Practical Design Guide

Planning and Designing Practical Transportation Solutions for Utah

02/01/2011

Table of Contents

I. Introduction

A. Background

Practical Design looks to address the problem of "how do we do more with less" in an era of increasingly limited resources and growing transportation needs.

Practical design has been used successfully by other transportation departments throughout the United States. The most prominent of these are Missouri, Idaho, and Kentucky. Each department has their own set of guidelines but, the overall concept remains the same. The success they have achieved includes:

- Missouri (MoDOT)
  - Implemented in 2004
  - Saved $1.2 billion from 2005-2009
- Idaho (IDT)
  - Implemented in 2007
  - Saved $27.2 million in first year of implementation
  - Saved over $50 million since 2007
- Kentucky (KYTC)
  - Implemented in 2008
  - Saved $4.7 million on one intersection

The success of practical design has greatly increased the capacity of these departments to stretch their resources and provide the best possible roadway system. The Utah Department of Transportation (UDOT) recognizes the success of these programs and embraces the principle of practical design. This manual provides guidelines for implementing practical design in planning and design of UDOT roadway projects.

B. UDOT's Practical Design Approach

The goal of practical design is to appropriately allocate limited resources to maximize system wide improvements. This approach focuses on maximizing improvements to the roadway system as a whole, rather than maximizing improvements to a few locations. MoDOT adopted the phrase, "…building a series of **good** not **great** projects will result in a **great system**" to describe this practical design approach.

Super Savings Power

MoDOT - **$1.2 Billion**
IDT - **$50+ Million**
KYTC - **$4.7 Million**

UDOT has identified four overarching goals, known as the Final Four, to focus all improvement projects:

- Take care of what we have
- Make the system work better
- Improve safety
- Increase capacity

Typically, the focus of each project's design has been to improve the specific project locations as much as possible with the budgeted resources. Is maximizing the improvements in one location the best allocation of resources? Is this approach generating the best return of investment? Is there a better approach?

The concept of "the point of diminishing returns" answers these questions. Each roadway improvement project is an investment. Much like all other investments, investing more in one specific area does not necessarily result in equal returns. The investor must identify the point of diminishing returns and only

invest to that point. Any investment above the point of diminishing returns is an inefficient use of resources that would yield higher returns if invested elsewhere.

UDOT's Final Four

Take care of what we have
Make the system work better
Improve safety
Increase capacity

Every improvement must focus on meeting the following in order to determine the point of diminishing returns for roadway system investments:

(1) Practical Design Goals

(2) Objective Statement

While there is some economy of scale savings for "maximizing improvements to the location while there," this approach does not maximize the improvement to the whole system. Economy of scale may be negligible when looking to improve the entire system.

The University of Kentucky illustrates these ideas through a study of improvements to an existing two-lane road with 10 foot lanes and 2 foot shoulders. The following table illustrates the alternative design options and their effect on improving safety and mobility.

				Improvement			**Total Improvement**	
Design Option	Cross Section	Crashes per Year per Mile	Travel Speed (mph)	Miles	Crashes per Year per Mile	Speed (mph)	**Crashes**	**Speed**
Existing	2 Lanes, 10 ft L, 2 ft S	5.4	41.4	--	--	--		
A	4 Lanes, 12 ft L, 8 ft S	**2.4**	55.9	23.3	-3.0	14.5	-69.9	337.9
B	**2 Lanes, 12 ft L, 8 ft S**	2.9	46.7	**69.4**	-2.5	5.3	**-173.5**	**367.8**

Option A: Typical Improvement Approach

- Highest **per mile** safety and mobility improvement.
- Improves 23.3 miles system.
- Does not improve overall system as much as Option B.

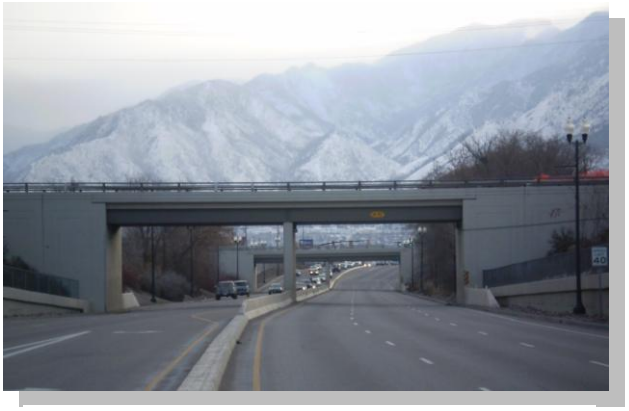
Option B: Practical Design Approach

- High per mile safety and mobility improvement.
- Allows for 46.1 more miles to be improved than Option A (200% more!).
- Safety improvements for the system are 150% better than Option A because more miles are improved.
- Overall capacity improves.

The data illustrates that by improving each location to the point of diminishing returns, the safety and mobility improvements were maximized for the system. In this instance, the approach of "good not great projects" resulted in a "great system."

For example, the recent S.R. 266 (4500 South) capacity improvement project used practical design to add much need capacity. The project team determined that additional lanes were needed to provide the necessary capacity. However, the roadway width was constrained by two existing railroad bridges. Replacing the existing bridges would have put massive budget, schedule, and scoping restrictions on the

design team and would have diminished the designed capacity improvements. By using practical design principles, the design team developed a solution to provide the additional lanes. Using sound engineering, design exceptions, and mitigating all safety concerns, the design team was able to meet the project objective.



S.R. 266 (4500 South) from 300 W to Main St.

Practical design does not eliminate the engineering standards, but aims to add the flexibility needed to produce the most efficient design to meet the system and project objective statements. UDOT currently has a clear process for obtaining approval and documenting exceptions, deviations, and waivers of standards. Practical design utilizes this process when it is appropriate.

Practical design requires a higher level of understanding, communication, and decision making than is typically practiced. Design advantages and disadvantages should be clearly defined and evaluated. Life cycle costs analysis is crucial to avoid pushing costs to maintenance. Practical designs do not find cost savings simply by making it "someone else's problem."

Keys for Practical Design Success

- Goals
- Objective Statement
- Collaboration
- Engineering Judgment

The most critical element in practical design improvement projects is the project's objective statement. Practical design is a "design up" approach, not a "strip down" process. Rather than starting with the desired level of improvement and removing items until they meet the budget, project teams are to look at the existing conditions and design improvements that meet the project's objective statement.

Adherence to goals, focus on the project objective statement, open collaboration, and a good use of engineering judgment will result in maximizing limited resources to optimize the roadway system.

Frequently Asked Question

What is the difference between Practical Design and Value Engineering?

Value Engineering

- Method to determine the most cost effective way to achieve proposed improvements.
- Typically focuses on maximizing project improvements.
- Tool for practical design.

Practical Design

- Method to determine the most cost effective way to achieve the objective statement.
- Focuses on maximizing roadway system improvements and UDOT's strategic goals.

II. Focus

A. Practical Design Goals

UDOT is known for delivering high quality, innovative, and efficient projects. The following three overarching goals of practical design will further improve upon UDOT's success.

Goal #1: Optimize the transportation system as a whole.

Optimizing provides a "big picture" approach to planning the general size, scope, and funding of UDOT's transportation program to guide all project-level practical design decisions.

Current Approach

- Develop prioritized list of improvement projects for 10, 20, and 30 year phases.
- Direct funding toward projects that fall on the prioritized list of improvement projects.
- Communication is inconsistent between the project sponsor and project teams.
- Clear understanding of the project objective statement is not always provided to the project team.
- Project teams typically lack sufficient information to analyze how project improvements best serve the objectives of the corridor and system.

Practical Design Approach

- Continue prioritizing list of improvements and directing funds toward appropriate projects.
- Project teams are given a clear understanding of how their project fits into the roadway system and corridor priorities as the driving force behind each project.
- Project teams are provided with a clear understanding of project objective statement and corridor context.
- Communicate corridor and system wide knowledge to the project team.
- Greater emphasis on analysis (i.e. Operational Safety Report) during the development of alternatives to satisfy the project objective statement.
- Project teams demonstrate how the design optimizes the highway system as a whole.

Goal #2: Meet the goals of the objective statement identified for each project.

All projects must track back to the defined priorities and objectives of the system and corridor. Project teams continually monitor to ensure all proposed improvements meet, but not necessarily exceed, the project objective statement and corridor priorities.

> *The decision to build "Chevys" instead of "Cadillacs" has given MoDOT districts more money to tackle more projects. "Sometimes good enough is better than best."* (1)

Current Approach

- Focus on maximizing improvements within project limits to address needs (i.e. bigger is better).
- Aim to maximize improvements and only use exception, waiver, and deviation to meet budget.
- Attempt to meet stakeholder's desires that do not meet the purpose or intent of the project such as lighting, street furniture, etc.

Practical Design Approach

- Focus on improving the project limits to a level that meets the objective statement (i.e. adding a turn lane may be all that is needed to meet necessary capacity).

- Use exceptions, waivers, and deviations to sufficiently meet the project objective (i.e. to meet, but not exceed the project objective statement).
- Meet stakeholder requests that are in harmony with the project objective statement.
- Develop designs that meet the objective statement and corridor priorities most efficiently.

Goal #3: Design the most efficient method (cost and function) to achieve the objective statement.

Every proposed improvement should look to achieve the most return for the least cost. Focusing on meeting the objective statement and finding efficient solutions will allow for an optimized roadway system.

Current Approach

- Use entire budget to maximize improvements within the project limits.
- Focus on stripping down design standards to meet budget.
- Use value engineering to determine the most cost effective way to achieve proposed improvements.

Practical Design Approach

- Focus on maximizing cost savings while meeting objective statement.
- Evaluate life cycle costs (i.e. attenuator type may be initially expensive, but may be inexpensive to replace when hit).
- Focus on building up from the existing conditions to eliminate over design costs.
- Question the value of every improvement to the corridor and system.
- Focus on saving project resources for use on additional improvement projects or other locations within the corridor.

B. Importance of Objective Statement

The objective statement serves as the foundation for system improvements and project development. Every project will have a documented objective statement that specifies the deficiencies to be solved and the long term goals to be achieved by the proposed improvement project. Any items that do not directly support the objective statement can be re-evaluated, redesigned, or eliminated altogether.

"Bigger is better and safer." Not always true and may result in an inappropriate project.

Practical design eliminates "over designing" improvements by aiming to achieve, but not exceed, the objective statement. This allows our limited resources to be stretched throughout the system. These savings allow unfunded projects to be completed. By making each project "good enough," more of UDOT's system can be improved.

The project sponsor (i.e. System Planning and Programming, Region Maintenance, Traffic and Safety) is responsible to define the initial objective statement. The project objective statement should be analyzed and updated as needed through the early life of the project (i.e. concept, EA/EIS, etc.) to ensure the objective(s) identified will adequately meet the system and corridor needs.

The objective statement states the goals of the project and not a specific solution. For example, the objective statement should *not* say, "The objective of the project is to add a lane." The following is a list of some of the key elements of the objective statement:

- Define in terms that are easily understandable to the general public.
- Present information as comprehensive and specific as possible.

- Be factually and numerically based.
- It is analogous to the solution. It is the what, not the how.
- State in a concise manner.
- State as an expected positive outcome.
- Address UDOT's Final Four.

A crucial element for developing an objective statement is to understand what the expected outcome of the project is and **not** expect more. For example, if a project objective states the desire for a 20 year pavement life, do not expect the design to exceed the designed 20 year life. It is critical to plan ahead for maintenance and provide a design life to make sure the *system's* needs are met.

III. Roles and Responsibilities

There are four principal groups that oversee and design Utah's roadway system. All groups must assist each other for practical design to be successful. A brief description is given for each principal group's general duties and responsibilities in implementing practical design. See Example A for an example of the relationships between each group during project development.

A. Utah Transportation Commission

The roles and responsibilities of the Utah Transportation Commission are outlined in the 2010 Strategic Direction & Performance Measures.

B. Project Sponsor

The project sponsor is the entity that initially identifies the project and funding. The project sponsor is responsible to perform the following to assist project teams in implementing practical design:

- Develop and document the project objective statement.
- Define how the project meets program objectives.
- Provide project teams with a clear understanding of the project objective statement (i.e. provide documentation used to develop the objective statement).
- Clarify general funding expectations.
- Provide available information and project vision to the project team.
- Support the design teams when they propose unique solutions to meet project objectives.
- Begin coordination of project information and objective(s) with the operations group.

C. Project Team

Multi-disciplinary project teams use information and direction provided by the project sponsor to make project design decisions and choose solutions. Project teams are currently performing many of the duties and responsibilities required for practical design, but a new focus on practical design will require a different approach to these duties and responsibilities.

All team members are responsible to participate in the following practical design tasks:

- Evaluate the project objective statement.
- Design project improvements that meet the project objective statement.
- Eliminate improvements that needlessly exceed the objective statement.
- Evaluate all project improvements in a corridor context, not just a project context.
- Evaluate all project improvements from the standpoint of maintainability in the long term.
- Offer practical solutions that may be outside of the project limits that will help meet the project or corridor objective statement.
- Design based on the idea of "build up" from existing conditions to meet objective statement, not "strip down" design standards to meet budget.
- Offer design solutions that help other disciplines meet their requirements at a lower cost (i.e. drainage designer identifies drainage solutions that reduce roadway design costs).
- Coordinate practical design solutions with project stakeholders (municipality, residents, businesses, maintenance, traffic operations, etc.).
- Determine cost/benefit of design solutions, especially if not meeting design standards.

Practical design and the above duties and responsibilities will require each team member to continue performing the following tasks, but at a much higher level:

- Collaborate with team members and stakeholders to offer technical perspective.
- Encourage other team members to offer solutions.
- Document **ALL** decisions related to the project design and development.
- Evaluate projects for viability, given program parameters, funding, and schedule.
- Be alert and alert others to shifts in assumptions, parameters, and design solutions.

Project managers are responsible for the following to help practical design benefit their project:

- Determine the point the design is good enough or sufficient.
- Maintain the right balance for the overall project and system when evaluating trade-offs.
- Ensure decisions are being integrated or implemented appropriately and fulfill the project objective statement.
- Ensure the project team continually reviews the scope to meet project objectives.

The project team is required to coordinate with the operations group for the following:

- Evaluate project and corridor maintenance concerns.
- Address project and corridor long term operations.

D. Operations Group

The operations group is responsible for the long term operation and maintenance of the system. Coordination with the operations group is necessary to develop object statements and to implement successful practical design.

The operations group is responsible for the following to help the other groups implement practical design successfully:

- Give clear understanding of maintenance costs and long term operational needs.
- Assist in evaluating and developing practical design solutions that meet the objective statement.

IV. Success Indicators

A. Institutionalized Practical Design Philosophy, Values, and Goals

All parties involved in the development of transportation improvements must integrate practical design practices into all decision making for practical design to be successful. The success indicators include:

- All proposed projects have a clear objective statement that describes how the project will help the system meet the Final Four.
- Each proposed project is clearly the best system wide solution (i.e. KYTC example).
- Project teams identify, monitor, and document practical design.
- Project teams focus on improving the system as a whole, not just within their project limits.
- Project teams report savings due to practical design.

B. Performance Measures

To measure the performance of practical design implementation, the following indicators will be measured:

- Total cost savings for the overall program*
- Percent savings for the overall program*
- Percent savings per project*
- Percent of projects using practical design
- Percent savings by project type (new construction, maintenance, etc.)
- Percent savings by project size

*Project savings will be managed and redistributed by UDOT per the Project Budget Recovery Process.

V. Practical Design in Practice

Scrutinize the Standard

Building right sized projects to meet the project objective statement meets the roadway system's objective statement.

Practical design requires flexibility. Design standards typically do not allow the necessary flexibility for practical design. Rather than focusing on meeting all minimum standards, practical design establishes the existing condition as a baseline and the design is evaluated as the project is improved beyond the existing conditions. A design standard may be waived when the objective statement is satisfied and all impacts from not meeting design standards are mitigated.

UDOT is not eliminating the design standards and will only allow exceptions, deviations, and waivers when overall safety and mobility are not compromised. Practical design aims to use the exception, deviation, and waiver procedures to obtain the necessary flexibility.

<u>Current Approach</u>

- Design standards dictate the desired level of improvement.
- Exceptions, deviations, and waivers are used when resources do not allow for the design standard to be built.

<u>Practical Design Approach</u>

- Design standards are the "ideal" improvement.
- The project objective statement clearly describes the expected outcome of the project.
- Exception, deviations, and waivers are used when either of the following applies:
    - The design standard exceeds the objective statement.
    - A lower cost solution not meeting design standards is identified which does not compromise safety.
- The design starts with the existing conditions and builds up to meet the objective statement. The design is not a stripped down version of the design standards.

The following references may assist the project team in analyzing exceptions, waivers, and deviations.

- AASHTO Green Book
- A Guide for Achieving Flexibility in Highway Design
- AASHTO Highway Safety Manual (quantifies safety)
- AASHTO Highway Capacity Manual (quantifies capacity)

Below is a list of exception, deviations, and waivers that were found to be the practical design solution for their specific projects. They do not necessarily represent exceptions, waivers, or deviations that would normally be approved or considered. Each project, location, and objective statement is unique and must be approached as such. Always design with future maintenance issues in mind to find life cycle cost savings.

- Reduced shoulder paving width from full to half.
- Bridge rehabilitation deemed acceptable vs. bridge replacement.
- Bridge deck replacement deemed acceptable vs. bridge replacement.
- Pavement rehabilitation deemed acceptable vs. replacement.
- Bridge width needs only match existing roadway width.
- Narrow lane width from 12 feet to 11 feet.
- Pavement thickness reduced based on design life of 15 years as opposed to 20 years.

- Appropriate design life reduced to 15 years from 30 years.
- AADT projects for 10 years deemed sufficient.

All design considerations have positive and negative impacts on a project. The goal is to prioritize, mitigate, and justify all impacts and decisions using best engineering practices.

Example A: Project Design Delivery

**(Practical design steps underlined)

Utah Transportation Commission (UTC)

The Utah Transportation Commission allocates funding for the purpose of improving safety by reducing crashes, preserving the system, and making efficient investments for high risk conditions.

Project Sponsor

The Systems Planning and Programming group identifies that there is a consistently high correlation between run-off-the-road crashes and fatalities on most rural segments of the highway system. The program manager identifies a specific segment in the system that is experiencing this type of condition and provides the assigned project team with an understanding of the corridor deficiencies and objective statement.

Project Team

The project team evaluates and develops a project objective statement to reduce the number of high severity crashes in the specified area. Among a range of solutions (shoulder widening, slope flattening, curve corrections, etc.) the team discovers that the most practical and cost-effective way to address the project objective statement is to invest in a combination of effective markings, permanent striping, and rumble strips. The team saves allocated project resources that are then applied to other locations for improvement.

Example B: Practical Design Solutions – S.R. 108

**(Practical design steps underlined)

UDOT implemented practical design in the following example:

In 2006, UDOT and the Federal Highway Administration initiated an Environmental Impact Statement to examine how proposed improvements to the S.R. 108 corridor would impact the natural and human environments. The Record of Decision identified the selected alternative as the five-lane section which included two lanes in each direction with a center turn lane or raised median in some areas.

Due to budget constraints, only 3 miles of S.R. 108 could be widened to five lanes. However, to provide the greatest improvement value and meet the immediate needs of the public, the project team developed a practical design solution.

The project team used available funds to re-stripe the roadway, and in some areas widen, to provide three-lanes (one lane in each direction and a center turn lane) for the full length of the corridor.

By improving the entire corridor, rather than full build out for only 3 miles, the project team was able to provide more capacity and stretch the resources to the fullest potential.

VI. References

(1) Kentucky. Transportation Center. *Practical Solution Concepts for Planning and Designing Roadways in Kentucky.* Research Report KTC-08-30/SRP369-08. Kentucky Transportation Center [October 2008].

(2) Missouri. Department of Transportation. *Meeting Our Customer's Needs Practical Design.*

(3) Missouri. Department of Transportation. *MoDOT's Approach to Program Management*. Department of Transportation [2007].

(4) Missouri. Department of Transportation. *MoDOT Staff Summary.* Practical Design Case Study. Department of Transportation [May 2007].

(5) Oregon. Department of Transportation Highway Division. *Practical Design Strategy*. Department of Transportation [March 2010].

(6) UDOT. Utah Department of Transportation. S.R. 108 Environmental Impact Statement & Project Information. http://www.udot.utah.gov/main/f?p=100:pg:0:::T,V:3076,

Appendix A: Objective Statement Development

Make every effort to develop a concise objective statement that focuses on the main transportation problems to be addressed. Use the information in the Importance of Object Statement section and the following steps to develop the objective statement:

1. **Identify the current conditions.**

Gather necessary information about the existing conditions at the specified location. Some of the necessary information may include the following:

- Stop conditions
- Lane configuration
- Culvert locations and sizes
- Structural elements and conditions
- Adjacent roadside objects and facilities
- Terrain
- Existing ROW
- Additional necessary information

2. **Determine the existing deficiencies.**

Determine the existing Final Four deficiencies at the location. The type of project will dictate the data and the precision needed to generate the objective statement. Gather enough information to provide a benchmark for the project team to measure improvements. You cannot effectively determine where you want to go if you don't know where you are.

3. **Identify the deficiencies to be improved.**

Determine which of the existing deficiencies will be improved as part of the proposed project. Focus on the needs of the public and the improvements that will yield the highest returns.

4. **Determine the project objective.**

Determine the extent of the improvements for each identified deficiency. This becomes the project objectives and all proposed improvements will aim to achieve it. The objectives must be set to maximize investment returns.

For example, if the current LOS for a mile stretch of freeway is F, you may want to set the project goal at LOS C. LOS C may be ideal, but due to resource restraints and other system wide improvements that can yield higher returns of investment, the goal may be best set to LOS D or even LOS E.

Look at the surrounding area to determine practical goals. Is improving beyond LOS E for this mile adding the desired value to the system if the LOS of the previous three miles is E, and the three miles afterward is E?

5. **Clearly and specifically describe the objective statement of the project.**

Develop a clear and specific statement describing the objectives for the project once all deficiencies and project objectives are determined. This statement will be the focus of all design efforts throughout the project.

Appendix B: Scoping Phase – Suggested Questions Checklist

Safety

- ☐ Will the project maintain or improve safety?
- ☐ Are there any effective low-cost measures that can improve safety?
- ☐ Has a crash analysis been done to confirm improvements addressing the primary safety problems that are being experienced?

Corridor Context

- ☐ What is the purpose of the corridor and nature of the community?
- ☐ How is the area currently used for alternative travel? (bus, pedestrian, bike, rail, etc.)
- ☐ What is the design speed for this segment of the corridor?
- ☐ Is the solution in harmony with the rest of the corridor or future plans for the corridor?

Optimize the System

- ☐ What is the problem?
- ☐ What are the possible solutions and do they effectively solve the problem?
- ☐ Will the project be maintainable and buildable?
- ☐ Does the solution optimize the infrastructure life-cycle cost?
- ☐ Does the solution provide an operational improvement?
- ☐ Does the solution improve connectivity and coordination with other systems?
- ☐ Can we design a system that can be flexible for future expansion?
- ☐ Is a construction project the right solution? (vs. enforcement, education, etc.)

Public Support

- ☐ Who are the stakeholders?
- ☐ Has community input been considered?
- ☐ How will decisions be communicated after gathering public input?
- ☐ Do we ourselves have a good understanding of the problem?
- ☐ Is the problem clearly documented?
- ☐ Do the stakeholders understand and agree with the problem?
- ☐ How do stakeholders define success?
- ☐ What kind of support exists from city or local jurisdictions and primary users of the facility?
- ☐ Has "minimum expected value" been met?

Efficient Costs

- ☐ Can any elements of the project be eliminated, phased, or separated to a more appropriate project and still address the problem?
- ☐ Have we identified the alternatives and the cost/benefit (value) of each in relation to risk?
- ☐ What is the return on investment (quantifying time, money, economic growth, etc.)?
- ☐ What is the lifespan of the solution?
- ☐ What are the future maintenance/operation costs?
- ☐ What is the minimum fix and what will trigger a larger, more expensive fix?