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

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Table of Contents

Problem Statement

Wyoming Highway Patrol (WHP) is a data-driven organization which uses multiple measures that are outlined in its Balanced Scorecard (as adopted as a part of the WHP 2011-2013 Strategic Plan which complements the WYDOT Strategic Plan) to assess performance. These performance measures are grouped under seven different areas such as (i) safety, (ii) enforcement, (iii) employee care, (iv) performing duties, (v) customer service, (vi) future growth, and (vii) fiscal responsibility (WHP 2011). The organization consists of 18 different divisions which undertake the patrol operations under different external (and uncontrollable) conditions (such as traffic volumes, climate, etc.) based on the decisions made at the division level. Performance of these divisions can be assessed with respect to the different measures for each of the seven areas listed above as outlined in the Balanced Scorecard such as the number of fatal crashes annually, number of incapacitating injury crashes annually, number of moving violation citations, rating from customer satisfaction survey cards, etc. Furthermore, these measures can be used by WHP to perform comparisons between different divisions in an effort to identify the best performing divisions and thus the best practices used by those divisions for the purpose of benchmarking. However, this process involves the utilization of a single performance measure at a time and may result in difficulties in identifying the overall performance which is characterized by the combination of multiple measures. Therefore, there is a need to develop a performance assessment system that can identify the overall performance of these different divisions in the presence of multiple measures so as to enable WHP benchmark the overall performance of its divisions to attain organization-wide performance improvement.

Problem Background

Performance Assessment and Benchmarking with Multiple Measures and Data Envelopment Analysis

Performance in the transportation domain is typically assessed with respect to different measures such as safety, cost, schedule, quality, impact on public, end-user satisfaction, etc. Furthermore, these measures are used by the transportation agencies for comparative performance assessment in an effort to benchmark best performing units and thus best practices implemented by those units (Ozbek and de la Garza 2011). Benchmarking, more specifically internal benchmarking, is a technique utilized in various industries for continuous improvement. It is used by organizations to understand how different divisions are doing compared to each other and to identify best practices of the best performing divisions to enable other divisions to learn from those best practices to ultimately be able to improve organization-wide performance (Ozbek 2010).

The importance of benchmarking and identifying best practices in the transportation domain has been highlighted at the national level. A study by the National Cooperative Highway Research Program (NCHRP) recommends, as a part of the action plan to address the challenges and opportunities facing the state departments of transportation (DOTs), to initiate a national effort to identify the best practices and to benchmark the performance of peer states (NCHRP 2003). Furthermore, another study entitled "Transportation System Preservation, Research, Development, and Implementation Roadmap", identifies a number of research topics that have to do with identifying benchmarks/best practices, and rating each state DOT in terms of its status related to other state DOTs (FHWA 2008).

However, as mentioned earlier, it is challenging to assess and benchmark the overall performance in the presence of multiple measures. To address this challenge, an innovative approach to performance assessment, Data Envelopment Analysis (DEA), was developed. DEA is a mathematical method based on production theory and the principles of linear programming. DEA can be used to assess and benchmark the overall performance incorporating multiple measures and enables one to assess how efficiently a firm, organization, agency, or such other unit uses the resources available (inputs) to generate a set of outputs relative to other units in the data set (Silkman 1986; Ramanathan 2003). Within the context of DEA, such units are called Decision Making Units (DMUs).

The main idea of DEA is to construct a frontier of efficient DMUs representing the best practices. DMUs located on such frontier (i.e., efficient frontier) act as the benchmarks (peers) for the inefficient DMUs in the data set. The challenge is to find the position of the efficient frontier and then compute the distance from it to each inefficient DMU to identify the efficiency score of such DMU. The efficiency score is constrained to the interval of 0%-100% (de la Garza, Groesbeck et al. 2005).

Figure 1 presents the application of DEA for a process with two outputs and a single input. For example, let's assume that the process under investigation is the highway patrol operation performed in Wyoming. The input of the process is the resource used; i.e., the number of patrol staff (x). The output of the process can be measured with respect to two performance measures as outlined in the WHP Balanced Scorecard: (i) the rating from customer satisfaction survey cards (y_1) and (ii) % of calls responded to within 20 min (y_2). The DMUs (e.g., different divisions of WHP undertaking the patrol operation) shown in dots, are plotted on an x-y plane by using the values for their input (x) and outputs (y_1 and y_2). Then, the efficient frontier, containing the DMUs with 100% efficiency score (relative to the other DMUs in the data set), is identified by running the appropriate linear programming formulations set forth in the DEA literature. For this example, DMUs (i.e., WHP divisions) represented by "C", "D", and "E" have an efficiency score of 100% (and thus form the efficient frontier as shown in Figure 1) and DMUs represented by "A", "B", and "F" have efficiency scores that are between 0% and 100%. The efficiency

score for any inefficient DMU can be calculated by measuring its relative distance from the efficient frontier. For example, efficiency score of DMU B can be identified to be 87.7% by computing the ratio of $|OB|$ to $|OB'|$ as shown in Figure 1. It is important to note that DEA, not only identifies the efficiency score for each DMU, but also identifies the peer DMUs for inefficient DMUs. For the example presented in Figure 1, the peer DMUs for DMU B can be identified as DMU C and DMU D as the projection of DMU B on the efficient frontier, B′, is a weighted combination of such peer DMUs. While the example presented herein depicts a scenario with one input and two outputs only, DEA can deal with as many inputs and outputs as necessary to assess the performance in the presence of multiple measures.

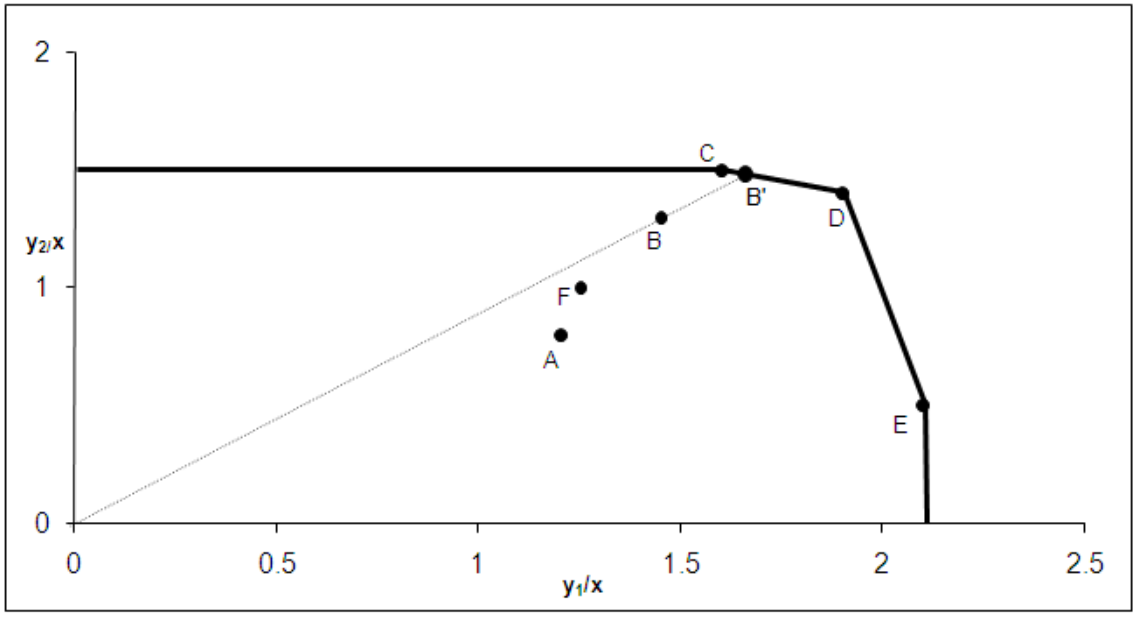


Figure 1: DEA Model for the Highway Patrol Process with a Single Input and Two Outputs

As can be understood, DEA is a relative efficiency calculation technique as efficient frontier is not absolute but determined by the data set under investigation (Ozbek, de la Garza et al. 2009; Ozbek, de la Garza et al. 2009). Furthermore, as will be discussed later in this proposal, DEA can deal with factors that are external to the process and that cannot be controlled by the decision-maker. This ensures that a fair comparison is made since such uncontrollable factors affect the performance of the units of comparison (Rouse 1997; Ramanathan 2003).

In conclusion, DEA is a methodology that is utilized to assess the overall efficiency performance of organizations in the presence of multiple performance measures in an effort to provide the managers of these organizations with a benchmarking tool to improve overall performance organization-wide (Ozbek, de la Garza et al. 2009). Therefore, DEA methodology is well suited to be adopted to address the needs of WHP with respect to the problem identified in the previous section.

Utilization of Data Envelopment Analysis for Performance Assessment of Police Forces

DEA has been utilized to facilitate benchmarking in many domains; and DEA literature has many examples of comparative performance assessment of hospitals, university academic units, K-12 schools, banks, non-profit organizations, airlines, and even soccer teams (Ozbek, de la Garza et al. 2010). More importantly, papers by Thanassoulis (Thanassoulis 1995), Shinn (Shinn 2002), and Nyhan and Martin (Nyhan and Martin 1999) show the application of DEA for performance assessment and improvement in police forces. Specifically, the study by Thanassoulis assesses and compares the overall performance of 41 police forces in England and Wales; the study by Shinn measures the relative efficiency of the 14 police precincts in Taipei city, Taiwan; and the study by Nyhan and Martin undertakes a comparative performance assessment of the 20 municipal police forces across the United States.

Study Objectives

The proposed research's overall objective is to develop a DEA-based multi-measure performance assessment system to address the need that was discussed earlier; i.e., the need to identify the overall performance of WHP's different divisions in the presence of multiple performance measures so as to enable WHP benchmark the performance of its divisions. This system will perform comparative performance assessment of the 18 divisions of WHP using data from a multi-year period and its results will enable benchmarking.

Study Benefits

The utilization of the abovementioned multi-measure performance assessment system will result in the identification of the best-performing (i.e., most efficient) divisions of WHP. These best-performing divisions can, then, be used as peers/benchmarks for the divisions that do not perform as good so as to help those divisions improve their performances. In other words, results of the proposed research will trigger decision-makers to identify the differences in formal structures, operational practices (managerial practices, field practices etc.), or other organizational factors of the divisions that may account for the observed efficiency differences; with the ultimate purpose of improving the performance of the divisions that perform at a lower level than their peers so as to ensure organization-wide performance improvement for WHP with respect to the performance measures outlined in its Balanced Scorecard (which includes items like safety, customer service, etc. as discussed earlier). Such organization-wide performance improvement will be the direct outcome of this project and will ultimately enable WHP to utilize its resources more efficiently and thus provide cost savings for the organization. While at this point (i.e., before full implementation), it is difficult to perform a cost/benefit analysis (as cost savings would be quantified in the long run), a follow-up study should be performed to do that

after giving WHP enough time to implement the results and thus clearly identify the organization-wide performance improvement.

Work Plan/Scope

This research will perform the following six tasks: (i) identify the variables (i.e., inputs and outputs) that will be used in the DEA models such as the manpower, number of fatal crashes, number of moving violation citations, etc., (ii) identify the uncontrollable factors that affect highway patrol performance (e.g., traffic volumes and climate), (iii) gather the data for the input-output variables and uncontrollable factors for 18 divisions for a multi-year period and prepare it for use in the models (iv) develop and run the appropriate DEA models, (v) analyze the results from the models and facilitate the benchmarking process and (vi) develop a final report documenting the research effort. These tasks are described in detail in the sections below.

Task 1: Identifying the Variables to be used in the DEA Models

This task calls for the identification of the input-output variables (representing the highway patrol operations) that will be used in the DEA models. These variables should carefully be selected from the performance measures that are outlined in WHP's Balanced Scorecard and should sufficiently represent resources (i.e., inputs) utilized by- and the performance (i.e., outputs) achieved as a result of- the highway patrol operations. This task will be accomplished by (i) performing a thorough literature review of the studies which utilized DEA for police operations to identify the common variables used in those studies and (ii) conducting interviews with the key decision-makers in WHP and utilization of multi-criteria decision-making tools such as Analytic Hierarchy Process to identify the measures that are deemed to be the most important to define the overall performance of highway patrol operations. While the ultimate purpose of this task is to identify one set of variables to be used in the DEA model that will define the overall performance of highway patrol operations, if desired, it is also possible to identify different sets of variables to be used in different DEA models, each of which can represent a different performance dimension. It is important to note that, as is typical in any modeling approach, this task will entail an iterative process to identify the set(s) of variables.

Task 2: Identifying the Uncontrollable Factors that affect Highway Patrol Performance

Within the DEA context, an uncontrollable factor (also referred to as non-discretionary, environmental, and exogenous factor in the DEA literature) is the factor that the DMU has no control or influence over. Nonetheless, it affects the performance of the process as it may affect the ability of a DMU adversely in performing its operations efficiently. Given their effects on the efficiency of the process that is investigated, all uncontrollable factors should be incorporated into DEA models (Golany and Roll 1993; Rouse, Putterill et al. 1997; Burley 2006).

There are many uncontrollable factors that can potentially affect the highway patrol operations such as the environmental factors (e.g., climate) and operational factors (e.g., traffic volumes). Disregarding such uncontrollable factors may lead to unfair comparisons in which the performance of a patrol division may look better than another just because the former is being executed in a highway portion that is easier to operate in due to its advantageous location as far as such uncontrollable factors are concerned. Therefore, the developed multi-measure performance assessment system needs to incorporate all of such factors into DEA models to provide leveled comparison for different WHP divisions trying to operate in highway sections facing different circumstances. Identification of the uncontrollable factors that affect WHP's performance will be accomplished by (i) performing a thorough literature review and conducting interviews with WHP and WYDOT staff to identify potential causal relationships between different uncontrollable factors and highway patrol operations and (ii) performing sensitivity and multiple statistical analyses to finalize the list of uncontrollable factors to be incorporated into the DEA models.

Task 3: Gathering and Preparing the Data

Once the input-output variables and uncontrollable factors to be used in the DEA models are identified, the data for those variables and factors will need to be gathered. Given that some of the variables (e.g., citations) may have confidential information which should not be accessible by the principal investigator, a portion of raw data will need to be provided to the principal investigator by WHP or its designee. This is already discussed with the project sponsor and agreed upon. The data will cover a multi-year period, the exact time frame to be determined with the feedback from the project sponsor once the project is underway. As in any data-intensive modeling approach, the raw data gathered for the input-output variables as well as the uncontrollable factors need to undergo a substantial amount of processing to prepare it to be used in the DEA models such as: (i) mining and cleaning to be able to obtain accurate records that can be used in the DEA models and (ii) conversion into the format suitable to be used in the DEA model.

Task 4: Developing and Running the Appropriate DEA Models

DEA literature provides numerous different approaches to modeling. Such approaches can be mainly grouped as (i) the models for DMUs experiencing constant returns to scale or the models for DMUs experiencing variable returns to scale, and (ii) input oriented models or output oriented models (Ozbek, de la Garza et al. 2009). This task will require the principal investigator to develop the most appropriate models to assess the performance of WHP's divisions. Once the development of the models is completed, such models will be run using the data finalized in Task 3. Given the heavy computation requirements of the DEA models, usually this phase is performed with the help of appropriate software that is specifically designed to solve DEA

formulations. Such software is available from a number of developers. With the progress of DEA within academia, variations to the original formulations have been developed. DEA software developers have followed this trend and kept pace with the academic developments by producing software that offers solution mechanisms to such advanced modeling formulations, graphical user interfaces, interoperability with other applications, and the ability to quickly solve DEA formulations with a larger number of DMUs in the data (Ozbek, de la Garza et al. 2009). After a thorough evaluation of the available software packages, the software which offers the best value will be selected and used to run the models developed by the principal investigator.

Task 5: Analyzing the Results from the Models and Facilitating the Benchmarking Process

As discussed earlier, the results of the DEA-based multi-measure performance assessment system will identify the efficient WHP divisions, quantify the inefficiency in each of the remaining divisions, and also identify inefficient divisions' peers. Furthermore, the results will identify the performance targets that inefficient divisions should aim for (e.g., with respect to number of moving violation citations, reduction in the number of fatal crashes) to improve their efficiencies in the future.

Even though DEA can identify inefficiencies, it does not directly pinpoint the underlying causes of inefficiencies of DMUs (Triantis 2005). Nevertheless, the results of the DEA models can be used to direct decision-makers' attention to developing a better understanding of the reasons why some WHP divisions are located on the efficient frontier and are thus efficient and why others are inefficient; and can guide managerial actions and policymaking. The overall objective of DEA is to assign organizational meaning to the observed efficiency differences and to determine the organizational changes that the inefficient DMUs will need to undertake and how to implement such changes. The common method used to reach such objective is utilizing the peer DMUs identified by the model (benchmarking) and describing and documenting the best practice processes of such DMUs that are located on the efficient frontier (Charnes, Cooper et al. 1994).

Given the abovementioned discussion, the results gathered from the models will be used for the benchmarking process to enable inefficient divisions learn from the best practices of the efficient ones. The principal investigator will conduct workshops with the attendance of the decision-makers from both inefficient and peer WHP divisions to facilitate this benchmarking process.

Task 6: Developing a Final Report Documenting the Research Effort

For this task, the principal investigator will synthesize and summarize the information acquired and results obtained in Tasks 1-5 and produce the final report. The principal investigator will prepare a clear and easy-to-read final report which documents all of the different tasks, key findings, and conclusions. This will allow the research effort to be replicated by the interested individuals in WYDOT and WHP, as well as other state DOTs and highway patrols across the nation if desired.

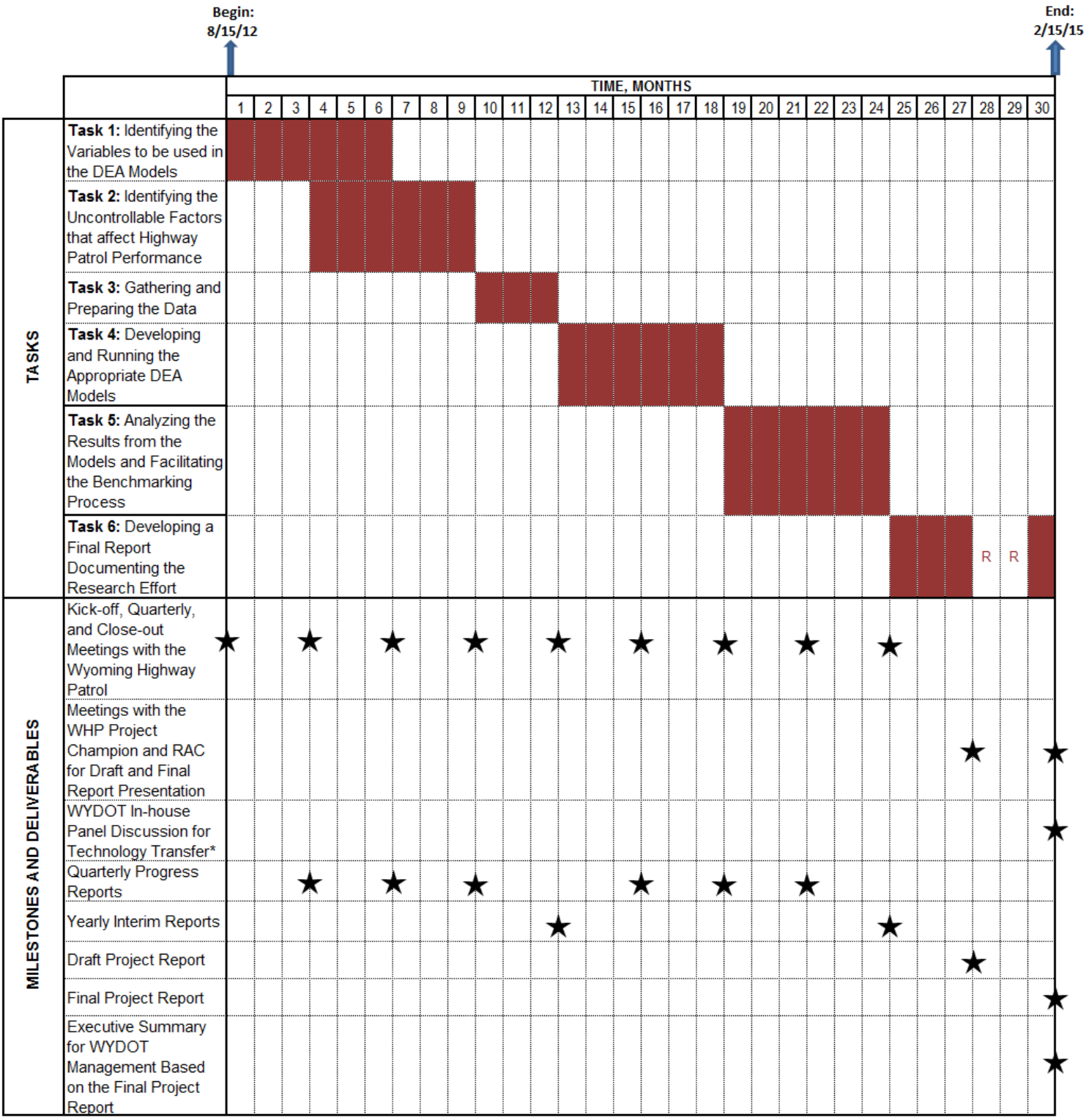
The main target of the final report will be the decision-makers in WHP. It may become intuitively difficult to explain DEA to the non-technical audience and/or decision-makers (Rouse 1997; Ramanathan 2003). Nevertheless, the principal investigator will use simple and easy to comprehend examples to introduce the concept and how it works as he has already done so in multiple meetings with WYDOT and WHP staff. By avoiding excessive technical terminology and with the help of visuals, the principal investigator will be able to convey the findings from the research. This way, the DEA-based multi-measure performance assessment system developed by this research can become transparent to the end-users. Once end-users realize that the performance assessment system they are using is not just a black box to which they provide data and from which they obtain results, they will be more willing to rely on and utilize the results and findings gathered from such system.

The principal investigator will submit a draft report to the WYDOT Research Advisory Committee (RAC) and the WHP project champion for review and approval. The research plan provides a 3-month period for review and revision of the draft report. The principal investigator will be available for a meeting with RAC and the WHP project champion to discuss the draft report. A presentation will be prepared for this meeting to effectively communicate the highlights of the report to RAC and the WHP project champion. The principal investigator will then make revisions to the draft report using the feedback to develop the final report and present that to RAC and the WHP project champion as well.

It is important to note that, in addition to the draft and the final report, quarterly progress reports will also be delivered in the format established by RAC.

Work Schedule

Figure 2 on the next page depicts the work schedule which includes (i) the tasks discussed in detail in the "Work Plan/Scope" section of this proposal and (ii) the milestones and deliverables. The meetings with WHP and the WYDOT in-house panel discussion are discussed in the "Implementation Process" and "Technology Transfer" sections of this proposal respectively.



R : Review of the Draft Report by the WHP Project Champion and RAC.

*** : In addition to this in-house panel discussion, dissemination for technology transfer purposes will include presentations in 2 conferences towards the end of the project as outlined in the "Technology Transfer" section of this proposal.**

Figure 2: Work Schedule

Cost Estimate

Table 1 presents the budget breaking down the total cost ($173,452) for this project. As indicated in Figure 2 (Work Schedule), the duration of the project is 2.5 years (30 months); however the majority of the research tasks will be completed by the end of the 2nd year, leaving the last 6 months mainly for the production of the draft report, WYDOT's review of the draft report, and production of the final report. Last 6 months will also include the other technology transfer activities as follows: 1 in-house panel discussion at WYDOT (with the attendance of different divisions of WYDOT) and 2 presentations in national conferences as outlined in the "Technology Transfer" section of this proposal. In Table 1, the column entitled "Year 3" shows the expenses to be incurred in the last 6 months of the project. The budget narrative explaining each line item is provided right below Table 1.

Table 1: Cost Estimate

	Year 1	Year 2	Year 3	Total
Personnel Salaries				
Dr. Mehmet Ozbek	$16,328	$25,472	$8,830	$50,630
Fringe	$3,919	$6,343	$2,230	$12,492
Graduate Research Assistant (TBD)	$16,944	$17,622	$0	$34,566
Fringe	$881	$969	$0	$1,850
Total Salary	$33,272	$43,094	$8,830	$85,196
Total Fringe	$4,800	$7,312	$2,230	$14,342
Total Personnel	**$38,072**	**$50,406**	**$11,060**	**$99,538**
In-state Tuition	**$8,392**	**$9,021**	**$0**	**$17,413**
Domestic Travel	**$200**	**$450**	**$4,150**	**$4,800**
Software	**$650**	**$0**	**$0**	**$650**
TOTAL DIRECT COSTS	**$47,314**	**$59,877**	**$15,210**	**$122,401**
FACILITIES & ADMINISTRATIVE (INDIRECT COSTS)	**$18,877**	**$24,767**	**$7,407**	**$51,051**
TOTAL	**$66,191**	**$84,644**	**$22,617**	**$173,452**

Personnel Salaries

- Dr. Mehmet Ozbek (the Principal Investigator) will allocate 2 months of his time in Year 1, 3 months of his time in Year 2, and 1 month of his time in Year 3 most of which will be used to generate the final report. His salary is $8,164/month in Year 1 and expected to be $8,491/month in Year 2, and $8,830/month in Year 3 assuming a 4% raise.
- One graduate research assistant (TBD) will be hired for 24 months at 0.5 Full-time Equivalent (FTE). Her/his salary will be $1,412/month in Year 1 and expected to be $1,469/month in Year 2 assuming a 4% raise.

Fringes

Table 2 shows the fringe rates for Dr. Mehmet Ozbek and the graduate research assistant during this project. In Table 2, the column entitled "Year 3" shows the fringe rates in the last 6 months of the project.

Table 2: Fringe Rates

	Year 1	Year 2	Year 3
Mehmet Ozbek	24.00%	24.90%	25.25%
Graduate Research Assistant	5.20%	5.50%	NA

In-state Tuition

The tuition request for the graduate research assistant is for 4 semesters during Year 1 and Year 2 of the project. The in-state tuition will be $4,196/semester for the first year and is expected to be $4,511/semester for the second year assuming a 7.5% increase.

Domestic Travel

- Over the course of the project, Dr. Mehmet Ozbek will have the following day trips to Cheyenne, WY with his personal vehicle. The reimbursement is based on 100 miles roundtrip at $0.50/mile for all of these trips as shown in Table 3 below. In Table 3, the column entitled "Year 3" shows the travel expenses to be incurred in the last 6 months of the project.

Table 3: Cheyenne, Wyoming Travel Summary

Purpose of Trip	Year 1	Year 2	Year 3
Meet with the Wyoming Highway Patrol (WHP) to provide quarterly project updates and discuss the progress to get feedback	$200 (4 trips)	$250 (5 trips)	
Conduct WHP benchmarking workshops		$200 (4 trips)	
Present the draft report to the WHP project champion and RAC			$50
Present the final report to the WHP project champion and RAC			$50
WYDOT in-house panel discussion for technology transfer purposes			$50
TOTALS	$200	$450	$150

In addition, the following travel expenses are requested for technology transfer purposes as outlined in the "Technology Transfer" section of this proposal:

- One trip to Washington, DC to present this research in the Transportation Research Board Annual Conference. $2,000 is allocated to this trip to include roundtrip airfare, accommodation, airport transfers, and per diem meals (Year 3)

- One trip to a location TBD to present this research in a highway safety-patrol related conference. $2,000 is allocated to this trip to include roundtrip airfare, accommodation, airport transfers, and per diem meals (Year 3)

Software

One license for Data Envelopment Analysis software (academic pricing) will be acquired to develop the models proposed in this research. One time license fee will be $650 (Year 1). WYDOT will be able to use the delivered software model ad infinitum as well as the full results from the research. WYDOT may also release the results of the research for peer exchange with other State DOT's, for the purpose of exchange of information and best practices. Colorado State University shall retain all rights to the software model used in this research project, and WYDOT will not, as part of awarding the subgrant or contract, obtain rights in the intellectual property for the "On-the-Shelf" software tool.

Facilities and Administrative (Indirect Costs)

Budgeted at 48.5% of Modified Total Direct Cost (MTDC) in Year 1 and 48.7% of MTDC in Year 2 and Year 3. Tuition is not included in the base amount for indirect costs.

Implementation Process

The decision-makers in WHP will take the leadership role in implementing the results of this research and immediately initiate benchmarking efforts within WHP to promote the identification and sharing of best practices among different WHP divisions. These benchmarking efforts will result in organization-wide performance improvement that WHP can clearly identify with respect to the performance measures outlined in its Balanced Scorecard (which includes items like safety, customer service, etc. as discussed earlier). As discussed earlier (under Task 5), the principal investigator will be instrumental in facilitating these benchmarking efforts through workshops. It is critical for the principal investigator to facilitate the benchmarking process to prevent the following potential barrier to implementation: Non-technical audience who does not have background in linear programming may not deem DEA as transparent and may find it difficult to comprehend its results (Rouse 1997; Ramanathan 2003). Nonetheless, this issue will be overcome by the principal investigator who is experienced in explaining the DEA process in simpler terms and by proper use of charts and tables to communicate the results. As mentioned earlier, the principal investigator has already explained the DEA concept and process to WYDOT and WHP staff in multiple meetings prior to the writing of this proposal and as a result was requested to propose this research (as WHP has understood the concept and shown an interest in sponsoring this research). It is important to note that even though the principal investigator will facilitate the benchmarking workshops, the leadership team of WHP will be

primarily responsible for organizing these workshops and promoting/assuring attendance by the division staff.

Another potential barrier to implementation is the "resistance to accept the results" problem. Some divisions (especially the ones that are found to be the least efficient as a result of this research) may feel that the comparative performance assessment system is developed just to compare divisions and point out the inferior ones; and then may try to question why the model identified them to be performing relatively inferior (or find excuses as to why they may be performing relatively inferior) as opposed to just accepting the results. This concern will be addressed both by the WHP leadership team and the principal investigator during benchmarking workshops by reassuring all divisions that the ultimate purpose of this research is to promote overall performance improvement in WHP by helping the divisions identified to be less efficient learn from the best practices of the divisions identified to be efficient. In other words, the results from the models (i.e., the efficiency score of each division) will only be used to identify the peers for the other divisions to be used for benchmarking and sharing of best practices; not to develop a "top 10" or "worst 10" type of list to offer rewards or penalties. All divisions will be informed that DEA-based performance assessment models enable "relative" comparisons; i.e., the fact that a division is ranked the last does not mean that such division is absolutely inefficient but rather has room for improvement as its peer divisions are performing better relative to such division. Divisions will also be informed that DEA-based performance assessment models have long been used in many organizations across the world to improve the performance of individual divisions of those organizations which ultimately assures overall performance improvement in the organization as a whole.

Another potential barrier is the "resistance to change" problem. Some divisions may be reluctant to adopt the best practices utilized by the efficient divisions on the premise of "we have always been doing business this way." This potential mentality, which is typical in organizations that have been in existence for a long time, will be addressed primarily by the WHP leadership team and also by the principal investigator during benchmarking workshops by reiterating that "there is always room for improvement, especially when your peers are doing better than you" and "this is your opportunity to learn from the best practices of those peers". After all, "what gets measured gets improved."

A final potential barrier could be the reluctance of better performing divisions to open up and share their best practices with other divisions. This potential barrier, while very unlikely to surface, can be detrimental to the success of this research. If it happens though, it will be addressed by the WHP leadership team by reminding all divisions that the overall performance of WHP as a whole depends on the individual performance of its divisions and thus it is crucial that divisions help each other by sharing best practices to improve the performance of WHP as a whole.

It is important to note that throughout the course of this research ,which is planned to take 2.5 years (30 months) as shown in the "Work Schedule" section, the principal investigator will attend quarterly patrol meetings (in addition to project kick-off and close-out meetings) to (i) keep all stakeholders informed of the progress that have been made and what is yet to be accomplished, (ii) to share the intermediate results which can potentially be used by WHP for some initial/intermediate benchmarking efforts and then for providing feedback to the principal investigator so as to help the principal investigator with the iterations of the model, (iii) to keep the stakeholders interested in the research and excited to learn the results and what is yet to come, and (iv) to build a rapport with all stakeholders so that when it is time to implement the results of this research and perform the actual benchmarking workshops towards the end of the research period, the potential barriers for implementation discussed above can more easily be addressed.

Technology Transfer

While the immediate audience and beneficiary of this research is WHP, the principles and modeling approach used in this research can be adopted by other divisions of WYDOT and possibly by other state DOTs and highway patrols across the nation. Therefore, it is imperative to transfer the knowledge to those potential users. While the technology transfer will primarily be accomplished by the comprehensive final report (as discussed under Task 6 in detail) which will allow the research effort to be replicated, some other possible options are:

- Holding an in-house panel discussion with the attendance of different divisions of WYDOT at the conclusion of this research.
- Disseminating information in two conferences towards the end of the project:
  - The most prominent international transportation conference, i.e., the Transportation Research Board (TRB) Annual Conference.
  - A conference with a focus on highway safety-patrol.
- Providing news releases.
- Providing a copy of the final research report to various state DOTs, specifically the ones that WYDOT has a working relationship with and participates in same programs such as the Mountain-Plains Consortium University Transportation Center.

Over time, it would be insightful to assess to what degree the implementation has been useful to WHP in improving the overall performance of its divisions (and thus organization as a whole). Therefore, a follow-up study using the DEA-based multi-measure performance assessment system developed by this research and plugging in the data for that future period would be very beneficial. With the knowledge transferred to WHP (through any of the means described above), WHP should be able perform such a follow-up study with minimal assistance, if not with no assistance at all.

Principal Investigator's Qualifications

The principal investigator for the prosed research, Dr. Mehmet E. Ozbek, holds a Ph.D. in Civil Engineering. He is an assistant professor and the graduate program coordinator at the Department of Construction Management at Colorado State University (CSU) where he teaches contracts- and sustainability- related courses and performs research related to performance assessment and improvement, infrastructure asset management, and project delivery. He has also been appointed as a visiting faculty for the summer session within the Civil, Environmental, and Architectural Engineering Department in the University of Colorado at Boulder twice. He has 10 years of experience in the transportation engineering domain.

He has been very active in both state DOT- and federally- funded transportation research. He had leading roles in a number of research projects funded by the Virginia Department of Transportation (VDOT). Such research projects not only involved providing continuous technical support to VDOT, but also generated valuable and applied research products that are now being utilized by VDOT as well as being considered by other state departments of transportation for possible implementation. Some of the findings/products of these research projects are cited in two NCHRP studies, "NCHRP Synthesis 389: Performance-based Contracting for Maintenance" and "NCHRP Project 20-24(61): Issues and Practices in Performance-based Maintenance and Operations Contracting." He also recently completed a research project for the Colorado Department of Transportation (CDOT). He was invited to present the results of this research in the 2012 TRB Annual Conference and also via a FHWA-sponsored webinar. The projects sponsored by VDOT and CDOT entailed developing performance measures and targets, performance assessment and improvement, benchmarking, comparative performance assessment, levels of service, data collection and analysis to assess performance, establishing QA/QC procedures to validate data, multi-criteria decision-making, and performance reporting.

As for the federally-funded transportation research projects, Dr. Ozbek worked in a National Science Foundation (NSF) project in which a DEA-based (i.e., the modeling approach which forms the backbone of this proposed research) framework was developed and implemented to perform multi-measure comparative performance assessment of VDOT's counties in maintaining the highways with the ultimate purpose of benchmarking (using a very similar approach to the approach proposed in this research). Most recently, he was awarded three research projects by the Mountain-Plains Consortium University Transportation Center[1].

[1] Mountain-Plains Consortium (MPC) is a competitively selected university program sponsored by the U.S. Department of Transportation through its Research and Innovative Technology Administration. (http://www.mountain-plains.org/about/)

Dr. Ozbek has published numerous articles related to performance assessment/improvement and the use of DEA in the transportation domain in journals such as TRB's Transportation Research Record journal, American Society of Civil Engineers (ASCE) Journal of Transportation Engineering, ASCE Journal of Infrastructure Systems, and ASCE special publication on Alternative Project Delivery, Procurement, and Contracting Methods for Highways. He serves as a peer reviewer for numerous journals as well as for TRB's Committee on Asset Management and Committee on Maintenance and Operations Management. He has been invited to present his research in the TRB Annual Conference numerous times. He serves in three national committees one of which is ASCE Transportation and Development Institute Infrastructure Systems Committee.

Dr. Ozbek's CV is included in Appendix A.

Equipment and Facilities

The equipment and facilities that are available to the principal investigator are presented in Appendix B.

References

Burley, H. T. (2006). Accounting for the Influence of the Environment in a Two-Stage Analysis- Public Hospitals. Productivity Analysis in the Service Sector with Data Envelopment Analysis. N. K. Avkiran. Ipswich**:** 181-192.

Charnes, A., W. W. Cooper, et al. (1994). Data envelopment analysis : theory, methodology, and applications. Boston, Kluwer Academic Publishers.

de la Garza, J. M., R. Groesbeck, et al. (2005). Evaluation of Alternative Approaches to Highway Maintenance- Proposal Submitted to the Virginia Department of Transportation, Virginia Polytechnic Institute and State University.

FHWA (2008). Transportation System Preservation Research, Development, and Implementation Roadmap. Washington, DC.

Golany, B. and Y. Roll (1993). "Some extensions of techniques to handle non-discretionary factors in data envelopment analysis." Journal of Productivity Analysis **4**(4): 419-432.

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Nyhan, R. C. and L. L. Martin (1999). "Assessing the Performance of Municipal Police Services Using Data Envelopment Analysis: An Exploratory Study." State & Local Government Review **31**(1): 18-30.

Ozbek, M. E. (2010). Performance Measurement and Improvement in the Construction Industry by Benchmarking. 1 st CSU CM Industry and Academia Research Symposium. Denver, CO.

Ozbek, M. E. and J. M. de la Garza (2011). A Multi-measure Performance Measurement Framework for Transportation Projects. 2nd International Conference on Transportation Construction Management. Orlando, FL.

Ozbek, M. E., J. M. de la Garza, et al. (2009). "Data Envelopment Analysis as a Decision Making Tool for the Transportation Professionals." ASCE Journal of Transportation Engineering **135**(11): 822-831.

Ozbek, M. E., J. M. de la Garza, et al. (2009). Development of a Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies using Data Envelopment Analysis. *Proceedings of the 12 th AASHTO/TRB Maintenance Management Conference , Transportation Research Circular E-C135*, Annapolis.

Ozbek, M. E., J. M. de la Garza, et al. (2010). Utilization of Data Envelopment Analysis as a Benchmarking Tool in the Construction Industry Construction Industry Institute 2010 Annual Conference. Orlando, FL.

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Rouse, P., M. Putterill, et al. (1997). Methodologies for the Treatment of Environmental Factors in DEA. Working Paper, The University of Auckland.

Shinn, S. (2002). "Measuring the relative efficiency of police precincts using data envelopment analysis." Socio-Economic Planning Sciences **36**(1): 51-71.

Silkman, R. H. (1986). Editor's Notes. Measuring Efficiency: An Assessment of Data Envelopment Analysis. R. H. Silkman. San Francisco, Jossey-Bass Publishers.

Thanassoulis, E. (1995). "Assessing police forces in England and Wales using data envelopment analysis." European Journal of Operational Research **87**(3): 641-657.

Triantis, K. (2005). Data Envelopment Analysis: An Evaluation of the Production Function. ISE 5144 Fall 2005 Class Notes. Virginia Polytechnic Institute and State University, Blacksburg.

WHP (2011). Wyoming Highway Patrol 2011-2013 Strategic Plan. Cheyenne.

Appendix A- CV of the Principal Investigator

CONTACT INFORMATION

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Colorado State University
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E-mail: Mehmet.Ozbek@colostate.edu
Web site: http://mycahs.colostate.edu/Mehmet.E.Ozbek/

EDUCATION

Doctor of Philosophy, Civil Engineering, December 2007
Vecellio Construction Engineering and Management Program
Virginia Tech, Blacksburg, Virginia
Dissertation: "*Development of a Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies using Data Envelopment Analysis*"

Master of Science, Civil Engineering, May 2004
Vecellio Construction Engineering and Management Program
Virginia Tech, Blacksburg, Virginia
Thesis: "*Development of Performance Warranties for Performance Based Road Maintenance Contracts*"

Bachelor of Science, Civil Engineering, January 2002
Construction Engineering and Management Track
Middle East Technical University, Ankara, Turkey

ACADEMIC POSITIONS

(August 2009-Present)	Assistant Professor and Graduate Program Coordinator, Department of Construction Management, Colorado State University
(June 2010)	Visiting Professor, Civil, Environmental, and Architectural Engineering Department, University of Colorado at Boulder
(June 2009)	Visiting Professor, Civil, Environmental, and Architectural Engineering Department, University of Colorado at Boulder
(August 2008-August 2009)	Assistant Professor, Department of Construction Management, Colorado State University
(December 2007-August 2008)	Postdoctoral Research Associate, Department of Civil and Environmental Engineering, Virginia Tech
(August 2002-December 2007)	Graduate Research Assistant, Department of Civil and Environmental Engineering, Virginia Tech

OTHER POSITIONS

(Summer 2001)	Estimator and Claims Analyst, VINSAN Headquarters, Ankara, Turkey
(Summer 2000)	Field Engineer, VINSAN, Infrastructure Project, Marmaris, Turkey
(Summer 1999)	Field Engineer, VINSAN, Infrastructure Project, Marmaris, Turkey

RESEARCH INTERESTS

- Infrastructure asset management
- Performance and productivity measurement-improvement
- Performance-based contracting
- Sustainable project delivery and management
- Construction contracts

REFEREED CHAPTERS IN BOOKS

Ozbek, M. E., and de la Garza, J. M. (2007). "Development of Performance Warranties for Performance-Based Road Maintenance Contracts." *Alternative Project Delivery, Procurement, and Contracting Methods for Highways*, K. R. Molenaar and G. Yakowenko, eds., American Society of Civil Engineers, Reston, 20-45.

REFEREED JOURNAL ARTICLES

Arensman, D.B. and **Ozbek, M. E.** (2012). "Building Information Modeling and Potential Legal Issues." *International Journal of Construction Education and Research* 8 (2), 146-156.

Ozbek, M. E. and de la Garza, J. M. (2011). "Comprehensive Evaluation of Virginia Department of Transportation's Experience with its First Performance-Based Road-Maintenance Contract." *ASCE Journal of Transportation Engineering* 137 (12), 845-854.

Ozbek, M. E., de la Garza, J. M., and Pinero, J. C. (2010). "Implementation of Level-of-Service Component for Performance-Based Road Maintenance Contracts." *Transportation Research Record* (2150), 1-9.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2010). "Data and Modeling Issues Faced during the Efficiency Measurement of Road Maintenance using Data Envelopment Analysis." *ASCE Journal of Infrastructure Systems* 16 (1), 21-30.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2010). "Efficiency Measurement of Bridge Maintenance using Data Envelopment Analysis." *ASCE Journal of Infrastructure Systems* 16 (1), 31-39.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2009). "Data Envelopment Analysis as a Decision-Making Tool for the Transportation Professionals." *ASCE Journal of Transportation Engineering* 135 (11), 822-831.

de la Garza, J. M., Pinero, J. C., and **Ozbek, M. E.** (2008). "Sampling Procedure for Performance-Based Road Maintenance Evaluations." *Transportation Research Record* (2044), 11-18.

REFEREED CONFERENCE PROCEEDINGS

Thompson, R.D. and **Ozbek, M. E.** (2012). "Utilization of a Co-location Office in conjunction with Integrated Project Delivery." *Proceedings of the Associated Schools of Construction 48th Annual International Conference*, April 11-14, Birmingham, UK.

Ozbek, M. E., Clevenger, C.M., and Fillion, A. C. (2012). "A Quantitative Decision-making Framework to Evaluate Environmental Commitment Tracking Systems for the Colorado Department of Transportation." *Proceedings of the 2012 TRB 91st Annual Conference*, January 22-26, Washington D.C.

Clevenger, C.M., **Ozbek, M.E.**, and Reaves, D. (2011). "Service-learning for Sustainable Construction." *Proceedings of the International Association for Research on Service-Learning and Community Engagement (IARSLCE) Conference*, November 2-4, Chicago, IL.

Ozbek, M. E., Fillion, A., and Prakash, S. (2011). "Construction Industry Institute (CII) Best Practices Course for Construction Management Programs." *Proceedings of the Associated Schools of Construction 47th Annual International Conference*, April 6-9, Omaha, NE.

Clevenger, C.M., **Ozbek, M.E.**, Glick, S., and Porter, D. (2010). "Integrating BIM into Construction Management Education." *Proceedings of the EcoBuild BIM-Related Academic Workshop*, pp S100-4.1- S100-4.8, December 7-9, Washington, D.C.

Ozbek, M. E. and Youssef, T. (2010). "Identification and Analysis of the Issues that might be Slowing the Adoption of Integrated Project Delivery: Perceptions of Construction Industry Participants." *Proceedings of the 6th International Conference on Innovation in Architecture, Engineering and Construction*, pp 755-764, June 9-11, State College, PA.

Ozbek, M. E., Youssef, T., and Prakash, S. (2010). "Synthesis and Taxonomy of Systems used to Generate Revenues to be used for Highway Construction and Maintenance." *Proceedings of the Associated Schools of Construction 46th Annual International Conference*, pp 637-646, April 7-10, Boston, MA.

Ozbek, M. E., de la Garza, J. M., and Pinero, J. C. (2010). "Implementation of the Level-of-Service Component of the Performance Measurement Framework for Performance-Based Road Maintenance Contracts." *Proceedings of the 2010 TRB 89th Annual Conference*, 17 pages, January 10-14, Washington D.C.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2009). "Development of a Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies using Data Envelopment Analysis." *Proceedings of the 12th AASHTO/TRB Maintenance Management Conference*, Transportation Research Circular E-C135, pp 19-31, July 19-23, Annapolis, MD.

de la Garza, J. M., Pinero, J. C., and **Ozbek, M. E.** (2009). "A Framework for Monitoring Performance-Based Road Maintenance." *Proceedings of the Associated Schools of Construction 45th Annual International Conference*, pp 433-441, April 1-4, Gainesville, FL.

de la Garza, J. M., Pinero, J. C., and **Ozbek, M. E.** (2008). "Sampling Procedure for Performance-Based Road Maintenance Evaluations." *Proceedings of the 2008 TRB 87th Annual Conference*, 15 pages, January 13-17, Washington D.C.

REFEREED AND INVITED PRESENTATIONS AND POSTERS AT NATIONAL AND INTERNATIONAL CONFERENCES, SYMPOSIA AND PROFESSIONAL MEETINGS

Clevenger, C.M. and **Ozbek, M.E.** (2012). Using Service-Learning as a Focus for Integrative Learning. *Colorado State University Institute for Learning and Teaching Summer Conference on Learning, Teaching, and Critical Thinking*, May 16, Fort Collins, CO. **(Invited Speaker)**

Ozbek, M. E. (2012). "A Multi-measure Performance Measurement Framework for Transportation Projects and Possible WYDOT Implementation." *Presentation for the Wyoming Department of Transportation*, January 27, Cheyenne, WY. (**Invited Speaker**)

Ozbek, M.E. and Clevenger, C.M. (2012). A Quantitative Decision-making Framework to Evaluate Environmental Commitment Tracking Systems for the Colorado Department of Transportation. *FHWA Volpe Center Eco-Logical Webinar Series*, January 12, Fort Collins, CO. **(Invited Speaker)**

Clevenger, C.M. and **Ozbek, M.E.** (2011). Evaluation of Environmental Commitment Tracking Systems for Use at CDOT. *Webcast for the Colorado Department of Transportation*, October 26, Fort Collins, CO. **(Invited Speaker)**

Ozbek, M. E. (2011). "A Multi-measure Performance Measurement Framework for Data-Driven Organizations." *Presentation for the Wyoming Highway Patrol*, October 12, Cheyenne, WY. **(Invited Speaker)**

Ozbek, M. E. (2011). "A Multi-measure Performance Measurement Framework for Transportation Projects." *Presentation for the Wyoming Department of Transportation*, May 5, Cheyenne, WY. **(Invited Speaker)**

Burrows, M., McLeod, D., Lewis, F., and **Ozbek, M. E.** (2011). "Involvement of Electrical Contractors in Integrated Project Delivery." *Annual Celebrate Undergraduate Research Showcase*, April 19, Fort Collins, CO. **(Presented by Undergraduate Advisees)**

Canterbury, J., Everson, C., **Ozbek, M. E.**, and Clevenger, C.M. (2011). "Applied Sustainable Project Delivery." *Annual Celebrate Undergraduate Research Showcase*, April 19, Fort Collins, CO. **(Presented by Undergraduate Advisees- Won Best Poster Awards in the General Category and Service-Learning Category)**

Ozbek, M. E. and de la Garza, J. M. (2011). "A Multi-measure Performance Measurement Framework for Transportation Projects." *2nd International Conference on Transportation Construction Management*, February 7-10, Orlando, FL.

Ozbek, M. E. (2010). "Performance Measurement and Improvement in the Construction Industry by Benchmarking." *1st CSU CM Industry and Academia Research Symposium*, November 4, Denver, CO. **(Invited Speaker)**

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2010). "Utilization of Data Envelopment Analysis as a Benchmarking Tool in the Construction Industry." *Construction Industry Institute 2010 Annual Conference*, August 3-5, Orlando, FL.

Ozbek, M. E. (2010). "Involvement of Electrical Contractors in Integrated Project Delivery." *ELECTRI International Foundation Board Meeting*, July 27-28, Chicago, IL. (**Invited Speaker**)

Ozbek, M. E., and de la Garza, J. M. (2010). "Contract Maintenance in Virginia: Virginia Department of Transportation's (VDOT) Experience with its First Performance-based Asset Management Contract." *37th Rocky Mountain Asphalt Conference, International Annual Flexible Pavement Research Symposium*, Feb 24, Denver, CO. (**Invited Speaker**)

Ozbek, M. E., and de la Garza, J. M. (2009). "A Comprehensive Evaluation of Virginia Department of Transportation's Experience with its First Interstate Asset Management Contract." *TRB's 8th National Conference on Transportation Asset Management*, October 19-22, Portland, OR.

Ozbek, M. E., and de la Garza, J. M. (2009). "Development of Performance Warranties for Performance-Based Road Maintenance Contracts." *1st International Conference on Transportation Construction Management*, February 9-12, Orlando, FL.

Ozbek, M. E. (2009). "A Comparative Efficiency Performance Measurement Framework for Transportation Decision-Makers." *2009 TRB 88th Annual Conference*, January 11-15, Washington D.C. (**Invited Speaker**)

Ozbek, M. E. (2008). "Development of a Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies using Data Envelopment Analysis." *2008 Construction Research Council Spring Meeting*, June 10, Chicago, IL.

de la Garza, J. M., Triantis, K., and **Ozbek, M. E.** (2008). "A Comprehensive Framework for the Efficiency Measurement of Road Maintenance." *2008 National Science Foundation CMMI Grantee Conference*, January 7-10, Knoxville, TN.

Ozbek, M. E., and de la Garza, J. M. (2007). "Development of Performance Warranties for Performance-Based Road Maintenance Contracts." *TRB's 7th National Conference on Transportation Asset Management*, November 6-8, New Orleans, LA.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2007). "A Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies." *TRB's 7th National Conference on Transportation Asset Management*, November 6-8, New Orleans, LA.

de la Garza, J. M., Pinero, J. C., and **Ozbek, M. E.** (2007). "Sampling Procedure for Performance-Based Road Maintenance Evaluations." *TRB's 7th National Conference on Transportation Asset Management*, November 6-8, New Orleans, LA.

de la Garza, J. M., Pinero, J. C., and **Ozbek, M. E.** (2007). "A Framework for Monitoring Performance-Based Road Maintenance." *TRB's 7th National Conference on Transportation Asset Management*, November 6-8, New Orleans, LA.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2007). "Efficiency Measurement of Road Maintenance." *Institute for Operations Research and the Management Sciences 2007 International Conference*, July 8-11, San Juan, PR.

Ozbek, M. E., de la Garza, J. M., and Triantis, K. (2007). "Efficiency Measurement of Road Maintenance." *10th European Workshop on Efficiency and Productivity Analysis*, June 27-30, Lille, France.

Ozbek, M. E. and de la Garza, J. M. (2007). "Development of a Comprehensive Efficiency Measurement Framework to Evaluate Different Approaches to Road Maintenance using Data Envelopment Analysis." *Graduate Student Assembly 23rd Annual Research Symposium and Exposition*, March 28, Virginia Tech, Blacksburg. **(Paul E. Torgersen Graduate Student Research Excellence Award Finalist)**

Ozbek, M. E. and de la Garza, J. M. (2006). "Development of Performance Warranties for Performance-Based Road Maintenance Contracts." *Graduate Student Assembly 22nd Annual Research Symposium and Exposition*, March 29, Virginia Tech, Blacksburg.

Burde, A., Pinero, J. C., **Ozbek, M. E.**, Prince, E., Fedrowitz, W., Gray, J., and de la Garza, J. M. (2006). "Highway Maintenance Monitoring Program." *Graduate Student Assembly 22nd Annual Research Symposium and Exposition*, March 29, Virginia Tech, Blacksburg.

Ozbek, M. E. and de la Garza, J. M. (2005). Development of Performance Warranties for Performance-Based Road Maintenance Contracts." *54th Virginia Transportation Conference*, October 26- 28, Roanoke, Virginia. **(Best Student Paper Award)**

TECHNICAL REPORTS

Clevenger, C.M. and **Ozbek, M.E.** (2011). Evaluation of Environmental Commitment Tracking Systems for Use at CDOT. *Technical Report submitted to the Colorado Department of Transportation*, September, Fort Collins, CO.

Ozbek, M.E. (2010). A Study of the Privatization of State-Chartered Workers' Compensation Funds. *Technical Report submitted to the Colorado Association of Mechanical and Plumbing Contractors*, April, Fort Collins, CO.

WHITE PAPERS

Guggemos, A., Plaut, J., Bergstrom, E., Gotthelf, H., Haney, J., and **Ozbek, M. E.** (2010). Greening Structural Steel Design, Fabrication, and Erection: A Case Study of the National Renewable Energy Laboratory Research Support Facilities Project. Fort Collins, CO.

RESOURCE GUIDE

The World Bank was granted copyright permission to use my M.S. Thesis entitled "Development of Performance Warranties for Performance Based Road Maintenance Contracts" in a resource guide it published. Bibliographical information of such is provided below:

Ozbek, M. E. (2006). "Development of Performance Warranties for Performance Based Road Maintenance Contracts." *Resource Guide: Performance-based Contracting for Preservation and Improvement of Road Assets*, N. Stankevich, N. Qureshi, and C. Queiroz., eds., The World Bank, Washington D.C.

GRANTS

2012-2014	PI for the project entitled "Assessing Existing Transportation Sustainability Rating Systems for use in Mountain-Plains Consortium States" funded by the Mountain-Plains Consortium University Transportation Center
2012-2014	PI for the project entitled "Understanding Public Perceptions of Different Revenue Generation Systems for Highway Construction and Maintenance" funded by the Mountain-Plains Consortium University Transportation Center
2012-2014	Co-PI for the project entitled "Quantifying Uncertainty in Nondestructive Bridge Inspection Methods for use in Performance-Based Inspection" funded by the Mountain-Plains Consortium University Transportation Center
2012	Co-PI for the project entitled "Building Social Sustainability Through Service-Learning" funded by the Bohemian Foundation Pharos Grant
2011	PI for the Institute of Teaching and Learning Service Learning Faculty Mini Grant entitled "Applied Sustainable Project Delivery"

(2010-2011) Co-PI for the project entitled "The Evaluation of Environmental Commitment Tracking Programs for Use at CDOT" funded by the Colorado Department of Transportation.

(2010-2011) PI for the Early Career Award project entitled "Involvement of Electrical Contractors in Integrated Project Delivery" funded by the NECA ELECTRI International Foundation.

2010 Co-PI for the training program entitled "Training CDOT's Center for Equal Opportunity Employees in a Simulated Bid Environment" funded by the Colorado Department of Transportation.

2010 PI for the project entitled "A Study of the Privatization of State-Chartered Workers' Compensation Funds" funded by the Associated General Contractors of Colorado, Colorado Association of Home Builders, Colorado Association of Mechanical and Plumbing Contractors, Denver Metro Chamber of Commerce, and Metro Denver Economic Development Corporation.

(2007-2008) Senior Personnel for the project entitled "A Comprehensive Framework for the Efficiency Measurement of Road Maintenance" funded by the National Science Foundation (Award # 0726789).

TEACHING INTERESTS

- Construction contract administration
- Infrastructure asset management
- Sustainable project delivery

PROFESSIONAL ACTIVITIES

- Member of the Editorial Board for ASCE Journal of Construction Engineering and Management
- Reviewer for ASCE Journal of Construction Engineering and Management
- Reviewer for ASCE Journal of Infrastructure Systems
- Reviewer for ASCE Journal of Management in Engineering
- Reviewer for ASC International Journal of Construction Education and Research
- Reviewer for Journal of Construction Management and Economics
- Reviewer for Transportation Research Board's Transportation Research Record Journal
- Reviewer for International Journal of Sustainable Transportation
- Reviewer for Journal of Advanced Transportation
- Reviewer for ASC Annual Conference Proceedings
- Reviewer for Transportation Research Board's Annual Conference Proceedings
- Reviewer for the 2nd International Conference on Transportation Construction Management Proceedings
- Reviewer for CII 2011 Annual Conference Poster Session
- Reviewer/panelist for the National Science Foundation

COMMITTEE MEMBERSHIP

- American Society of Civil Engineers Construction Institute Management Practices in Construction Committee
- American Society of Civil Engineers Transportation and Development Institute Infrastructure Systems Committee
- Construction Industry Institute Academic Committee
- Construction Management Association of America Colorado Chapter Student Chapter Committee
- Board Member for Three Birds, a non-profit organization whose mission is to improve education, energy use, and the environment through renewable energy initiatives at public schools in low-income communities
- Organizing Committee for the 1st CSU CM Industry and Academia Research Symposium
- Organizing Committee for the 2nd CSU CM Industry and Academia Research Symposium
- Colorado State University College of Applied Human Sciences Graduate Coordinators Committee
- Colorado State University College of Applied Human Sciences Information Technology Faculty Advisory Committee
- Colorado State University Department of Construction Management Graduate Education Committee, Chair
- Colorado State University Department of Construction Management Professional Advisory Development Board Research and Outreach Committee, Co-Chair (2009-2012)
- Colorado State University Department of Construction Management Curriculum Committee
- Colorado State University Department of Construction Management Communications Committee
- Colorado State University Department of Construction Management Appeals Committee (2008-2009)
- Colorado State University Department of Construction Management Faculty Search Committee (2009-2010)
- Colorado State University Department of Construction Management Web Site Development Task Force
- Colorado State University Department of Construction Management BIM Curriculum Development Task Force

STUDENT MENTORING AND OUTREACH

- Serving as the faculty advisor for the Construction Management Association of America (CMAA) Student Chapter at Colorado State University (CSU). Founded the CSU CMAA Student Chapter in November 2008 and currently serving as the faculty advisor.
- Appraiser in the "Construction Challenge", a competition between the teams formed by high school students. This national competition is aimed at providing a real-world experience to inspire youth to explore and pursue careers in the construction industry.
- Judge for Colorado State University's Celebrate Undergraduate Research and Creativity Showcase
- Appraiser for Associated General Contractors of CO Awards for Construction Excellence

- Mentored 2 undergraduate students to perform research for the funded research study entitled "Involvement of Electrical Contractors in Integrated Project Delivery" and put together a poster to be presented in the Celebrate Undergraduate Research and Creativity Showcase.
- Mentored 2 undergraduate students in putting together a poster about the "Applied Sustainable Project Delivery" course to be presented in the Celebrate Undergraduate Research and Creativity Showcase. They won 2 awards for their outstanding poster: High Honors in the general posters category and Highest Honors in the Service-Learning posters category.
- As a part of the Service-Learning Class that I offered, I participated in recruitment sessions for the Centennial High School students.
- Participated in the CM Undergraduate Recruitment Open House.

PROFESSIONAL AFFILIATIONS

- Associate Member, American Society of Civil Engineers, Construction Institute
- Construction Research Council
- Construction Management Association of America
- Associated Schools of Construction
- Chi Epsilon, the National Civil Engineering Honor Society

HONORS AND AWARDS

- Outstanding Young Alum Award, Virginia Tech, Myers-Lawson School of Construction (2012)
- Associated Schools of Construction Teaching Award (2012)
- NSF Proposal Writing Workshop Participation Award (2010)
- CII Annual Conference Participation Award (2010)
- ELECTRI Council Meeting Travel Award (2010)
- Colorado State University, the Institute for Learning and Teaching Service-Learning Scholar (2009)
- Outstanding Graduate Student Award, Virginia Tech, Myers-Lawson School of Construction (2007)
- Scholarship Award, Construction Management Association of America Foundation (2006)
- Best Student Paper Award, 54th Virginia Transportation Conference (2005)
- Chi Epsilon, the National Civil Engineering Honor Society (2005)
- Vecellio Fellowship, Virginia Tech (2004-2005)

PROFESSIONAL CERTIFICATES

- **Future Professoriate Graduate Certificate (2007)**: This certificate is awarded by Virginia Tech upon the completion of nine credit hours of course work and/or practicum in an effort to prepare future faculty and academic leaders by exposure to the concepts of transformation in higher education.
- **Human Research Protection Certificate (2009)**

Appendix B- Equipment and Facilities Available to the Principal Investigator

Equipment

The Department of Construction Management at Colorado State University (CSU) is provided information technology (IT) resources via the College of Applied Human Sciences. In addition to computer workstations with 100MB TCP/IP network access, Department is provided with unlimited storage space. The storage is located on an EMC CX3-20 Storage Area Network (SAN), with redundant FC-4 architecture. All data from the SAN are then replicated to a secondary, off-site SAN from which a tape backup copy is made. Specifically, the tape backup is performed daily to maintain any differential changes in data, and a full-backup of data is performed on a weekly basis. Data is then held for approximately three months as a part of the College's disaster recovery plan.

The CSU Computer Center and the Information Technology Services in the College of Applied Human Sciences offer assistance with computer hardware and IT access services, communications services, software, training seminars, and on-line consulting. The entire campus of CSU is connected via a redundant, fiber-optic connection as a part of the Front Range GigaPOP consortium. This consortium includes, but is not limited to, Colorado State University, the University of Wyoming, and the Poudre School District. Unlimited remote internet access is also provided to all faculty and graduate students.

Facilities

CSU is a land-grant institution and a Carnegie Doctoral/Research University-Extensive. CSU is ranked in the top tier national universities in the *U.S. News and World Report's* rankings of "America's Best Colleges and Universities." Annual research expenditures exceeded $300 million in FY10.

Dr. Mehmet Ozbek has ready access to all of the university facilities, including the system of libraries available in the State of Colorado. The University Libraries consist of the main library and two branch libraries throughout campus. The main library has holdings of over 2 million books, bound journals, and government documents and 300 public terminals to access specialized indexes, e-journals, and web-based sources. Over 500 subscription-based electronic resources and 8,000 journal subscriptions are available on site or by remote access. An interlibrary loan service with access to all other research universities in Colorado and nationwide research institutions is available for expedited delivery of materials not available at CSU.