Roadway Safety Data Program

COLLECTION AND USE OF ROADWAY ASSET DATA IN UTAH

ROADWAY SAFETY DATA AND ANALYSIS

CASE STUDY

FHWA-SA-14-078

Prepared for

Federal Highway Administration

Office of Safety

Roadway Safety Data Program

http://safety.fhwa.dot.gov/rsdp/

Improved Data Collection & Analysis → More Informed Decision Making → Better Targeted Safety Investment → Fewer Fatalities & Serious Injuries

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U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
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Notice

Quality Assurance Statement

ACKNOWLEDGEMENTS

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ACRONYMS

AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
DOT	Department of Transportation
FDE	Fundamental Data Elements
FHWA	Federal Highway Administration
GIS	Geographic information system
GPS	Global positioning system
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Program
HSIS	Highway Safety Information System
HSM	Highway Safety Manual
KML	Keyhole Markup Language
LIDAR	Light detection and ranging
MIRE	Model Inventory of Roadway Elements
MIS	Management Information System
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
OIT	Office of Information Technology
TMS	Traffic Monitoring System
XML	Extensive Markup Language

EXECUTIVE SUMMARY

Quality data are the foundation for making important decisions regarding the design, operation, and safety of roadways. While crash data have been a consistent element of highway safety analysis, in recent years there has been an increased focus on the combination of crash, roadway and traffic data to make more precise and prioritized safety decisions. The application of advanced highway safety analysis processes and tools requires a comprehensive inventory of roadway safety data combined with crash data to better identify and understand problems, prioritize locations for treatment, apply appropriate countermeasures, and evaluate the effectiveness of the those countermeasures. Comprehensive roadway safety data include information on roadway and roadside features, traffic operations, traffic volumes, and crashes.

INTRODUCTION

State DOTs manage multi-million dollar assets. Being able to quantify those assets helps not only to improve efficiency of funds allocated within the agency, but also to improve safety and design of the State maintained roadways. In Utah, the four largest assets by cost value are pavement, bridges, culverts, and signs. Gathering data on these assets has traditionally required an excessive amount of time for field site evaluations conducted by UDOT staff or contractor survey crews. Additionally, safety is a concern for those collecting asset data near moving traffic.

The purpose of this case study is to describe the successes and ongoing challenges related to statewide data collection to support asset management, safety, and planning activities. This report has relevance for State DOTs as an example using new technologies and enhanced data management practices to create a multipurpose resource. The example may be extended to local agency participation as well.

BACKGROUND

The Utah Department of Transportation (UDOT) maintains 5,869 centerline miles[1] of roadway and 310 miles of freeway ramps, which together comprise 15 percent of the total roadway centerline miles (41,508) open to the public in Utah. 19,056 of these miles consist of unpaved roads. The UDOT-maintained roads carry 67 percent of the vehicle miles traveled in the State.[1]

The scope of the case study includes data collected on the State system only. Each road was driven in both directions during data collection, resulting in approximately 12,000 total miles driven.

The data collection effort performed by UDOT was a first-of-its-kind, surveying the entire state roadway network and obtaining a wide set of data elements. LiDAR (a term that combines "light" and "radar") was used by the selected vendor to collect a variety of asset data. The LiDAR technology creates a three dimensional model of the assets scanned along the roadway, and is performed in a single pass at highway speeds.

This project has improved the way that UDOT manages roadway assets. It has also helped the agency be more transparent because the data are available to the public through several online programs. The main capabilities and benefits are:

- UDOT knows the quantities of the assets to a degree of accuracy never achieved before through previous methods. (For example, the maintenance division now knows how many signs they manage and the percentages of types of signs – guide, warning, regulatory, etc. Previously, estimates ranged between 100,000 and 140,000 signs. Data from this project showed that they have approximately 97,000.) [5]

- The design group may be able to use the data to create topographic maps with greater detail than traditional surveying. If this effort proves successful, surveyors may experience safer working conditions by not needing to be near travel lanes. This could also reduce data collection time and lane closures.[7]
- Increased ability to share roadway attribute data across divisions. [5]
- Data and maps are available online at http://uplan.maps.arcgis.com/.[6]

OBJECTIVE

The project had the following objectives:

- Obtain data for use in making safety, pavement, and asset management decisions. [1]
- Deploy state-of-the-art collection methods to improve and develop rigorous safety, maintenance, and preservation programs. [8]
- Gather the most data pertaining to roadway condition, location, and roadway assets in an economical way, while maintaining a high level of accuracy and quality. [8]

Specifically, the agency wanted to improve data on pavement distress and quantify square footage of pavement. The Maintenance Division also wanted to improve their sign data accuracy. UDOT added other roadway attributes to the collection effort as the project developed over time.

AUDIENCE

This case study applies to the following audiences:

- State Departments of Transportation: Safety Engineering, Design, Planning, Maintenance, GIS, and Asset Management Units.
- Local and Regional: City and County Public Works/Engineering/Transportation Departments, Metropolitan Planning Organizations, and Regional Planning Commissions.
- Local and Tribal Technical Assistance Programs.

PROCUREMENT PROCESS

The procurement process for this project was long (approximately 7 months), primarily due to the fact that the data collection methods being proposed at the time were a new concept that was not known to be attempted by previous State DOTs. Initially, the champions of the project learned of new technologies for gathering roadway asset data and decided to issue a Request for Proposal (RFP). To prepare for the RFP, UDOT welcomed presentations from eleven different companies, each highlighting different data collection methods. UDOT drafted the RFP based on the average level of technology so as not to exclude potential solutions providers from bidding. The RFP did not specify the LiDAR technology instead was neutral on the technology that was to be proposed by potential vendors.

Vendors demonstrated their product, including a presentation, field test, and working in the computer lab to test data transfer compatibility with UDOT databases. UDOT ranked the shortlisted companies based on qualifications and cost. Mandli Communications Inc. won the contract with a proposed data collection method that utilized 3D LiDAR.

The UDOT Asset Management Division engaged other departments regarding what data would be beneficial to their asset management decisions. [8] UDOT developed the final dataset and requirements through an iterative process of internal UDOT discussions, testing by the contractor, and validation. The dataset was broken up into smaller pieces and each piece was given an internal owner (e.g., Maintenance, Traffic & Safety, etc.). Each owner chose how to validate the data. Some divisions had internal staff perform QC/QA and other divisions had help from consultants.

ROADWAY ASSET DATA COLLECTED

The UDOT Roadway Imaging and Inventory contract required collection of specific roadway assets, including: [8]

- Roadway condition data.
- Roadway photolog.
- Pavement photolog.
- Number, length, and type of lanes.
- Ramps and collectors.
- Median and barrier presence (type and width).
- Guardrails, shoulder barrier, and end treatments.
- Striping and pavement messages.
- Bike lanes.
- Intersections (quantity, type, and signal equipment).
- Bridges, overhead obstructions, and other structures.

- Surface areas and pavement width.
- Lane miles.
- Sign supports and faces.
- Striping and pavement markings.
- Shoulders.
- Rumble Strips.
- Curb and Gutter.
- Drainage features (mainly drop inlets).

To gather the above data, the contractor used a vehicle with the following equipment: [8]

- Velodyne LiDAR sensor.
- Laser road imaging system.
- Laser rut and crack measurement system.
- Road surface profiler.
- Position orientation system.

The contractor obtained the roadway asset information through the equipment above, which also included photologs. The LiDAR data produced position and size of assets. The other sensors captured the pavement condition and the photos aided in post processing. [4]The contractor completed post processing before sending to UDOT. One post-processing example included scanning the photos to identify the correct barrier end treatment. [4]

UDOT received the data from the contractor and conducted a rigorous process of quality assurance, organizing the data and formatting to comply with their existing databases and software, which include:

- Oracle and Oracle spatial.
- Custom packages written in PL/SQL.
- ESRI geodatabase.
- ESRI ArcGIS server and an open source GIS.
- Some special purpose programming to support the process and web applications.

UDOT conducted QC/QA weekly meetings with the contractor and Stanley Consultants (who was enlisted as a partner to quality check some of the attributes). [8]

BENEFITS

After this extensive data collection effort, UDOT improved its procedures for managing agency assets. Specifically, UDOT knows for each asset the location, certain attributes, and start/end points along the State-maintained roadway system. For example, UDOT knows the location and quantity of nearly all aboveground assets. Additionally, the project produced the following benefits:

- Knowledge of the quantity and quality of roadway assets improves budgeting for the department.
- Knowledge of the number of signs to manage.
- Enabled divisions to work more closely together by having shared access to roadway information.
- Enhanced the Traffic and Safety Division's ability to perform systemic safety analyses based on roadway attributes and crash data. Specific methodologies being used include HSM Part C and Part D analyses, United State Road Assessment Program (usRAP), and a Bayesian model being developed by Brigham Young University.
- Enabled the Design Group to initiate a pilot project to create topographic survey maps for two locations.

DATA COLLECTION TECHNOLOGY

Figure 1 depicts the vehicle used by the contractor to collect the roadway asset data.

Figure 1 The contractor's vehicle with LiDAR senors and other equipment

After collecting the data, the contractor delivered to UDOT an accumulation of data from the various sensors as well as real time photographs. Figure 2 shows a small segment of the point cloud comprised of the individual data points detected using the vehicle-based sensors.

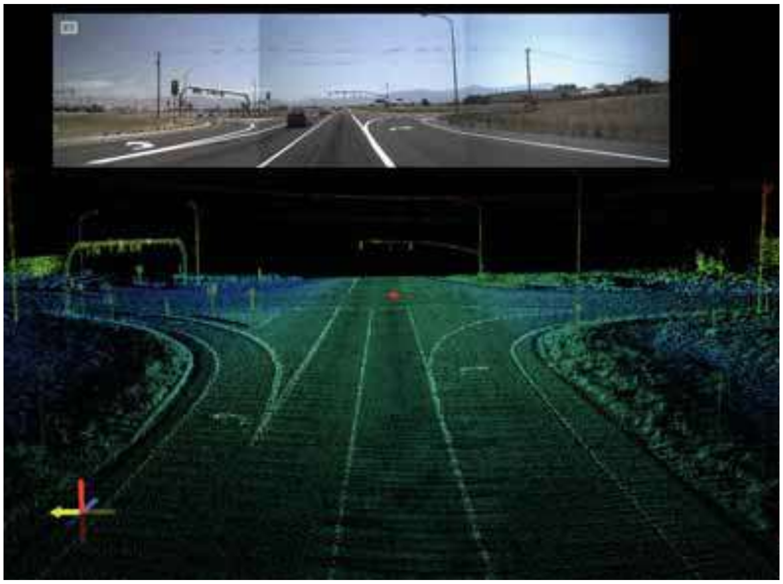

Figure 2 Photographs taken with the data maps

The contractor collected the point cloud with line-of-sight detection from the vehicle to the features on the roadway and stored it in a spatial database recording the 3D coordinates of each point. The resulting database consists of seven to ten terabytes for the point cloud alone. [6]

SUMMARY

Management:

The success of this project was in part due to the project champion. Each step of the process needed collaboration from different departments as well as approval from the agency executives. The champion of the project, Stan Burns, was able to promote the project and keep interest alive through completion of the initial data collection and beyond. Several challenges included the learning curve with new equipment, software, and technology as well as the size of the data collection effort. 5UDOT executives wanted to know future plans for keeping the information up-to-date. The project team agreed to gather the data every two years. [5]Furthermore, the team developed software to ease the process of updating data. [5]As a result of the initial data collection round, UDOT learned the importance of setting clear contract requirements for data delivery timing and compatibility. They also learned the importance of using attribute nomenclature that would be consistent with the databases where the information would ultimately be stored.

Personnel/Level of Effort:

The Utah roadway imaging and inventory project was initiated by the UDOT Asset Management Division and championed by Stan Burns of that division. Stan Burns and Michael Butler provided the overall management and promotion of the project. During the project, Stan Burns spent an estimated 15-20 percent of his time on this effort, while Michael Butler spent approximately 35 percent. Additionally, the following UDOT division managers spent a percentage of their time to the effort over the course of a year: [2]

- Systems Planning & Programming – Gary Kuhl (10 percent), Lee Theobald (20 percent).
- Central Maintenance – Lynn Bernhard (20 percent), Lloyd Neeley (5 percent).
- Central Traffic & Safety – W. Scott Jones (10 percent), Travis Jensen (10 percent).

Additionally, the following departments contributed the estimated levels of effort on the project over the course of a year (in addition to the individuals listed above): [2]

- Traffic – 3 staff involved, FTE: 0.25.
- Structures – 2 staff involved, FTE: 0.05.
- Maintenance – several staff involved on the QA efforts, FTE: 0.25.
- Asset Management – 5 staff involved, FTE: 0.5.

GIS/Engineering Technology Service – 3 staff involved, FTE: 1.0.

Funding:

Funding was a main concern for a project of this magnitude. The total cost for the first round of data collection was $2.25 Million – a relatively large sum for a data project in UDOT. [1]The champion worked with each of the divisions involved to establish a method for funding the project prior to the RFP. The majority of the funds were from Systems, Planning, and Programming; Central Maintenance; and Central Traffic & Safety. By pooling funds together, each group gained a sense of ownership over the project. 3Two sources of federal funding were used in the data collection effort – $725,000 of HSIP and $825,000 of SPR. The rest of the money used was state funds. Figure 3 shows the distribution of funding.

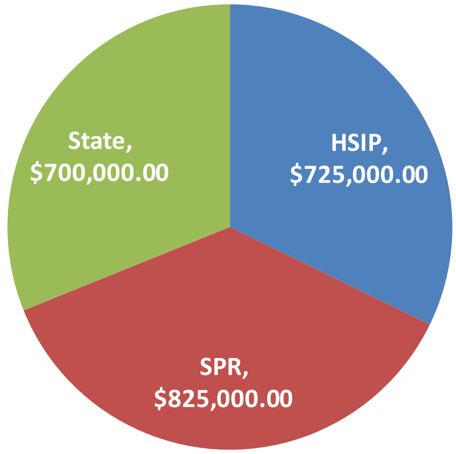

Figure 3 Distribution of funding contributions

Planning:

The planning phase involved the champion, the agency executives, the three main divisions (Systems, Planning, & Programming; Central Maintenance; and Central Traffic & Safety), and the contractor. The contractor gathered the first round of roadway asset data in 2012 and will collect the first update in 2014. The agency plans to update the data every 2 years within a 6-year contract to the vendor. Based on the experiences with the initial data collection, UDOT created software to help integrate data from future updates into UDOT's databases and has streamlined a process of checking, organizing, and storing the data. Industry collaboration has included ESRI, Oracle, Bentley, Mandli, Deighton, AgileAssets, Virtual Geomatics, and the AAA Foundation for Traffic Safety. [1,10]

Challenges (prior to implementation):

One challenge to overcome was creating definitions of roadway elements. Overall, eight to ten different groups within UDOT had requested roadway data and there were slight differences on how each group defined parts of the roadway. For example, the Maintenance Division defines the shoulder as the non-paved area beyond the edge of the pavement, where others define the shoulder as the paved area beyond the edge line. UDOT internally had to resolve these differences prior to data collection so that the vendor could collect each asset using a single, precise definition.

Challenges (after implementation):

Once the vendor supplied the data, UDOT performed quality checks and integrated the data existing databases and business processes. UDOT expected that a new data collection effort of this magnitude was likely to run into unanticipated delays and challenges. Accuracy and precision tolerances were set in the data delivery contract and these tolerances were generally met, although a few variables such as horizontal curvature and barrier end treatments did prove challenging to accurately assess. For example, several barrier end treatments needed to be identified and some were indecipherable by looking at a static photo. Another challenge was reconciling different versions of UDOT's linear referencing system (LRS) because it changed between the time UDOT gave it to the contractor (before the data collection) and when data were being delivered.

Another issue was with the vertical clearances of a subset of bridges. The contractor provided thousands of points beneath an overpass and from this produced a vertical clearance. The structures group field verified these clearances and found discrepancies up to 1.5 inches (for approximately 10 percent of the structures). There were two reasons given by UDOT for these differences:

- The structures survey was not at the exact low point during field verification.
- The LiDAR sensors may have picked up "noise" or points that were outside of the expected range.

It is important to note that all of the contractors reported clearances were of a smaller value than the field-verified survey. In other words, the contractor's values were always more conservative than the field-verified values.

Added Value:

The LiDAR point cloud is considered mapping grade with an absolute accuracy of plus or minus 1 meter. While this accuracy is suitable for feature extraction it is not usable for design applications. UDOT worked with a local survey company (Meridian Engineering) and a software company (Virtual Geomatics) to transform the point cloud to design grade accuracy of plus or minus 3 cm on two pilot design projects. Cost and schedule savings of approximately 25 percent were achieved over traditional surveys.

UDOT has further added value to the design and construction process by prepopulating project quantities directly from the asset inventory. UDOT has developed software integration tools between its asset and construction databases. At the click of a mouse, a designer can extract any number of assets (e.g. signs, paint striping, pavement, etc.) and incorporate the quantities with appropriate attributes into the construction bid set. The dataset does not include all desired data elements, but the location of each asset and some condition information is readily available.

Lessons Learned:

The project proved effective for managing roadway assets for UDOT in several ways. One outcome is that the data will be stored in one centralized data warehouse for all of the UDOT divisions to use. The cost savings this will create for each of the divisions is large, but not easily measured due to the potential for increased efficiency and time savings.

The data also improved pavement management and sign management. The 3D technology accurately recorded cracks in the pavement, which in turn gave UDOT a more accurate basis for deterioration models and funding projections. Similarly, knowing the total number of signs and their locations has improved sign maintenance and spending forecasts. Besides cost savings, UDOT created time savings for staff and its contractors through the data and the software developed to manage the data. For example, the bicycle coordinator was able to find out how many bicycle lanes the State maintains within 30 minutes. Previously, that task would have been difficult to do and taken at least several days to complete.

Specifically, the following lessons were learned from this Case Study: [1]

- Prepare a plan to store, distribute, analyze, and utilize the data.
- Build support from senior leadership. This was accomplished by the champion meeting with senior leadership to make them aware of and up to date on the project. He also presented the concept to the Utah Transportation Commission and the Executive Director of UDOT.
- Provide adequate time for the procurement process.
- Work extensively with the vendor from selection to final data collection/delivery.
- Do not expect to fund your entire data wish list up front.

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Maintenance Management Quality Assurance (MMQA) measures performance of assets, sets targets, and helps to establish budgets.

Mobile LiDAR is a data collection technology that when mounted to a vehicle "creates a point cloud for a continuous accurate measurement of pavement and all surrounding roadway assets". (11)

Operations Management System (OMS) is the system housing much of the asset inventory data pertinent to maintenance operations, used by the Maintenance Division to plan and manage budgets, allocate resources including manpower, equipment, and materials, record work done, and analyze maintenance needs. The MMQA program is housed within OMS.

UGate is the UDOT Oracle database for the point cloud data.
http://www.udot.utah.gov/ugate/f?p=111:2:0::NO

uPlan is a program created by the UDOT Systems Planning & Programming Division to share all the data needed to plan and program a project. [1] uPlan is distributed on an ArcGIS platform, in conjunction with UDOT's existing Oracle – based systems.[8] http://uplan.maps.arcgis.com/