but still have the experience to know when they should be doing certain things and not doing certain things, what's worth for them and what things to avoid and there's also that, with experience comes age, where a got fresh out of

the academy would go crazy chasing down a speeder doing 10 miles/hr over and probably cause more issues than help, a guy that's been on for 20 years would probably say I'm not going to risk that for the sake of a 10 miles/hr speeder and I'll get the next one, that's patience and thought process. I don't know the average years of experience in my division, but I guess the guy with the least experience has 4-5 years and our most is probably 20, high teens.

Interview #4 Transcription, with Major Perry Jones

**Note: MJ is Maral Jalili, MO is Mehmet Ozbek and P is Perry Jones*

MJ- Just for the record, could you please tell your full position?

P- I'm the support services commander, so I supervise 4 captains on the support services side.

MJ- I'm going to start with the general agency level Balance Scorecards (BSC), WHP has 7 different categories in its overall BSC, I want to know your opinion in ranking these 7 categories, in order of their importance?

P- safety number 1, enforcement number 2, future growth number 3, customer service number 4, performing duties number 5, employee care number 6 and fiscal responsibility number 7.

MJ- do you think any category might be missing? Or anything that might be unnecessary that needs to be modified or changed or deleted?

P- I think it's problematic when we lump such categories as enforcement and customer service and fiscal responsibility and highway safety with the whole domain of taking care of our people and developing our people and mentoring our people. They all happen simultaneously but they are 2 different mindsets; and so in my opinion it has been easy for our agency to concentrate on the things that we do and the things that we can count and widgets that we can produce at the end of the day, sometimes it is expensive developing our people and so I've always been a little bit uncomfortable with our BSC and strategic planning when those 2 things are lumped into one because we as cops, default in stuff that we can get in there and count.

MO- I think that was kind of our question because we were trying to figure out whether you as an individual feel comfortable with the 7 categories and the BSC as it is or you think it may need some refinement or improvements?

P- for example, obviously I hope that anyone who interviews with you, would put highway safety as their number 1 priority. I think we can achieve that in 2 ways, I don't know which way is the best way but really taking care of our people and really helping them meet their needs and helping develop our troopers and our lieutenants and our middle management and really working on the whole people development and the tangible result of that is highway safety, because we have happy workers making good decisions. My training and philosophy in life is that's the way we should go about it but I think our agency traditionally has really worked on here's how many tickets you write, here's how many miles you drive a day, here's how many hours you work a week and as a result, we'll get better highway safety which is probably true statement as well. I think one of them is more lasting and self perpetuating and one of them is less so, so I don't know how we're doing on that but at least we're talking about that which is good.

MJ- so I'm going to move on with more detailed questions about safety. There are different measures in that category, can you rank them based on what should be more focused on in WY according to its certain characteristics?

P- I thought a lot about this measure, here's how I looked at it, the difference between an injury crash and a fatal crash may not have anything to do with anything we can control, it's the position of the person at the time of impact and which way the hit was turn, there are a lot of factors that can turn an injury crash into a fatal crash, the car that they're driving, the condition of the car, so many factors, so if we hang our hat on how many fatals we had year to year we're

really taking the chance there on the roll of the dice, so I ranked number of injury crashes as number 1. Obviously, we need to separate the property damage crashes out where the guy slides off the road and hits the bolt, those are pretty preventable but probably understandable. Injury crashes I think is probably the most [important], if the crash is serious enough to have injury whether or not there's a fatality, that'll put the crash into a more serious nature, we want to prevent injury crashes, and if we do that we'll prevent fatal crashes. If we try to prevent fatality crashes, we may not affect all the injury crashes. So I put number of injury crashes as number 1, and then I chose number of fatal crashes number 2 because I don't want to seem careless about fatalities, CMV crashes number 3, CMV fatalities number 4, number of impaired driver fatal crashes number 5, total number of fatalities number 6 and fatalities during special recognized holidays number 7.

MO- do you think it really does matter to break down the number of fatalities into CMV versus drunk driving or just fatality is fatality and that's still bad as it is without really giving much importance to why and how it was caused?

P- unfortunately I think we need to do simply because some of our federal grants, some of the influence we get from the feds, is based on CMV crashes and fatalities, so sometimes we're at a position where we're defending our high CMV fatality rate to the federal government when they're really not a significant cause of fatalities or injury crashes, just because we're in the interstate system.

MJ- do you think anything's missing from that list?

P- well it is but it's covered elsewhere in our strategic plan, the whole idea of community outreach and education.

MO- do you actually think that the outreach and safety education efforts should be a part of the safety category as opposed to enforcement?

P- I do. It should be part of the safety.

MJ- do you think it would help if you divide the demographics of the people in WY in order to be able to control them better or promote the safety, like teen drivers or pedestrians, cyclists, CMVs, etc.?

MO- along with that, is it really necessary to have the crash data broken down to say teen drivers, impaired driver, aggressive driver, etc? Is it a federal mandate to do that or do you see any value in actually categorizing the crashes under different headings?

P- I think in terms for us developing our strategies, especially for education and community outreach, we need to know the statistics on teen driving, drunk driving, elderly driving, types of vehicles and all those things that we're capturing data on. It occurred to me that some of our most successful programs, Alive at 25 (it's a CO based program but has been very successful in WY) and some other that we have, seem to be embraced by public and our employees, are those that are narrowed down and focused on a specific behavioral or age group. We have a motor cycle safety program here that's successful, people go through that and tend to statistically have less motor cycle crashes, that's really specific program as opposed to a broad one. Same with the Alive at 25 and some other driving campaigns.

MJ- I'm going to ask the same set of questions, this time for the second category which is enforcement. There are 4 different measures. Can you rank them based on their importance in your opinion?

P- absolutely, I'll rank seatbelt usage as number 1, targeted enforcement as number2, outreach programs is number 3, and I don't even think the 4th one should be on there.

MO- can you talk about that a little bit as to why?

P- Percentage of the citations issued per investigated crashes... Philosophically, we should be writing a citation on every crash, unless it's an act of god, unless an eagle flies into the sight of car or a bolt of lightning strikes, there's a human behaviour involved in that and we should be in the business of modifying human behaviours, so perhaps goal of increasing the number of citations we write on crashes would be a goal of somewhat to have in our agency. I've often talked to troopers about that. That's what we do, we write tickets for people who don't follow along, that's the business we're in and that's our primary bread and butter. Certainly, if we write speeding tickets for poor driving behaviours, then they display that same behaviour and they result in a crash and we don't issue them a citation, we're contradicting ourselves.

MO- what you're saying is that it should be a given not even a measure, every crash unless it was an act of god, should result in a citation.

P- correct.

MJ- do you think the number of citations should be classified into different categories?

P- well, in terms of giving our agency some foundation from which to develop a policy or training, we need to have that data, for so many years we've separated speeding citations from all other moving violations and tracked speeding citations in our daily activities for troopers but generally the agency assigned a value to an employee based on speeding citations. During the first10 years of my career, the trooper in state who wrote the most speeding citations got an

award from the Colonel. I kind of get that, generally I was a very hard working trooper as well but you could certainly write lots of speeding citations and never arrest a driver -which in one year that was the case, the trooper in Laramie, who received the award from the Colonel for writing the most speeding citations, had arrested no drunk drivers, which is a virtual impossibility to have that many contacts in Laramie, and not get in contact with an impaired driver so the implication there is that the trooper either wasn't paying attention or was purposely neglecting something, which is probably significantly a bigger safety issue- so I think in terms of data and having availability of that, it's important but just in terms of moving violation, I think an unsafe lane change or following too close, are perhaps more serious than speeding, so there should be a value assigned to that as much as a moving violation, and correlation between moving violation and safety is easy for anyone to draw I think.

MO- anything that you think is missing from the list of measures under the enforcement?

P- maybe a little bit. I often thought that maybe there should be...as a benchmark or a base line in our agency, giving some guidance to our troopers about what the ratio should be of the citations to warnings, and/or citations to contacts with people. We could have a very active trooper who makes lots and lots of contacts with drivers for driving behaviours but he issues 3 warnings for every citations that he issues. I don't know what the answer is but I suspect there is a ratio there that would be optimum for achieving the desired result of changing someone's behaviour, sometimes getting in their pocket is that, so you can make lots of contacts and look really good on paper at the end of the day but maybe not having the courage in doing the tough part of your job which is writing people tickets and letting the judicial system then be the entity which decides whether that ticket has cost some money or whether it's dismissed; but I don't know what the answer to that is, probably different on each traffic stop with each driver before

evaluating our impact on that person, not letting the violator decide whether they're going to get ticket or not, letting the cop decide on that.

MJ- so you're leaning more towards citations rather than warnings?

P- well, yeah. I think that's a valuable tool, perhaps lost a little bit of value. We're becoming a little bit soft, I don't think we write as many tickets as we used to and I think we're trying to over analyze the job that's a little bit basic. I believe that most people when they see red and blue lights in their rear view mirror think they're going to get a ticket, that's their immediate reaction, so when they don't, was that trooper advocating that what the driver was doing was more of warning, so it's really ok to do it. We arbitrarily set speed limits by not enforcing them until 6 or 7 miles/hr over the speed limit and what we've done is for people to think "it's ok to go 80 miles/hr". But I don't know what the answer to that is, I mean if we tell our troopers to write tickets at 80 miles/hr or else and they go out to do that, that is always the best enforcement action to take? To stop a 53 year old woman who has never been stopped before and it's a traumatic experience in his/her life, it probably doesn't make any difference whether she gets a ticket or warning, she's probably going to watch her speed which is ultimately what we want to do.

MJ- could you think of any other strategies that could be implemented to improve/change public behavior, so they can develop some safer driving manners, other than citations/warning/educational contact?

P- I have an opinion about that but I don't know if I would call it professional or whether it's an agency response, I'm often irritated by the failure of the industry in general to think about what they're doing that makes our job of highway safety more difficult. As we buy a new car it has a navigation system and it has a Bluetooth, it has many conveniences that distract drivers from

their primary job of driving down the road. For example, I'm very reluctant driving with my wife, when I'm riding in her car because she is distracted by many things that are beyond my control, not as a husband but a law enforcement officer, there's Bluetooth, there's the navigation screen, there's buttons all over the steering wheel, to answer the phone, to turn the phone off, to change the radio station, to change the color of the navigation screen, those are the things that are beyond our control, those are conveniences put onto the driver by the industry, but we can't do anything about that other than to educate folks.

MJ- to do an overall comparison with all the performance measures, can you pick the top 5 performance measure that you think are the most important?

P- Sometimes I tend to over simplify the things that are complex but what seems fairly obvious to me that we can validate the things that contribute to the injury crashes which I rated as number 1, are those that are related to seat belt usage, impaired driving, and distracted driving. So it's counter intuitive for us not to have safety belt usage and impaired and distracted driving as pure top safety measures, so for our performance measures we should be really concentrating on those issues that seem to me that should be our number 1 priority and how we value that in our agency in terms of giving credit to troopers who write safety belt ticket as opposed to speeding tickets. Though, I don't know how to do that in the agency. If I believe that some crashes are random events that are going to happen, we're not going to prevent all the crashes from happening, what's the next best thing that we can do is to make sure that people are driving slower, they're not impaired and they're wearing their seatbelt so when they get in those crashes, they stand the greatest chance of surviving, so the whole concept of public education and getting people to do the right thing and then concentrating our efforts on targeted enforcement so that we're highly visible in areas where we know crashes are prone to occur and when they're prone to occur, what

day of the week, what time of the day, during what season, that changes from season to season, all the things that Joe McCarthy has been working on, that's all the right stuff. And then getting on the whole effective side, that's much more important than how many tickets they write, how many miles they drive. Having a trooper at the right place at the right time for the right reason has a much greater probability of saving someone's life than having a really hard worker in an area where it's really easy to write a lot of tickets where we're not having a lot of problems. Joe and I have talked about this, I can remember as a young trooper when we would get a federal grant which allowed us to work over time, and we had to concentrate on writing speeding tickets and we had a quota for that, to have to write at least 2 tickets/hour to get paid overtime. Well what I would do when I decided to go work out a few hours, I would go to an area where I knew I could write 2 tickets an hour for speeding without ever thinking about "Is this where we're having crashes related to speeding and it isn't". I would go north of I25, because it's wide open highway, not a lot of traffic, so people tend to speed but we didn't have a lot of crashes up there and it wasn't until I was into my career 12 or 15 years and got into management and would start with the strategic plan and I thought how ridiculous that was. I would have been much better served to work south of Cheyenne on I25 where there's lots of traffic and do my speeding tickets there for much lower speed limit, a lot of differential speed, a lot of different drivers and trucks and cars and commuter traffic.

MO- how much of a decision power the lieutenant in each division has when it comes to educating young troopers and saying "hey, it's not about writing 2 speeding tickets per hour but it's about finding the right place and writing the right ticket at the right time"?

P- prior to this position, I was a district captain, so we have 5 districts in the state, so I was on the field side, I was the commander of District 1, south east of WY, big busy district with I25

and I80, 17 years I was in that position, yes, I share that with young troopers and lieutenants and try to really talk about what you do and why you do it are more important than how many of them you do, but that was entirely up to me to run my district in that way. I thought I had first line supervisor lieutenants who were receptive to that, they were young, they were smart, they were driven, they were intuitive, so we developed that team concept of district 1 and we spent a lot of time talking about “I don’t care how many tickets, we are interested in crashes, so let’s try to work in the right places at the right times” and I thought we did a good job of that, whether it was the right thing to do or not isn’t important, but I did that all with no confidence that my 4 counter parts, the other 4 districts, were doing the same thing. We just had not evolved as an agency yet to the point where we had the command staff and the executive staff for driving that process. That was personality driven not agency driven. I think now we are a lot closer to driving that from an agency perspective, which is why you’re here right now and why Derek’s getting in this relationship with you and Joe McCarthy and he’s talked about it in staff meetings, so we are a lot better off now than we were 5 years ago or 10 years ago, with regards to that. But in a big state, with 18 divisions and 5 captains and 18 lieutenants, I don’t know what a lieutenant in Teton County is doing, we haven’t developed internally that way yet. I was thinking that maybe we are developed mentally as an agency in our timeline of how we are grown over the decades but the time is right for what we are talking about right now because back in the day that I was out on the road, I would come out to work and spend probably 7 hours of my 8 hours shift out on the road working and if I wanted to go north, west or east and write tickets I did, and it was generally pretty proactive kind of work. I was out looking for driving behaviors. That has decreased significantly in the last 10 years with the advent of cell phones in particular; our troopers now are spending an enormous amount of time in the reactive mode, we have precious

little time to go out and look for people who are misbehaving and try to modify their behaviour. If you go on a ride along, I think you will be surprised when you will see how much time a trooper spends to run from one end of a county to another end of the county chasing something that somebody else saw and they felt like it was a bad driving behaviour, which very well may have been but very well may not have been (maybe somebody cut me off and made me mad), but we have to respond to those calls because if somebody makes a call that we suspect it's a drunk driver or a dangerous driver and we don't respond and then that person goes down the road and kills somebody, then we have the liability. So, if you were to interview troopers and ask them what the most frustrating thing about being a trooper is, I know that majority of them would say "I don't get a chance to do what I know I could do which is to go out and change people's behaviours because I'm constantly responding to calls for service". That's a fact in life now, we are not going to change that, but what we need to do is figure out a way to maximize when I have a couple of hours when nobody's bothering me, where can I go where I stand the greatest opportunity to get the biggest bang for my buck. I got to go to the areas where I know there are crashes and I know what's causing them and I know why they're happening at what time of day, and I got to go and concentrate on that behaviour, which is kind of that data driven enforcement that Joe's working on and it's related to what you're talking about, his is more what to do and yours is how effective is it, what are the best practices.

MJ- the next question is essentially talking about the external factors that are beyond your control but have some effects on patrolling performance, and through literature review and thinking about it, we have come up with the list of things like climate, the amount of traffic, etc, so please go through them and comment on how you think they may affect patrol performance?

P- climate: cops don't want to get wet any more than citizens do so if it's raining or snowing or the wind is blowing real hard, that's not the ideal condition in which to be patrolling and taking proactive enforcement activities which is when we probably should because that's when it's most dangerous to be out driving so climate does affect that. Here's how we've tried to address that, we said we get it, you can't really patrol when it snows, because it's hard to catch people, it's dangerous to stop them on a slippery road so let's change their behaviour before it snows and hope they behave the same when it is snowing. So I think adverse climate causes to patrol less and additionally adverse climate conditions have already got us busy doing things that keep us from patrolling (responding to accidents, etc) so maybe the best practice would be when we know we have adverse climate conditions, we increase our manpower during those times when they are predictable so a part of our manpower can respond to crashes and the other folks can patrol.

The amount of daily traffic, well it's hard to patrol when there's lots of traffic, it's dangerous, it's harder to catch people, it's not harder to identify that behaviours but it's hardest to turn around and actually get them to stop on the side of the road, so I think what happens is unless there are directions or guidance, is that we tend to shy away from areas where there's lots of traffic and go to areas where it's easier to do our job but it's not as effective to do the job, like we talked about earlier, I don't think that happens, I know that happens. I should not have qualified all of WY, my entire career had been here in Cheyenne so I tend to think about WY state troopers as people who work here in Cheyenne, Division A, and that's probably not true for somebody who's in another area. I think that same thing would be true for Casper, so it's a valid point; it's just not true for everybody across the state.

Special occasions, public holidays or time of day is, again this could be my perspective towards Cheyenne, but in Cheyenne you know that from 7-8:30 in the morning and from 4-6 in the afternoon, I25 south of Cheyenne is a really high traffic area, there are a lot of people commuting to CO or vice versa and delivery trucks and those kinds of things. We are aware that during public holidays we have a lot of people travelling through our state that typically aren't in the state so they may not be familiar with driving on windy or snowy conditions. I don't know how it affects patrolling, I don't think that troopers really care for these, "it's the President's day so I'm going to do things differently than last week", there's so much work to do, there are so many violators, there are so many things that need to be addressed that it doesn't really make any difference if it's Christmas or the 4th of July, there is a lot of stuff that needs to be done out there, so I don't think we have the luxury of really gearing our patrolling towards a specific holiday. But I think we have started to talk to our supervisors, saying schedule more people on the 4th of July weekend, schedule everybody and give them the next 3 days off, let's have everybody out on those especial holidays where we know there's lots of traffic, so that we can be reactive and proactive and have more feasibility. We never did that when I was a trooper, it was just all discussion about that, we are pretty good about that now with scheduling everybody on our big holidays, especially our summer three, Memorial day, 4th of July, Labor day, everybody's required to work, even us from the office (the division lieutenant, who is the first line supervisor will tell them that you need to all work this weekend). What sense would it be for CSP to be out between Fort Collins and Denver at 5 pm in the afternoon other than the visibility that people see them and slow down, but you can't possibly work in that bumper to bumper traffic, it would be a little bit dangerous in that traffic to stop people, we've all been into a traffic jam between Denver and Loveland where we think "Oh my god, there must be a big crash up here", you just slow

down for 20 minutes and you get there and it's just a trooper on the side of the road writing somebody a ticket and everybody slowed down, so there is some validity here. But here's what I see supervisors do and that's saying, once we start to talk about let's get heavy on our weekend, then they start asking questions, well, rather than scheduling everybody on the weekend of 4th of July which is a Sunday, we know that everybody is going to travel on the Friday before and the Monday after, so let's schedule folks on Monday and Friday as opposed to the Christmas, we don't need to have troopers out on the Christmas day, we need them out 4 days before Christmas and 2 days after Christmas when everybody's on and from grandma's house so those kinds of practices out in the divisions I think if we can identify those and encourage those kinds of creative ways, when our people most likely to crash, they're probably most likely to be poor drivers on their way home after the vacation than when they are on the way to the vacation, because they have over eaten, they have consumed much alcohol, they haven't gotten enough sleep because they've been around grandkids, etc.

MO- do you see any difficulties in patrolling or enforcement efforts when you deal with different types of vehicles?

P- absolutely, we have a division called Division P, it's a small division with 8 or 9 troopers, it's sandwiched between the large division of Rawlins and the large division of Laramie, those 2 divisions used to be the only 2 divisions there and we created a division which is a lieutenant and 8 troopers in between those 2, and there's no commuter traffic, there's no local traffic, the town's 200 people or less, there's 3 or 4 towns in that general area, farmer communities, that division does nothing but work truck traffic on I80, those are the trucks going from the east coast to the west coast back and forth. So, an analysis of their activities compared to a division with a similar sized division such as Torrington with 8 troopers, would be completely different like apples and

oranges, best practices would be different, time, what they are looking for, how they go about doing businesses, it's completely different, it's almost like working for 2 different agencies, they're not particularly concerned about drunk driving, their issue is trucks, and by the way, trucks are probably not the problem most of the time, the problem with trucks is that they drive too slow not too fast, the problem with trucks is the differential speed they create between themselves and the fast moving passenger vehicles, and when we have that differential speed is when we have problems with passing and breaking and all of those things involved. So, the days that the truck drivers got hammered for driving 90 miles/hr across the country are over, that was gone 10 years ago when gas prices hit \$4 a gallon, trucks can't afford to do that and most of the companies have the trucks even governed at a slower speed, 60-65 miles/hr is the maximum they could go; so when we are out working truck traffic which Division P does a lot of, they're not writing speeding tickets to trucks, they're looking for safe lane changes, following too close or driving intent and backing up lots of passenger vehicles when everybody's trying to pass. There's a misconception that the trucks are the problems because they go real fast and they run into people, I don't think that's accurate. Our cable median guardrails have had a significant impact on our patrol, I don't know if it's good or bad, it's just changed the way we patrol, we can't patrol or it's easiest to patrol because of those but maybe we don't need to because they're accomplishing what we were doing when we were patrolling by keeping people from head on collisions.

MO- anything you may want to add?

P- I believe we hire people, and they're in this business because they want to go out and make a difference and save lives and feel at the end of the day that they have contributed to highway safety. I'm speaking as an upper level manager now; as a result, it is our obligation to give them

the opportunity to do that by telling them how to do it and not letting them guess it. So, anything that you could do or Joe could do that gives the troopers a better idea of getting in their car in the morning and say what should I do, if they can pull something up on their computer and say here are the best practices and here's the best place to do them at this time of day, we're going to be better off, we're going to save lives if we do that. You're analyzing data that we're not capable or qualified to do because we're not trained that way.

Interview #5 Transcription, with Captain Tom Stoker

**Note: MJ is Maral Jalili, MO is Mehmet Ozbek and T is Tom Stoker*

MJ- for our records, can you state your full title?

T- I am the captain over at District 1.

MJ- there are 7 categories in the overall agency Balanced Scorecard (BSC) and I'm going to ask you to rank them in order of their importance?

T- number 1 safety, number 2 customer service, enforcement, employee care, performing duties, fiscal responsibility and the last one future growth.

MJ- do you think there's any category that is missing and should be added to that overall BSC? Any of them unnecessary in there?

T- No.

MJ- I'm going to move on to a more detailed set of questions in safety, there are different measures under that category; can you rank them in order of their importance in your opinion?

T- number of fatal crashes, number of impaired driving related fatal crashes, number of fatalities, number of injury crashes, number of fatalities during specially recognized holidays, and that should leave us with number of CMV fatalities and crashes.

MJ- do you think it actually helps to have them broken down into CMV crashes and impaired crashes, etc?

T- I like them broken down. There are certain kinds of enforcement that you take on a CMV versus a passenger car or a truck. They have stronger, more regimented equipment requirements. With a passenger car you have a state statute that tells you how your car should operate; with CMVs you have a thick book that tells that your tires have to be this size, your breaks within adjustment to this percentage, you have to have certain certificates to be a driver and the whole product, so yes preferably broken down and the reason why is that CMV is held to a higher standard than a personal car or truck.

MJ- do you think any measure is missing from that list?

T- No.

MJ- do you think it is appropriate to divide the crashes with respect to driver's age, or vehicle type or impaired drivers, aggressive drivers, pedestrians, cyclists?

T- yes, there are things that will affect young drivers compared to older drivers, right now what we're worried about with the younger drivers is talking on the cell phone and texting, maybe it's not necessarily the same with an older driver but with an older driver you have to worry about their skills and vision compared to a younger person, as far as the vehicle types, absolutely, you're talking generations of vehicles, the older vehicles are made out of metal which will stand a greater impact and it's a total different outcome when the vehicle was made back then compared to the vehicles that are made now.

MJ- I'm going to ask the exact same question (ordering) as the last one, this time regarding the second category in BSC which is enforcement.

T- number of hours dedicated to targeted enforcement efforts and the percentage of seatbelt usage, percentage of citations issued per investigated crash and number 4 the number of outreach programs and presentations. And maybe the causation of the crash would be the only thing that I can see that may be added to the list, what that particular driver was doing when the crash occurred, that will give us something to target.

MO- if there's a crash and there's a responding officer, will they be able to figure out the causation of the crash and record it?

T- sometimes it is very difficult, because that person, they do not want to specifically say "this is why I got into the crash" because they're ultimately afraid of being either cited or arrested depending on the severity. I might be driving down the road and I may be texting which is a violation but just because I'm in a hurry I didn't put my seatbelt on, so as an officer I look at the case and I have 2 violations, so what I'm trying to do is not to drive up the number of tickets that I write, what I try to do is to try to issue a citation to change that behavior and how do I change that behavior? I try to change that behavior by the best means for that person, there are some people that you write the citation to get that behaviour changed, there are some people that you can make a suggestion "next time you may want to wear your seatbelt", there are some people that need that ticket to get that message across, so it's not a true that we like to write a ticket for everybody for everything's that in the book, it's not the case, it's at our officer's discretion where he/she is going to make the biggest impact.

MJ- can you think of any other strategies that can be implemented that can improve public awareness so that they can drive more safely and change their behaviour?

T- the way that that trooper handles the investigation, the way maybe I can convey a personal experience and how I can relate to that and show to that young driver what happened during the crash because maybe it happened to me and I could explain how it would affected me. So, I guess maybe talking to them on a personal level. Obviously it's great that we have documentation that we can show this person was involved in our crash on this highway, this county at this time but there's no personal fact and there's no way that by issuing a ticket someone can say this happened to me and if you don't take these remedies you're going to be in worse condition next time. There are not a lot of troopers who would take that time into explaining it on a personal level. Most troopers want to get the information to write a ticket and go on; there are a few troopers who would actually want to take the time.

MJ- based on your ranking, do you think issuing citation and warnings have a greater impact rather than outreach programs and presentations?

T- yes and no. yes, because again when you receive a ticket you're basically put on notice that you did something that the officer/trooper found at fault with an action but on the other hand, if you know the type of person that is involved in that crash, a simple conversation may go further than the ticket. If you think about the citation, it's a note to say "hey you did something wrong and now here's a penalty for it", it is typically a monetary penalty. Little people take note that it also goes into your driving record and it could be one of the 4 moving violations in a year, a lot of people don't think about that but during that personal contact that the officer has with that person, that should all be explained "it's a sad thing that you're involved in a crash but this is what you did to cause the crash. I am trying to get your attention and I am trying to change your behaviour, here's a citation, please understand that this will affect your driving record, it also will affect your insurance and not only does it have a monetary fine that you're going to have to

make payment to the court, but now this is going to be a part of your driving history and it's going to drive your insurance off and nowadays, because you have a poor driving history, that affects your credit" so if you drill those points and especially with a young driver, hopefully that will click, with the driver thinking "wow I didn't think of it, all I thought about was texting my friend and that's it."

MJ- there are no measures on different types of citations, e.g. speeding, child restraint, etc, do you think it is necessary to have those citations broken down into different categories?

T- I think breaking down the citations is good feedback to the officers, certainly they'll know what to look for and not only is it just a category, it's also the time of day and the location where we can use this data to effectively put enforcement detail in those areas.

MJ- if you want to look at all these performance measures through all of the 7 categories, do you have a list of top 3 or 5 that should be focused on throughout the state?

T- to effectively rank them, I think some of these are joined together. When you talk about safety, you're also talking about the number of presentation programs, you're also talking about the crashes and finding out what the causation is and then again when you figure out the causation, you're talking about the enforcement and given the manpower and I'm going to tie them all together with the future growth. This is one of those things that we can say that we had 4400 crashes this year and 38% of those were speed related and out of those 25% didn't wear their seatbelts, how do I take care of that? I have to take data that was given to us, I have to sit down with the first line supervisor and the troopers and then we have to try and figure out with our given manpower. We would love to have future growth so we would be able to do more enforcement activities which the public says "oh we don't want troopers unless we absolutely

need them, and then the time we need them is during the crash when somebody violates the law and no one's around, that's when we want the troopers", so I guess safety would be number 1, it's really hard to try and pick one out because without safety, you need enforcement and to enforce, we also need the future growth and you have to have a customer service. Like I said earlier, if you can find that time and talk to that young or middle aged or old person and relate to them, so I think all these are intertwined and it would be hard for me to categorically pick one over the other one.

MJ- do you know of any specific measures that are implemented in the surrounding neighbors of WY and are not used here?

T- I don't, I've been a captain for just 2 months, they reassigned me from safety and training to this, so I barely got the district 1 BSC and have been looking over that I see that there are some very vague standards and measures that we need to work on.

MJ- do you see any conflict in the number of citations issued for speeding for instance with how well it's reflecting the contribution it has to highway safety?

T- where I used to work, we have a 2 lane highway for 12 miles, by me effectively thinking the shift change which is typically between 5 to 7 in the morning, then the next shift change is about 3 to 5 pm, so by me thinking that I want to make an impact, I like to be there when I know there's going to be a lot of traffic and then I take that information that you guys give me or somebody else puts together that says the number one killer in the state of WY is one vehicle roll over with unrestrained occupant, how can I change that? I will go out and I will work that rush hour traffic from that 5-7 am. Somebody may say "you write 200 speeding tickets on that road and you have low crashes", well the reason why we have low crashes, is because I put myself in that

position, I'm out there effectively and efficiently enforcing the speeding law, twofold, because I'm out there writing tickets and that's how we gain a change in behavior with some higher speed because I write that ticket, I could also write a warning but where I get a better attention is with a ticket but the big thing is that when they see that black car with red and blue light on, that's visibility, because they see that car they see somebody's pulled over, when they see those lights the typical response is to slow down, so I may be on the side of the road with somebody and I'm writing them a citation but also I get that visibility so for me being out there, I get 2 added benefits that by putting out a notice that this is not an acceptable behaviour that WHP is going to tolerate but also getting that visibility saying I'm out here and I care and that's why.

MJ- the next question is essentially talking about the external factors that may be beyond your control but they are affecting the patrolling performance, can you please go through them and think of the effects that they may have.

T- climate has an obvious effect, during the storm where it is not really conducive to go out and do traffic stops because I don't want to put people at risk, I'm not going to stop them on a very slick road, couple of reasons why: if they're travelling above the speed limit, last thing I want to do is to come in behind them, turn on the lights, have them apply the breaks, have their car slide off and now I have a crash to work, I don't want that. I get paid to put my life in jeopardy so it's ok for me to be out there but I don't want to put somebody who may be exceeding the speed limit in that position where I keep them along the side of the road and a car loses control and slides into them, so climate plays a very big part of it. If the weather's not good enough for traffic stops, then you only get the visibility out of it but you kind of wait and you try to be proactive by driving up and down the road, you act kind of as a pace car, especially on I80, when you do have a lot of snow and you drive slow and people are afraid to pass a trooper typically so

you set the pace and you find a place to turn around and you go back so effectively you're making circles so you have an influence on the traffic.

Amount of daily traffic, you're going to see different things during different times of the day, your driving habits are going to be a lot different in Cheyenne, if you're a little bit more aggressive than a rural setting, you'll have the people that are tailgating, the ones that fail to use a turn signal, they're in and out of traffic and maybe in a rural setting you don't have so much of that, you may have the speeds but it's the person who's trying to get from one city to another because there's that long stretch of nowhere and they think nobody's out here, I don't see any animals so I can exceed the speed limit, so you have to treat those people a little bit differently than you do with the people in the city.

Public holidays and special occasions may typically affect patrolling, on your 3 day holidays you'll see a lot of traffic on a Friday evening and you'll see a lot on a Saturday morning but on Sundays it's fairly quiet, then you may see a little bit of pick up a traffic on a Monday but Monday afternoon that's when it'll get very busy, when everybody's trying to get back home.

Types of vehicles, you have to understand when you decide to go out and work, there may be a time when you say I'm going to work on the commuter traffic or I'm going to work on the traffic between these 2 towns but there's also a time where you're going to say I need to work on CMV traffic, maybe it's that area of the road that has a higher flux on truck crashes because it's a downgrade where we're seeing a lot of truck crashes there, so depends on the trooper or the officer, do I want to work on passenger traffic, do I want to work on trucks, or during the Sturgis the emphasis is on working motorcycles to make sure they get enough rest to make sure they can make it safe back home.

Maybe not necessarily road surface, there are some stretches of road where they have done a channel ground in the road, so during bad weather when you have snow and ice, the water seep into those channels then it freezes then the water rises up to the top, then you have a solid sheet of ice, where the surface treatment would have some effect of the traffic. The prime example would be you've seen cable barriers and you've seen guardrail, it is hard to enforce some laws, especially speeding when you're driving on one side and the traffic's going on the other side, if you don't have an off ramp or a cut across or cut through between that 2 to make that turn and effectively chase them down and enforce the law, so sometimes yes, we have troopers that will avoid that area because it's hard to work.

As far as the road type (interstate, rural, 2 lane highways) for me it's pretty much equal.

Construction zones, it can affect the patrol performance, especially given an example of an interstate highway, they have the easy bound lane shut down so now you have opposing traffic, east and west bound, on one side of the highway, it's hard to do that because now you have to worry about who's coming up behind you, you have to worry about can I make this turn in front of somebody else coming up the opposite direction, and then when I do make that traffic stop do I have enough room to safely get me and the person off the road without being hit and become a hazard to the traffic even more that what the construction zone is.

MO- how does the BSC at the district level work?

T- I have not done this as a district captain, so the last time I actually did a BSC for a field was when I was a lieutenant, essentially is that you're given some raw data for the division which starts at this mile post and ends in this mile post, to say I had X amount of crashes and out of these crashes so many were impaired drivers or drivers that were not wearing their seatbelts, so

then what I'll do as a lieutenant I will sit down with my troopers and I will say this is the 2 particular areas where they had a high number of crashes. One is one vehicle rollovers which we attribute to speed and then we have some impaired driving crashes. So how do we make a change in that? What time of day are these happening? How can we reduce that? I need you guys to be out on these areas on regular days, but how do we make that number go down? Maybe we should do a detailed meeting where we get the whole division out there or maybe during these time on these days that we see that we have a high incident rate, maybe that's when we put a trooper or 2 in that area and that's all they do, look for speeding in that area or if there's a time when the people are leaving certain drinking establishment, we'll have them in that area and we start looking more aggressively for the smaller violations so that will give us the contact to evaluate that driver to make sure that they can operate the vehicle safely (they are not under the influence). On a district level too, that's how I plan on working at it, what are my issues, I know I have a high number of crashes, I know I have a high number of truck crashes, how am I going to make it work in this area? Because maybe I don't have the same areas or issues in this division, so I have to sit down that with lieutenant and the divisional troopers and figure out what are our issues, if we're having a high number of crashes involving animals, then what can we do to do that, maybe during dawn and dusk we need to have a car go up and down the highway, maybe if we start to see them jump over the fence and gather up, maybe I'll have that trooper pull over for a minute and hunk and chase them back over, so we're trying to figure out what are our issues, are we having crashes, are we having intoxicated drivers or impaired by either drugs or alcohol, whatever that need is we need to figure out and say "ok this is our problem, let's try to figure at least 3 solutions out and in reality, can we make at least one of those solutions work." By me sitting down and posing those questions to a trooper, troopers say "yeah we can make that

happen”, and they’ll say “I believe in what you’re saying and I see the importance of it and I’m going to go out and do that” and that’s why you’ll see on a BSC some of the numbers that are really high then the next year you’ll see that those numbers have decreased dramatically because those troopers bought into that and they see the need to effectively enforce those. So it’s more time consuming to figure out here are my needs and how do I come up with the necessary actions versus to send a trooper out to go fix it. The way I look at it is that a district BSC should look at the division’s BSC and encompass all of those and there may be more enforcement needed in this area versus over here, but what we see as a district is that ok, maybe we had 20 or 40 fatalities, division 1 and 3 you’re low, division 2 you’re very high, how do I effectively address that? What is this division doing that this one’s not, I need to figure out a way to say you’re really high, you’re really low, so there’s something that you’re doing, so that’s why I think you should sit down and look at every division individually and then put everything together as the captain and say here’s what we will impose. I haven’t looked at the division BSCs yet, but we just had meetings with 2 divisions and we’ve started to talk about this, and we already have measures in place. We’ve seen a great response from the troopers and this target area is now really low in crashes but we have seen in other areas that the community hasn’t seen the troopers, why? Because they were very focused in coming up to the target area and they’re neglecting some of the responsibilities back here which is good and bad, it’s great because they did focus and they got those numbers down, bad thing is now we may not have issues in the targeted area but the public is not seeing troopers as much as they used to in the other area. I have to find that happy balance, my suggestion is that it’s great that you have that target area and now the way our troopers are “I’ve got to get from my home station here to work because I work here, I write the tickets, I do the warnings and the activities count because this is our target area, I really don’t

want to do anything over here or on my way to the target area because it's not really going to count toward the big picture". Well, that's not why we're here; the big picture is your whole area where you're assigned and eventually the state of WY.

MJ- Did you see any big difference in the BSCs of the 2 divisions that you just mentioned?

T- Lieutenant Walther's BSC has no number on it, the one that I was at 3 days ago, has a BSC that says I want 10 stops/week here, I want certain numbers of impaired driver arrests, certain numbers of CMV inspection out of this area, so yes there's a big difference that I see between these BSCs that we need to work on. Not having numbers may work, having too many measures may also work; but maybe with that you lose focus of the big picture trying to meet those numbers and neglecting the violations you see on your way because that is not a target area or a target measure.

Interview #6 Transcription, with Captain Shawn Dickerson

**Note: MJ is Maral Jalili, MO is Mehmet Ozbek and S is Shawn Dickerson*

MJ- thank you again for you time, could you state your position for the record?

S- I'm the District 2 commander, covering Casper, Torrington, and Douglas.

MJ- how many divisions are there in District 2?

S- 3.

MJ- I'm going to start with the Balanced Scorecard (BSC) at the agency level. There are 7 categories in there, can you go through them and rank them based on their importance?

S- ultimately the reason we exist is safety, so safety is at the top, I would put enforcement almost as a subcategory of safety, enforcement and education combined they are the means by which we obtain safety. I would kind of do the same thing with performing duties, customer service and fiscal responsibility, performing duties being the primary, customer service and fiscal responsibility falling under that. Same thing with future growth and developing our employees, future growth is a part of developing a career for our employees. So I would go safety with the subcategory of enforcement and education, and then performing duties with the subcategory of fiscal responsibility and customer service and then future growth with the subcategory of employee care.

MJ- can you think of any other category that is not here and needs to be added, that is missing from the BSC?

S- No, I'd say it pretty well encompasses everything.

MJ- the first category that you picked is safety, and there are 7 measures in that category. Can you rank these based on what you think is important?

S- obviously fatalities and fatal crashes, they go hand in hand, we want to reduce both, I guess it's important to measure both but they ultimately go hand in hand and I think if we could eliminate impaired driver crashes, we could put a big dent in the number of our fatal crashes so that would be critical as well, I would say that the others I believe are all important to entertain our goal. I think I kind of question the specially recognized holidays, I understand the importance of it because it's a high travelling period and historically, I assume I don't know for a fact, possibly, a high fatality time period. However I would say it falls under everything else ultimately; we want to eliminate fatalities regardless of the time. I would put the number of injury crashes and CMV crashes at the bottom of that list, nice things to measure but not as critical as fatal crashes.

MJ- can you think of any other measure that is not in that list?

S- seatbelt related or lack of seatbelt, youths and fatal crashes, I would say if we could eliminate DUI and if we could get everybody to wear their seatbelt, our fatal crashes would plummet.

MJ- do you think it's necessary to have the measure broken down to CMV crashes or it doesn't really matter and all the crashes and fatalities are of the same importance?

S- well, personally and as far as I'm concerned they're all the same, however I think public perception of CMV is critical and when CMVs are involved in a crash, they tend to focus on that and the media focuses on that and it becomes a bigger deal, so I think in order for us to be able to answer that question it's important that we monitor it.

MJ- do you think it would be beneficial if you had the crashes database broken down to different age groups or different behavioral aspects like aggressive/impaired/distracted driving?

S- It would be beneficial for educational purposes because it gives us an idea of who to target, not so beneficial for enforcement purposes because we don't get to stop vehicles based on age. But for educational purposes and we can target if we know that this group A is prone to this hazardous behavior then we can target them and try to educate them and change that behavior.

MJ- I'm going to continue with the next question which is basically the same set of questions as the last one, only this time under enforcement category?

S- seatbelts will certainly be at the top, I think we should have impaired driver enforcement in there, somewhere probably right with or below seatbelt. I would put outreach and education next, I do think it's important that our troopers issue citations on crashes but I guess I don't see that as being critical in this measurement, that's a reactive education/enforcement effort and not just being proactive and then I'll go with the targeted effort down next.

MJ- can you think of anything that needs to be added?

S- the impaired driver enforcement. CMV enforcement is critical but I think we have that covered under... or that might just be my strategic plan, so CMV enforcement could probably be under there as well.

MJ- do you think citations should be broken down into categories, like speeding categories, child restraint, etc? We know that you have that data, when you write the citation you record the reason why, but do you think there should be separate performance measure for each type of citation?

S- I think we need to differentiate because I think there are certain behaviors that are demonstrated historically and are more dangerous like DUI, not wearing a seatbelt, other moving violations which is something that we don't monitor and maybe difficult because it encompasses a variety of violations, but those behaviours I think are critical for us to measure and to know that we're being proactive. But, does that have an outcome on our performance? I guess in fact yes, because we can encourage our troopers to look for those and to strive to be proactive and take enforcement in those dangerous areas.

MJ- would you personally see any conflict with the number of citations and how it can be a measure for the performance?

S- ultimately our goal here is a change of behaviour but what I encourage my troopers to do is to take whatever the action that is going to be the most effective to change that behaviour whether that is a warning or a citation. Although I discourage road side lecture, there's a time and a place where you think you can get through the person, that might be appropriate. I believe through my experience and this is a generalization, with the majority of public a warning doesn't work, they think you're a nice guy but its impact doesn't go as far and with that, with the citation the impact would only go so far, I think ultimately our presence out there and the fear of getting caught carries weight and obviously self discipline on the drivers' part. To answer your question, if you're issuing more citations, does that mean there's more violation or does that mean we're doing a good job? I think it means we're doing a good job, from my personal experience, I used to be the division lieutenant in Pinedale and that division was the top division 2009 when I was the supervisor there, granted that a lot of it is based on stats. I also was a trooper there and I was a lieutenant there, and I lived there for a long time. I saw the change of the behaviour from the public, as a trooper there I didn't write tickets until people were about 10 over, I was not super

aggressive in DUI enforcement, if I found one great but I didn't go out and hunt for them. Then I got some new troopers there shortly after I became a lieutenant and I really encouraged them to be proactive and they were proactive and as a supervisor I started buying into the fact that you know what? We can change this and I encouraged my guys to be out and not doing the 10-11 over before they cite or stop but start following our policy which is 6 over citation and the average speed obviously in my own perception of traffic, in that area decreased. The number of DUI arrests increased dramatically however the number of DUI crashes decreased dramatically. As a trooper there it used to be that its guaranteed to investigate a handful of DUI crashes a year, last time I talked to the guys there, they don't remember the last DUI crash they investigated. So I believe it does have an impact.

MO- I think you made a great point that there is a relationship between the rest and the crashes; so your citations, your visibility actually lead to accidents being reduced.

MJ- I realized you mentioned something about lecturing people of the road side, can you think of any other strategies that may increase public awareness about safe driving manners?

S- what I would like to have the opportunity to do is related to road side... and it kind of goes along with Alive at 25. Last week, I stopped an 18 year old young man, he came up behind me on the interstate, I pulled him over, walked up there and I could see his cell phone sitting there on the passenger seat with texts, so I asked him "Were you texting? Let me see your phone". So I looked at his texts and it says "doing 105 right now!" So not only is he texting while driving, but he's going at 105 and he's bragging about it to his buddy. So I wrote him both tickets and I stressed to him that I wanted him to go to Alive at 25 and attend the training. Unfortunately on the roadside I can't make him do that, I can only recommend that he does that. I believe Alive at

25 is a valuable tool, I think that it would be beneficial to have more tools at roadside, if we could or even if the judges could assign driver education courses to the drivers. I also believe that we would benefit greatly from and I don't know how much the public will like this but when you have to renew drivers license periodically having to take a driving test and having to take a written test, one or the other or both would be great because if somebody hasn't taken the driving test in 20 years, it is forgotten, they've developed habits that should probably be corrected. We can't correct it in one traffic stop on the side of the road and I think that is something beyond the trooper's control and maybe beyond the patrol's a little bit, well I think the patrol can influence that, but I think obviously it would take legislative actions to do something like that. But, that doesn't mean we couldn't offer similar courses to Alive at 25 and get judges and courts buy into educating people in that way. I think as much as it doesn't come naturally, education is more critical than enforcement. I think if we could educate the public on as to why it's unsafe and how better to handle the situation whether it's a snowy road or etc, we could prevent a lot more crashes than the citation could.

MJ- I want you to pick the top measures across the categories, that you think should be focused on in WY?

S- this may contradict what I said earlier, but I would put education and outreach at the top of the list which I think we have some strong points under that but we can still have a lot of improvement. Then, I would go with seatbelt and impaired driver enforcement as critical performance measures and the ultimate goal that follows from all those is to increase the safety and reduction of fatal crashes.

MO- so what you're saying is that if you do all these, fatalities will go down as an end result?

S- Yes.

MO- do you know anything about the performance measures and strategies that are happening in your neighbour states that you think would benefit WY?

S- I don't have any knowledge to it but I have to imagine that we could certainly learn from our counterparts. I'm sure they can hopefully learn something from us too but there's knowledge out there and it certainly wouldn't hurt us to tap into that.

MJ- the next question is essentially talking about external factors that may be beyond troopers' control but eventually can affect their patrolling performance?

S- yes, climate certainly affects patrol performance whether it is wind, snow, rain, obviously good weather, I think there are certain areas in the state that have harsher climate to deal with, because of the wind and that does impact their ability to be out and patrol, when the weather hits they become completely reactive but I would say majority of the state all deals with climate in some ways or another, but maybe that's not a safe assumption. But, being a trooper in Pinedale it was cold, our snow didn't melt there from November until April, so it was always cold but the wind didn't blow nearly as bad as the rest of the state so you could go out and work traffic and the roads would clear up and you could work traffic and I could be making traffic stops in Pinedale whereas other guys would be working crashes. So, it's certainly not fair across the border and not only does bad weather affect how well a trooper is able to be proactive, but good climate is easier to be self motivated in when the sun's out and the weather's good, typically the drivers drive faster when the sun's out and it's a whole lot easier to be motivated and feel like going out and doing something. So, I think if you combine both of those and it makes a nice

sunny area with good weather, certainly it's easier to be more productive. On the opposite end, when somebody's getting slammed by the weather, they're being completely reactive.

The amount of traffic does affect patrolling performance and it can go both ways, there are areas in the state where the traffic is so slow that it is hard to find a stop especially at night shifts. Late at night, we always say that the town rolls the carpet up and there's nothing going on and there's no cars out but on the opposite end to that, there could be so much traffic that you can't get turned around to make the stop or you can't differentiate between the 20 vehicles coming at you that are all going 10 over but one's going 12 over, you can't tell and even if you could, you couldn't get turned around and make the stop so it certainly does have an impact and again both ways.

Time of the day, special occasions and public holidays, can have an effect. Being a trooper in Pinedale, I can remember when Yellowstone opened, all of a sudden traffic picked up, it was like somebody opened a gate, so we went from being that quiet little town that rolled the carpet up at the night to all of a sudden there were so many cars riding the road. So, public holidays obviously tend to be busy, especially the summer ones. Time of day because you're going to have commuters, even in the rural part of WY you have shift changes (oil plants, coal mines) in which you could have a quiet piece of road for the last 8 hours but all of a sudden has bumper to bumper traffic for the next hour and then it's a quiet road again.

I wouldn't say there's a whole lot of difference between patrolling performance with regards to different types of vehicles, I guess if there's more trucks, trucks don't go as a general speed as much percentagewise as cars do so all you have is trucks that are going at lower speeds and that

can certainly affect you but at the same time, that provides opportunity for commercial inspection, but I don't know if it has a lot of impact.

As far as the road condition, narrow shoulders. I think the troopers don't even realize that they will naturally go to areas that have good roads, because well traffic tend to pick up on good roads and at higher speeds but also where you have good shoulders where you can get off the road, make a traffic stop safely, I think they naturally move to those areas.

I'm going towards saying that area type, if all conditions were the same, I don't see a lot of difference between them. I think road construction areas and lots of intersections, they're difficult to work, they're difficult to turn around behind a car, there tends to be not a lot of area on the shoulder to make the stop, it's already confusing for the traffic so to throw a traffic stop in there, and all the stuff in there makes it worse, so it's unfortunate but I think a lot of those areas, troopers tend to avoid because it's difficult to work there.

MO- any other factors?

S- cell service call volume, if we have a remote location that has no cell tower, troopers can get out and work traffic, versus some that has good cell coverage, they're constantly getting called for traffic complaints or for ready report, so they're more in responsive mode rather than being proactive and out making stops, because when they're going there to there from call to call, unless something really demands their attention, they're not at the liberty to make traffic stops even though they might be driving by violations.

MJ- can you think of any measures with regard to troopers' safety themselves and not the travellers on the road?

S- the one thing we did in my division and we do in the district is patrol car crashes, we do measure that. Now that you mentioned it, it's a very valid point, to try not only prevent patrol car crashes, but trooper injury, whether it is in a use of force situation fight or something like that, I think it could be beneficial. I'm not sure obviously right off the top of my head, of a good way to do that, I don't want to discourage a trooper from going hands on with somebody when they need to go hands on with somebody but obviously I don't want them to get hurt, so if we could figure that out, it could be beneficial.

MO- can you talk a little bit about the process of coming up with the district BSC? Could it be significantly different from the division or the overall agency BSC?

S- I sit down with my division lieutenants, I also deal with my port of entry supervisors so I have the district BSC from my sworn side and from my port side, they mirror each other as much as possible. In doing that, we review the WHP BSC at the agency level and my guidance to my supervisors is that whatever we list here, although doesn't have to be identical to the WHP one, should in some way support it, because ultimately those are the ones that we are striving for as an agency and we are divisions of this agency. I believe the majority of our goals, if they're not identical, closely mirror the primary goals of the agency. How we usually differ is that we mirror their performance measures but we might increase the percentage or we might say "you know what? I don't believe that we can reduce the number so let's just try to maintain it where it is" or we might throw a couple more measures in there of the things that we think we can do locally. But, if the patrol has set a specific number of mobile enforcement details (say 30), then we as one of the 5 districts need to contribute to at least a fifth of that number and we can certainly shoot for more of it but we need to contribute to at least 6 of that.

MO- what's a mobile enforcement detail?

S- the port of entries, they have a mobile education enforcement team and they go out and do CMV inspections in size and weight enforcement, usually in the summer they set up and every truck that goes by has to stop, kind of like a mobile port of entry.

MJ- so if you work off of the division's BSC and you keep the overall agency BSC in mind, there shouldn't be significant differences between them?

S- not in my mind, but I am aware of the other districts that I believe have some significant difference.

MO- do you have any directives from the central agency that, say when your BSC is way different than what's in the overall agency level BSC, would come and say you need to change that? Or you have full flexibility?

S- like I said, I always mirror it so I've never been asked but I believe that we have near full flexibility. I do believe that if you come up with something that was off, you probably would be asked to justify that but honestly I do not know how closely the headquarter will look at it.

MJ- do you happen to have a percentage of how many hours the troopers spend doing patrol operations versus office work?

S- this is something that we veered from WHP, WHP has a goal of patrol time and what I've done in my district is not just counting the patrol time but also the visible time, when we're on the road visible, whether we're doing a CMV inspection or on a crash or on the side of the highway still visible to the public and counting all of those categories, my district goal is 60% and I don't know if we met that in 2012, I believe in 2011 we did but it was barely. Now if you

go to just patrol time when you're actually out making traffic stops, not investigating the crashes or doing anything else, I think agency wide we're lucky to be at 50%.

MO- how often do you update the BSC in the district level?

S- right now it's 2011 to 2013 plan, so every 3 years, however at the end of each year, I will sit down with the supervisors and I want to see their accomplishments and statistics from 2012 and we'll discuss 2013 being the last year of this 3 year plan, do we need to make any revisions or adjustments.

MO- anything you would like to add?

S- I would say that I like the concept of the strategic plan, I think its valuable and had a positive impact on our agency, however I do feel at times we've kind of become flat with it and at times it's just a piece of paper, we as an agency don't monitor it closely enough to see how we measured up, I think we could do better with that.

APPENDIX D: WHP TIME LOG SHEET (aka P-26)

WHP's time log sheet (also known as form P-26) along with the instructions sheet to fill out the form is presented in the following pages.

APPENDIX E: WHP CRASH FORM

WHP's crash form is presented below.