

RESEARCH



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INVESTING IN UTAH TRANSPORTATION RESEARCH

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Submitted By:

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Champion Tribute: The author would like to extend a tribute to Denis D. Stuhff, UDOT Senior Hydraulics Engineer. Mr. Stuhff was a dedicated and enduring champion of Utah Research, an exceptional innovator, and a loyal personal friend. Denis was the champion of eight projects included in this study, and unfortunately much information related to these projects was lost upon his passing. He will be missed in many ways.

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16. Abstract <p>Measuring the benefits of transportation research investments is important to justify the expenditure of research funding and maintain the support of management. Understanding the benefits of research can better establish how future available funds are utilized and maximize how the funding is allocated.</p> <p>This study was initiated to estimate the benefits of UDOT's research projects over a four-year period, and estimate a benefit-cost ratio for the program. Benefit information gathered in this study indicate that the studies completed during the years 2009 through 2012 by the UDOT Research Program had an estimated benefit-cost ratio of 14. This included 76 deliverables produced by 66 projects.</p> <p>Projects were also assigned a grade based on the success of the project and the value of the deliverables. The four year program received a grade of 3.0 based on a 1 to 4 rating system. In addition ratings were compiled for the project managers, principal investigators, and the UTRAC Process used to select projects for funding. Recommendations were provided to aid UDOT research managers in improving the implementation of research deliverables and products.</p> <p>A process was developed and outlined for use by the UDOT Division of Research to gather benefit information related to research projects on an annual basis.</p>			
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Introduction

The continued success of our state and region is directly dependant on sustaining efficient and safe transportation systems. Transportation plays a vital role in moving people and goods, and ensuring that our local institutions thrive. Research programs are crucial elements in enhancing these systems and solving problems facing transportation stakeholders.

Transportation resources have decreased or remained stagnant resulting in further challenges. Engaging in research endeavors to boost efficiency is the best strategy for making transportation budgets and manpower go further.

Reviewing the benefits of transportation research on a routine basis allows engineers and managers to determine which research methods and investment types are the most effective. This aids transportation leaders to apply the limited research budgets in the most effective way. Funding can be dedicated to meet the strategic goals of agencies and address the state's most pressing interests.

Research initiatives by governmental, academic, and the private sector professionals have been undertaken over the years on nearly every aspect of transportation. Advancements have been introduced that have enhanced the safety, efficiency, and cost effectiveness of transportation networks. Innovation within these institutions must be continued to maintain our productivity and standard of living.

Utah faces a unique set of transportation related challenges that must be addressed to meet the short and long-term goals of the state:

- Utah's population is one of the fastest growing in the country. A variety of transportation systems and strategies must be used to accommodate the projected increase in vehicle-miles of travel, more heavy vehicles, and growing congestion.
- Utah's geological location is crucial to the transportation needs of the country. Known as the "Crossroads of the West" Utah supports some of the most critical connections from both East/West and North/South corridors.
- The state is made up of a combination of high density cities, sprawling suburbs, and vast regions of rural lands. UDOT has struggled with finding the correct strategies and funding levels to address the unique needs of each of these areas.
- A wide variety of geographical regions must be considered by the department, including towering mountainous areas, high open ranges, and low elevation deserts. Utah has the highest number of freeze-thaw cycles per year in North America. These factors must be considered when generating designs, maintenance strategies, and safety standards.
- Utah is blessed with unique but delicate environmental regions and species. Protection of these special assets must be considered in all aspects of every transportation initiative.
- Mining industry support, energy development, and national long-haul traffic are key aspects that impact Utah's transportation systems.
- Transportation budgets and manpower have been reduced or stagnated.

Assets must be dedicated in the form of funding, personnel, and policies to address these issues. UDOT research, innovative planning, and technology transfer are the best approaches to meeting these challenges. It is vital to meet these challenges in conjunction with UDOT division and region experts.

Study Objectives

- 1- Estimate the benefits of major research projects and compare them with the costs expended on the studies.
- 2- Determine which types of projects produce the highest benefit-cost ratios and which projects are more often unsuccessful or marginal.
- 3- Determine why some research findings do not reach full implementation, and recommend strategies to correct these issues.
- 4- Identify trends apparent over time by comparing the results with previous benefit-cost studies both for the general program and for the various types of projects.
- 5- Make recommendations concerning the research program and the types of projects undertaken in the future.
- 6- Provide information on the management and support of research projects including modifications in implementation strategies.
- 7- Recommend methods to evaluate the performance of principal investigators conducting research for UDOT.
- 8- Develop a program to track research benefits on an annual basis as a performance measure for the Research Division.

Tasks

- 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- Conduct a thorough literature search to determine how other agencies measure research benefits, promote implementation of deliverables, and evaluate those who conduct the research.
- 3- Modify the research approach of this study based on methods used by other agencies as needed and recommended by the TAC.
- 4- Determine the Annual Work Programs that would be meaningful in the analysis and should be included in the study.
- 5- Compile a list of projects for evaluation from the selected programs.
- 6- List each project title, key champion, project manager, project cost, and all deliverables received.
- 7- 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.
- 8- 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.
- 9- Assign a grade to each project based on input from the champion.
- 10- 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.
- 11- If implementation actions were unsuccessful on individual projects, gather information from the champions and end-users on how the deliverables could have been better utilized or promoted for use.
- 12- Identify and analyze any trends observed in the information by comparing the new project findings with the results of the studies done in previous years.

- 13- Propose improvements to the research program, project management procedures, and the UTRAC project selection process.
- 14- Make recommends concerning the research program including the types of research projects that are likely to produce significant benefits, topics to avoid, and implementation strategies for adoption.
- 15- Develop a process to evaluate the performance of principal investigators within the research program. This may include forms, questions, milestones, and other methods to determine if the goals of the work plan have been achieved as the project progresses.
- 16- Develop a process that can be used to measure research benefits on an annual basis. This will include procedures for use on both the project and program levels. The process will include tools such as :
 - a. Forms and surveys to gather research benefits as they are identified.
 - b. A matrix to apply to every project.
 - c. Questions that could lead to better projects.
 - d. Individuals responsible to complete each task.
 - e. The timeframe and interval that each task should be carried out.
- 17- Provide a detailed description of best practices identified for use in conducting benefit-cost projects of this type. This will be in a form for use by consultants that may be performing these studies in the future.

Research Approach

This study was initiated to estimate the benefits of UDOT's major research projects conducted during the years 2009 through 2012, and make comparisons with the costs expended to conduct the studies. In addition estimates are provided for the benefits of various types of projects, including those related to infrastructure, operations, administration, and policy research. A survey was distributed to project champions and end-users of the project deliverables. Follow-up interviews were used to aid in completion of the survey and to encourage project participation.

The assembling of research benefits, especially financial benefits, enables UDOT leaders to evaluate the Research Program in terms of "outcomes" as opposed to simple "output". It allows end-users of research deliverables to convey how these products enhance the way the traveler is benefited and how UDOT experts change the way they do business. The study findings provide an indication of the direct "worth" of research investments.

Some research initiatives are not fully implemented immediately after the project is completed. For this reason it is necessary to allow a period of time between the project completion and the assessment of the benefits derived from 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. This approach has worked well in past benefit-cost studies. For this project however, the gap between project completion and a benefits review did not result in optimum feedback and data gathering. Many project champions have retired, left UDOT, or changed positions resulting in low survey completion.

Benefit Measures and Ratings

The benefits of research enterprises can take many forms. For this reason it can be 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 surveys and interviews to understand how the projects contributed to the transportation state-of-the-practice and knowledge. A detailed summary of these benefit types is described in Appendix A.

Benefits in Terms of Dollars

An estimate of the dollar value of the research studies was solicited from the project champions. These included ways to make UDOT more efficient and effective.

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

- Enhanced infrastructure and assets (better designs, reduced construction costs, lower maintenance requirements, reduced materials costs, etc)
- Savings to UDOT operations (reduced manpower, lower bids, lower operational costs, more efficient equipment, etc)
- Benefits to the public (reduced congestion, improved safety, enhanced environment, etc)
- Benefits in the form of Institutional Knowledge (IK)
- Zero financial benefits 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:

- 1- Each champion was asked to provide minimum benefit values that they could be supported with data or 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 may have contributed significantly to the effort separately from the project.
- 3- Where a range was provided by the champion the lower end of the range was used in the calculations.

Benefits as a Portion of a Program

Research deliverables often result in improvements to a UDOT program. The benefits of the research findings may be estimated by assuming that the enhancements represent a “percentage” of the program budget.

Example: The use of new pile cap design may improve the foundation design methods by 1%. Using a three-year program budget of \$20M the estimated benefit of the research is \$200,000.

Research Benefits as a Percentage of an Initiative

On occasion a research project is conducted as part of a larger initiative. Research objectives and the resulting deliverables may be only a small percentage of a significant UDOT goal. This coordinated approach should be considered when estimating the benefits of a research project.

Forms and methods used to gather benefits of research projects should utilize these types of calculations to estimate and track research product value.

Example: The use of cable barrier may provide \$50 million in benefits over a ten-year period statewide. A research project aimed at determining where to place the barrier may contribute 10% to UDOT processes and policy on the issue and appropriate implementation of the concept. A \$5 million benefit could then be assigned to the research project.

Project Grades

Each research product was evaluated to estimate the usefulness of the project findings. Each deliverable was given a grade corresponding to the definitions listed in Table 1 below.

**Table 1
Grade Definitions**

Grade	Definition
A	Major impact: New or revised specifications, policy, methods, etc.
B	Significant impact: Improved operations, procedures or policies.
C	Contributed to state-of-the-practice or institutional knowledge
D	Unclear or contradicting findings: More study needed
E	Major tasks not completed: Objectives not met

Projects and Deliverables Evaluated

This study compiled benefits and costs from 66 research projects completed in 2009, 2010, 2011 and 2012 by the UDOT Research Program. These projects produced 76 deliverables. A list of the reports documenting the deliverables is provided in Tables 2A, 2B, 2C and 2D.

Table 2A
2009 Research Projects Evaluated

Number	Title	Report #
9A	Infrasound Avalanche Monitoring System	UT-09.01
9B	Truck Traffic Accuracy Study	UT-09.02
9C	Type III Micro Surfacing to Extend the Life of Old Concrete Pavement on I-70 in Region Four	UT-09.03
9D	Evaluation of Optimal Traffic Monitoring Station Spacing on Freeways	UT-09.05
9E	Seismic Retrofit Guidelines for Utah Highway Bridges	UT-09.06
9F	Economic Development Criteria and Project Prioritization	UT-09.07
9G	Seismic Vulnerability Assessment and Retrofit Recommendations for State Highway Bridges: Case Studies	UT-09.08
9H	Feasibility of Using High-Strength Steel and MMFX Rebar in Bridge Design	UT-09.09
9I	UDOT's Calibration of AASHTO's New Prestress Loss Design Equations	UT-09.10
9J	Implementation Requirements for the Mechanistic-Empirical Pavement Design Guide: Validation, Calibration, and Development of the MEPDG User's Guide	UT-09.11
9J(a)	Draft User's Guide for UDOT Mechanistic-Empirical Pavement Design	UT-09.11a
9K	Fish Passage at Utah Culverts	UT-09.12
9L	Liquefaction Mitigation in Silty Sands Using Stone Columns with Wick Drains	UT-09.13
9M	Investigation of Improvement of Deck Concrete Mix Design and Curing Practice	UT-09.14
9N	Constructability Evaluation of Two Geogrids at Tie Fork Rest Area on SR-6 in Region Three	UT-09.15
9O	In-Situ Culvert Rehabilitation: Synthesis Study and Field Evaluation	UT-09.16
9P	A-Jacks and Aquawrap Installations in Utah	UT-09.19
9Q	Slip Lined Culvert Retrofit and Fish Passage-Phase I	UT-09.20
9R	An Inspection, Assessment, and Database of UDOT MSE Walls	UT-09.21

Table 2B

2010 Research Projects Evaluated

Number	Title	Report #
10A	Evaluation of Movable Barrier in Construction Work Zones	UT-10.02
10B	Modeling and Analysis to Quantify MSE Wall Behavior and Performance	UT-10.03
10C	Repair of Concrete Girder Ends and Girder Collision Repair	UT-10.04
10D	Failure of Surface Courses Beneath Pavement Markings	UT-10.05
10E	LiDAR Technologies for Bridges	UT-10.06
10F	Using Falling-Weight Deflectometer Data for Network-Level Flexible Pavement Management	UT-10.07
10G	Development of Methods to Control Cold Temperature and Fatigue Cracking for Asphalt Mixtures	UT-10.08
10H	Shear Capacity of In-Service Prestressed Concrete Bridge Girders	UT-10.09
10I	Gilsonite as an Anti-Stripping Agent in Hot Mix Asphalt	UT-10.10
10J	Methods for Estimating Magnitude and Frequency of Peak Flows for Small Watersheds in Utah	UT-10.11
10K	Transportation Safety Data and Analysis	UT-10.12
10L	Development of a Decision Support Tool for Assessing Vulnerability of Transportation Networks	UT-10.13
10M	Laboratory Testing and Finite Element Modeling of Precast Bridge Deck Panel Transverse Connections	UT-10.14
10N	Passive Force Deflection Behavior for Abutments With MSE Confined Approach Fills	UT-10.15
10O	Laterally Loaded Pile Cap Connections	UT-10.16
10P	Lateral Pile Cap Load Tests with Gravel Backfill of Limited Width	UT-10.17
10Q	Dynamic Passive Pressure on Abutments and Pile Caps	UT-10.18
10R	Numerical Analysis of Dense Narrow Backfills for Increasing Lateral Passive Resistance	UT-10.19
10S	Assessing Corrosion of MSE Wall Reinforcement	UT-10.20
10T	Understanding the Economics of Transportation in Utah	UT-10.21
10U	Construction Machine Control Guidance Implementation Strategy	UT-10.22
10V	Variable Slope ABT® Trench Former® MD200 Drain on US-89, American Fork, Utah (Experimental Feature X(06)03))	UT-10.23

Table 2C

2011 Research Projects Evaluated

Number	Title	Report #
11A	Design, Analysis, and Seismic Performance of a Hypothetical Seismically Isolated Bridge on Legacy Highway	UT-11.01
11B	Culvert Roughness Elements for Native Utah Fish Passage: Phase I	UT-11.02
11C	Exploratory Study of Partial Isolation of Highway Bridges	UT-11.03
11D	Evaluation of the Effect of a Variable Advisory Speed System on Queue Mitigation in Work Zones	UT-11.04
11E	Automated Delay Estimation at Signalized Intersections: Phase I Concept & Algorithm Development	UT-11.05
11F	Field Evaluation of Asphalt Overlays on State Route 30 in Northern Utah	UT-11.06
11G	Recommended Protocol and Standards for Utility Data Submittals	UT-11.07
11H	GFRP Reinforced Lightweight Precast Bridge Deck Panels	UT-11.08
11I	Evaluation of an Independent CADD Platform for UDOT	UT-11.09
11J	Freeways to Fuel: A Baseline Study of Biofuel Feedstock Growth on Non-Traditional Agronomic Lands in Utah	UT-11.10
11K	Streamlined Research Project Selection and Reporting	UT-11.11
11L	Resource Matching for Research	UT-11.12
11M	Non-Destructive and Destructive Investigation of Aged-in-the-Field Carbon FRP-Wrapped Columns	UT-11.16
11N	Evaluation of Bridge Deck Seal Treatment for ABC Bridge Deck Using Precast Panels	UT-11.17
11O	Utah Historic Bridge Inventory	UT-11.18
11P	Evaluation of Utah Work Zone Practices	UT-11.19
11Q	Sustainable Long-Life Concrete Specifications	UT-11.20

Table 2D
2012 Research Projects Evaluated

Number	Title	Report #
12A	Strong Motion Instrumentation Plan for the Utah Department of Transportation	UT-12.01
12B	Health Monitoring of Precast Bridge Deck Panel Reinforced with Glass Fiber Reinforced Polymer (GFRP) Bars	UT-12.03
12C	Reduction In Wick Drain Effectiveness with Drain Spacing for Utah Silts and Clays	UT-12.04
12D	UDOT Diverging Diamond Interchange (DDI) Observations and Experience	UT-12.05
12E	Traffic & Safety Statewide Modeling and GIS Modeling	UT-12.06
12F	Determining Wildlife Use of Wildlife Crossing Structures under Different Scenarios	UT-12.07
12G	Evaluation and Development of Unmanned Aircraft (UAV) for DOT Needs	UT-12.08
12H	Culvert Roughness Elements for Native Utah Fish Passage: Phase II	UT-12.09
12I	Safety Impacts of Design Exceptions in Utah	UT-12.10
12J	Utah Winter Severity Index: Phase 1	UT-12.12
12K	Identifying characteristics of High-Risk Intersections for Pedestrians and Cyclists: A Case Study from Salt Lake County	UT-12.13
12L	Plan Recommendation for Traffic Sign Management	UT-12.14
12M	CPT Evaluation of Liquefaction Mitigation with Stone Columns in Interbedded Soils	UT-12.15
12N	Identifying a Profile for Non-Traditional Cycle Commuters	UT-12.16
12O	Raised Median Economic Impact Study	UT-12.17
12P	I-15 Reconstruction Long-Term Embankment Monitoring Study – Final Report	UT-12.18
12Q	Design and Evaluation of Expanded Polystyrene Geofoam Embankments for the I-15 Reconstruction Project, Salt Lake City, Utah	UT-12.19
12R	Estimation of Liquefaction-Induced Lateral Spread from Numerical Modeling and its Application	UT-12.20

Program Benefit-Cost Ratio

Utilizing the survey and interviews with project champions a dollar estimate was obtained of the value of the deliverables and products of the UDOT research projects completed from years 2009 through 2012.

A summary of the methods and calculations used are provided in the following sections. This analysis provides an indication of the worth or value of the deliverables relative to the investment dedicated through research funding and other resources.

Benefit Calculations:

✚ Benefits = Number x Value x Percentage

- Number of items increased, saved, avoided, etc
 - Facility life in years
 - Crash number/severity prevented
 - Person-hours saved
- Value of item
 - Annual cost of facility, crash costs, wages, etc
- Percent attributed to research project
 - Portion of initiative enhanced by the research project

The total estimated benefits of the 76 deliverables was \$68.02 million.

These benefits are shown in Appendix B in Tables B1, B2, B3 and B4.

Cost of Research Estimates:

✚ Cost = Contract amount + TAC costs + PM costs

(Note- Program cost estimates included all project costs even for projects where benefits could not be identified)

Contract amount

The contract amounts were obtained from the Annual Work Program documents for the years evaluated.

❖ **Program Contract Cost = \$3.462M**

Technical Advisory Committee (TAC) Investment

Technical Advisory Committees provided oversight, data, information, deliverable reviews, and discussions in meetings. It was assumed that an average TAC had eight members, met six times, and required three hours of time for each member including preparation. An hourly wage of \$40 with 50% overhead was assumed.

❖ **TAC Costs = 8 members x \$60 /hr x 3 hrs x 6 meetings x 66 projects = \$570,000**

Project Management (PM) Costs

Assume 20% of project contract

$$\text{❖ PM Costs} = 20\% \times \$3.462\text{M} = \underline{\$692,000}$$

The total cost of the 66 projects is estimated at \$4.724 million.

Benefit-Cost Ratio Calculations:

$$\text{✚ Benefit/Cost} = \underline{\underline{(\text{Number} \times \text{Value} \times \text{Percentage}) / (\text{Contract} + \text{TAC} + \text{PM costs})}}$$

$$\text{Benefit/Cost} = 68.02\text{M} / 4.724\text{M} = 14.4$$

The estimated Benefit-Cost Ratio for the Research Program from 2009 to 2012 is 14.

This benefit-cost estimate indicates that for every dollar invested on research projects results in a return of \$14 in transportation enhancements and advancements.

The benefits estimated in this study are considered to be somewhat lower than the actual values. This is due to the poor response from the surveys distributed to the project champions.

Only 42% (28) of the surveys were completed and returned. This is significantly lower than response levels in previous benefit-cost studies. Surveys were distributed on two additional occasions if they were not returned initially. Follow-up interviews, emails, and telephone conversations were used to promote response to the surveys.

This low response was due to a number of factors including:

- Excessive turnover within UDOT positions
- A large number of employee retirements
- Champions feel that they are too busy to respond
- No dollar benefits included in some completed surveys

A number of the champions completing surveys did not feel knowledgeable enough to include benefit estimates in the form of dollars and left that part of the survey blank. Of these, six projects were given an “A” grade, and four were given a “B” grade, but no dollar benefits were included. Meetings with these project champions were unsuccessful in resolving these inconsistencies.

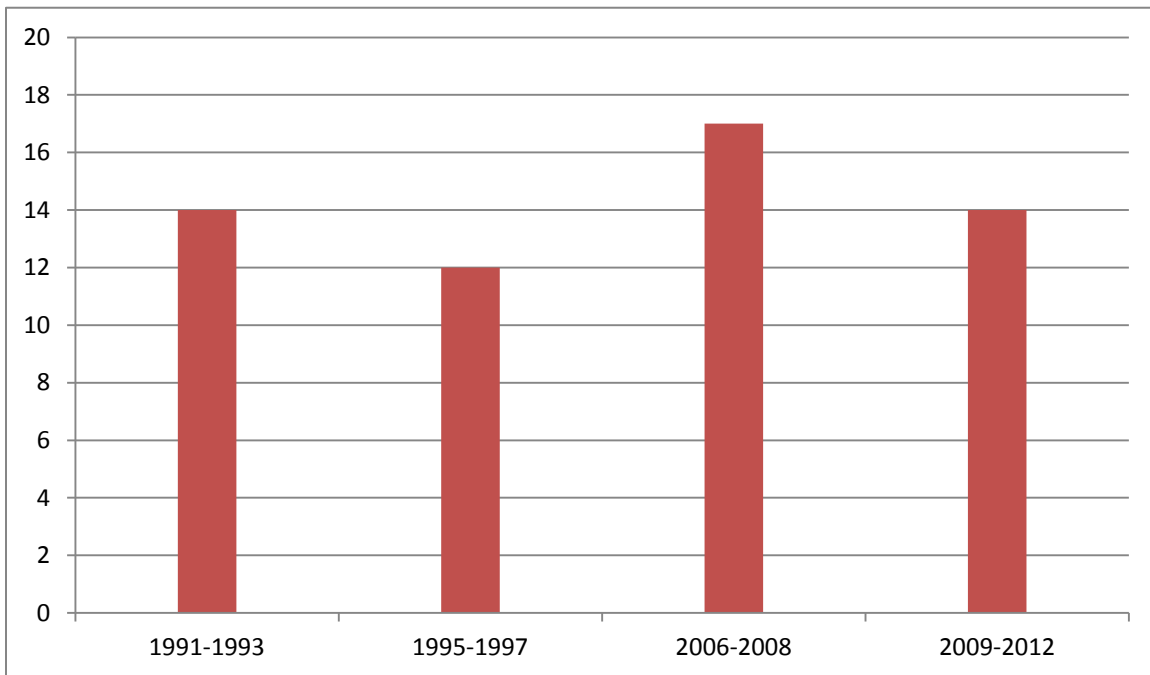
Trends in Benefit-Cost Ratio

The measured benefit-cost ratios from previous studies and this project were reviewed to determine what trend in the ratios might be observed if any. Table 3 and Figure 1 illustrate this information.

Table 3
Benefit-Cost Ratios from Previous Studies

Year Reported	Years Evaluated	Benefit/Cost Estimates	Number of Projects
1995	1991-1993	13-15	18
2000	1995-1997	12	22
2010	2006-2008	17	41
2016	2009-2012	14	66

Figure 1
Benefit-Cost Ratio Trend



Similar benefit-cost ratios were estimated for the four studies that have been completed over the last 20 years with values ranging from 12 to 17. No apparent trend can be observed over this time period. All four of these studies produced benefit/cost values that are considered to be conservative and on the low side. Again this is especially true for the value estimated from this study due to the low number of surveys returned.

Project Grade Scores

Each study was given a grade by the project champions based on the definitions listed previously in Table 1. This information is summarized in Tables 4 and 5 below.

Table 4
Project Grades

Grade	Number	Percentage of Surveys	Percentage of Projects
A	11	39%	17%
B	8	28%	12%
C	7	25%	11%
D	1	4%	1%
E	1	4%	1%

Table 5
Summary of Project Grades
By Functional Area

Functional Area	A	B	C	D	E	GPA
➤ Structures	1	2	2	0	0	2.8
➤ Geotechnical	6	1	4	1	0	3.0
➤ Safety/Traffic/ITS	1	4	0	0	0	3.2
➤ Construction	1	0	0	0	0	4.0
➤ Maintenance	0	0	0	0	0	-
➤ Materials/Pavements	1	1	0	0	0	3.5
➤ Hydraulics	0	0	0	0	0	-
➤ Environmental	1	0	0	0	1	2.0
➤ Planning/Asset Mgt	0	0	1	0	0	2.0
Total	11	8	7	1	1	3.0

An average score of 3.0 (on a 0 to 4 scale), or a ‘B’ grade was generated from the submitted surveys for the 66 projects evaluated.

Structures related projects (2.8), Geotechnical studies (3.0), and Safety deliverables (3.2) received good scores. The grade averages for the functional areas is obviously not useful where the number of surveys submitted is low.

Program Balance

It is important for the UDOT Research Program to engage in all areas of significance within the Department. Program balance should be evaluated on a regular basis to review the number of projects in each functional area. The program balance for the four years observed in this study is illustrated in Table 6.

Not all functional areas should necessarily be equally represented, but a conscious effort should be made to evaluate and rebalance the research program as needed. This information should be reviewed by key leaders in the department and feedback to research managers should be provided on this aspect of the research program.

The relative “success” of these functional areas should be considered when making decisions related to program balance. Leaders in the Division of Research may choose to increase the number of projects and/or project funding levels where feedback from end-users indicates that project deliverables have high benefits. This could be done through the UTRAC project selection process.

Table 6
Research Program Balance
(Example from previous study)
2009-2012

Functional Area	Number of Projects	Percent of Projects	Percent of Funding
➤ Structures	13	20%	26%
➤ Geotechnical	10	15%	21%
➤ ITS/Traffic/Safety	9	14%	11%
➤ Construction	7	11%	8%
➤ Maintenance	6	9%	1%
➤ Materials/Pavements	6	9%	11%
➤ Hydraulics	6	9%	7%
➤ Environmental	3	4%	9%
➤ Planning/Asset Management	6	9%	6%

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

- **High Value Transportation 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 emphasis 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 processes and programs.
- **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 national and local levels. 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, 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 ways possible.

Benefits Related to UDOT’s Vision, Mission and Strategic Goals

Not all benefits derived from the Research Program carry the same impact as defined by key leaders in the Department. UDOT administrators have identified areas of emphasis for UDOT that must in turn be emphasized within the Research Program. These strategic goals and key areas should be part of the research project selection process and impact significantly on the type of deliverables the projects produce.

UDOT’s *Vision- “Keep Utah Moving”*, and *Mission- “Innovating transportation solutions that strengthen Utah’s economy and enhance quality of life”*, are general in scope but are excellent overall guidelines for the Research Program direction. The Department’s *Strategic Goals, Emphasis Areas and Core Values* provide more focused topics for approval and funding of specific research projects.

Strategic Goals

- Zero Crashes, Injuries and Fatalities
- Optimize Mobility
- Preserve Infrastructure

Emphasis Areas

- Integrated Transportation
- Collaboration
- Education
- Transparency
- Quality

UDOT’s Core Values

- Innovation
- Passion
- Fiscal Responsibility
- Dedication
- Integrity
- Public Responsibility

It has been a strong tradition for many years, and followed well by current Research Managers, to ensure that these areas and topics are well represented in the Annual Research Work Program. The UTRAC Process and Workshop are structured to include these areas through selection of the breakout sessions and the subsequent funding procedures. Priority should be given to these targeted problem statements during the UTRAC selection and funding process.

Project Management Ratings and Adjustments

In addition to compiling the benefits of each study, information was gathered to aid research managers in making improvements in the oversight of research projects. This included feedback from project champions on how effective the research program provided funding, project management, technical support, and implementation activities. A 1 to 5 rating system was used.

Feedback from the champions and other stakeholders interviewed indicate that the research projects conducted by the UDOT Research Division have been conducted and managed in an acceptable manner. Many received excellent ratings. The champions rated the various aspects of the projects as shown in Table 7.

Project funding on most projects was rated as adequate. Both the principal investigators and project managers received good ratings overall. The work plans prepared adequately represented the objectives outlined in the Problem Statement, and the work plans approved by both the champion and Technical Advisory Committee members resulted in a successful project. The project time expended was generally acceptable. The TAC meetings and membership was rated from adequate to very good. The projects in general have been managed as outlined in the UDOT Research Manual of Instruction.

Table 7
Project Aspect Ratings

Project Aspect	Average Rating	Low	High
➤ Project Funding Level	4.7	3	5
➤ Principal Investigator	4.7	3	5
➤ Project Manager	4.6	3	5
➤ Work Plan	4.3	3	5
➤ Project Time Expended	4.3	3	5
➤ TAC Meetings/Members	4.1	3	5
➤ Project Met Objectives	4.1	2	5
➤ Overcoming Obstacles	4.1	2	5
➤ Final Report	3.9	1	5
➤ Chance for Success	3.8	1	5
➤ Implementation	3.4	1	5

The surveys indicated that there is room for improvement in some areas. A few projects were lacking in meeting the objectives, and some project teams did not overcome obstacles facing the project very well.

The quality of final reports and other deliverables were rated on a wide range from inadequate to high. Some reports fell short of what is needed to implement the project findings. This is reflected in the project's rating for "chance for success", which also was reflected in the full range from 1 to 5.

The implementation effectiveness both during the study and recommendations for implementation in the final report both received inconsistent ratings. This indicates that more emphasis is needed on implementation of results. This process should be formalized with plans, milestones, funding and performance measures. An implementation meeting should be held quarterly to discuss the progress on the adoption of research deliverables both during the study and after the deliverables have been produced.

A number of deliverables reviewed in this study showed a lack of implementation partly due to loss of a champion for the project. UDOT has experienced a great deal of turnover in positions throughout the department, a high number of experts retiring, and many leaving for the private sector.

The Division of Research staff should commit resources to aid in the implementation of a number of these deliverables. Many of the products appear to have significant value and could provide benefits to the department without an excessive outlay of labor and costs.

Principal Investigator Evaluation Process

It is the duty of a UDOT Research Project Manager (PM) to evaluate the effectiveness of each Principal Investigator (PI) that conducts projects within the research program. Project managers need methods to apply as on-going measures within the project schedule as the study progresses. The following issues are suggested for use in a process to undertake these evaluations:

Milestones

Obviously each project is different based on a variety of factors. It is recommended that more formal and detailed milestones be inserted into the contracts. Feedback at each of the established milestones should be provided to better identify any problems that are observed.

In general, few milestones may be appropriate if the project is straight-forward technically, the research approach is simple, and/or short in duration. More milestones should be imposed when the project is somewhat technical, complex in nature, and/or has a lengthy scope.

This process will facilitate more efficient and effective management of the projects, and provide better feedback to the PIs on steps that should be taken to further the project. In this way PIs can better judge how well they are performing as the project progresses.

Recognizing budget problems soon in the project schedule is crucial. The Technical Advisory Committee (TAC) should get involved to determine if scope creep or other issues are occurring and if appropriate actions are needed. If it is determined that a project needs to be terminated, good management techniques aid in minimizing the costs. The use of budget milestones will aid in identifying these issues in a timely manner.

Outcomes as an Indicator of Success

Project managers and TAC members must keep in mind what “success” means with respect to transportation research. Success rarely is completely achieved with the publication of a final report. Expectations beyond simply reporting on the project findings must be elevated to a higher level [1].

Successful research projects result in outcomes that significantly enhance the way people or goods are transported, or improve the way UDOT does business. Although scope, schedule and

budget are important factors in sound project management, achieving desired outcomes are by far the most important factor in evaluating the worth or value of a research project.

For this reason evaluation methods should be structured to place significant importance on if the project achieved the proposed outcomes outlined in the proposal and contract. Scope changes or budget increases can be acceptable (or at least tolerated) if the project results in substantial benefits.

Ratings Based on Useable Deliverables

Principal Investigators should be evaluated on the value of the deliverables that they produce. Achieving the desired outcomes is heavily reliant on insisting that useable deliverables are created during the project. Again it is very important to select deliverables from the list in Table 8 early in the project selection process, problem statement preparation, and contract approval.

A great idea generating a valuable problem statement is not sufficient to justify project approval and funding. Extending the project all the way to a valuable outcome is needed. The Research Project Evaluation Form should certainly include aspects such as scope, schedule and budget, but a higher influence should be placed on the value provided to the traveler and UDOT business areas. Implementation of useable deliverables is the prominent goal.

The sections of the Project Evaluation Form that rate the performance of the PIs should be heavily linked to the value of the deliverables, and if they were implemented.

Project Manager Feedback Process

In addition to evaluating Principal Investigator (PI) progress and quality, it is crucial for UDOT to measure their own performance through feedback methods to evaluate each Project Manager (PM). The three best ways to accomplish this are:

1. Survey the PIs on a regular basis to compile their comments and feedback
2. Hold an open forum from time to time where PIs can discuss their ideas related to project management
3. Conduct one-on-one sessions with key PIs and stakeholders to obtain feedback
4. Meet with contract oversight personnel at the universities and consulting firms to address contract language, invoicing issues, and problems with meeting completion dates.

Possible survey questions that could be included in survey to evaluate the project management process are included in Appendix E.

UTRAC Process Enhancements

The UTRAC process, in particular the UTRAC Workshop, is the main way that the Research Program is focused on the UDOT’s most pressing issues. Selection of the most appropriate topics for study is a very important aspect of obtaining optimum benefit for the budget expended.

The award winning UTRAC process reliably aligns the available funding with the topics voted on by end-users, managers and stakeholders. The research program developed through this process, and a successful completion of the projects, provides an excellent contribution to the objectives listed in the UDOT Strategic Goals and Areas of Emphasis.

The UTRAC Workshop has a strong history of providing the following:

- Appropriate problem statements submitted
- Effective project selection methods
- Excellent interaction and teambuilding between the governmental, academic, and private sectors in Utah

Preferred Project Products and Deliverables

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. Leaders in the Division of Research should continue to use and improve the UTRAC process.

The survey was utilized to obtain opinions from the project champions on the best products and deliverables for concept implementation. The deliverables listed in Table 8 were included in the survey.

**Table 8
Project Deliverables to Enhance Implementation**

➤ Training Session & Materials	➤ Executive Summary
➤ Policy & Procedures	➤ State-of-Practice Summary
➤ Specifications	➤ Experimental Feature
➤ Design Methods	➤ Peer Exchange
➤ Software	➤ Demonstration Project
➤ User’s Manual	➤ Laboratory Tests
➤ Workshop	➤ Performance Measures
➤ Scanning Tours & Workshops	➤ New Product Evaluation
➤ Web Page/Web Site	➤ Final and Interim Reports

The champion surveys ranked the research products and deliverables shown in Table 9 as the most valuable in attaining implementation of the project findings.

Table 9
Recommended Products and Deliverables

Ranking	Product/Deliverable	Champions Recommended
1	➤ Scanning Tours & Workshops	11
2	➤ New Product Evaluation	9
3	➤ Experimental Feature	8
4	➤ Final Report	8
5	➤ Training Sessions & Materials	7
6	➤ State-of-the-Practice Summaries	7
7	➤ Peer Exchanges	6
8	➤ Design Methods	6

The results of the survey indicate that champions believe that “hands on” types of products are the most effective in implementing the results of research projects.

The Division of Research should have a more prominent role in the evaluation and implementation of new products. The Division of Maintenance currently manages the New Products Evaluation Program. This change would ensure a more broad influence on many products that are not maintenance related.

Implementation Activities at UTRAC

The breakout sessions at the annual UTRAC Workshop are a vital venue for revisiting the implementation effort of completed research projects. Each of the six breakout sessions should allocate time to address the implementation plans for the top research products recently completed within that group.

The voting members of the breakout session may choose to allow an implementation plan for a previous project to compete for research funding against new projects. Another strategy would be to allocate two funding sources within each breakout session: A-New Projects, and B-Implementation Activities. Any funding not allocated for implementation activities would be used to fund additional new projects.

Ballot Changes to the UTRAC Process

The UTRAC voting process should be modified to reward projects that reflect the best chance for significant benefits to the department and highway users. The ballot process should give preference to problem statements that include deliverables that lend themselves to implementation of the findings (not just a report), have a clear plan on how the project will develop the deliverables, and provide an estimated benefit-cost ratio for the benefits vs. the project budget. The research contact for the breakout session must approve the logic, assumptions, and numbers used on the benefit-cost estimate used in the Problem Statement Form.

Revisions to Research Division Forms

The UDOT Research Division utilizes six forms during the concept review, project management, implementation of deliverables, and feedback phases of each project. These forms could be

modified to better include and track the project benefits and how they will be adopted within the Department.

Additions are proposed for each form listed as follows:

UTRAC Problem Statement Form

- This form should include a list of the deliverables that will be developed as part of the proposed project. Deliverables beyond a final report are preferred. A checklist should be included with the potential deliverables listed in Table 8.
- The form could be modified to be more specific to each of the six breakout session topics, and require a detailed description of how the project (if funded) would improve operations or reduce costs. A discussion should be required that outlines the specific benefits that will be achieved through the deliverables and how they will be implemented.
- An estimate of the benefit-cost ratio of the project should be included. The research contact for the breakout session must approve the logic, assumptions and numbers used on the benefit-cost estimate. This will require significant staff time, but should make a positive impact on producing a higher number and more valuable research products.
- UDOT experts that are eligible to vote should be instructed to give preference to problem statements that include deliverables that lend themselves to implementation of the findings (not just a report). Instructions on how to complete the form should include all of the rules associated with voting, and which aspects of the problem statement will receive higher weighting on the ballot.

Implementation Plan Form

- A section should be added that specifically identifies the benefits resulting from the project, and the financial value to the department that will be achieved.
- This plan is a crucial part of the research process. For the implementation plan to be effective it must be reviewed and updated throughout the research process.
 - A preliminary plan should be part of the UTRAC selection process
 - A more detailed update is needed during the contract development
 - A final plan should be developed at the end of the contract periodAs the plan is updated each version of the plan should be labeled in the title.
- Each TAC meeting should have an agenda item to review the existing plan and make any needed improvements. If funding is recommended for activities such as training sessions, user's manuals, or additional products the TAC should take actions to address this need. The Division of Research could utilize a dedicated line item in the Annual Work Program, or submit the issue to the appropriate breakout session at the UTRAC Workshop for funding.

Research Project Management Checklist

- Under the "Project Deliverables" task in this form (2.2.5) provide the same checklist of potential products and deliverables (Table 8) that could be developed as listed on the UTRAC Problem Statement Form. This allows for a more complete evaluation of the potential deliverables that could be incorporated in the project. The contract should include as many of these products as needed to allow for appropriate implementation of the initiative into UDOT's programs and processes.

Mid-Project Evaluation Form

- The review of an on-going project should include a more detailed evaluation of progress made on the implementation plan. Specific milestones should be evaluated at this point in the project. Special attention should be given to the progress made on the products and deliverables included in the contract. This form should have a list of the deliverables included in the contract and a description of how each product has been completed to this point.

Research Assessment and Implementation Report

- This report should emphasize the benefits of the project in terms of deliverables achieved, improvements to UDOT's programs, and provide an estimate of a benefit-cost ratio for the project.

Research Project Evaluation Form

- Add a section to the form that will provide an estimate of the monetary value of the project deliverables. Briefly describe how these values can be obtained and who should be contacted to determine/verify the estimates.
- The information should be supplied by one of the following stakeholders:
 - Project Champion
 - A key TAC member
 - A Region Director that has or will use the results
 - A Division Head who has or will use the results
- The dollar amounts listed should be conservative. Ranges may be recommended where clear estimates are not yet known.
- Place a higher emphasis on evaluating the "outcomes" of the project and less on aspects such as scope, schedule and budget. Conducting the project in compliance with UDOT guidelines is important, but implementation of the end products is by far the most essential issue.

Implementation Strategies to Optimize Benefits

The importance of implementation to a research program cannot be overstated. Achieving all of the steps needed to realize buy-in by end-users is often difficult. Research conferences and national initiatives have been devoted to break down the barriers to implementation for many years.

Experts conducting the research often feel that their responsibility is completed when the final report is published. Also relationships between UDOT staff and the project principal investigators (university professors and professionals in consulting firms) are casual at best. One of the most important byproducts of the annual UTRAC Workshop is the strengthening of these relationships between UDOT, the private sector, and academia.

It is imperative to utilize a variety of implementation methods to ensure that the end products of the research are applied into UDOT operations. Implementation tracking applications such as forms and matrixes are beneficial tools for use in establishing implementation tasks, tracking strategy progress, and measuring the value of each product to the target users.

Each project is unique and selecting the appropriate products and deliverables to aid in moving the concept into practice is essential. Each of the products and deliverables listed in Table 8 should be considered to enhance the implementation process.

Often more than one of these tools is needed to facilitate the implementation of the research initiative. It is important to obtain the opinions and feedback from all stakeholders in the process. This should include the champion, TAC members, division and regional key managers, end users, the research project manager, and technology transfer experts.

Budgeting and Planning for Implementation Initiatives

Funding for implementation activities should be included as part of the research project contract when possible. Under instances when it is not practical or appropriate to fund work such as training sessions, user's manuals, formal specifications, administrative rules, etc., funding may be included under a part 2 of the project, or other available funding.

A thorough plan to achieve implementation enhances the chance for success. A clear vision of what deliverables will be produced is essential. The following questions should be answered at all phases of a research project:

- 1- What implementation related deliverables will be created?
- 2- What tasks will be needed to achieve implementation?
- 3- Who will be the key personnel during the implementation activities?
- 4- What funding and other resources will be needed for implementation?
- 5- Will products such as training sessions, user's manuals, software, demonstrations, improved equipment, modified policies, revised specifications, new testing methods, or performance measures be needed?
- 6- What is the estimated benefit-cost ratio for each product proposed? Overall project?

Adoption of more efficient and innovative practices should be a basic underlying philosophy of the entire Department not just within the Research Program and staff. Reviewing new ideas and processes in a significant investment in resources for the Department, but this commitment by UDOT management has been shown to help the organization work smarter and more efficiently.

Matrix to Track Implementation by Project Phase

An understanding of the implementation potential of a research project and how it will be achieved should be addressed in all project phases. These phases include the problem statement, work plan, at TAC meetings, in progress and final reports, and within the project products themselves.

A high emphasis must be placed on the concept of continuous implementation planning to accomplish this goal. Every phase of a research undertaking should have a link to how the products and outcomes of the project will be used. The matrix illustrated in Table 10 aids in task monitoring and allows for the project stakeholders to track required investments, estimated benefits, and a projected benefit-cost ratio for the applications.

Table 10 - Matrix to Track Implementation Tasks and Product Value by Project Phase

Project Phase	Activities	Personnel	Estimated Investment	Estimated Value	Projected Benefit/Cost
A- Problem Statement	-Required at the UTRAC Workshop -Deliverables & products identified	PI & reviewer	Initial cost estimate	Benefits in dollars	Rough estimate
B- Work Plan & Contract	-Major aspect of Work Plan -More detail on deliverables -List manuals, training, etc.	PI, PM & TAC members	Project cost	Benefits in dollars & other	Refined estimate
C- TAC Meetings	-Ideal time to plan with end-users -Implementation on every TAC agenda	All stakeholders	Track expenditures	Benefits in dollars & other	Refined estimate
D- Progress Reports	-Implementation section required in Progress Report	All stakeholders	Track expenditures	Revised benefits	Refined estimate
E- Final Report	-Major section in Final Report -Plan with detailed tasks -Revisit products (manuals, training sessions, feedback data, etc)	All stakeholders	Total investment estimate	Detailed benefits in dollars	Calculated estimate for project
F- Deliverables & Products	-Each deliverable is provided with implementation plan & budget	All stakeholders	Investment for each product	Estimate value of each	Calculated estimate for deliverable

Technology Transfer Benefit/Cost

Implementing innovative concepts from other agencies and industries carries a very high benefit-cost value. Initiatives such as literature searches, state-of-the-practice studies, scanning tours, experimental features, and new product evaluations can provide successful improvements with very modest investments.

Benefits can be achieved by unsuccessful research. This is dreaded by every research stakeholder but it will invariably happen. Processes should be in place to deal with research that does not meet expectations, and reporting of unsuccessful research should not be avoided. It is the responsibility of researchers from all aspects of the work to learn from negative research findings. Benefits may be achieved through acquiring knowledge that leads to avoiding inferior or expensive actions.

Region and Division Visits

It is valuable for UDOT Division of Research personnel to have a basic understanding of the problems and challenges facing the UDOT engineers and managers. The best way to accomplish this goal is to visit with the region and division personnel on a regular basis.

Region and division visits are important to maintain a practical relationship with the operational aspects of the department. This activity will improve the number and quality of the problem statements submitted to the UTRAC Workshop and increase the number of special requests submitted for processing.

Planned region visits are needed including visits to staff meetings and videoconferencing sessions when appropriate. The division staff meeting is an excellent way to obtain feedback on problems and the needs of UDOT experts. Winter months are especially constructive for meetings since workloads may be lower and the UTRAC Workshop is a few months away. Participation in the workshop should be encouraged. These visits can be used to align UDOT professionals with university and private sector experts to gain the strengths of all three sectors, uniting them in addressing problems and improving efficiency.

Policy as a Tool for Implementation

The implementation of new and innovative deliverables can be greatly promoted through the use of policies. The use of policy to further the use of new design techniques, specifications, testing methods, and new products has not been fully utilized by UDOT managers and leaders.

Policies may be used by the organization on the centralized or decentralized levels. Decisions related to the use of some research deliverables are best left to region personnel while others should be made at the department level. Training sessions, the use of software, the adoption of user's manuals, and other implementation tools should be reviewed and formally promoted by the department at a high level.

Patents and Spin-off Companies

The UDOT Division of Research should, when appropriate, participate with the private sector in the creation of patents through new product enhancement. Public funds and other resources cannot be used to aid in the development of products, but should assist companies in evaluating if new products or ideas are viable. There is definitely some grey area in this relationship, but many new products cannot be properly investigated or evaluated without involvement by experts in transportation agencies.

An example of this cooperation is the use of Temporary Markers. These markers provide delineation on newly surfaced pavements such as aggregate seals and flush coats where traditional pavement markings cannot be placed until curing has occurred. UDOT was instrumental in showing the advantages of Temporary Markers in approving safety to both the traveler and UDOT workers. They also save money by eliminating crews to measure and mark

where the new lines are to be placed. Temporary Markers have been used all over the world for more than 20 years.

New Products Evaluation

Surveys received from the research project managers indicate that the Division of Research should have a greater role in the evaluation of new products that are submitted to the department for consideration. Oversight of this program was formerly managed by the research staff, but was transferred to the Division of Maintenance a few years ago.

UDOT key leaders should consider moving the New Products Evaluation Program to the Division of Research once again, or as a minimum involve research personnel in the process. This would give the assessment of new products a more broad and formal forum for evaluation. New products should receive one or more of the following recommendations:

- The product meets current standards
- The product should be rejected
- A literature search should be conducted
- It should be used in a field test section
- A scanning tour should be funded

Additional Uses for Benefit-Cost Information

UDOT Program and Project Decisions: Reverse Engineering

Information related to the benefits and costs of transportation initiatives can be used in the decision-making process for UDOT programs. Although both the benefits and costs of research projects may not directly align with UDOT programs, the information can be very valuable in the types of decisions Region Directors and Division Heads are faced with on a regular basis.

Process

- 1- Determine an acceptable B/C for the program or project feature
- 2- Back-calculate the required benefit. This may be accomplished by using traditional methods typically accepted by UDOT divisions such as crash data, user delay estimates, and construction costs.
- 3- Compare the resulting estimated benefits and the benefit-cost ratio with other potential projects or facility upgrades.
- 4- Recommend an action to include or exclude the initiative from the program or project scope.

Benefit/Cost Library

UDOT should consider creating and maintaining a Benefit/Cost Library. Values of B/C for various initiatives would be included for use by engineers and planners statewide as follows:

- Traffic and Safety (rumble strip, cable barrier, deer fence, etc)
- Construction (design-build, lane rental, etc)
- Structures and Geotechnical (SPMT off-site bridge construction, geofoam foundations, wick drains, etc.)
- Materials and Pavements (mechanistic-empirical design, composite pavements, etc)
- Environmental (wetland banking, mitigation methods, noise abatement, etc)

Benefits Entered into the Library

Modifications to the values gathered through research studies must be completed before they can be used in the Benefit/Cost Library. Research project generated benefits will be useful but values may need to be initialized by mile or item. Benefit information by itself can be useful in addition to the benefit-cost ratios monitored in the library.

Costs Entered into the Library

The costs related to an initiative are very different than the values used to calculate research benefit-cost ratios. The costs included must be related to the design, construction and maintenance of the feature whereas the research costs are in the form of the contract, management and TAC costs.

Example: Cable Barrier

A value of \$130,000 per mile has been established for cable barrier installation. A minimum Benefit/Cost of 15 is set by UDOT managers. Cable barrier should be used where historical crash data shows one or more fatal or incapacitating cross-over crash occurring during its life-cycle (\$1,960,000/\$130,000).

Example: Fast-Track Construction

A Benefit/Cost of 10 is set by policy for fast-track construction, and it costs \$400,000 over traditional construction methods. User savings in the form of reduced congestion and crash mitigation must be estimated at \$4 million or more during the project to justify the innovative construction methods.

Media Marketing

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 and other innovative UDOT activities.

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 a 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 can build support from the traveling public, funding agencies and partners, and the Utah State Legislature.

Public/Private Partnerships

The Utah Department of Transportation Division of Research should evaluate the benefits of promoting more private/public partnerships. Many opportunities exist with motor carrier groups, wildlife advocates, wild-lands experts, construction and design specialists, authorities, professional groups, etc.

This strategy was employed recently at the 2016 UTRAC Workshop. The workshop was expanded to include the Utah Transit Authority (UTA). A separate breakout session was included for the UTA at the workshop. This provides for opportunities to improve operations that coincide with the two agencies.

These collaborations can produce the following types of solutions to UDOT problems:

- High-tech advancements
- Cross-industry applications
- Computer generated products
- Organizational innovations

Processes to Track and Measure Future Research Benefits

The benefits of transportation research initiatives and functions should be evaluated on a routine basis by the Division of Research. The findings can be used to dedicate resources in the form of personnel and funding to the most appropriate aspects and the most pressing issues facing our transportation experts and systems.

A guide was prepared as part of this contract entitled, “Program to Measure Research Benefits and Track Implementation, Manual of Instruction” [2]. This guide is intended to aid in the implementation and operation of a research benefits measuring program at UDOT. The manual discusses the types of benefits produced by research projects, benefit measuring methods available, and recommended uses of the information.

The document includes processes and tools for use in evaluating Utah’s research program on an annual basis. The recommendations in the process include actions at both the project and program levels.

Outlined is a feedback process for use in evaluating the degree of implementation for each completed project and identifying deliverables needing additional implementation actions. The manual recommends details related to the following aspects of the process:

- Process organization
- Goals of the program
- Personnel requirements
- Information needs
- Examples of benefit/cost
- Meeting schedules
- Program deliverables

Also included is an overview of best practices for use by consultants conducting more comprehensive studies to measure research benefits on a 3 to 5 year interval.

Conclusions

1. Research has been an essential and valuable component of addressing the problems facing our transportation systems. Information from a literature search indicates that transportation research initiatives have contributed to the efficient and safe movement of people and goods. Future demands and challenges for transportation will grow over time and research programs will be crucial in addressing these issues.
2. Sixty-six research projects were completed in the years 2009, 2010, 2011 and 2012 by the UDOT Research Program. These projects produced seventy-six deliverables. Surveys were submitted by project end-users to compile the benefits from the studies. **This information indicates that the UDOT Research Program had an estimated \$68.02 million in benefits, and a benefit-cost ratio of 14.** These values are considered to be conservative and lower than the actual values due to the low number of surveys returned (42%). Also conservative methods were used to calculate these benefits.
3. The benefit/cost estimate of 14 is similar to values for the UDOT Research Program published in studies completed in 1995(14), 2000(12), and 2010(17).
4. Completed surveys indicate that the **UDOT Research Program had an average grade of 3.0** using a 1 to 4 grading scale. This indicates the program received a “B” grade over the four-year period.
5. The investment of resources dedicated to the UDOT Research Program is unquestionably justified in the form of useable outcomes and products. The program has been administered professionally, and most projects have been managed in an efficient manner. The research project managers overall were successful in providing technical oversight and financial support for the studies.
6. Areas for improvement in the Research Program were suggested in the survey results. These project aspects were related to implementation and producing practical deliverables. A wide range in performance for these areas was reported. Many products were rated as high while others were lacking in practical use.
7. End users of research products indicate that the UTRAC Process and Workshop are effective in identifying topics related to the most pressing issues facing UDOT and its stakeholders. Improvements in the balloting process, however, could fund projects that propose the most usable and implementable deliverables.
8. Implementation of research deliverables require more focus and dedicated resources. Many excellent products of research are not fully implemented. The challenges and barriers to implementation must continuously be addressed for the research program to realize its full potential.

Recommendations

1. The Utah Department of Transportation should continue to foster a “Culture of Innovation” as described in the Mission, Strategic Goals and Areas of Emphasis. Key leaders within the department should utilize the UDOT Division of Research as a vital partner in this process.
2. The Utah Department of Transportation should fully fund Research and Development Programs based on their excellent estimated benefit-cost ratio of 14. This includes research projects, implementation activities, state-of-the-practice studies, training sessions, scanning tours, videoconferencing information exchange, and the UTRAC Workshop.
3. The UDOT Division of Research should implement a more formal process to better monitor and manage completed products from research projects. This proposed program is outlined in detail in a Manual of Instruction entitled “Program to Measure Research Benefits and Track Implementation”, Report [2]. This process includes personnel commitments needed, recommended processes, milestones, and performance measures related to implementation.
4. The UDOT research program should be evaluated on a regular basis to measure the benefits of the projects funded. This should be done both in-house annually, and by an independent consultant every three to five years. These evaluations indicate which types of research activities are the most effective. Also it is important to determine if the right level of funding is being dedicated to each aspect of transportation to control program balance.
5. The Division of Research should continue to use and improve the UTRAC Workshop. Customers of the Research Program indicate that the UTRAC process is a valuable tool. Some aspects of the Workshop breakout sessions should be expanded in scope. Part of the time should be dedicated to identifying, planning and funding initiatives to implement recently completed research products into practice.
6. The research implementation process should be expanded to enhance the adoption of the project deliverables. These recommended modifications are in the form of imposing emphasis for implementation on each of the research phases as follows:
 - a. Project Selection (UTRAC): The voting process used to select projects should include higher emphasis on projects that propose deliverables that are easily implemented such as those listed in Table 8, and require an estimated benefit-cost ratio for the project.
 - b. Work Plan Development: A detailed description of the deliverables should be incorporated in the final work plan and contract documents. This would include the products to be developed, detail on what items will be included, who the target end-users will be, and how the product will be implemented.
 - c. Conduct of the Research: All milestones, progress reports, and TAC meetings should address the implementation of the end products, and update the implementation plan.

- d. Implementation Phase: The project manager should maintain the project and related deliverables in a process for a minimum of two years after completion. Quarterly implementation meetings should be held to monitor the progress of the products.
7. The UDOT Research Division should make minor modifications to all six of their standard forms as listed in this report. Improvements to the forms could aid all stakeholders to better require, track and implement research deliverables.
8. A Media Marketing Program can be a very important tool in illustrating the benefits of research initiatives. This program has been shown in the past 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, stakeholders, the Utah State Legislature and the public. It is recommended the UDOT reinstate this program.
9. UDOT leaders should consider taking steps to get the research staff more involved in the New Products Evaluation Program. This would give the assessment of new products a more broad and formal forum for evaluation.

References

1. “Developing a Plan for Outcome Measurement”, Center for Program Evaluation and Performance Measurement, Office of Justice Programs' Bureau of Justice Assistance
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3. Athey Creek Consultants, June 2013, “Best Practice Guide for Qualifying the Benefits of MnDOT Research- for MnDOT”
4. 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.
5. Zmud, J., Paasche, J., 2009, “Communicating the Value of Transportation Research Guidebook”- NCHRP 610, TTI
6. Transportation Research Board, NCHRP Report 750 Series, 2014.
7. Anderson, D.I., 2010, “Measuring the Benefits of Transportation Research in Utah”
8. Anderson, D. I., May 2000, “Benefits of Research Projects in Utah”, Utah Department of Transportation, Final Report

Appendix A

Benefit Types

Improved Transportation Facilities

Enhancement to UDOT facilities is a fundamental aspect of the Research Program. Improving the way the department plans, designs, constructs, and maintains Utah's transportation facilities can have a huge impact on the economy, environment, and tourism in the state.

Examples of how research enhances these facilities are:

- Pavement and bridge life extension
- Improved rehabilitation and maintenance methods
- Highway design advancements
- Traffic control enhancements

Cost Savings to UDOT

The most direct and useful benefit that may be measured is related to costs. The main types of cost information are in the form of direct savings to the Department, savings to the traveling public, and benefits to key partners.

The Utah Department of Transportation strives to become more efficient and effective in all aspects of the programs and projects under its authority. Excellence is expected from UDOT staff, consultants contributing the work load, and contractors completing facility construction. UDOT managers are committed to interacting with all stakeholders with transportation interests to improve operations. Research projects have been shown to be an effective way to accomplish goals including:

- Reduced construction costs
- Lower operational costs
- Decreased manpower requirements
- More efficient and trained staff
- Reduced materials costs
- More efficient equipment
- Better utilization of existing equipment
- Improved management techniques

Safety Benefits

Innovative processes, regulations and products are introduced to the transportation industry on a routine basis to improve safety. Reductions in crash numbers can be directly measured in some instances, and estimated on a systematic basis in other cases. Safety goals include:

- Crash number reduction
- Accident rates decreased
- Severity of crashes reduced
- Construction zone safety enhanced

Congestion Reduction Benefits

Efficient track flow is a crucial benefit to the public and main goal for UDOT. Measurements of travel time and levels of service on major facilities are valuable input related to the effectiveness of innovative processes. Congestion mitigation goals are:

- Commute congestion decreased
- Construction zone delays minimized
- Crash delays reduced
- Multi-modal programs to reduce highway trips

Environmental Benefits

Many of UDOT's programs and facilities have a direct impact on the environment. For this reason a significant goal for UDOT is to achieve the benefits listed below. Minimizing these impacts provides a benefit to the general welfare of the public, and is a key goal for the Department.

- Minimize the footprint of transportation facilities
- Decrease emissions and particulates into the air
- Reduce chemical discharges from pavement placement and maintenance
- Mitigate wetlands that are impacted
- Reduce impacts to endangered species and their habitats
- Control noxious weeds on right-of-ways and neighboring lands
- Reduce or minimize noise to communities

Decisions To "Not" Do Something

Sound research methods and conclusions can lead to policies and actions by the department to "not" adopt or engage in a new initiative. These may include:

- Avoid inefficient highway expenditures
- Modify standards to eliminate poor designs
- Replace specifications and policies that are unsuccessful
- Reassign staff where not productive
- Find alternatives to inferior technologies

Institutional Knowledge

Some research projects provide a direct benefit to transportation experts and managers in the form of institutional knowledge. These include:

- Informed staff and stakeholders
- Understanding industry advancements
- Knowledge of future trends and challenges
- Improved knowledge of UDOT's goals and focus areas
- Enhanced program management skills

Appendix B Project Benefit and Cost Tables

**Table B1
2009 Program Results**

Number	Title	Benefits Million	Grade
9A	Infrasound Avalanche Monitoring System	\$9.67	A
9B	Truck Traffic Accuracy Study		
9C	Type III Micro Surfacing to Extend the Life of Old Concrete Pavement on I-70 in Region Four		
9D	Evaluation of Optimal Traffic Monitoring Station Spacing on Freeways		
9E	Seismic Retrofit Guidelines for Utah Highway Bridges		
9F	Economic Development Criteria and Project Prioritization		
9G	Seismic Vulnerability Assessment and Retrofit Recommendations for State Highway Bridges: Case Studies		
9H	Feasibility of Using High-Strength Steel and MMFX Rebar in Bridge Design		
9I	UDOT's Calibration of AASHTO's New Prestress Loss Design Equations		
9J	Implementation Requirements for the Mechanistic-Empirical Pavement Design Guide in Utah: Validation, Calibration, and Development of the UDOT MEPDG User's Guide		
9J(a)	Draft User's Guide for UDOT Mechanistic-Empirical Pavement Design		
9K	Fish Passage at Utah Culverts		
9L	Liquefaction Mitigation in Silty Sands Using Stone Columns with Wick Drains		
9M	Investigation of Improvement of Deck Concrete Mix Design and Curing Practice		
9N	Constructability Evaluation of Two Geogrids at Tie Fork Rest Area on SR-6 in Region Three		
9O	In-Situ Culvert Rehabilitation: Synthesis Study and Field Evaluation		
9P	A-Jacks and Aquawrap Installations in Utah		
9Q	Slip Lined Culvert Retrofit and Fish Passage-Phase I		
9R	An Inspection, Assessment, and Database of UDOT MSE Walls	TBD	C

Table B2
2010 Program Results

Number	Title	Benefits	Grade
10A	Evaluation of Movable Barrier in Construction Work Zones	\$2.1	A
10B	Modeling and Analysis to Quantify MSE Wall Behavior and Performance	TBD	C
10C	Repair of Concrete Girder Ends and Girder Collision Repair	\$20.88	A
10D	Failure of Surface Courses Beneath Pavement Markings		
10E	LiDAR Technologies for Bridges		
10F	Using Falling-Weight Deflectometer Data for Network-Level Flexible Pavement Management		
10G	Development of Methods to Control Cold Temperature and Fatigue Cracking for Asphalt Mixtures	\$27.5	A
10H	Shear Capacity of In-Service Prestressed Concrete Bridge Girders	IK	C
10I	Gilsonite as an Anti-Stripping Agent in Hot Mix Asphalt		
10J	Methods for Estimating Magnitude and Frequency of Peak Flows for Small Watersheds in Utah		
10K	Transportation Safety Data and Analysis	\$1.0	B
10L	Development of a Decision Support Tool for Assessing Vulnerability of Transportation Networks		
10M	Laboratory Testing and Finite Element Modeling of Precast Bridge Deck Panel Transverse Connections		
10N	Passive Force Deflection Behavior for Abutments with MSE Confined Approach Fills	\$0.675	A
10O	Laterally Loaded Pile Cap Connections	TBD	A
10P	Lateral Pile Cap Load Tests With Gravel Backfill of Limited Width	IK	C
10Q	Dynamic Passive Pressure on Abutments and Pile Caps	\$0.375	A
10R	Numerical Analysis of Dense Narrow Backfills for Increasing Lateral Passive Resistance	IK	C
10S	Assessing Corrosion of MSE Wall Reinforcement	TBD	A
10T	Understanding the Economics of Transportation in Utah		
10U	Construction Machine Control Guidance Implementation Strategy		
10V	Variable Slope ABT® Trench Former® MD200 Drain on US-89, American Fork, Utah (Experimental Feature X(06)03))		

Table B3
2011 Program Results

Number	Title	Benefits	Grade
11A	Design, Analysis, and Seismic Performance of a Hypothetical Seismically Isolated Bridge on Legacy Highway		
11B	Culvert Roughness Elements for Native Utah Fish Passage: Phase I		
11C	Exploratory Study of Partial Isolation of Highway Bridges		
11D	Evaluation of the Effect of a Variable Advisory Speed System on Queue Mitigation in Work Zones	\$0.2	B
11E	Automated Delay Estimation at Signalized Intersections: Phase I Concept & Algorithm Development		
11F	Field Evaluation of Asphalt Overlays on State Route 30 in Northern Utah		
11G	Recommended Protocol and Standards for Utility Data Submittals		
11H	GFRP Reinforced Lightweight Precast Bridge Deck Panels		
11I	Evaluation of an Independent CADD Platform for UDOT		
11J	Freeways to Fuel: A Baseline Study of Biofuel Feedstock Growth on Non-Traditional Agronomic Lands in Utah	-0-	E
11K	Streamlined Research Project Selection and Reporting		
11L	Resource Matching for Research		
11M	Non-Destructive and Destructive Investigation of Aged-in-the-Field Carbon FRP-Wrapped Columns	TBD	B
11N	Evaluation of Bridge Deck Seal Treatment for ABC Bridge Deck Using Precast Panels	TBD	B
11O	Utah Historic Bridge Inventory	\$0.12	A
11P	Evaluation of Utah Work Zone Practices		
11Q	Sustainable Long-Life Concrete Specifications	TBD	B-

**Table B4
2012 Program Results**

Number	Title	Benefits	Grade
12A	Strong Motion Instrumentation Plan For the Utah Department of Transportation		
12B	Health Monitoring of Precast Bridge Deck Panel Reinforced with Glass Fiber Reinforced Polymer (GFRP) Bars	IK	C
12C	Reduction In Wick Drain Effectiveness with Drain Spacing for Utah Silts and Clays		
12D	UDOT Diverging Diamond Interchange (DDI) Observations and Experience		
12E	Traffic & Safety Statewide Modeling and GIS Modeling	\$1.0	B
12F	Determining Wildlife Use of Wildlife Crossing Structures under Different Scenarios		
12G	Evaluation and Development of Unmanned Aircraft (UAV) for DOT Needs	IK	C
12H	Culvert Roughness Elements for Native Utah Fish Passage: Phase II		
12I	Safety Impacts of Design Exceptions in Utah		
12J	Utah Winter Severity Index: Phase 1		
12K	Identifying Characteristics of High-Risk Intersections for Pedestrians and Cyclists: A Case Study from Salt Lake County		
12L	Plan Recommendation for Traffic Sign Management		
12M	CPT Evaluation of Liquefaction Mitigation with Stone Columns in Interbedded Soils	TBD	B
12N	Identifying a Profile for Non-Traditional Cycle Commuters		
12O	Raised Median Economic Impact Study	\$4.0	B
12P	I-15 Reconstruction Long-term Embankment Monitoring Study – Final Report	\$0.5	A
12Q	Design and Evaluation of Expanded Polystyrene Geofoam Embankments for the I-15 Reconstruction Project, Salt Lake City, Utah	TBD	A
12R	Estimation of Liquefaction-Induced Lateral Spread from Numerical Modeling and its Application		D
Total		\$68.02	B (3.3)

Appendix C Literature Search

Best Practice Guide for Qualifying the Benefits of MnDOT Research- for MnDOT by Athey Creek Consultants, June 2013 [3]

This is a comprehensive evaluation of best practices used to measure the benefits of transportation research by various DOTs around the country. Surveys of all DOTs were conducted through the RAC Listserv. More detailed summaries were documented in the form of case studies of certain DOT programs and practices. These case studies were recorded for Utah, Missouri, Florida, and Louisiana. Additional concepts were recorded from Indiana, Iowa, and Illinois.

The foremost recommendations to MnDOT were to:

- 1- Increase focus on research benefits by those involved in the research,
- 2- Encourage implementation and communicate success stories of projects throughout the entire research process.

The Missouri DOT has been successful in documenting specific benefits within the deliverables of individual projects. This strategy greatly enhances the chances for implementation of the project findings by directly demonstrating how the changes will benefit the traveling public and the DOT. These benefits are published the Missouri DOT Tracker.

The Florida DOT conducts a “Research Deployment Plan Survey” that is required prior to research contract finalization. A baseline deployment plan is prepared from the information which is updated during the project and used to guide implementation activities and products.

Florida also conducts implementation after completion to document implementation success. They use a form “Florida DOT Implementation Tracker” to compile the needed information.

“Louisiana DOTD Program-Level Performance Measures” are used to measure the success of the research program. They utilize a list of goals and targets to improve performance of their operations, deliver cost-effective products, improve customer service, and effectively manage their financial resources. Louisiana also publishes a project Fact Sheet for each project.

The Indiana DOT publishes project findings in the form of a “Research Pays Off” periodical. The Iowa DOT publishes a “Research at Work” summary outlining project results. These summaries document the benefits of the projects and aid in implementation.

The “Illinois DOT Implementation Worksheet” is used to plan the implementation activities and needed resources. Potential challenges, the required personnel needed, and the estimated benefits of a successful implementation are recorded and used in the plan.

Valuing Benefits of Transportation Research: A Matrix Approach, Florida 2002 [4]

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.

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, [5]

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.

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 and 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 C1 provides a good research tool to prepare for communicating with the various customers of research projects.

Table C1
Key Audiences for Transportation Research [5]

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

NCHRP Report 750 Series [6]

These reports summarize the many changes that are projected for the transportation industry. They provide a discussion of how DOTs must work differently in the future. The reports address topics such as freight movement, climate change, technology, sustainability, energy, and socio-demographics.

The UDOT Research Division must play a key role as the department transitions to these new transportation aspects. A retreat is recommended with key UDOT leaders to brainstorm how the department can prepare over time to address these issues.

VOLUME 1: FREIGHT Economic Changes Driving Future Freight Transportation.
Explore and plan for the future of freight with a scenario planning toolkit

VOLUME 2: CLIMATE CHANGE Climate Change and the Highway System: Impacts and Adaptation. How to prepare for extreme weather events.

VOLUME 3: TECHNOLOGY Expediting Future Technologies for Enhancing Transportation System Performance. Select the right technology investments at the right time.

VOLUME 4: SUSTAINABILITY Sustainability as an Organizing Principle for Transportation Agencies.
Organize transportation agencies to support a sustainable society.

VOLUME 5: ENERGY Preparing State Transportation Agencies for an Uncertain Energy Future. Identify and assess strategic responses to a variety of future energy scenarios.

VOLUME 6: SOCIO-DEMOGRAPHICS The Effects of Socio-Demographics on Future Travel Demand.
Envision and model the transportation impacts of shifting demographics.

Measuring the Benefits of Transportation Research in Utah- September 2010 [7]

This project estimated the benefit-cost ratio for the program years 2006, 2007 and 2008.

Concepts recommended to gather future information on research benefits include:

- 1- A detailed survey for champions of projects aimed at documenting the benefits in terms of deliverable quality, management performance, implementation successes, and project funding.
- 2- A table used to accumulate the benefits related to assets, user impacts, safety, quality of life, environmental impacts, knowledge building, and policy input. Each type of benefit is converted to dollars saved or losses prevented where possible.

Benefits of Research Projects in Utah- May 2000 [8]

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.

The basic results of the 2000 study are including in the appendix. Table C2 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 for infrastructure (15), operations (13), administration (6) and policy research (5).

Table C2
Benefit-Cost Ratios for Project Types
(Example from a previous study)
1995-1997

Project Type	Costs x 1,000	Benefits x 1,000	Benefit/Cost
➤ Infrastructure	\$482	\$7,270	15
➤ Operations	\$297	\$3,815	13
➤ Administration	\$31	\$201	6
➤ Policy Research	\$164	\$803	5
Totals	\$974	\$12,088	12

Appendix D Crash Related Costs

**Table D1
Average Cost per Crash (FHWA) Based on Severity
-Currently Used by UDOT-**

Fatality	\$ 1,961,100
Serious Injury	\$ 1,961,100
Non-Capacitating	\$ 122,400
Possible Injury	\$ 62,500
Property Damage Only	\$ 3,200

Further documentation on the derivation:

1. TIGER Benefit-Cost Analysis (BCA) Resource Guide supplement to the 2014 Benefit-Cost Analysis guidance for Tiger Grant Applicants
2. Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analysis.

Appendix E

Example Questions

Project Management Survey

General Questions:

- How can UDOT research managers better interact with you or your organization to improve the transportation research projects?
- Are there any reoccurring problems associated with UDOT research projects? If so, what are they and how could they be handled differently?
- What modifications would you like to see in the UTRAC Workshop format or process?
- Is the project TAC membership and involvement adequate? How can the TAC involvement in projects be better?

Deliverables and Outcomes:

- Are adequate types of deliverables and products required to enhance implementation of the project concepts?
- Is sufficient funding for implementation programmed?
- How can UDOT better aid in the implementation of research deliverables?
- Should implementation of the completed project deliverables be discussed at the annual UTRAC Workshop?

Scope:

- Are UDOT research projects on average too broad, too narrow, or adequate in scope?
- Does scope creep typically become a problem during projects? How can this be avoided?

Schedule:

- Does the contract and work plan allow enough time to complete the project tasks?
- How often do UDOT personnel delay the completion of a project due to the lack of needed information, consultant actions, or other feedback? How can this be avoided?

Budget:

- Are the budgets processed into contracts for research projects typically adequate to complete the tasks listed in the work plan?
- What changes in the project budgeting practices are needed?
- Is the contract process and language adequate?
- Do you experience conflicts with UDOT's administrative processes or personnel?
- Do you have reoccurring conflicts with your administrative processes or personnel?