

RESEARCH



Utah Department of Transportation - Research Division  
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# MEASURING THE BENEFITS OF TRANSPORTATION RESEARCH IN UTAH

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<p>16. Abstract</p> <p>It is important to measure the benefits of transportation research programs on a regular basis to determine if research budgets have been used effectively, and to maintain the support of management. The findings can better channel how future available funds are utilized. This study was initiated to estimate the benefits of UDOT's research projects over a three-year period, estimate a benefit-cost ratio for the program, and provide feedback on the management processes used by the research staff.</p> <p>The data gathered in this study indicate that the studies completed during the years 2006, 2007, and 2008 by the UDOT Research Program had an estimated benefit-cost ratio of 17. This included the results from 46 deliverables produced by 41 projects.</p> <p>The highest benefits were achieved by studies on big ticket items, such as highways, bridges, traffic control devices, and right-of-way. Safety related studies also show significant benefits.</p> <p>UDOT should continue to use innovative techniques to reduce the negative impacts of construction on the public. Initiatives such as Innovative Contracting Methods, Accelerated Bridge Construction (ABC), Access Management, and the use of Movable Barrier have been shown to have a high benefit. These benefits are in the form of reduced congestion, enhanced safety, and lower impacts to businesses.</p> <p>Some champions interviewed indicated that specific project findings need additional implementation effort. These initiatives need continued support by the Research Division over time to obtain full benefits from the project deliverables.</p>			
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## Introduction

Improvements to our transportation networks are crucial to the success of our economy, educational system, recreational endeavors, environmental initiatives and our general quality of life. Transportation research programs are a valuable national and local resource needed for our society to function in an effective manner. Innovative concepts have been developed over the years by governmental, academic, and private sector experts. Nearly every aspect of transportation has seen advancements that improve safety, increase efficiency, and enhance the cost effectiveness of transportation networks. The adoption of improved policies and bringing new technologies to the forefront creates extraordinary benefits for society, increasing both our productivity and standard of living.

The demands placed on transportation systems have increased dramatically. These demands are in the form of increased vehicle miles traveled, more heavy truck loading, higher operating costs, materials shortages, and impacts to the environment. Transportation professionals must continue to strive for improvements that address these important issues. The mission and goals of research programs are aimed at meeting these needs.

The benefits of transportation research should be evaluated on a routine basis. The results of these studies can be used to justify the expenditure of transportation funding and to determine the most appropriate use of the available budgets. It is crucial that transportation leaders dedicate resources in the form of personnel and funding to the most appropriate aspects and the most pressing issues facing our transportation systems.

An effective research program should strive toward focus and balance in a number of ways.

These include:

- Transportation Asset Aspects (pavements, bridges, safety, environmental, etc) - It is important for a research program to dedicate resources to all aspects of transportation. This is not to imply that resources should be dispersed equally. The appropriate distribution of funds should be based on the current needs of the area, as well as the importance of the aspect. For example, big ticket items such as pavements and bridges

should receive an appropriate portion of the research budget and emphasis. Also safety improvements must also be given a high priority.

- Problem Solving vs New Methods - An effective research program should maintain a balance between these two project types. Programs limited to problem solving tend to maintain the status quo, while too much reliance on innovative solutions fail to give existing technologies sufficient chance to succeed that may need only a minor adjustment. Implementing entirely new technologies too often can also be more costly compared to fine-tuning existing methods.
- Hard Research vs Soft Research vs Policy Research – Each of these types of research initiatives has been shown to produce very high benefit-cost ratios. Hard aspects of transportation receive large expenditures of the transportation budgets, and even modest improvements can be very beneficial. Soft research enterprises can result in significant improvements in reducing impacts to the environment, the traveling public, and businesses. Policy research is a crucial piece of any program, and can result in a high benefit for a small investment in program resources.
- National Initiatives vs Local Issues - Transportation Research is a crucial aspect of our society on both a national and local level. Transportation agencies must provide support for both of these levels in the form of funding and technical assistance. Studies performed on a national level provide enhancements that all regions of the country can use, and on transportation issues requiring consistency from one state to another. Research initiatives undertaken at the state and local levels generally deal with issues and problems unique to each region.
- Applied Research vs Basic Research – Most transportation research programs in the country dedicate a vast majority of the available resources to applied research. Basic research initiatives are left to academic institutions, the private sector, and specific governmental programs.

When evaluating the benefits of research, and how research funds are expended, these types of issues should be considered. The benefits resulting from each of these aspects of research should be used to fine-tune the research program to meet the needs of the organization and public in the best way possible. This study made an attempt to make recommendations with these issues in mind.

## **Study Objectives**

- 1- Estimate the benefits of major research projects and compare them with the costs to conduct the studies.
- 2- Determine which types of projects produce the highest benefit-cost ratios and which projects are more often unsuccessful or marginal.
- 3- Provide information on the management and support of research projects.
- 4- Make recommendations concerning the research program and the types of projects undertaken in the future.

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## Methodology

- 1- Form a Technical Advisory Committee (TAC) for the study made up of research managers, and others who are likely to use the findings.
- 2- Determine the project timeframe for evaluation and the Annual Work Programs that would be meaningful.
- 3- Compile a list of projects from the selected programs.
- 4- List each project title, key champion, project manager, project cost, and all deliverables received.
- 5- Meet with the key champion and others familiar with the research products, and outline a plan to obtain a good estimation of the study benefits and total costs.
- 6- Convert project benefits into a dollar value where possible. If this cannot be done the benefits will be listed as “Unknown”, and no benefits will be shown. The project costs will be included in the analysis even if no benefits can be determined.
- 7- Assign a grade to each project based on input from the champion.
- 8- Compile all data and calculate a benefit-cost ratio. This will be done for individual projects, the total three-year time period, and for each project type.
- 9- Make recommendations concerning the research program, project management procedures, and the UTRAC project selection process.

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## **Research Approach**

Information for this study was gathered by interviewing each project champion. Typically a project champion is involved throughout the study, and has the best knowledge of the project's successes and failures. A form (Figure A1) was completed for each study finished during the three-year period, and the project champion rated the various aspects of the study. Ratings were provided on the management of the study, a grade for the usefulness of the project, and an estimate of the benefits of the deliverables in dollars.

Some research initiatives are not fully implemented immediately after the project is completed. For this reason it was necessary to allow a period of time between the project completion and the assessment of the benefits of the deliverables. By allowing this time period, end users of the research products have had sufficient time to determine if the concept will really work as reported, and a better estimation of the benefits has emerged.

A literature search was also conducted to gather any information done by other agencies on the benefits of transportation research.

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## **Benefit Estimate Types and Methods**

The benefits of research enterprises can take many forms. For this reason it is difficult to compile and evaluate these contributions to the various aspects of our transportation programs and operations. Various types of benefits were gathered in the interviews to understand how the projects contributed to the transportation state-of-the-practice and knowledge.

### **Benefits as Cost Savings**

An estimate of the dollar value of the research projects was solicited from each champion. These included ways to make UDOT more efficient. They included methods resulting in a reduction in traffic accidents, injuries, and fatalities using crash cost data. Cost savings could also be an estimate of reduced congestion due to implementing a research tool or policy.

The financial benefits captured on the project form typically were entered and compiled as one of the following:

- Savings to UDOT operations (reduced manpower, improved assets, lower bids, etc)
- Benefits to the public (reduced congestion, improved safety, enhanced environment, etc)
- Zero financial benefits (no savings from the deliverables)
- Benefits are not known at this time; implementation continues; future benefits may be achieved, and are “to be determined” (TBD)

Steps were taken as part of the interview process to ensure that the benefit estimates used in the study remain conservative. The following three methods were employed to obtain benefit values that can be justified easily and logically:

- 1- Each champion was asked to provide minimum benefit values that could be supported with data and other analysis.
- 2- A percentage was used for some projects where only a portion of the total benefit of the initiative could be attributed to the research project. Other divisions or regions within UDOT contributed significantly to the effort separately from the research project.

- 3- Where a range was provided by the champion the lower end of the range was used in the analysis.

### Benefits as Improved Operations

Each research product was evaluated to determine the usefulness of the project findings. Each deliverable was given a grade corresponding to the following definition:

<u>Grade</u>	<u>Description</u>
A	Major impact- Enhanced operations (specification, standard, policy, method, etc.)
B	Significant impact- Improved operations
C	Contributed to state-of-the-practice
D	Unclear or contradicting findings- More study needed
E	Major tasks not completed- Objectives not met

In addition to compiling the benefits of each study, information was gathered to aid research managers in making improvements in the research process. This included feedback from project champions on how effective the research program provided funding, project management, technical support, and implementation activities.

## Literature Search

### Benefits of Research Projects in Utah- May 2000

A study similar to this project was undertaken in 2000. The UDOT research projects conducted in 1995, 1996, and 1997 were evaluated. A study of this type is recommended on a three to five year cycle to determine the current benefits and to consider any recommendations to improve the research program. The lessons learned from the previous study were incorporated into this project to enhance the research methods and results [1].

The basic results of the 2000 study are included in the appendix. Table A1 provides the benefit-cost ratios estimated in the study. A composite benefit-cost ratio of approximately 12 was estimated for the UDOT Research Program at that time. In addition to the composite value, benefit-cost estimates were calculated separately for Infrastructure (15), Operations (13), Administration (6), and Policy Research (5).

### Valuing the Benefits of Transportation Research: A Matrix Approach- Florida 2002

The results of this study indicate that there is no single method suited to evaluate projects across all proposed categories. Even within a single category different approaches may be appropriate depending on agency constraints and objectives [2].

This research team developed a matrix approach for categorizing projects as a means of determining the appropriate methods for calculating benefit. In addition to the well-established methods such as Benefit-Cost Analysis and Net Present Value, a Real Options Approach is recommended.

The authors believe that the Real Options Approach is capable of providing a better assessment of transportation research projects whenever there is an element of risk and uncertainty. Transportation research projects have the potential to produce enormous benefits, but they come with risk that actual benefits, costs, and other factors affecting implementation may differ greatly from those predicted.

The option approach enhances the decision-making process so that it does not consist merely of a choice whether to invest in a research project. It also consists of a management perspective that considers a range of possible decisions, with the potential value of each decision measured in terms of its option-creating value. The Real Options Approach is not only a way of estimating expected project benefits, but also is a way of thinking about research programs.

The matrix approach cannot be used to evaluate all project types and therefore should be used along with other methods only when appropriate. It may also be useful in creating an optimal research portfolio geared towards maximizing returns when annual research budgets fluctuate.

#### Communicating the Value of Transportation Research Guidebook- NCHRP 610, 2009

This guidebook is an excellent resource for research personnel and others participating in the implementation of an innovative practice. It provides strategies for communicating with research partners, stakeholders, and administrators. The guide lists concepts to aid in communicating with specific audiences, such as research program managers, legislators, policy makers, the media, and the public. It also includes case studies from government, academic, and private organizations [3].

The guide emphasizes the need to convey the value of any research initiative to maintain the support of management and to justify the expenditures of funding. This crucial step is needed for support of existing initiatives as well as investments in research in the future. The guide also promotes the need for illustrating the value of any research undertaking throughout the project. This will help to create buy-in by potential end-users and policy-makers, leading to enhanced planning, funding, conduct, and deliverables for the project.

Demonstrating research benefits should include facts that show that the deliverables are aimed at the right issue, they portray the right level of importance, and they are being implemented at the right time.

“Communicating value, or worth, is more than providing numbers, as in benefit-cost formulas.

Decision makers frequently assess value in terms of how they **perceive** the importance and worthiness of the research outcomes. The invisible, intangible perceptions they form and will remember can mean the difference between funding a transportation research program or cutting it.”

To obtain full benefits from any research product every potential user must be involved in the implementation process. This seems obvious but is overlooked by principal investigators and project managers more often than research officials would like to admit. The guide stresses that; “People can spend a lot of time figuring out exactly what to say without giving much consideration to who it should be said”. It is very important to identify your implementation targets and then research them so you fully understand your audience and how their key values and interests relate to your research.

“Successfully communicating the value of your research to a targeted audience requires tailoring your communication to resonate with its needs, interests, and backgrounds. Linking your research to tangible benefits for the audience will capture their attention. Members of your audience are more likely to listen to you if they can readily understand why and how the research is important to them.

Many modes are available for communicating your research story, such as websites, advertising, brochures, fact sheets, and reports. These are important to fully portray the value and benefits of the research products. Successful communication sends the right message in the right medium. It also uses the appropriate messenger to deliver the message to the proper audience.

The guide emphasizes that research benefits should be measured and presented in the proper context. The value of a research endeavor is not enough to understand the full benefit. For example, the use of cable barrier prevents nearly 100% of the head-on collisions along a corridor. But a better indication of benefit is that it saves 20 lives per year, which is about 5% of the total fatalities statewide. The use of appropriate context is crucial.

The following concepts are useful for applying context effectively:

- Link current data and messages to long-term trends.

- Interpret the data: Tell the audience what is at stake and what it means to neglect this problem.
- Define the problem so that audience influences and opportunities are apparent— connect the dots, both verbally and in illustrations.
- Focus on how effectively the community/state/nation is addressing this problem.
- Connect the problem to root causes, conditions, and trends with which people are familiar.

Source: FrameWorks Institute, “Framing Public Issues.”

Each customer of a research program has a different set of values. For this reason each end-user and stakeholder has a different way of evaluating the benefits of a research project. When calculating and demonstrating the benefits of research initiatives these different values systems should be considered. Table A2 provides a good research tool to prepare for communicating with the various customers of research projects.

## Projects and Deliverables Evaluated

This study compiled benefits and costs from forty-one research projects completed in 2006, 2007 and 2008 by the UDOT Research Program. These projects produced forty-six deliverables. A list of these projects is provided in Tables 1A, B and C below.

**Table 1A- 2006 Research Projects Evaluated**

Number	Deliverable	Report #	PIC #	PM
6A	Condition Analysis of Concrete Bridge Decks in Utah	UT-06.01		Hsiao
6B	Effect of Stay-In-Place Metal Forms on the Performance of Concrete Bridge Decks	UT-06.02		Hsiao
6C	Assessing the Economic Impacts of Transportation Improvement Projects	UT-06.03		Anderson
"	Assessing the Economic Impacts of Transportation Improvement Projects Exec Summary	UT-06.03a		"
6D	Highway Worker Visibility	UT-06.04	UT05.103	Anderson
6E	Development of an Index for Concrete Bridge Deck Management in Utah	UT-06.05		Hsiao
6F	UDOT Rock-fall Hazard Rating System: Final Report and User's Manual	UT-06.07	UT97.542	Leonard
6G	Assessing the Safety Benefits of Access Management Techniques	UT-06.08	AM05.003	Anderson
6H	Wildlife Connectivity Across Utah's Highways	UT-06.09		Page
6I	Utah Commercial Motor Vehicle WIM Data Analysis and Calibration Methodology	UT-06.10		Anderson
6J	Evaluation of Advance Warning Signal Installation: Phase I Final Report	UT-06.11		Lindsey
"	Evaluation of Advance Warning Signal Installation: Phase I Summary Presentation	UT-06.11a	"	"
6K	UDOT Wetland Functional Assessment Method (Part I)	UT-06.12 & 13	UT01.301	Leonard
"	UDOT Wetland Functional Assessment Method (Part II)	UT-06.12 & 13	"	"
"	UDOT Wetland Functional Assessment Method (Part III)	UT-06.12 & 13	"	"
6L	Good Roads Cost Less Executive Summary (2006 Study Update)	UT-06.15a	UT05.510	Wakil
6M	UDOT Data Almanac- Software and User's Manual	Manual	AM03.002	Anderson
6N	Video Detection of Pavement Cracking			Anderson

**Table 1B- 2007 Research Projects Evaluated**

Number	Deliverable	Report #	PIC #	PM
7A	Time-Dependent Effects from Monitoring of State St Bridge RFP Composite Retrofit	UT-07.01		Hsiao
7B	Time-Dependent Effects & Validation of Post-Tensioned Spliced Girders & Deck Joints	UT-07.02	TB02.001	Hsiao
7C	Assessment of Specific Gravity Test with Mud Balance-Grout in Ground Nail Installation	UT-07.04		Anderson
7D	A Prioritization Process for Access Management Implementation in Utah	UT-07.05		Anderson
"	A Prioritization Process for Access Management Implementation in Utah: Exec Summary	UT-07.05a	"	"
7E	Evaluation and Installation Guidelines for Utah Advanced Warning Signal Systems	UT-07.06		Hsiao
7F	A Safety Analysis of Fatigue and Drowsy Driving in the State of Utah	UT-07.07	UT06.603	Leonard
7G	The Effect of PG Grade Uniformity of Asphalt Binder on Pavement Performance	UT-07.08		Anderson
7H	Spatial and Temporal Analysis of Work Zone Crashes	UT-07.09		
7I	Influence on Bond Strength of Prior-to-Cast Corroded Reinforcing Steel	UT-07.11		Hsiao
7J	Rumble Strip Effectiveness on Utah's Highways			Lindsey

**Table 1C- 2008 Research Projects Evaluated**

Number	Deliverable	Report #	PIC #	PM
8A	Variable Speed Limit Signs Effects on Speed Variation in Work Zones	UT-08.01	AM07.006	Hsiao
8B	Evaluation of the Applicability of the IHSD Model to Safety Audits of Two-Lane Highways	UT-08.02	UT06.602	Anderson
8C	Evaluation of Advanced Warning Signal Installation, Phase II: Long-Term Monitoring	UT-08.04		Lindsey
8D	I-215: 4500 South Structure Project Lessons Learned	UT-08.06		Hsiao
8E	UDOT Wildlife and Domestic Animal Accident Toolkit	UT-08.07		Page
8F	Fish Passage at UDOT Culverts: Prioritization and Assessment	UT-08.08	UT06.901	Fazio
8G	Roadway Pavement Grinding Noise Study	UT-08.15	AM07.402	Wakil
8H	Effects of Initial Surface Treatments Timing on Chloride in Concrete Bridge Decks	UT-08.19		Hsiao
8I	Sensitivity of Half-Cell Potential Measurements to Properties of Concrete Bridge Decks	UT-08.21		Hsiao
8J	Crashes in the Vicinity of Major Crossroads	UT-08.25		Anderson
8K	NRCS Curve Number Calibration Using USGS Regression Equation	UT-08.26		Hsiao
8L	Analysis of the Hamburg Wheel Tracker to Predict Behavior Different Test Temperatures	UT-08.29	UT03.201	Anderson
8M	Evaluation of the UDOT Weather Operations/RWIS Program		AM05.004	Anderson
8N	Materials Characterization for the AASHTO 2002 Pavement Design Guide		UT03.203	Anderson
8O	Bridge Scour Measures		UT00.305	Hsiao
8P	Web-Based Pavement Condition and Traffic Data	User's Manual	AM03.002	Anderson
8Q	Calibration and Validation of I-15 VISSUM Model		UT06.507	Lindsey

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## **Project Findings**

Interviews with project champions were very successful in gathering information related to the value of UDOT research projects completed in 2006, 2007 and 2008. Information was also compiled related to the effectiveness of the current research processes and policies. This information is contained in Tables A3, A4 and A5.

### **Benefit-Cost Ratio**

The financial benefits of the projects were related to internal savings of project costs, longer lasting materials, lower cost to produce the same quality, reduced manpower needs, a reduction in accidents, a lower impact to the environment, and reduced delays to the traveling public.

**The total estimated benefits of the 46 deliverables was \$80.8 million.**

The contract related costs of the 41 projects was \$3.9 million. The cost of managing these projects is estimated at 17%, or \$663,000. Technical Advisory Committees provided oversight, data, information, deliverable reviews, and discussions in meetings. These activities resulted in a cost of about \$242,000 for the 41 projects. (Appendix- Table A6).

**The total cost of the 41 projects is estimated at \$4.81 million.**

The data gathered in this study indicate that the studies completed during the three-year period by the UDOT Research Program had an estimated benefit-cost ratio of 17. This benefit-cost ratio was calculated using benefit estimates from the champions of the projects, and the total costs to conduct the studies.

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**The estimated Benefit-Cost Ratio for 2006, 2007 and 2008 programs is 17.**

This indicates that for every dollar allocated for a research project, the program returns a benefit of about \$17.

**Benefits by Type**

The highest benefits were achieved by studies on big ticket items, such as highways, bridges, traffic control devices, and right-of-way. Safety related studies also show significant benefits.

The various types of research projects conducted were evaluated separately to obtain information on how successful each were in delivering benefits to the goals of the Department. The projects were classified into one of the following types: Infrastructure Related Research, Operations Related Research, or Policy Related Research.



The analysis resulted in the findings provided in Table 2 below.

**Table 2- Benefits by Project Type**

<b>Type</b>	<b>Number of Projects</b>	<b>Benefit \$ x 10<sup>6</sup></b>	<b>Percentage</b>	<b>Benefits x 10<sup>6</sup> Per Project</b>
Infrastructure	18	\$28.8	36%	\$1.6
Operations	16	\$38.5	47%	\$2.4
Policy	7	\$13.5	17%	\$1.9
Totals or Average	41	\$80.8	100%	\$2.0

Project Grade Scores

Each study was given a grade based on the definitions listed on the evaluation form. The following is a summary of the project grades gathered.

**Table 3- Project Grade Score Summary**

<b>Grade</b>	<b>Description</b>	<b>Total</b>
A	Major impact- Enhanced operations (spec, policy, method, etc.)	12
B	Significant impact- Improved operations	12
C	Contributed to state-of-the-art	7
D	Unclear or contradicting findings- More study needed	-0-
E	Major tasks not completed- Objectives not met	-0-

**This information indicates that the program has a grade point average of 3.2 on a 4.0 scale.**

UTRAC Process Feedback

A very important aspect of showing a benefit for the budget expended is to illustrate that the research projects undertaken represent to most pressing issues facing UDOT. The UTRAC

process, in particular the UTRAC Workshop, is the main way that the Research Program is channeled to focus on these issues.

This award winning process reliably aligns the available funding with the topics voted on by end-users, champions, and stakeholders. The research program developed by the UTRAC process, and a successful completion of the projects, provides an excellent contribution to the goals listed for the Department in the UDOT Final Four document.

Comments from the project champions indicate that the UTRAC process is very effective. When adequate deliverables are achieved through the projects funded, the program consistently solves problems facing UDOT staff or improves the way the department conducts business. The Research Division managers should continue to use and improve the UTRAC process.

### Project Management

Feedback from the champions and other stakeholders interviewed indicate that the research projects conducted by the UDOT Research Division have been managed in an acceptable manner. Many of these projects received excellent ratings. The work plans prepared represented the objectives outlined in the Problem Statement, and the work plans were approved by both the champion and Technical Advisory Committee members. Both Principal Investigators and Project Managers consistently received high ratings.

The quality of reports and other deliverables were rated adequate to high. The implementation effort both during the study and recommendations for implementation in the final report received high ratings. However, the author believes that more emphasis is needed on implementation of results. This process should be formalized with plans, milestones, funding and performance measures. An implementation meeting of the research staff should be held quarterly to discuss the progress on the adoption of research deliverables.

### Implementation Initiatives

Communicating innovative activities within UDOT and to their partners is very valuable. The Media Marketing Program can be a very important tool in illustrating the benefits of research initiatives. The program employs professional communication experts at two important levels between the researcher and the traveling public. Public relations personnel within UDOT and professionals within the media can greatly enhance the message that the research deliverable is of value. The Media Marketing Program in the past has delivered very useful information in powerful and useful forms. These include enhanced tools, news clips, slow-motion video, and high-level professional mediums. These activities build support from the traveling public, funding agencies and partners, and the Utah State Legislature.

The UDOT Research Division should utilize the “Exit Survey” form whenever possible to gather benefit information related to research projects and identify any unfinished implementation tasks. The full benefits of any research project may not be known at the end of the formal research project when the Exit Survey is generally completed. When appropriate the form should be sent to the champions and end users a second time. This may be as long as 12 to 18 months following the project completion.

#### Additional Implementation Tasks Recommended

As the champions of the research projects were interviewed a number of additional tasks needed to complete the implementation of some deliverables were identified. These tasks included adopting policies, design methods, and specifications by the Department. This will require actions by the Research Division to further promote the new concept, and additional work by UDOT managers and end users to achieve full implementation.

These projects are as follows:

##### *1- Development of an Index for Concrete Bridge Deck Management in Utah*

This project identified the factors that are needed to provide an estimate of remaining life of bridge decks. This is similar to an estimate given by insurance companies when estimating the life expectancy of people applying for life insurance (current age, health habits, etc). Factors such as design types, materials quality, climate, etc are used. The life estimate can be used to program funding, select rehabilitation strategies, and provide feedback to future designs.

## *2- Time-Dependant Effects from Monitoring of State Street Bridge RFP Composite Retrofit*

The results of this monitoring program need to be analyzed and documented. This will lead to a policy for the use of RFP composites on bridge retrofit projects.

## *3- Variable Speed Limit Signs Effects on Speed Variation in Work Zones*

Many construction zones around the state experience high speeds during working hours when lanes are closed, but don't allow appropriate running speeds when lanes are open and no work is being performed. This problem has resulted in needless congestion and crashes in the past. This study demonstrated both the positive and negative aspects of the available equipment to allow higher speeds during non-working hours in construction zones.

## *4- Evaluation of Applicability of the IHSD Model to Safety Audits of Two-Lane Highways*

An analysis of various test routes demonstrated the potential of this software and modeling method. Training for users in the Safety Division and Regions should be conducted, along with a policy and procedure on when and where the methodology should be used.

## *5- Materials Characterization for the Mechanistic-Empirical Design Guide*

The new M-E Pavement Design Guide is methodically being implemented at UDOT. The new method will change many aspects of transportation operations including laboratory testing, traffic data gathering, vehicle loading data, and how environmental information is used in a pavement design.

The following major activities have been initiated to move toward the use of the new M-E Pavement Design Guide:

- State-of-the art equipment has been acquired and calibrated
- Users of the software have been trained
- Traffic information has been gathered and input as needed
- Software input criteria unique to Utah has been recommended

The Research Program has contributed about 50% of the funding and effort needed to achieve the current level of implementation. Designers and managers have developed a plan to begin using the new method to design pavements in Utah and monitor the accuracy and

appropriateness of the designs over time. The Research Division should continue to play a role in this effort.

#### *6- Bridge Scour Countermeasures*

The findings of this project could be used to select methods and strategies to protect scour critical bridges around the state. An estimate of \$50,000 to \$100,000 savings per bridge could be achieved if the correct action and timing could be programmed.

## Conclusions

1. Highway research is a valuable and essential component in meeting the growing needs of our transportation systems. Studies have shown that research initiatives in the public, academic, and private sectors have improved the effectiveness, efficiency and safety for the traveling public.
2. **The analysis of the benefits from the 41 studies evaluated indicates that the UDOT Research Program had an estimated benefit-cost ratio of 17. The total estimated benefits of the 46 deliverables was \$80.8 million. The total cost of these projects from the 2006, 2007 and 2008 programs is estimated at \$4.81 million.**
3. The highest benefits were achieved by studies on big ticket items, such as highways, bridges, traffic control devices, and right-of-way. Safety related studies also show significant benefits.
4. The UTRAC process is effective in identifying topics related to the most pressing issues facing UDOT and its stakeholders. Overall the projects funded, effectively address the goals in the UDOT Final Four.
5. The Research Project Managers were successful in providing technical oversight and financial support for the studies. The management processes that they utilize are effective, and they generally operate as stated in the UDOT Research Manual of Instruction.
6. The Principal Investigators conducting the studies were consistently given high ratings by the champions interviewed.
7. The quality of reports and other deliverables were rated adequate to high. The implementation effort both during the study and recommendations for implementation in the final report both received high ratings. However, a number of the champions believe that more emphasis is needed on implementation of results.
8. A portion of the research budget and staff time should be dedicated to implementing the findings of successful studies.

## Recommendations

1. Research programs should be evaluated on a regular basis to understand which types of research endeavors are the most effective. Also it is important to determine if the right level of funding is being dedicated to each pressing issue.
2. The research projects with the highest potential to produce significant benefits are those conducted on the department's big ticket items. A portion of the research budget should be dedicated to studies on these transportation aspects.
3. A dedicated budget should also be allocated for safety related studies. A Safety Research Program may be considered to select the best topics, most knowledgeable investigators, dedicated champions, and implementation strategies.
4. Continue to use and improve the UTRAC process. Customers of the Research Program indicate that the process is a valuable tool.
5. The UDOT Research Division should utilize the "Exit Survey" form whenever possible to gather benefit information related to research projects. Create performance measures using the information acquired through the form.
6. UDOT should continue to use innovative techniques to reduce the negative impacts of construction on the public. Initiatives such as innovative contracting methods, Accelerated Bridge Construction (ABC), Access Management, and the use of movable barrier have been shown to have a high benefit. These benefits are in the form of reduced congestion, enhanced safety, and lower impacts to businesses. The Research Division has a major role in identifying these techniques, delivering them to UDOT experts, and aiding in their implementation.
7. Some champions interviewed indicated that the project deliverables needed additional implementation effort. A list of these has been provided for consideration by the Research Division on pages 14 and 15.
8. A formal process should be created to monitor the implementation of research findings. This process should include plans, milestones, funding and performance measures. An implementation meeting should be held quarterly to discuss the progress on the adoption of research deliverables.
9. The Media Marketing Program can be a very important tool in illustrating the benefits of research initiatives. This program has been shown to be of benefit to UDOT, as well as

the public, in the form of enhanced tools, news clips, slow-motion video, and high level professional mediums. These media events help to educate and build support from UDOT partners and stakeholders.

10. The research staff should increase the use of implementation tools such as the NCHRP Report 610, “Communicating the Value of Transportation Research Guidebook”. This guide lists concepts to aid in communicating with specific audiences, such as research program managers, legislators, policy makers, the media, and the public. It also includes case studies from government, academic, and private organizations.

## References

1. Anderson, Douglas I., “Benefits of Research Projects in Utah”, Utah Department of Transportation, Final Report, May 2000.
2. Concas, S., Reich, S., and Yelds, A., “Valuing the Benefits of Transportation Research: A Matrix Approach”, Center for Urban Transportation Research at the University of South Florida, Final Report BC353-24, September 2002.
3. NCHRP Report 610, 2009, “Communicating the Value of Transportation Research Guidebook”, Zmud, J., Paasche, J., Zmud, M., NuStats LLC, Lomax, T., Texas Transportation Institute, Schofer, J., Northwestern University, Meyer, J., Public Information Associates.
4. Strategic Direction & Performance Measures, UDOT Final Four Strategic Goals,
  - 1- Take Care of What We Have
  - 2- Make the System Work Better
  - 3- Improve Safety
  - 4- Increase Capacity

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Appendix A

Figure A1

**Research Project  
Benefit Assessment Form**

Champion Information

Name: \_\_\_\_\_  
Title: \_\_\_\_\_  
Email: \_\_\_\_\_  
Phone: \_\_\_\_\_  
Date of Assessment: \_\_\_\_\_

Project Information

Research Project Title \_\_\_\_\_  
Contract Number \_\_\_\_\_  
Principal Investigator \_\_\_\_\_  
Organization \_\_\_\_\_  
Date Began \_\_\_\_\_ Date Completed \_\_\_\_\_ Duration \_\_\_\_\_ months  
Contract Amount \$ \_\_\_\_\_ (including modifications)  
Which functional area does this research fall under? (May select more than one)

- |                         |                           |                |
|-------------------------|---------------------------|----------------|
| Construction            | Environmental             | Geotechnical   |
| Intelligent Trans       | Maintenance               | Planning       |
| Traffic Engineering/TOC | Roadway Design            | Safety         |
| Materials               | Structures                | Administration |
| Hydraulics              | Engineering Tech Services |                |

Objectives of the Study:

Deliverables and Primary Products:

## Project Quality

Please rate the following questions as: 5-very good, 4-good, 3-fair, 2-poor, 1-very poor

1-How well did the study meet the objectives listed in the Problem Statement? \_\_\_\_

2-What was the quality of the Work Plan prepared and approved by the TAC? \_\_\_\_

3-Were the appropriate divisions, regions, and stakeholders represented on the TAC? \_\_\_\_

4-How well did the Principal Investigator perform and meet your expectations? \_\_\_\_\_

5-How well did the Project Manager from the Research Division coordinate with other divisions and agencies, monitor TAC activities, and administer the project contract? \_\_\_\_\_

6-How well did the Research Division support the project with funding and other resources? \_\_\_\_

7-What was the quality of the reports and other deliverables? \_\_\_\_\_

8-Was implementation adequately addressed and anticipated during the study? \_\_\_\_

9-How well were implementation strategies defined and outlined in the final report? \_\_\_\_

10-How would you rate the chance for successful implementation of the study recommendations and products? \_\_\_\_

11-Was sufficient funding allocated for the study tasks? \_\_\_\_

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## **Benefits of the Project**

Please provide estimates of the cost benefits associated with the project in the categories listed in the table below. Cost estimates should be conservative in nature, and based on the best information available. They should include costs to the traveling public, UDOT and our transportation stakeholders.

(Note: For each assessed grade greater than a “C”, a written narrative explaining the benefits should be included.)

What grade would give this study? A, B, C, D or E (Grade each aspect of the project in the table below according to the following descriptions)

<u>Grade</u>	<u>Description</u>
A	Major impact- Revised operations (spec, policy, etc.)
B	Significant impact- Improved operations
C	Contributed to state-of-the-art
D	Unclear or contradicting findings- More study needed
E	Major tasks not completed- Objectives not met

Comments or suggestions: (Use additional sheets if needed)

Benefit Category	Grade
<p><b>Asset Management</b>  This project has contributed to the management of UDOT's assets.  Financial Benefit: \$ _____. (Could include savings related to <u>not</u> doing the wrong thing)  Explanation:</p>	
<p><b>User Impacts</b>  This project has reduced the impacts to the traveling public.  Financial Benefit: \$ _____. (Could include savings related to <u>not</u> doing the wrong thing)  Explanation:</p>	
<p><b>Safety</b>  This project has improved the safety of the traveling public, UDOT and/or contractor employees.  Financial Benefit: \$ _____. (Reduced property damage, injuries and fatalities)  Explanation:</p>	
<p><b>Quality of Life</b>  This project has improved the quality of life of residents and visitors to the state, including aesthetic beauty, convenience, comfort and security.  Financial Benefit: \$ _____.  Explanation:</p>	
<p><b>Environmental</b>  This project has improved the quality of the natural environment.  Financial Benefit: \$ _____.  Explanation:</p>	
<p><b>Level of Knowledge</b>  This project has expanded the level of knowledge in this research area.  Financial Benefit: \$ _____. (Could include savings related to <u>not</u> doing the wrong thing)  Explanation:</p>	
<p><b>Administration and Policy</b>  This project has provided for improved administrative, management and policy decisions.  Financial Benefit: \$ _____.  Explanation:</p>	
<p><b>Grade of Project Overall</b></p>	
<p><b>Total Financial Benefit</b></p>	<p>\$ _____.</p>

**Table A1**  
**Benefits of Research & Development Projects**  
**by Category**  
**(May 2000)**

<u>Category</u>	<u>Cost- \$k</u>	<u>Benefit-\$k</u>	<u>Benefit/Cost</u>
Infrastructure	\$482	\$7,270	15
Operations	\$297	\$3,815	13
Administration	\$31	\$200	6
Policy	\$164	\$800	5
<b>Total 3-Year</b>	<b>\$974</b>	<b>\$12,085</b>	<b>12</b>

Table A2

Key Audiences for Transportation Research

Audience	Potential Communication Objectives	Benefits of Communication
<b>Research Program Managers</b>	<ul style="list-style-type: none"> <li>-Ensure continued funding and support.</li> <li>-Communicate technical aspects of research.</li> <li>-Form partnerships for collaboration or coalitions.</li> </ul>	<ul style="list-style-type: none"> <li>-Increases acceptance of the research program across the field.</li> <li>-Increases the ability to leverage existing resources.</li> </ul>
<b>Congress, Legislators, and Staff</b>	<ul style="list-style-type: none"> <li>-Explain the significance of research.</li> <li>-Demonstrate benefits to constituency.</li> <li>-Link spending to research outcomes.</li> </ul>	<ul style="list-style-type: none"> <li>-Introduces legislation that benefits the field.</li> <li>-Increases the potential to gain governmental funding for research.</li> </ul>
<b>Policy Makers</b>	<ul style="list-style-type: none"> <li>-Document a real need for research.</li> <li>-Explain the benefits of the research or program.</li> <li>-Demonstrate the success of the program.</li> </ul>	<ul style="list-style-type: none"> <li>-Implements action recommended by the research.</li> <li>-Adopts new products and processes.</li> </ul>
<b>Media</b>	<ul style="list-style-type: none"> <li>-Publicize the need for research.</li> <li>-Publicize the benefits through success stories.</li> <li>-Reach a broad audience.</li> </ul>	<ul style="list-style-type: none"> <li>-Increases exposure for the program.</li> <li>-Puts research on public's "radar."</li> <li>-Highlights a need for change or benefits of a practice or product.</li> </ul>
<b>Public</b>	<ul style="list-style-type: none"> <li>-Explain research findings in non-technical terms.</li> <li>-Show the importance of research to daily life.</li> </ul>	<ul style="list-style-type: none"> <li>-Creates a better informed public.</li> <li>-Creates community-level support for initiatives.</li> </ul>

**Table A3- Benefits of 2006 Deliverables**

Number	Deliverable	Report Number	Grade	Benefit in Millions of Dollars
6A	Condition Analysis of Concrete Bridge Decks in Utah	UT-06.01	B	\$5
6B	Effect of Stay-In-Place Metal Forms on the Performance of Concrete Bridge Decks	UT-06.02	A	\$3
6C	Assessing the Economic Impacts of Transportation Improvement Projects	UT-06.03		-
"	Assessing the Economic Impacts of Transportation Improvement Projects Exec Summary	UT-06.03a	-	-
6D	Highway Worker Visibility	UT-06.04	B	\$3
6E	Development of an Index for Concrete Bridge Deck Management in Utah	UT-06.05	A	TBD
6F	UDOT Rock-fall Hazard Rating System: Final Report and User's Manual	UT-06.07	C	-0-
6G	Assessing the Safety Benefits of Access Management Techniques	UT-06.08	C	\$4.5
6H	Wildlife Connectivity Across Utah's Highways	UT-06.09	B	\$10
6I	Utah Commercial Motor Vehicle WIM Data Analysis and Calibration Methodology	UT-06.10	B	-0-
6J	Evaluation of Advance Warning Signal Installation: Phase I Final Report	UT-06.11	(Defer to 8C)	(Defer to 8C)
"	Evaluation of Advance Warning Signal Installation: Phase I Summary Presentation	UT-06.11a	-	-
6K	UDOT Wetland Functional Assessment Method (Part I)	UT-06.12	(Defer to Part 3)	(Defer to Part 3)
"	UDOT Wetland Functional Assessment Method (Part II)	UT-06.12	(Defer to Part 3)	(Defer to Part 3)
"	UDOT Wetland Functional Assessment Method (Part III)	UT-06.12	B	\$2
6L	Good Roads Cost Less Executive Summary (2006 Study Update)	UT-06.15a	A	\$0.25
6M	UDOT Data Almanac- Software and User's Manual	Manual	C	\$0.5
6N	Video Detection of Pavement Cracking	System	C	-0-

**Table A4- Benefits of 2007 Deliverables**

Number	Deliverable	Report Number	Grade	Benefit in Millions of Dollars
7A	Time-Dependent Effects from Monitoring of State St Bridge RFP Composite Retrofit	UT-07.01	B	TBD
7B	Time-Dependent Effects & Validation of Post-Tensioned Spliced Girders & Deck Joints	UT-07.02	-	TBD
7C	Assessment of Specific Gravity Test with Mud Balance-Grout in Ground Nail Installation	UT-07.04	B	-0-
7D	A Prioritization Process for Access Management Implementation in Utah	UT-07.05	-	-
"	A Prioritization Process for Access Management Implementation in Utah: Exec Summary	UT-07.05a	C	\$1.5
7E	Evaluation and Installation Guidelines for Utah Advanced Warning Signal Systems	UT-07.06	(Defer to 8C)	(Defer to 8C)
7F	A Safety Analysis of Fatigue and Drowsy Driving in the State of Utah	UT-07.07		
7G	The Effect of PG Grade Uniformity of Asphalt Binder on Pavement Performance	UT-07.08	A	\$1
7H	Spatial and Temporal Analysis of Work Zone Crashes	UT-07.09		
7I	Influence on Bond Strength of Prior-to-Cast Corroded Reinforcing Steel	UT-07.11	-	TBD
7J	Rumble Strip Effectiveness on Utah's Highways		A	\$3.5

**Table A5- Benefits of 2008 Deliverables**

Number	Deliverable	Report Number	Grade	Benefit in Millions of Dollars
8A	Variable Speed Limit Signs Effects on Speed Variation in Work Zones	UT-08.01	C	TBD
8B	Evaluation of the Applicability of the IHSD Model to Safety Audits of Two-Lane Highways	UT-08.02	B	\$3
8C	Evaluation of Advanced Warning Signal Installation, Phase II: Long-Term Monitoring	UT-08.04	B	TBD
8D	I-215: 4500 South Structure Project Lessons Learned	UT-08.06		
8E	UDOT Wildlife and Domestic Animal Accident Toolkit	UT-08.07	A	\$2
8F	Fish Passage at UDOT Culverts: Prioritization and Assessment	UT-08.08	A	\$3.5
8G	Roadway Pavement Grinding Noise Study	UT-08.15		
8H	Effects of Initial Surface Treatments Timing on Chloride in Concrete Bridge Decks	UT-08.19	A	\$14
8I	Sensitivity of Half-Cell Potential Measurements to Properties of Concrete Bridge Decks	UT-08.21	B	\$3
8J	Crashes in the Vicinity of Major Crossroads	UT-08.25	B	\$6
8K	NRCS Curve Number Calibration Using USGS Regression Equation	UT-08.26	B	\$0.05
8L	Analysis of the Hamburg Wheel Tracker to Predict Behavior Different Test Temperatures	UT-08.29	A	\$0.5
8M	Evaluation of the UDOT Weather Operations/RWIS Program		A	\$3
8N	Materials Characterization for the AASHTO 2002 Pavement Design Guide		A	TBD
8O	Bridge Scour Measures		C	TBD
8P	Web-Based Pavement Condition and Traffic Data	User's Manual	B	\$10
8Q	Calibration and Validation of I-15 VISSUM Model		A	TBD

**Table A6**

**Technical Advisory Committee Cost Estimate**

<b>TAC Members</b>	<b>Hourly rate plus loading</b>	<b>Number of meetings</b>	<b>Hours per meeting</b>	<b>Number of projects</b>	<b>Total TAC related costs</b>
8 members	\$60 per hour	6 meetings	2 hours	41 projects	\$236,000