Project Briefs for

SHRP 2 Reliability Research

Preparing for the Future

Data and Analysis for Travel Time Reliability Performance

Reliability in Planning, Programming, and Geometric Design

Organizing Transportation Agencies to Improve Reliability

Reliability Project L13

Requirements and Feasibility of a System of Archiving and Disseminating Data from SHRP 2 Reliability and Related Studies

MAY 2011

In this project a feasibility study was conducted to assess the technical, economic, and business aspects of developing, operating, and maintaining an archive for data from SHRP 2 Reliability and related research projects. The archive would make this data accessible to researchers and practitioners for up to 50 years. In the course of the feasibility study, the research team developed three alternative solutions for the data archive. The actual archive would be created and implemented in Project L13A: Design and Implement a System for Archiving and Disseminating Data from SHRP 2 Reliabilities and Related Studies/Assistance to Contractors to Archive their Data for Reliability Projects. This document summarizes the final report of the feasibility study, Project L13. The final report is available on the SHRP 2 website: www.TRB.org/SHRP2. Zongwei Tao, Jeffrey Spotts, and Elizabeth Hess of Weris, Inc. comprised the project team. David Plazak, the responsible program officer, can be contacted at dplazak@nas.edu.

The Need for an Archive

The reliability of travel times on transportation facilities can only be assessed in the context of a statistical distribution of travel times. A number of factors impact travel times on a day-to-day basis, including fluctuations in travel demand, inadequate base capacity, weather, traffic incidents, special events, work zones, and poorly functioning traffic control devices. Months and months of travel time and related data, such as weather conditions, are needed to understand reliability problems and how they can be addressed on a regional or corridor basis. Reliability research in SHRP 2 will generate a great deal of such data that will be useful in the development of models, tools, and strategies for improving reliability, but only if the data are both preserved and accessible to researchers. To address this need, Project L13 conducted a study to examine the feasibility of creating such an archive and maintaining it for up to 50 years.

The data archive should meet three goals: (1) preserve all valuable digital assets collected and produced by SHRP 2 Reliability and related research projects for up to 50 years; (2) provide transportation researchers and practitioners with a way to discover and access these digital assets in standard, open formats; and (3) establish an extensible architecture that facilitates future expansion of the archival system to preserve digital assets from other projects, enhance discovery by integrating related data, provide data integration or mash-up services, and create a collaborative community.

A conventional relationship database system was determined to be inadequate to achieve these goals. The researchers proposed that the archive follow the structure of a digital library or museum. Libraries and museums focus on preserving information, maintaining its provenance, and putting it into context. Libraries and museums also have growing

bodies of standards, software tools, and best practices that are gaining worldwide adoption.

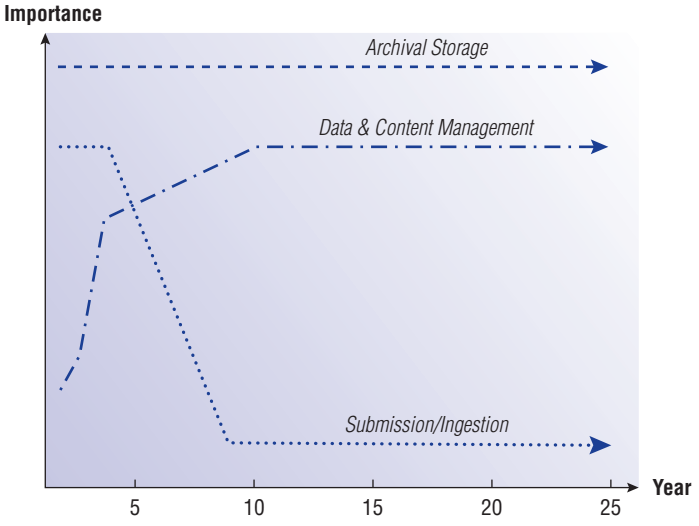
Users

The primary purpose of the Reliability data archive system would be to allow users to validate the research results from relevant SHRP 2 projects and to refine and build on research results into the future. The archive would be designed for leaders of transportation agencies, technical staff of transportation agencies, non-transportation professionals with some relationship to transportation operations (such as law enforcement officers, fire fighters, and special event venue managers), researchers, and analysts. Access to the archive is expected to be free of restrictions. In general, there is no perceived negative impact with respect to data rights as the majority of raw data used by the Reliability projects comes from the public sector and has few confidentiality or security issues.

Data

Reliability projects include a diverse array of file types and formats to embody the intellectual products of the research. For example, products will include structured datasets on roadway incidents; volume, occupancy, and speed; roadway characteristics; and extraordinary events, each in significantly or subtly different formats. The data archive must then accommodate both raw and aggregated datasets, for which relationships and linkages to conclusions must be maintained; derived data; models; tools; code; and written reports. Additionally, metadata and a data dictionary will be critical components of the archive.

FIGURE 1 ***Relative Importance of Functionality over Time***



Principal Implementation Agent

The research team recommends that a principal implementation agent be responsible for migrating the Reliability data archive to a production environment once its development is completed under SHRP 2. The implementation agent would be responsible for long-term stewardship of the data archive—including system administration, maintenance, and upgrade—and communicating activities of the archive to the user community. The agent would also establish relevant policies and procedures for using the archival system and maintain coordination with stakeholders at both strategic and technical levels.

Functionality

Determining a solution for the data archive requires identifying which software and hardware technologies might address the functionality and operational requirements of the archival system and how the technology could be acquired and implemented. The options include commercial off-the-shelf technology, open source software, in-house software development, hosting, cloud storage, and software-and-storage-as-a-service. An additional challenge is that the importance of each functionality requirement is not static; they will vary during the life of the archive system. The relative importance of functionality over time is illustrated in Figure 1.

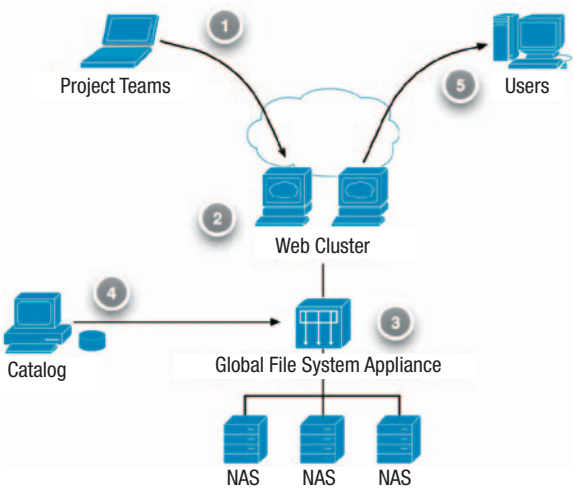
The Three Alternatives

In the course of this project, three alternative solutions for the archive were developed; each is briefly described in the following sections. Two critical issues that will influence the selection of potential alternatives are the relative importance of system functionality over time and the estimated total data volume to be preserved. Alternatives were evaluated for ability to meet the requirements, conformity with conceptual design, initial and recurring costs, benefits to stakeholders, risk mitigation, and schedule.

Alternative Number 1

This is the bare minimum alternative. It is simple and straightforward to implement, and it meets the minimum essential requirements to be considered a viable solution. This alternative is based on the use of a hierarchical file system to organize the files from each research project. A directory structure that follows basic naming conventions would establish an implied taxonomic hierarchy. The overall concept is depicted in Figure 2.

FIGURE 2 ***Concept of Alternative Number 1***
(NAS is an acronym for network attached storage)



Alternative Number 2

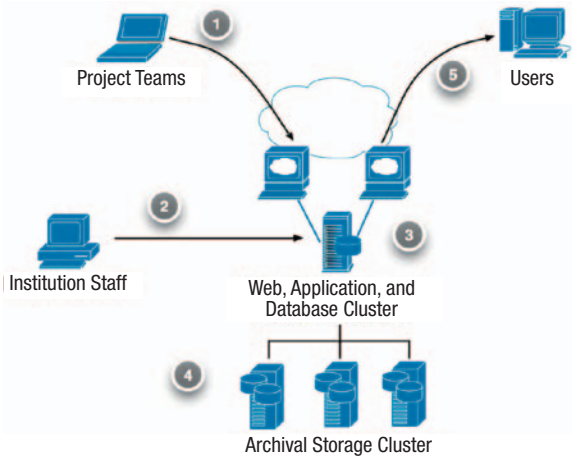
This alternative is based on digital object repository management software designed for universities, libraries, museums, archives, and information centers. This concept, depicted in Figure 3, was selected because the functionality provided by these software suites maps very closely to the functional requirements and conceptual design of the envisioned archival system.

Alternative Number 3

Alternative Number 3 is based on the same class of off-the-shelf software as Alternative 2, but instead of archiving data in self-hosted storage, archived data is preserved in a cloud-storage service. Cloud storage services store and retrieve files via a simple web service interface, in essence, providing an object-based storage service. An object is stored and retrieved using a persistent identifier over encrypted communications in conjunction with a session authentication token. Each stored object is replicated within the storage cloud for high availability and fault tolerance (three ephemeral copies of an object is typical of these services). At many levels, the model maps well to archival storage requirements.

User access to the system is exactly as described for Alternative 2, except that the digital object repository management software, in its role as trusted intermediary to archived data, retrieves the requested object(s) from a cloud storage service instead of from a self-hosted storage. Figure 4 illustrates this concept.

FIGURE 3 ***Concept of Alternative Number 2***



Benefits

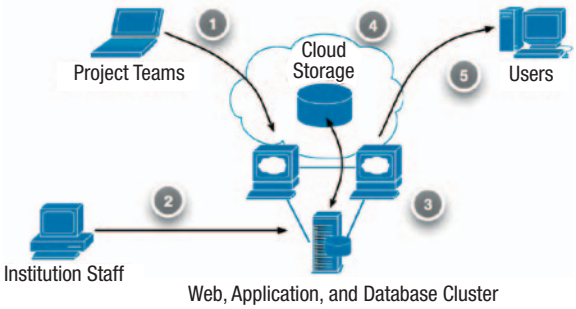
Project L13 determined that the entire SHRP 2 program could benefit from the implementation of the Reliability data archive. The benefits can be assessed with respect to long-term data preservation, sharing of system capabilities across projects and programs, and how the alternatives are best positioned to support the implementation of the SHRP 2 program results.

The Reliability archive could benefit a wide range of users. The final report includes assessments of user benefits—such as business functionality; follow-on research, testing, and evaluation; and advanced user accessibility. The report also assesses how each alternative enables system performance and reliability, as well as their relative complexity to manage over time. The table shows the research team's assessment of the relative benefits of the three alternatives.

Conclusion

Project L13 determined that it is highly feasible for the SHRP 2 program to cost-effectively deploy a data archival system that meets all the goals and objectives envisioned by its major stakeholders. The research team recommended

FIGURE 4 ***Concept of Alternative Number 3***



Benefit Targets	Benefit Aspects	Alternative 1	Alternative 2	Alternative 3
SHRP 2 Program				
	Initial investment under $1.2 M budget	No	No	Yes
	Can be implemented in 18 months	Possible	Possible	Lowest Risk
	Long-term preservation	Yes	Yes	Yes
	Sustainable (avoids obsolescence, migration management)	Yes, but with highest effort	Yes	Yes, lowest effort
	Potential leverage for other SHRP 2 programs and projects	Minimal	Good	Best
	Capacity for greater information sharing	Minimal	Good	Best
	Support for possible future institutional structures and governance models	Least Flexible	More Flexible	Most Flexible
	Support of program implementation strategy	Minimal	Good	Best
User Community				
	Basic data access and functionality	Minimal	Yes	Yes
	Follow on research, testing, and evaluation	No	Good	Best
	Advanced user accessibility	No	Good	Best
Long-term Implementation Agent				
	System administration burden	Highest	Moderate	Lowest
	System maintenance burden	Moderate	Moderate	Lowest
	Recurring cost	Higher	Higher	Lowest
	Internal expertise required	Higher	Higher	Lowest
	Long-term stewardship	Acceptable use of resources	Better use of resources	Best use of resources

that SHRP 2 proceed with Project L13A: Design and Implement a System for Archiving and Disseminating Data from SHRP 2 Reliability and Related Studies/Assistance to Contractors to Archive their Data for Reliability Projects. An RFP for Project L13A was released in July 2010 and a contract is pending award approval.

A Reliability Project Brief

Travel Time Reliability 2030

Innovations and Strategies for Today and Tomorrow

MAY 2013

What will the reliability of the transportation system be like in the year 2030? Over the next two decades, many factors that can impact roadway travel conditions, congestion, and reliability are expected to change—namely technology, climate, economy, and energy—but it is hard to predict exactly what the changes will be. With so many variables, how can we be ready for what may come?

Projects from the second Strategic Highway Research Program (SHRP 2) are exploring innovations and possible trends that can shape the future of travel time reliability. This brief provides an overview of two of those projects: SHRP 2 Project L11 (Evaluating Alternative Operations Strategies to Improve Travel Time Reliability), which identified and evaluated strategies and tactics for improving travel time reliability for users of the roadway network in urban and rural areas; and SHRP 2 Reliability IDEA Project L15B (Proximity Information Resources for Special Events), which developed technology for automatically measuring pedestrian crowd metrics, including the size, movement, directionality, and density of crowds.

Evaluating Alternative Operations Strategies to Improve Travel Time Reliability

Travel time reliability is reflected in the variation in travel time for the same trip from day to day. If the variability is not predictable, then travelers and shippers cannot count on arriving at their destination when planned or within some acceptable time window. They build in extra travel time to arrive on time, which has a real cost. Some variability occurs regularly, for example the weekday cycle between peak and off-peak traffic. But at least half the variability is due to unpredictable events such as traffic incidents, weather, work zones, special events, surges in demand, and traffic devices not working properly. Addressing these problems saves time, reduces frustration, and improves safety. Indeed, a consensus is building that motorists value improvements in reliability roughly the same as improvements in average travel time.

The final report for Project L11 (SHRP 2 Report S2-L11-RR-1, *Evaluating Alternative Operations Strategies to Improve Travel Time Reliability*) is useful for different types of planning—including corridor, long-range, and performance-based planning. This report has a strong user focus and at the outset seeks to characterize different reliability requirements. For person travel, key considerations are whether trips are daily or occasional and constrained or unconstrained. Reliability needs of freight movement stem from three factors: the level of schedule flexibility (flexible, inflexible), level of operational adaptability (complete, none), and cost of variability (high or low).

Project L11 identified and evaluated strategies and tactics for improving travel time reliability for users of the roadway network in urban and rural areas. The intent of this project was to

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

provide a short-term perspective regarding system operations and travel time reliability, and to produce a long-term view with innovative ideas that can be implemented in the future. The final report for this project presents a set of options regarding technological changes, operational solutions, and organizational actions that have the potential to improve travel time reliability both now and in the future (by the year 2030). SHRP 2 Report S2-L11-RR-1 is available at http://www.trb.org/Main/Blurbs/168142.aspx or by searching the report title at www.TRB.org.

Effectiveness of Agencies

The final report describes the current effectiveness of transportation agencies (state, local, toll authorities, and metropolitan planning organizations with operations responsibility), incident responders, and other stakeholders in meeting travel time reliability requirements. The report mentions existing measures used by agencies to assess travel time reliability or evaluate disruption events. It also documents the factors that influence the effectiveness of transportation agencies based on a comprehensive literature review. Lastly, transportation management infrastructure is analyzed to assess its influence on an agency's ability to achieve travel time reliability.

Goals and Performance Targets

Given the reliability needs of stakeholders and the ability to manage reliability by agencies, agency goals and performance measures were identified to improve travel time reliability. The final report describes existing data issues and the need for developing goals and performance measures to improve travel time reliability. The goals and performance measures are built on the previous findings and are presented in three parts:

1. Existing travel performance and disruption data,
2. Potential performance measures for agency use, and
3. Developing performance measures and setting goals.

Understanding how the reliability of roadway operations affects stakeholders, agencies can identify the statistics that track the attributes of roadway performance. However, those statistics are useful only if data can be collected to accurately populate the variables. The report describes the current practice in terms of data for roadway-performance travel time reliability and the factors that can adversely disrupt normal roadway operations and cause delay.

Based on the current needs of highway users and the availability of roadway-performance and disruption data, the report discusses the basic performance measures that roadway agencies could use. By combining the needs of individual travelers and freight movers, along with the needs and limitations of agencies, performance measures aimed at improving travel time reliability could be developed within the following three areas:

1. Roadway Performance—measures related to roadway performance (outcome measures);
2. Disruption Management—measures related to how an agency responds to disruptions in normal roadway operations (output measures); and
3. Information Dissemination—measures related to how well an agency informs highway users about current and expected travel conditions in order to improve the users' ability to manage their lives and businesses.

By setting goals and performance targets that fit the context of the current situation, agencies can report on the effectiveness of their programs (capacity increases, operational improvements, incident response programs) for improving roadway performance without being held to a performance standard that assumes a volume/capacity ratio that is not attainable. Where publically acceptable and realistic performance targets can be identified, they may be adopted. Good examples of these exist for managed lanes (for example high-occupancy toll lanes that need to operate in free flow conditions 95% of the time during peak periods) where the public has accepted the volume control measures (pricing) and the operating agencies have devoted the incident management resources necessary to allow the goals to be met.

The Cost Effectiveness and Economic Value of Reliability Improvements

The report includes considerable information on the effectiveness and benefits of strategies or actions that can improve travel time reliability. Such information comes from the US Department of Transportation Research and Innovative Technology Administration (RITA) Intelligent Transportation Systems (ITS) Database, the Benefits Desk Reference, the ITS Deployment Analysis System, and other literature and sources. The benefit data was combined with information on costs to provide some insight regarding the relative cost-effectiveness of different approaches to improving travel time reliability.

The research also sought to develop a way to impute to the dollar economic value of improvements in reliability. The customary approach is to make inferences based on actual or stated behavior. In this research an analytic method was developed that could be easily applied to a specific segment or trip. The approach is based on determining the certainty equivalent of the variability of speed. The analytic procedure—Black-Scholes—is widely used in the finan-

cial sector and those who devised it won the Nobel Prize. However, numerous experts could not agree on the validity of applying this economic analysis method to valuing travel time reliability. This innovative approach to valuing travel time reliability, even with the disagreements about validity, is likely to stimulate future research. Appendices describe in detail the method that was used along with examples.

Trends Affecting Travel Time Reliability

The final report provides an overview of the trends that are anticipated to shape future roadway travel conditions, congestion, and reliability. Particular attention was paid to research documents and other literature related to these topics:

1. Demographics, land use, and urbanization;
2. Environment and climate change;
3. Energy costs and availability;
4. Technological innovation;
5. Freight; and
6. Finance, road pricing, and privatization.

Emerging and Future Technology

Technological change, especially innovations that are likely to become reality by 2030, received considerable attention in this research. Among the technological developments identified were wireless mesh networks (e.g., connected vehicles), active traffic management, automation of passenger transport, many types of freight operations, robotic deployment of incident screens to reduce rubber necking, big data and real time analytics in a shared data and decision making environment, wearable computers and augmented reality, telepresence and holographic 3D imagery to support telecommuting, optimal routing and matching of supply and demand, real-time pricing, and resilient infrastructure that preserves functionality when perturbed.

Using Alternative Futures to Identify Trends

Alternative futures were crafted to group the current and potential range of trends and scenarios in order to identify the following:

- A range of cumulative impacts on the operation of the transportation system and the demands placed on it;
- The frequency of nonrecurring congestion;
- The priorities likely to be placed on mitigating such congestion;
- The technologies that may exacerbate the problem or facilitate effective responses to it; and
- The broader social, environmental, and contexts within which the future transportation system is managed.

These alternative futures are not forecasts but rather are a mechanism for bounding the trends that might impact congestion and reliability. To capture the range of possible impacts, these trends were combined to produce a set of three possible future scenarios:

- Alternative Future 1: The Optimistic Scenario
- Alternative Future 2: The Mediocre Scenario
- Alternative Future 3: The Pessimistic Scenario

Global climate change, economy, and energy were considered to be the defining variables within each alternative scenario. Likely influences on the other known trends and on the operation of the transportation system and travel behavior are described for each of the alternative scenarios. In addition, the potential effects of these trends on the sources of congestion are noted.

As the future gets closer, the attributes of the highway system naturally become clearer and strategies can be adapted to meet more specific challenges and needs. The immediate task is to develop strategies and treatments that can be used to assure the satisfactory performance of the transportation system under any and all of these possible outcomes.

Alternative Future 1: The Optimistic Scenario

The optimistic scenario assumes a positive outlook on the future as it relates to climate change, economy, and energy. A key assumption of this scenario is that technological advances in energy will provide alternative sources of energy at an expense comparable to today's levels. New technology will also dramatically reduce the contribution of transportation to greenhouse gas emissions, achieving a 75% reduction in greenhouse gas emissions relative to year 2000 levels by 2030. The impacts from climate change will also be less severe than expected. In addition to new technology providing a solution to anticipated

Source: Richard Kelly

Electric Vehicles Charging

escalating energy prices and climate change, economic growth will be stimulated with a steady increase in employment and population within the United States. The demand for reliable transportation will increase because of both (1) increased travel demand as a result of strong economic, population, and employment growth, and (2) new technology making more-reliable transportation systems feasible.

Alternative Future 2: The Mediocre Scenario

The driving variables—climate change, the economy, and energy—will be in a range that supports moderate economic growth as well as the deployment of advanced technologies for transportation systems and operations. Energy prices will continue to increase, but supply, in the form of traditional and alternative fuel sources, will be fairly reliable. The demand for reliable transportation will increase because of (1) a stronger economy and increased employment, (2) pressure for efficiency coming from climate change and energy constraints and regulations, and (3) emerging technologies making more-reliable transportation systems feasible.

Alternative Future 3: The Pessimistic Scenario

The driving variables—climate change, the economy, and energy—will be in a range that does not support economic growth due to, among other influences, frequent extreme weather events and increasing energy prices. In particular, it is assumed that the drivers of change will result in worst-case outcomes, such as an increasing rate of climate change, a worsening of economic conditions, and increasing energy prices. This scenario focuses on the effect of exogenous variables on travel costs and provides the basis for an overall assessment. The demand for reliable transportation will increase because of policies and goals focused on (1) reducing fuel consumption, (2) decreasing greenhouse gas emissions, and (3) supporting economic growth. With the high value of travel cost, delays will become a much stronger economic constraint. Strategies aimed at reducing delays and travel variability will become an important component of state and regional transportation strategies to improve system performance. Large-scale applications of technology, financial tools, and institutional arrangements will be needed to support this focus on system reliability.

Gas Pumps

Summary of Alternative Futures

These three different scenarios help to define the possible range of impacts. They span the set of reasonable predictions that are taken from a variety of studies. They provide a basis for developing a robust set of reliability-improving strategies for the future. These future scenarios also highlight the significant changes that may unfold to help transportation agencies and members of the transportation industry ensure that our infrastructure, both physical and institutional, is prepared to address the transportation needs during the next twenty years. In response to the scenario drivers and responding trends, agencies and the private sector have an opportunity to begin implementing strategies and treatments that can help mitigate a reduction in travel time variability.

Operations Strategies and Treatments to Improve Travel Time Reliability

The final report identifies a list of key strategies and their strengths, weaknesses, threats, and opportunities for improving travel time reliability under the baseline and three future scenarios developed. In order to identify the strategies and treatments that are most likely to have the greatest impact, a literature review focusing on previous and current work of other SHRP 2 Reliability and Capacity projects was conducted, including L03 (Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies), L06 (Institutional Architectures to Advance Operational Strategies), L07 (Evaluation of Cost-Effectiveness of Highway Design Features), and C05 (Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs). In addition to these projects, information from the Federal Highway Administration, state transportation agencies, universities, and other countries were reviewed to ensure a broad assessment of strategies and treatments. Innovative technologies that may impact travel time reliability in the future were also reviewed and included in the report.

Based on their general focus area, the strategies are grouped into six major categories as follows:

Flooded Road

1. Agency management, organization, and resource allocation;
2. Information collection and dissemination;
3. Vehicle technologies;
4. Incident and special event management;
5. Infrastructure improvements and demand optimization; and
6. Technology innovations.

A Concept of Operations

According to the US Department of Transportation, a concept of operations describes the roles and responsibilities of stakeholders with regard to systems and transportation operations within a region. Because of the complexity of the transportation system, as well as the roles and responsibilities of the stakeholders, a typical concept of operations is intended to be a high-level document. In fact, the depth of information of a concept of operations will likely rely heavily on the quantity and variety of systems and likely scenarios within a region. To that end, many regional intelligent transportation systems architectures use high-level operational scenarios to engage stakeholders and to better define their roles and responsibilities. For example, these scenarios may describe what happens during a major weather incident, hazardous material spill, or long-term construction project. As stakeholders assess these scenarios and document their concept of operations, the significance of their roles and responsibilities is readily apparent, which gives stakeholders time to prepare for gaps or challenges in regional operations. The resulting documentation can be a series of statements an agency or group of entities may wish to adopt that are binding, simply stated facts, or that establish a goal or direction.

The report includes a concept of operations document to define the roles and responsibilities that participating agencies play in applying strategies and treatments for improving travel time reliability. The agencies that can contribute to improving travel time reliability include those responsible for transportation systems (at the federal, state, and local levels), law enforcement, freight movement, emergency response, and vehicle manufacturers. If agencies are to achieve the vision of improving travel time reliability, they will have to work individually and in collaboration to implement those strategies most relevant to their region and be able to measure the performance of each strategy. This document has the following purposes:

- Establishing a baseline set of existing conditions describing the strategies that are employed today; and
- Describing the strategies that could be implemented over the next 20 years to enhance travel time reliability for both passenger and freight vehicles.

Cherry Blossom Festival, Washington D.C. | Eric T. Gunther

Strategies were developed to address the three alternative future scenarios spanning the range of future possibilities that could develop by the year 2030.

By anticipating changes in transportation services and travel characteristics, transportation agencies will be positioned to maintain or improve reliability and mobility in the context of increasing levels of demand. The report provides an overview of the organizational, business practices, and funding strategies that are needed to improve travel time reliability by 2030.

SHRP 2 Contact

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PRoximity Information System for Mobility

Travel time reliability—which is increasingly important to highways, arterials, transit, and air travel—is also important to pedestrians. When managing large crowds, performance measures relating to volume, density, and trajectory of pedestrians (crowd metrics) are essential. PRISM (PRoximity Information System for Mobility), which was developed in SHRP 2 Reliability IDEA Project L15B (Proximity Information Resources for Special Events), gives event organizers the ability to automatically measure crowd metrics. PRISM uses detectors that sense Bluetooth devices, such as cell phones, to identify the location of pedestrians. Software is then used to aggregate this data with data from Twitter and FlickR, and display the size, movement, directionality, and density of crowds in near-real time. The potential uses for these crowd metrics include emergency management and deployment of event staff.

The PRISM team was unified through common experiences while attending special events in the Washington, D.C., area. At these events, critical information related either to health, sanitation (restrooms), first aid, guidance, or mobility (parking, shuttles, and recommended driving routes) were frustratingly difficult to obtain. Many times event specific information such as the program,

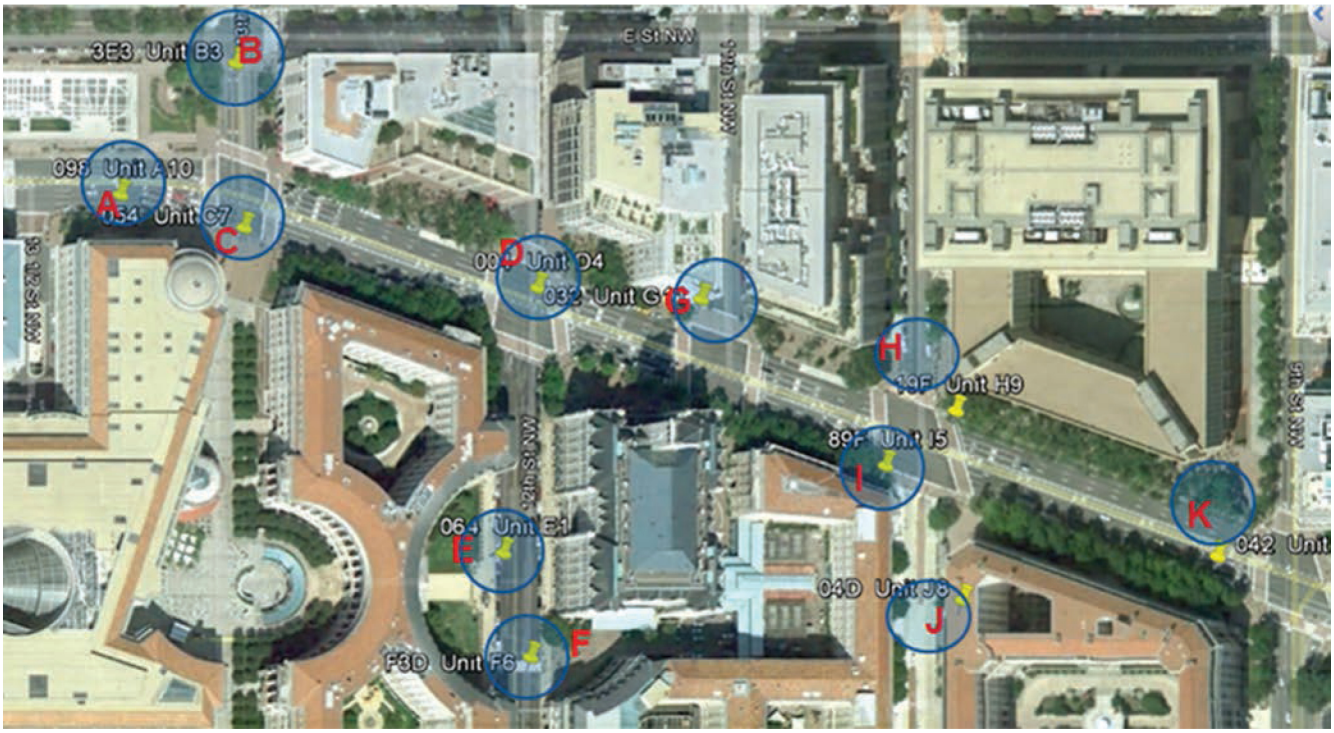
timetables and navigation of booths and stages were also inconveniently conveyed by event organizers. Stage I of the project consisted of sharing the PRISM concept, and its motivations to a number of potential stakeholders and experts. Through collaboration with this group, the PRISM concept was refined, and revealed that event organizers were similarly frustrated by the lack of objective information about the size and disposition of the crowd attending the event, and by lack of means to communicate with them, particularly in emergency situations. By the completion of Stage I, a number of smartphone applications had emerged to service conference venues, delivering a portion of the event specific information envisioned by the original PRISM concept.

Sakura Matsuri Demonstration Project

Stage II activities consisted of a number of small data collection experiments and prototype software development that led up to a major demonstration in cooperation with Sakura Matsuri, a cultural festival held annually in Washington, D.C., in conjunction with the Cherry Blossom Festival. Sakura Matsuri provided a compact venue with crowd densities similar to that of large National Mall events. Typical attendance at the one-day festival is estimated at 30,000 to 60,000; large enough to adequately exercise the pedestrian monitoring equipment. The Japan American Society of Washington DC (JASW) collaborated with the PRISM team, sharing many of the same needs identified by Stage I collaborators, particularly identifying the need for an objective source of real-time crowd metrics without having to rely on subjective crowd observations and estimates. With the cooperation of the JASW, the team was able to deploy its prototype PRISM system during the one day event and demonstrate many of the key features of the re-focused concept.

The JASW demonstration illustrated a number of capabilities and provided insight into a number of issues. Crowd monitoring was demonstrated using a deployment of 11 portable sensors at strategic locations—such as entrances, crossroads, and stages. Data from the sensors was delivered in real time to a monitoring station and was post-processed for in-depth analysis. Additional data streams from social media (Twitter and Flickr), simulated data streams reflecting the availability of space in nearby parking garages, and the location of a roving medic were integrated into the real-time monitor display. Key findings of the demo included:

- PRISM core monitoring technology was able to capture relative volume of pedestrians at entrances as well as at various locations and attractions within the festival. Although sensor range and placement need to be further optimized, the basic sensing capability was affirmed.
- Integrating social media sources, such as Twitter and Flickr, provided further dimension and color to the real-time monitoring system.



PRISM Sensor Deployment at Sakura Matsuri Festival

- Simulated data feeds for parking capacity and key personnel locations demonstrated extensibility of the system to provide a broad-based event monitoring platform.
- The data architecture relied on a cloud-based information publishing and subscription model that abstracts data integration. This approach minimized application complexity, eased the development of a custom display, and has the potential to greatly enhance reliability.

In depth post-processed data analysis of sensor data provided detailed information on the size, location, and movement patterns of festival attendees. Key accomplishments and findings included:

- The distribution of attendees determined by sensor data agreed favorably with the portions inferred from same-day ticket sales data provided by JASW.
- The estimated sampling rate of attendees was 1.5% to 2.0%. Uncertainty of actual festival attendance, discriminating attendees from passersby, and varying antenna detection characteristics limited the precision of this estimate.
- Detailed trip patterns from the sensor data revealed the time and sequence of visits to various locations and attractions at the festival. Based on this data, the relative attractiveness of various festival locations and attractions was analyzed.
- Attendance patterns (such as time of entry, time of exit, and length of stay) were extracted from the trip pattern analysis. The data sample was of sufficient density to create an animated simulation of the sampled trips, which provided a visual representation of the level of activity at the festival.

Final Report and Video

The final report for this SHRP 2 Reliability IDEA Project L15B is available at http://www.trb.org/main/blurbs/168235.aspx or by searching the Proximity Information Resources for Special Events at www.TRB.org. A video, which documents the demonstration at the Sakura Matsuri Festival, is available on the National Academies' Vimeo site at http://vimeo.com/57636858.

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Improved Models for Better Decisions

Planning Models, Traffic Operations Models, and Activity-Based Models

JANUARY 2012

Decisions about spending public funds for transportation improvements often are informed by estimates and forecasts developed through mathematical models. The more closely these models represent reality and include important influencing factors, the more confidence we can have in spending decisions. Models that can provide a better basis for predicting how highway improvements affect congestion, for example, or that reflect the differences in forecasting freight demand and passenger transportation will provide a more reliable picture of future needs.

The process is neither simple nor inexpensive, which is why taking up the challenge at the national level makes sense. Traffic operations and planning models generally require both demand and supply inputs. Travel demand could be static (for planning models), dynamic (for planning and operational models), or in the form of activity schedules (for activity-based models). In virtually all applications, actual travel demand cannot be perfectly forecast and is subject to a variety of disturbances, including special events, day-to-day variation in individual behavior, (unfamiliar) visitor traffic, and diversion from temporary unavailability of alternative modes. On the supply side, the operational capacity of network elements could be assumed as fixed, random, or systematically varying with traffic conditions through actuated signal controls, ramp metering, dynamic tolls, and so forth. Unreliability sources that affect supply-side attributes consist of incidents, work zones, weather, traffic control, dynamic pricing, and variation in individual driving behavior. To address these and other concerns, several projects from the SHRP 2 Capacity and Reliability focus areas are working to improve existing planning models, operations models, and activity-based models.

Models for Predicting Nonrecurring Congestion

How can we predict what effect an improvement will have on travel time reliability? Alternately, how can we characterize reliability as a function of highway, traffic, and operating conditions? To answer these questions, the research team in SHRP 2 Project L03: Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies developed models for predicting nonrecurring congestion, which is caused by events such as traffic incidents and weather conditions.

Three methods were used to estimate nonrecurring congestion, all based on empirical procedures: The first involved before-and-after studies; the second was termed a "data poor" approach and resulted in a lean and easy-to-apply set of models; and the third was called a "data rich model" and used cross-section inputs including data on selected factors known to directly affect nonrecurring congestion.

Much of the effort for the study went into the creation of a cross-sectional dataset from which statistical models could be developed. The final analysis data set for statistical modeling is highly aggregated: each record represents reliability, traffic, and event data summarized for a section for a

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year. Reliability is measured as the variability in travel times over the course of a year. As such, the cross-sectional model is a macroscale model: It does not seek to predict the travel time for a particular set of circumstances; rather, the overall travel-time characteristics of a highway section in terms of both mean and reliability performance. The cross-sectional model is, therefore, appropriate for adaptation to many existing models and applications with the same aim, and can serve as the basis for conducting cost/benefit analysis; however, it is not appropriate for real-time travel-time prediction.

Status: Project L03 is complete. The final report, currently in publication, will be available on the SHRP 2 website and as a printed document.

SHRP 2 Contact: William Hyman, whyman@nas.edu

Incorporating Travel Time Reliability Performance Measures into Traffic Simulation Models and Planning Models

Project L04 has dual objectives: to develop the capability of producing measures of reliability performance as output in traffic simulation models and planning models; and to determine how travel demand forecasting models can use reliability measures to produce revised estimates of travel patterns.

Addressing reliability in models, particularly operations, generally requires three elements. First is a scenario manager which captures outside sources of reliability such as special events, bad weather, work zones, and daily variation in travel demand. Second are simulation tools (micro or macro) that internally account for unreliability (e.g., flow breakdown, accidents). Third is a vehicle trajectory processor, which derives vehicle trajectories or paths from the simulation output. Trajectories can be used to develop travel time distributions, which in turn can be the basis for travel time reliability metrics.

The project team is currently adapting and calibrating existing traffic simulation models and applying them to an urban network. A mesosimulation model will provide a regional perspective and a microsimulation model will provide a close-up portrayal. To accomplish this, the project team is working with a regional transportation agency. The simulation models are expected to use random seeds, reflect the basic variability in travel time due to operations at saturation (such as recurring congestion), and produce one or more reliability performance measures as output.

The models are being developed for two primary sets of users: (1) practitioners and researchers, who may have a keen interest in the fundamentals of the modeling application to incorporate reliability in the analysis; and (2) operations managers and planners in transportation agencies, who may be interested primarily in the procedures employed to estimate reliability and the practical outcome of actions to improve reliability.

As part of this project, a guide is being written that will define the state of the art for incorporating travel time reliability in simulation-based operational studies. The guide will not be limited strictly to microscopic traffic simulation models, but rather will include any simulation that can produce individual vehicle trajectories.

Status: This project is active. The expected completion date is September 2012.

SHRP 2 Contact: William Hyman, whyman@nas.edu

Freight Demand Modeling

Freight is growing in volume, economic importance, and complexity—particularly in relation to sophisticated modal and information technology advances. Understanding freight flows and forecasting them is critical to determining the need for future transportation capacity on the nation's highways or other modal infrastructure. However, most existing freight demand forecasting models and data sources are based on methods and tools developed for passenger transportation, which are not well suited for forecasting freight movements or volumes. The overall objective of SHRP2 project C20: Freight Demand Modeling and Data Improvement Strategic Plan is to foster fresh ideas and new approaches to designing and implementing freight demand modeling.

In this project, a Freight Demand Modeling and Data Improvement Strategic Plan was developed to advance a broad new direction for improving freight planning; promoting continuous innovation for breakthrough solutions to freight analytical and data needs; and fostering a collaborative approach for private, public, and academic stakeholders. The plan was developed through an inclusive process of public and private stakeholders from the U.S. and international freight planning communities, culminating in the Freight Modeling and Data Innovation Symposium conducted in September 2010. A robust approach was followed to define needs and innovations, and to shape the long-term goals. The hallmark of this effort was considering the current state of the practice to maximize input from practitioners and decision makers. This entailed a review of research conducted on freight modeling and data improvement as well as analysis of current practices within the industry (both domestic and international).

The Freight Demand Modeling and Data Improvement Strategic Plan identifies a compelling direction for the freight planning community centered on meeting the

immediate needs of decision makers. The pragmatic focus on application and results also recognizes the parallel need to foster continued innovation and breakthroughs among researchers. This confluence of steady improvements in practice and continued research focus will be the basis for long-term improvements to freight modeling and data. This research project focused on defining the critical gaps in models, data, and decision making as the means to formulate a strategic and cohesive road map to guide the long-term initiatives identified throughout the research process.

Project Status: This project is complete. The final report and the strategic plan, currently in publication, will be available on the SHRP 2 website and as printed documents.

SHRP 2 Contact: David J. Plazak, dplazak@nas.edu

Integrated, Advanced Travel Demand Models

SHRP 2 has two projects (C10A: Partnership to Develop an Integrated, Advanced Travel Demand Model and a Fine-grained, Time-Sensitive Network [Jacksonville, Florida]; and C10B: Partnership to Develop an Integrated Advanced Travel Demand Model with Mode Choice Capability and Fine-Grained, Time-Sensitive Networks [Sacramento, California]) that will improve modeling and network processes and procedures in order to address policy and investment questions, and to facilitate further development, deployment, and application of these procedures. In addition, these models will produce a transferrable product, process, and sample data set that can be adapted for use elsewhere or used for research; incorporate SHRP 2 Capacity products from projects on pricing and operations into the model capabilities; incorporate travel time reliability into the modeling capabilities; demonstrate the application of outputs of the integrated model to estimate greenhouse gas emissions; and demonstrate the dynamic integrated model set in a real-world environment. Both model sets will reflect changes in the nature of demand, mode choice (including "new modes" such as work or shopping at home and nonmotorized travel), destination choice, timing, route of travel as a response to highway network congestion, roadway management strategies, road pricing, transit service, parking policies, and other public policies aimed at reducing congestion. Both sets will also deal with the consideration of reliability in travel choice.

Jacksonville, Florida: An Advanced Travel Demand Model and a Fine-grained, Time-Sensitive Network

In project C10A, the project team has partnered with the North Florida Transportation Planning Organization, whose region covers the Jacksonville metropolitan area. Jacksonville is the fifth most populous of Florida's 26 metropolitan planning organization (MPO) regions and is anticipated to grow to 1.6 million people by 2030. Jacksonville is the eastern terminus of Interstate 10, and Interstate 95 passes through the city, leading to substantial freight and interregional passenger car volumes on the region's transportation backbone. This local, regional, and interregional travel demand, when coupled with a road network that includes five major downtown bridges, leads to challenging traffic dynamics and interesting time-of-day and route choices.

The model system being tested comprises three primary components: DaySim, the TRANSIMS Router and Microsimulator, and the Motor Vehicle Emission Simulator (MOVES). DaySim is a travel demand forecast model that predicts household and person travel choices at a parcel-level on a minute-by-minute basis. The TRANSIMS Router and Microsimulator are dynamic traffic assignment and network simulation software that tracks vehicles on a second-by-second basis. MOVES is the next generation mobile source emission model being developed by the U.S. EPA. MOVES will estimate emissions from mobile sources and will replace MOBILE as the approved model for state implementation plans and regional or project-level transportation conformity analyses. The integrated model system will be established by enhancing and linking these model components in order to provide sensitivity at greater level of spatial and temporal resolution to the key policies.

The travel demand model to be used for this project is coded in a software framework called DaySim. DaySim was initially implemented in Sacramento, California, by the Sacramento Area Council of Governments (SACOG). It is being enhanced in Jacksonville to interface with the TRANSIMS Router. In addition, the project was amended to test transferability of model parameters to other cities (Tampa, Florida).

Status: This project is active. The expected completion date is February 2012.

SHRP 2 Contact: Stephen J. Andrle, sandrle@nas.edu

Sacramento, California: An Integrated Advanced Travel Demand Model with Mode Choice Capability and Fine-Grained, Time-Sensitive Networks

In project C10B, the project team has partnered with SACOG, the designated MPO for the Sacramento metropolitan area. Sacramento has light rail in addition to a bus system, providing a more varied modal environment for model development.

The project team will combine capabilities of an activity-based travel demand model with a traffic simulation model. The integrated model will combine the SACSIM activity-based model, the DynusT traffic microsimulation model, and the MOVES mobile source emission model. The Sacramento model will include a schedule-based transit simulation for assigning transit trips.

SACSIM is a complete modeling system that includes a disaggregate activity simulator called DAYSIM. DynusT is a recently-released, open-source license traffic simulation package already used in a number of areas, and it lends itself well to the integration with both SACSIM and MOVES. DynusT is a true disaggregate simulation model that tracks individual vehicles and transit travelers through the network—consistent with tracking traveler activities in a travel demand model. MOVES is designed to estimate emissions at scales ranging from individual roads and intersections to large regions.

The software architecture provides users the capability to access the integrated system from any web browser. The goal is to ensure that the integrated model software is efficient, modular, and maintainable so as to reduce the risk that changes to one model component will affect the operation of the model as a whole. The complete, integrated model will be available to the transportation community under open-source licenses.

Status: This project is active. The expected completion date is February 2012.

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A SHRP 2 Reliability Project Brief

Incorporating Reliability into the Transportation Planning and Programming Process

AUGUST 2013

The current federal surface transportation law, Moving Ahead for Progress in the 21st Century Act (MAP-21), requires transportation agencies to use a performance-based approach to planning and programming transportation projects. Travel time reliability and congestion reduction are explicit goals of the act. As agencies work to meet these goals, the timely results of significant research on data and tools to evaluate reliability can help them better understand and predict the variability of travel time and its impact on congestion.

To help transportation agencies integrate mobility and reliability performance measures into the transportation planning and programming process, a SHRP 2 research project on Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes (L05) has developed three reports: 1) *Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes* (Guide), 2) *Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: Technical Reference* (Technical Reference), and 3) *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes* (Final Report). This project brief provides an overview of these three reports.

Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes

The intent of the Guide is to help planning, programming, and operations managers apply the concept of travel time reliability to balance investment in programs and projects. Reliability performance measures help agencies (1) understand and communicate reliability; (2) identify the tools and methods to help them track transportation system reliability; (3) incorporate reliability into their existing analysis tools; (4) identify emerging analysis tools that will better help them evaluate reliability; and (5) make program and project investment choices that address the reliability of the system.

Understanding reliability performance is a critical first step to incorporating it into the planning and programming process. Reliability is different from most performance measures that agencies report on today because it is a measure of variability. Most performance measures, such as pavement or bridge condition, change year to year, but not day to day or hour to hour. The tools that agencies have used to examine system performance (four-step travel demand models, management systems, and the like) typically examine average annual conditions. As travel time reliability becomes a more significant issue, different tools will be needed to directly measure and forecast the type of variability that agencies face.

To incorporate reliability into the planning and programming process, transportation

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agencies need different data and tools than are typically used to examine and predict future performance. The Guide and the associated Technical Reference can help agency planners and system operators identify the data, tools, and methodologies for examining reliability. These include emerging analysis tools that can directly estimate or forecast reliability, as well as tools and methodologies that can help an agency measure reliability. The guidance is based on a few key principles:

1. **A collaborative approach to planning.** To collaboratively address reliability, transportation agencies need to partner with key system supporters, such as emergency response personnel and tow truck operators, who can contribute to the overall reliability of the transportation system by responding and clearing incidents quickly. The SHRP 2 Capacity focus area created a web tool to support collaborative, performance-based decision making throughout the planning process: Transportation for Communities—Advancing Projects through Partnerships, or TCAPP, which is available at http://www.transportationforcommunities.com.
2. **A performance-based approach to investment decision making.** Many agencies already use performance measures to help inform decision making, but MAP-21 began the process of crystallizing requirements around performance-based planning and programming. The Guide is built around these concepts, reliability being one of several measures that an agency may use to evaluate the performance of the system and make investment decisions at both program and project levels.
3. **A balanced approach to improving reliability that considers all project types on a level playing field.** Because reliability is affected by a variety of transportation challenges—such as incidents, weather, and bottlenecks—a wide range of solutions should be considered when attempting to improve it. Solutions include operations and management strategies—typically targeted at improving the reliability of the system—in addition to capacity additions, safety, and other investments. Because operations and management strategies occur in different project phases than projects to add capacity, examining the full life-cycle cost of investments (and their benefits) is especially critical to ensure the efficient use of limited resources.

The guidance also covers four key areas that are needed to incorporate reliability into the transportation planning and programming process:

1. **Developing and tracking a reliability performance measure.** Well-defined reliability measures based on quality supporting data are critical for understanding and communicating how the transportation system is performing.
2. **Incorporating reliability into policy statements.** To incorporate reliability, agencies must establish that reliability is among the core strategic goals or objectives the agency strives to achieve.
3. **Evaluating reliability needs and deficiencies.** As for any goal area, one first valuable step is to understand the extent of reliability deficiencies and needs. Where are travel times least predictable? What would it cost to address the deficiencies that exist? The outputs of this process (maps, charts, and figures) will provide background when developing policies, setting the size of the reliability program, and prioritizing projects.
4. **Incorporating reliability into investment decision making.** One key goal of the planning process is to help inform agency investment decisions. This part of the Guide addresses how to incorporate reliability into tradeoffs across investment types (including capacity, operations, safety, and preservation) and project prioritization.

Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes is available at http://www.trb.org/Main/Blurbs/168855.aspx.

Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: Technical Reference

The Technical Reference, which was designed to accompany the Guide, provides information that technical staff can use to select and calculate the appropriate performance measures to support the development of key planning products, including the following:

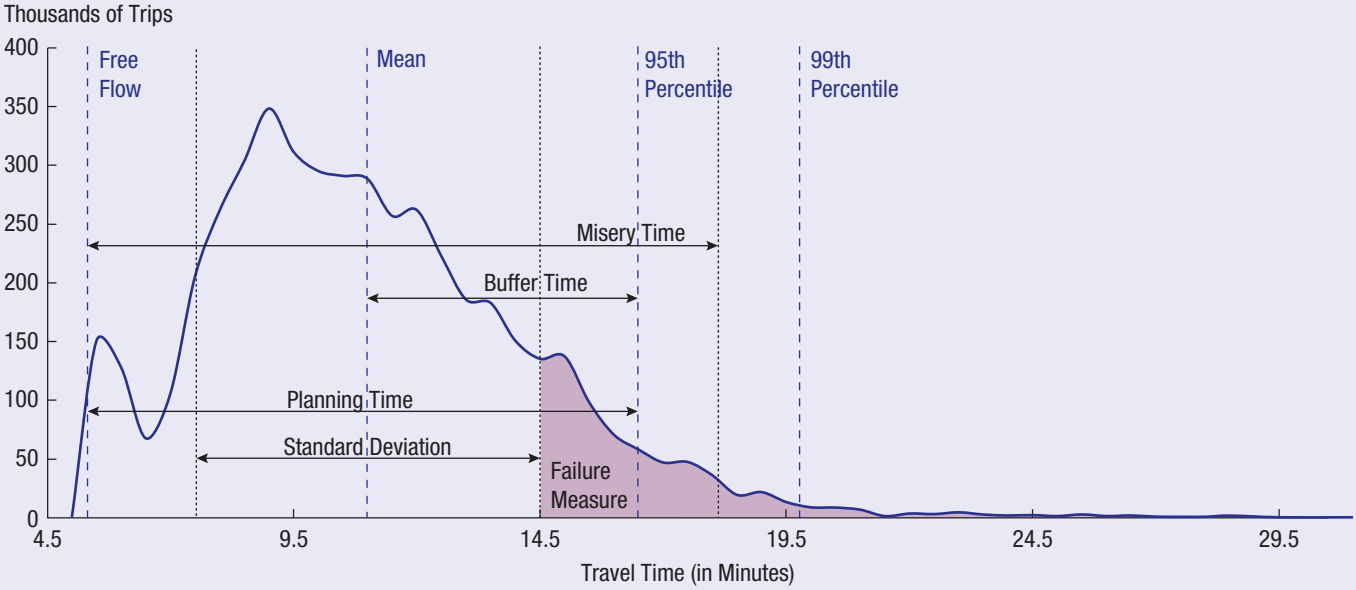
- Long-range transportation plans,
- Transportation programs,
- Congestion management process,
- Corridor planning, and
- Operations planning.

SHRP 2 Project L05 drew from the research and techniques developed by many other SHRP 2 projects, which are referenced throughout the Technical Reference. This document includes a table that summarizes these studies and their relationship to SHRP 2 Project L05.

The Technical Reference includes chapters on the following topics:

- **Overview of Travel Time Reliability.** This chapter summarizes foundational research on reliability, including a practical definition, how to measure

Figure 1. The Travel Time Distribution is the Basis for Defining Reliability Metrics



MEASURE	CALCULATION	DESCRIPTION
Planning Time Index* (PTI)	$\frac{95th\ Percentile\ of\ TT}{Free\ Flow\ TT}$	The extra time required to arrive at a destination "on time" 95 percent of the time. Can be calculated for trips, corridors, or segments. **The PTI is the recommended measure because it gives intuitive and consistent results.**
Buffer Time Index** (BI)	$\frac{95th\ Percentile\ of\ TT - Average\ TT}{Average\ TT}$ **(could replace Average with Median TT)**	The extra time required to arrive at a destination on time 95 percent of the time, compared to average or median travel time. A BI of 1.5 indicates that, 95 percent of the time, it will take you 50 percent more time to arrive at your destination than it would if the network were not congested.
Standard Deviation	$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(TT_i - Average\ TT)^2}$	The variation in travel time compared to the average. A standard deviation of 5 minutes indicates that it is not unlikely for it to take 5 minutes more to travel than it would during average congestion.
Semi-Standard Deviation	$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(TT_i - Free\ Flow\ TT)^2}$	The variation in travel time compared to free flow. A semi-standard deviation of 5 minutes indicates that it is not unlikely for it to take 5 minutes more to travel than it would during uncongested conditions.
Failure Measure	$\frac{Trips\ with\ TT < 1.1 * Median}{Total\ Trips}$	The percent of trips arriving on time. A failure measure of 85 percent indicates that 85 percent of trips are arriving on time.
Misery Index	$\frac{Average\ of\ the\ Highest\ 5\ Percent\ of\ TT}{Free\ Flow\ TT}$	How much longer it takes to travel on the worst 5 percent of all trips. A misery index of 4 indicates that the worst trips take 4 times as long as they would without congestion.

Note: * The travel time index (TTI) is the travel time for a point on the travel time distribution divided by the free flow travel time. The PTI is a specific instance of the TTI, calculated at the 95th percentile. A TTI value can be calculated at any percentile of the travel time distribution.

reliability, why reliability is important, and strategies for improving reliability. It is based on previous work in the SHRP 2 Reliability Program.

- **Description of Tools and Methods for Estimating Reliability.** This chapter summarizes the types of tools and methods that may be used to estimate reliability measures, including sketch planning, model post-processing, simulation or multiresolution, and monitoring and management.
- **Tool/Method Selection Process.** This chapter provides processes for selecting reliability analysis tools and methods and guidance for setting up the analysis.
- **Conducting a Reliability Analysis.** This chapter provides systematic guidance in applying reliability analysis methods and tools.
- **Benefit/Cost Analysis.** This chapter provides guidance on incorporating the results of the reliability analysis into a benefit/cost analysis.

- **Improving Planning and Programming Capability.** This chapter describes a Capability Maturity Model approach for incorporating travel time reliability into planning and programming.

The Technical Reference also includes appendices on the following topics:

- **Additional Resources.** This appendix provides annotated descriptions of references and other resources where the user may obtain additional relevant information, including descriptions of other parallel ongoing efforts related to performance measurement, analysis tools, and the planning process. It also includes a table summarizing all other SHRP 2 projects referenced in the Technical Reference and the Guide.
- **Trends in Reliability.** This appendix presents an excerpt from *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies* (SHRP 2 Report S2-L03-RR-1), which provides an illustrative example of the challenges in interpreting the varied results of a reliability analysis.
- **IDAS Incident Delay Rate Tables.** This appendix presents the look-up tables from the Intelligent Transportation Systems (ITS) Deployment Analysis System (IDAS) tool, which are required for some of the analysis methods.
- **Benefits and Costs of Full Operations and ITS Deployment.** This appendix presents additional information on completing a multiscenario post-processing method.
- **Data Collection Methods.** This appendix presents an overview of various types of traffic data and describes technologies and methods for collecting the data.
- **U.S. DOT Guidance on Performance Measures.** This appendix presents guidance on how to calculate various reliability measures from simulation model outputs.
- **Guidance to Improve Transportation System Management and Operations Planning and Programming Capability.** This appendix presents guidance on the types of actions needed to improve an agency's capability in the seven critical dimensions of transportation system management and operations planning and programming.

Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: Technical Reference is available at http://www.trb.org/Main/Blurbs/168856.aspx.

Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes

The objective of SHRP 2 Project L05 was to provide guidance to transportation agencies to help incorporate reliability into the transportation planning, programming, and budgeting processes. The Final Report summarizes this effort and provides a foundation of knowledge on the subject. It includes a summary of a literature review, state of the practice survey, and validation case studies conducted to test the concepts and methods evaluated as part of this project. This report also summarizes travel time reliability performance measures, strategies for improving travel time reliability, and tools available for measuring the impacts that the strategies have on travel time reliability. The Final Report also describes a framework for incorporating reliability performance into the transportation planning process. A detailed appendix describes the linkage between this project and the TCAPP web tool.

Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes is available at http://www.trb.org/Main/Blurbs/168854.aspx.

Reliability Project L01

A Guide to Improving Travel Time Reliability by Integrating Business Processes

MAY 2011

A goal of Reliability research in SHRP 2 is to identify ways to reduce traffic congestion by improving highway operations and travel time reliability. Reliability Project L01 addressed opportunities to employ operational efficiencies by making it easier for transportation and other agencies to coordinate their activities. The project produced a Guide, summarized here, and a final report that synthesizes successful practices. *The research was conducted by Kimley-Horn and Associates, Inc. in association with PB Americas; the project was managed by SHRP 2 Senior Program Officer David Plazak, who can be contacted at dplazak@nas.edu.*

Policy in Action

A crash on the roadway may bring traffic to a standstill, but the incident scene itself will be a busy place. Fire and emergency medical services may be there to aid victims, police, towing services, and transportation agency responders will investigate and clear the incident, manage traffic, establish detours, and provide traveler information. The crash scene is an extreme example that illustrates how the procedures and policies of many agencies interact in four dimensions. To a large extent, the effectiveness of this interaction affects how reliably travelers can estimate the time it takes to reach a destination.

Two-Level Integration

The research conducted in SHRP 2 Reliability project L01 produced a Guide to help transportation agency managers assess, develop, and integrate key business processes and, by doing so, improve travel time reliability. The Guide was developed from analysis of 10 case studies, a workshop with participants from federal, state, and local planning and operations agencies, and from a review of the literature. The case studies, part of the project final report that will be published on the TRB website, included:

- Washington State Joint Operations Policy Statement and Instant Tow Program, Washington State DOT
- Florida Road Rangers Freeway Service Patrol Program, Florida DOT
- United Kingdom Active Traffic Management, UK Highways Agency
- North Carolina DOT Traffic and Safety Operations Committee
- Michigan DOT Work Zone Traffic Control Modeling
- Kansas Speedway Special Event Traffic Management, Kansas DOT and Kansas Highway Patrol

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- The Palace at Auburn Hills Special Event Traffic Management, Road Commission of Oakland County, Michigan, and Auburn Hills Police Department
- I-80 Winter State Line Closures, Nevada DOT
- AZTech™ Regional Archived Data Server, Maricopa County (Arizona) DOT
- San Pablo Avenue Signal Retiming, Metropolitan Transportation Commission (San Francisco Bay Area, California)

The analysis showed that process integration to support travel time reliability must take place within two distinct levels of each organization. At the *operations level* there is often a direct link between the process and the outcome; the activities evolve and are coordinated among those with responsibility for them. These processes are often detailed and unique to each application. At the *programmatic or institutional level,* process integration becomes more complex and requires more formal adoption procedures and higher levels of decision makers.

Stepping Through the Process: From Influence to Institutionalization

The Guide focuses mostly on the programmatic level. It identifies influences that initiate process integration and common obstacles to implementation and it describes steps that lead to successful business process integration. The steps include defining specific reliability goals, documenting current processes, developing, implementing, documenting, integrating, and institutionalizing new processes.

The approach to process integration developed by the research team is summarized here and an example of each step is provided.

Influences

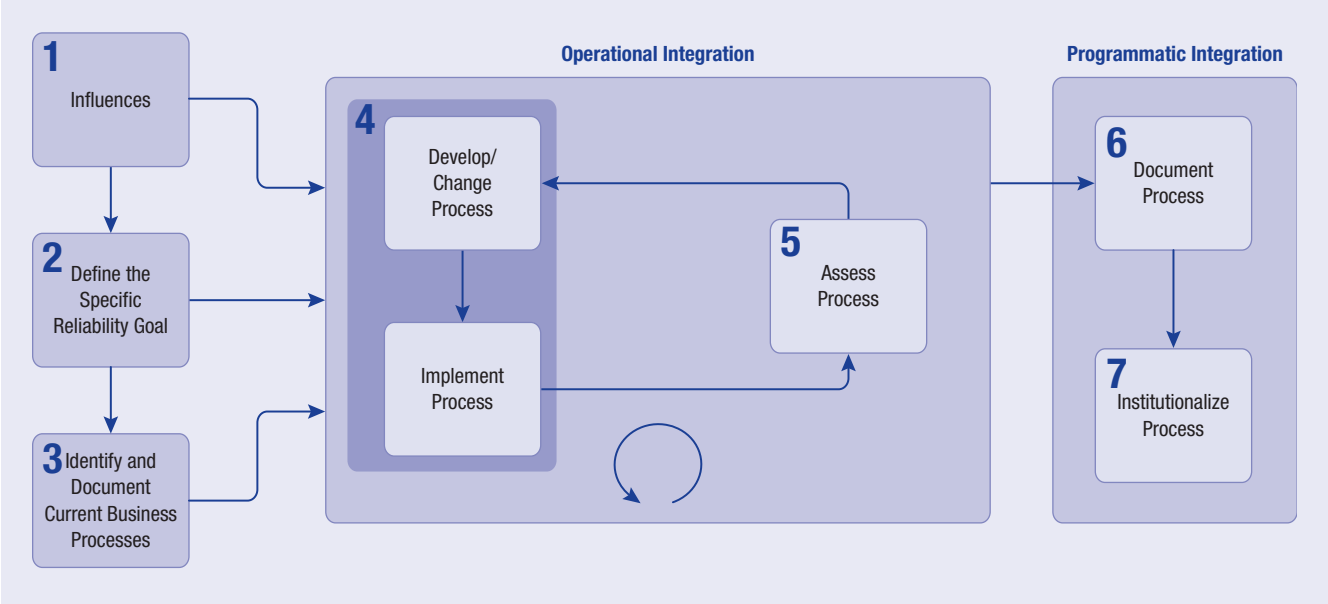
These are the catalysts that initiate the need for improved business process. They can occur as top down, event driven, or needs based. Examples of an influence are directives from senior management or elected officials, a significant natural disaster that exposes gaps in current agency processes or response plans, or just a recognized need for the improvement.

Big directive influences may be legislative requirements or management directives related to safety concerns, economic parameters, or larger government accountability initiatives. Directives tend to greatly accelerate process development, integration, change and accountability of implementers. Event-driven influences prompt process integration, but risk erosion after the first occurrence of the event. Needs or opportunity-based influences evolve over time. They typically affect day-to-day operations and begin at the grassroots level.

Example: Nevada DOT I-80 Corridor

Local NDOT staff were encouraged to investigate alternative ways to disseminate road condition information after a serious crash in eastern California stranded travelers for several hours in locations where amenities were not available.

Overview of the integration approach



Defining the Specific Reliability Goal

By establishing goals, the focus is pushed toward the problem at hand regardless of any specific process. Defined goals help to develop benchmarks that an agency can use to determine how well the process is meeting the need. Achieving goals such as reducing incident clearance time, providing 24/7 operations, or improving response efficiency often requires that multiple processes work together. A key challenge is when processes from multiple agencies are involved.

In recent years, agencies have begun to adopt more performance measures and goals to demonstrate the needs for projects and the effectiveness or impact of completed projects. Establishing goals that align with the agency's mission can drive the development of effective processes to improve the performance of the employees, projects, programs, and ultimately, the agency itself.

Example: North Carolina DOT Traffic and Safety Operations Committee

The NCDOT Work Zone Traffic Control section regularly establishes goals, objectives, and strategies for all projects. A committee is formed for significant projects so the impacts and effectiveness of the work zone plans can be continuously monitored throughout construction. Strategies are developed in response to some of the issues observed.

Identify and Document Current Business Processes

This step often is not performed by agencies, but thinking through the current business procedures in a very systematic way can identify gaps or potential issues. This step also can identify key components of a more efficient process, enabling stakeholders to see the connections between the different components of the process.

There are risks in not documenting the existing or baseline processes. Without documentation, an agency increases the possibility of overlooking critical roles, available resources, or operation activities that may enable a more efficient process. Although this information may be known by staff members, documentation ensures that the knowledge remains with the organization.

Example: North Carolina DOT Traffic and Safety Operations Committee

The NCDOT Committee looks at processes continuously throughout the life of a construction project. Each issue that arises is analyzed by the committee and a strategy is proposed to mitigate the issue. Solutions are monitored and adjusted as needed until an effective result is achieved.

Process Development and Implementation

This step is driven by a particular *Influence* identified in the first step. This step typically occurs at the grass-roots level of an organization by staff or champions who are at the center of the activities involved. The implementation can be formal or informal depending on the complexity of the process and the agencies involved. Once the process has been implemented, it is assessed or evaluated against the identified goals. The process is refined based on the performance against the goals in an iterative approach.

During process integration, it is important to involve all of the appropriate stakeholders. Buy-in is important from those who will provide inputs to the process and those who are affected by the process. All stakeholders are critical, whether they are in the field or in a central office, and their input needs to be an integrated part of the overall process.

Example: The Palace of Auburn Hills, Michigan

Prior to determining a new event management plan for the facility, the Auburn Hills Police Department, The Palace of Auburn Hills, the Road Commission for Oakland County, and MDOT assessed the current traffic management plans along with an assessment of the road network in the vicinity of the facility.

Assess the Process

Some level of assessment is important to determine the effectiveness of a process. This step is one element of the 3-part operational loop that continuously adapts and evaluates business processes, along with developing/changing and integrating the process. The type of assessment is often commensurate with the complexity of the process, but it is important to determine a measure of success, a method for continuous evaluation, and the data needed for the evaluation. The evaluation and measured benefits will provide a means of communicating the effectiveness of the process to senior-level managers.

Example: United Kingdom Active Traffic Management

In the UK, the Highway Agency monitored the impacts of an active traffic management deployment on the roadway network. The results of an evaluation survey showed an improved journey time and decreased accident rate. Such benefits have helped to gain support of government ministers and industry.

Document the New Process

Agencies differ in the complexity of their documentation processes. Documentation can be as simple as an interagency agreement or as complex as a multi-volume operations manual. Regardless of the type of documentation, it should capture details of the business process, the evaluation process, the stated benefits and lessons learned. It should also include the roles and responsibilities of the stakeholders and the performance measures associated with the overall process.

Documentation Examples:

The Palace at Auburn Hills documents their processes through evaluation meetings.

WSDOT and the UK Highway Agency produce performance monitoring reports that state the benefits and lessons learned from the process.

The MTC produces a report at the end of the process which is then incorporated into an annual report provided to the Federal Highway Administration.

The WSDOT Joint Operations Policy Statement Agreement call for a report that documents the performance measure developed to help the agency define how data are collected and reported.

Institutionalize the Process

This is the final step of the business process integration. Institutionalization requires buy-in and support from upper management as well as additional stakeholders who have a vested interest in the outcomes of the business process. This step will have a direct impact on the long-term survival of a process within an organization due to changes in staff. The most successful examples rely on linking processes to firmly established agency goals, objectives, or mission-critical activities; this helps to establish the priority among multiple operational entities.

Example: Michigan DOT Work Zone Traffic Control Modeling

MDOT has developed a tool to model work zones. Translation of the output is still being formatted, but once complete, the tool will allow construction managers to make modifications based on changing work zone configurations or schedules. This relationship between the planners and construction engineers demonstrates an important integration point.

Intended Audience

The Guide will be useful to managers within state and local agencies that are responsible for overseeing operations programs for traffic management, maintenance, traveler information, and incident response and management. The content and context of operational processes described are tailored for managers who are responsible for developing programs, liaising with internal and external departments within a department of transportation or law enforcement agency, and who can influence programmatic components. This includes recommending training needs, recommending or developing policy, or requesting funding through programming processes.

The Guide and the project final report will be available under the Publications tab of the SHRP 2 website. Please visit www.TRB.org/SHRP2.

A SHRP 2 Reliability Project Brief

A National Traffic Incident Management Training Course for Incident Responders and Managers

JULY 2013

Traffic incidents cause 25 percent of delay on highways (*1*). These incidents can be dangerous for responders. From 2010 through 2012, at least 10 firefighters (*2, 3, 4*), 4 paramedics (*5, 6, 7*), and 7 law enforcement personnel (*8*) died after being struck by vehicles while responding to incidents. Data on towing and recovery industry occupational fatalities are not well tracked, but the Towing and Recovery Association of America anecdotally reports losses nearing 100 towing operators in the line of service annually (*9*). A strong interdisciplinary traffic incident management program can improve responder safety; significantly decrease incident duration; and when combined with traveler information, can increase peak-period freeway speeds, reduce crash rates, and improve trip time reliability.

To improve traffic incident management (TIM), the "National TIM Training Course" for TIM responders and managers was developed and refined through a series of SHRP 2 projects. Improving Traffic Incident Scene Management (SHRP 2 Project L12) and Train-the-Trainer Pilot Courses for Incident Responders and Managers (SHRP 2 Project L32A) are completed while two others are under way—e-Learning for Training Traffic Incident Responders and Managers (SHRP 2 Project L32B) and Post-Course Assessment and Reporting Tool for Trainers and TIM Responders Using the SHRP 2 Interdisciplinary Traffic Incident Management Curriculum (SHRP 2 Project L32C). This brief provides an overview of the SHRP 2 TIM series of projects.

Improving Traffic Incident Scene Management (SHRP 2 Project L12)

This project developed the National TIM Training Course for TIM responders and managers. The course was designed to establish the foundation for and promote certification of responders to achieve the three objectives of the TIM national unified goal: responder safety; safe, quick clearance; and prompt, reliable, and interoperable communications. The intent is to establish a common set of core competencies in order to promote a shared understanding of TIM goals among responders from different stakeholder groups—law enforcement, fire and rescue, emergency medical services, the U.S. Department of Transportation, towing and recovery, and notification and dispatch.

The multiagency and multidisciplinary course uses a variety of adult-learning techniques, including interactive seminar, case study analysis, tabletop role-play and scenario, and field practicum. The training was developed for delivery through a two-day intensive format or a

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Figure 1. Field demonstration of exiting a response vehicle at an incident scene

modular (single lesson per session) format. A train-the-trainer curriculum also was developed to facilitate cost-effective cultivation of qualified trainers across the country. Core multidisciplinary competencies were identified with input from a group of experts in TIM. These competencies provided a framework from which the curriculum was built and design documents created. After development of the course materials, an evaluation was conducted by holding two pilot training sessions, and the input from participants was incorporated into the final materials.

The first two pilot training courses were delivered in Indianapolis, Indiana, and in Atlanta, Georgia, in the spring of 2010. Both of the pilot training courses were delivered by a multidisciplinary training team that combined practical TIM experience with extensive training experience. Participants received the training program well and viewed it as beneficial. When surveyed in a post-course evaluation, all of the participants said they would recommend the training to others.

Figure 2. Hands-on tabletop activity

Status: This project is complete.

Product Availability: *Training of Traffic Incident Responders* (SHRP 2 Report S2-L12-RW-1) is available at http://www.trb.org/Main/Blurbs/166877.aspx.

SHRP 2 Contact: David Plazak, dplazak@nas.edu

Train-the-Trainer Pilot Courses for Incident Responders and Managers (SHRP 2 Reliability Project L32A)

To validate the National TIM Responder Training course, five additional pilot courses were funded through Reliability project L32A. The project conducted four pilot train-the-trainer workshops, which trained nearly 200 new TIM responders in four states. Student-trainers from a diverse mix of primary TIM disciplines participated in the four train-the-trainer pilot workshops as shown in Figure 3. An alumni-led workshop was also held to evaluate the delivery of the National TIM Responder Training by first-generation graduates of the train-the-trainer course.

The L32A pilots were conducted at the following locations on the following dates:

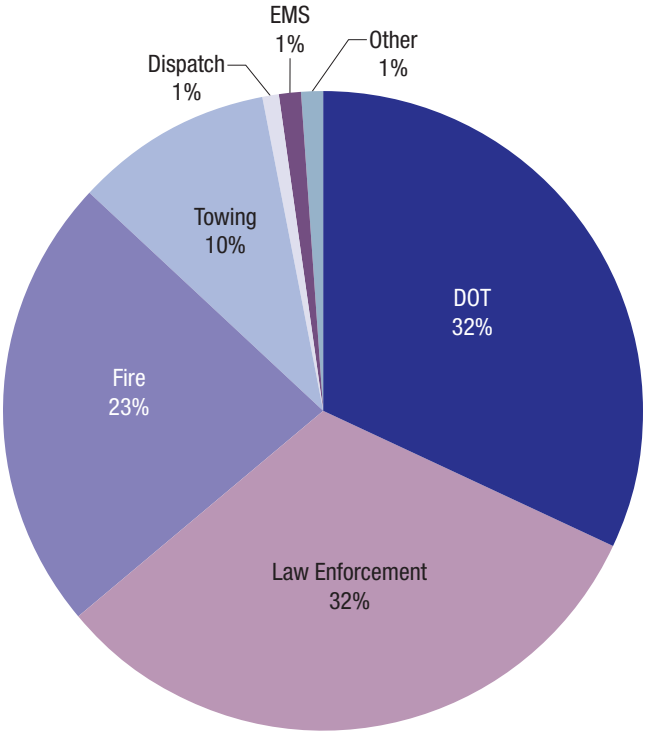
- Pilot 1: Nashville, Tennessee—June 19–20, 2012
- Pilot 2: Richmond, Virginia—June 27–28, 2012
- Pilot 3: Helena, Montana—July 11–12, 2012
- Pilot 4: Fort Lauderdale, Florida—August 8–9, 2012
- Alumni Pilot: Knoxville, Tennessee—September 12–13, 2012

Feedback from the five pilot workshops conducted through the L32A project resulted in nearly 1,500 discrete improvements to the curriculum, as well as materials enhancements, including a Pacer Guide to help instructors pace themselves throughout the training, materials checklists, and photographic enhancements to activity setup instructions.

More than 95% of graduates of the train-the-trainer course affirmed they would recommend this course to others. Of equal importance, 95% of graduates reported the course left them with a greater appreciation of the importance of safe, quick clearance principles, and 98% reported believing the course saved them research time when preparing to teach their own course.

Status: This project is complete. Project L32A prepared the TIM course to be delivered to the Federal Highway Administration (FHWA) for national implementation. FHWA is

Figure 3. Attendance by Discipline (Four Train-the-Trainer Pilots)



conducting workshops across all 50 states in addition to Puerto Rico and District of Columbia, and they will complete these workshops by December 2014. As of June 2013, FHWA has already held 32 training courses in 22 states, which trained more than 11,000 responders.

Product Availability: The final report for Train-the-Trainer Pilot Courses for Incident Responders and Managers (SHRP 2 Project L32A) is available at http://www.trb.org/main/blurbs/168921.aspx. For information on how to enroll in the training course, contact Paul Jodoin (paul.jodoin@dot.gov) at FHWA or Gummada Murthy (gmurthy@aashto.org) at AASHTO.

SHRP 2 Contact: David Plazak, dplazak@nas.edu

e-Learning for Training Traffic Incident Responders and Managers (SHRP 2 Project L32B)

To help disseminate the National TIM Training Course, SHRP 2 Project L32B is developing an e-learning system for the course that will be available in a modular format, based on modules developed in SHRP 2 Project L12 and refined by SHRP 2 Project L32A. The targeted learning will focus on law enforcement, fire and rescue, EMS, towing and recovery, transportation and service patrol, and notification and dispatch. The project will also develop tools such as videos and animations that are 2–6 minutes long.

Status: This project is active. The final report will be available in 2014.

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Testimonials from Participants in the L32A Pilots

"All of our participants came away with [a] new perspective of our job at the scene and a new understanding of how all the players need to work together to be safe."

—Towing Attendee (Montana Pilot)

"The main thing I've learned taking this course is there's more than just the law enforcement aspect of it. Actually also having the fire and rescue, and being able to use those as one big component, instead of you trying to do everything yourself."

—Law Enforcement Attendee (Tennessee Pilot)

"This course has driven home the importance of agencies working together toward a common goal—'Quick Clearance'—to prevent further incidents."

—Attendee (Virginia Pilot)

"I now understand that by communicating to the other departments that are responding to a scene will greatly reduce the time my guys and I will spend on the pavement in harm's way."

—Law Enforcement Attendee (Montana Pilot)

Post-Course Assessment and Reporting Tool for Trainers and TIM Responders Using the SHRP 2 Interdisciplinary Traffic Incident Management Curriculum (SHRP 2 Project L32C)

The objective of the National TIM Training Course is to ensure that students leave with a common set of core competencies that promote a shared understanding of TIM goals. In order to help make certain that these objectives are being met, SHRP 2 Project L32C is developing a post-course assessment and reporting tool. The tool will have two compo-

nents. The first is an assessment tool that trainers can use to assess the effectiveness of the training materials in helping students achieve the learning objectives of the curriculum. The second component is designed to help agencies identify resources or improved processes that may be needed to support successful TIM practices. The post-course assessment and reporting tool will apply across multiple target groups within incident response agencies and organizations at all levels, including executives, mid-level program managers, field responders, and trainers conducting the subject training.

Status: This project is active. The final report will be available in 2014.

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Improving Travel Time Reliability

OCTOBER 2011

Travel time reliability is an emerging topic that is increasingly important to understand because of the benefits it can offer. Reliable travel times are related to improved safety, efficiencies for freight transport, and improved quality of life for road users who experience less delay and frustration. Unreliable travel times are caused by recurring congestion (bottlenecks and poor traffic signal timing) and nonrecurring congestion (traffic incidents, weather, work zones, and special events). Managing these challenges and achieving the benefits of reliability will require a common understanding among transportation policy makers and professionals regarding the concept of travel time reliability and the methods by which it can be improved. SHRP 2 Reliability research is developing products that transportation professionals can use to improve travel time reliability, including tools to

- change business processes to support travel time reliability,
- monitor travel time reliability and usefully preserve the data,
- evolve the institutional arrangements of agencies,
- improve traffic incident scene management, and
- improve overall systems operations and management.

New Tools for Reliable Travel Times

7 Causes of Nonrecurring Congestion		SHRP 2 Products
	Incidents	Regional Operations Academy to help mainstream operations strategies. Executive workshops to convey the value of operations strategies to agency mission. Interagency Training for incident responders.
	Weather	Travel Information guide and analysis tool for selecting design treatments that improve reliability. Part of a new method to address reliability in the Highway Capacity Manual.
	Work Zones	Tools for travel time monitoring. Models for real-time congestion management.
	Fluctuation in Demand	Performance Measures. Value of Reliability. Incorporating reliability into planning & programming. Economic evaluation model.
	Special Events	Travel time monitoring. Organizational strategies to improve travel time reliability. Improving data for traveler information.
	Traffic Control Devices	Reliability Monitoring Systems. Methods for estimating capacity of urban streets.
	Inadequate Base Capacity	Guide for geometric designs that advance reliability. Analytical model for assessing effectiveness of strategies. Ways to incorporate reliability into planning & programming.

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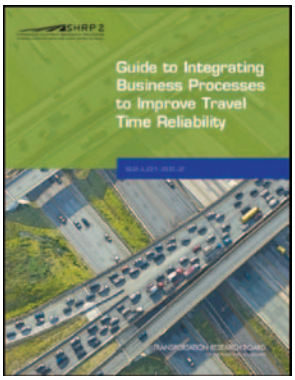
How can we change business processes to improve travel time reliability?

The *Guide to Integrating Business Processes to Improve Travel Time Reliability* was developed from research that used business process modeling notation to map traffic operations business processes. The guide examines the integration of business processes at the two key levels: operational and programmatic. It provides a step-by-step guide for agencies to assess their operational processes and identify opportunities to change or develop new processes. The guide is not specific to any one process. Its purpose is to assist any agency that is seeking to improve travel time reliability through improved coordination and integration of multiple processes and agencies.



The guide will be useful to managers within state and local agencies who are responsible for overseeing operations programs for traffic management, maintenance, traveler information, and incident response and management. The content and context of operational processes described in the guide are focused on managers who develop programs, who liaise with internal and external departments within a department of transportation or law enforcement agency, and who can influence programmatic components. Their responsibilities would include recommending training needs, recommending or developing policy, or requesting funding through programming processes.

SHRP 2 Reports S2-L01-RR-1: *Integrating Business Processes to Improve Travel Time Reliability* and S2-L01-RR-2: *Guide to Integrating Business Processes to Improve Travel Time Reliability* are available as Adobe PDFs on the SHRP 2 website and in hardcopy through the TRB bookstore. Information from the guide will be used to make standalone software that agencies can use to integrate business processes to improve travel time reliability.

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How can we monitor travel time reliability and convey that information to customers and data users?

A guidebook is being developed in SHRP 2 project L02: Establishing Monitoring Programs for Mobility and Travel Time Reliability that practitioners can be use to design, build, operate, and maintain a reliability monitoring system. Project L02 developed analytic methods for matching historical travel time patterns under different situations. The guidebook can help operating agencies develop systems (that is, hardware, software, and strategies) that can monitor travel time reliability and convey information to customers and other data users. It will include methods for extracting segment and route-level travel time reliability information, methods for combining segment-level travel time density functions into route-level density functions, and new techniques for system detectors to report information. The guidebook will be published in 2012.

A follow-on project will take these analytic methods and extend them to increase their usefulness for real-time operations and to enable system operators to better characterize the nature of unreliability, predict the effect on road users, diagnose the cause(s) of unreliability, and be more timely and responsive in managing the highway network—for example, changing traveler information on changeable message signs or updating the messages that reach mobile phones.

The final product is expected to improve the ability to manage highway condition in near-real time. It will be valuable to those responsible for systems operations and management (SO&M) in real time, such as key personnel in traffic management centers.

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How can we evolve institutional arrangements to better suit the special demands of congestion management?

SHRP 2 Project L06: Institutional Architectures to Advance Operational Strategies undertook a comprehensive and systematic examination of the way agencies could be organized to successfully execute operations programs that improve travel time reliability. SHRP 2 discovered how the Capability Maturity Model (CMM), which is used in the information technology field for organizational self-assessment and continuous improvement of quality and reliability, can be applied to an organization to improve operations and travel time reliability. The CMM was used to develop the *Guide: Institutional Architectures to Support Improved Congestion Management*. The guide starts with agency self-evaluation to determine the current state of play and provides related appropriate incremental strategies for evolving toward institutional arrangements most supportive of congestion management. The Institutional Capability Maturity Model is presented in a series of steps and strategy matrices that can be used to improve the effectiveness of SO&M.

This guide can be used by any organization with responsibility for management and operations of highways. The guide can support transportation agencies in developing institutional arrangements suitable to the special demands of congestion management, now emerging as a new transportation agency priority.

SHRP 2 Report S2-L06-RR-2: *Guide: Institutional Architectures to Support Improved Congestion Management* will be published in November 2011. SHRP 2 Report S2-L06-RR-1: *Institutional Architectures to Improve Systems Operations and Management* will be published in December 2011.

SHRP 2 established the foundation of applying the CMM to SO&M, and others are already building on this work. The American Association of State Highway and Transportation Officials (AASHTO) supported the conversion of the SHRP 2 Reliability Project L06 research into a web-based tool that is user friendly, easy to access, and updatable. This work was done under the Transportation Research Board's NCHRP Project 03-94: Transportation Systems Operations and Management Guide. The web tool, Systems Operations and Management Guidance, is available on the AASHTO website at www.aashtosomguidance.org. At the same time, under Phase 2 of the SHRP 2 L06 project, workshops with state DOTs and metropolitan areas are being conducted to validate the research and the findings will be incorporated into the web material.

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How can we improve traffic incident scene management?

SHRP 2 Project L12: Improving Traffic Incident Scene Management was designed to establish the foundation for and promote certification of responders to achieve the three objectives of the Traffic Incident Management National Unified Goal: responder safety; safe, quick clearance; and prompt, reliable, interoperable communications. The intent of this project was to motivate responders from different stakeholder groups—law enforcement, fire and rescue, emergency medical services, U.S. department of transportation, towing and recovery, and notification and dispatch—to acquire a common set of core competencies that promote a shared understanding of the requirements for achieving the safety of responders and motorists, quick response, and effective communications at traffic incident scenes.

Products of this research include a training and certification course for traffic incident responders, a train-the-trainers course for incident responders and managers, e-learning for traffic incident responders and managers, an interdisciplinary train-the-trainers post-course assessment tool, and a marketing plan for the training course. These products integrate the roles of all responders and help to establish priorities and reinforce interagency cooperation. They will strengthen the incident management programs currently offered by response agencies and offer a common denominator in providing training to the trainer community. Additionally, these products are expected to enhance quick clearance efforts and ensure responders' as well as motorists' safety. The products will be available in 2012.

Pilot tests were conducted in Indiana and Georgia as part of this research project. More pilot tests are planned that will further refine the training courses. Marketing activities will be carried out to implement these training courses nationally.

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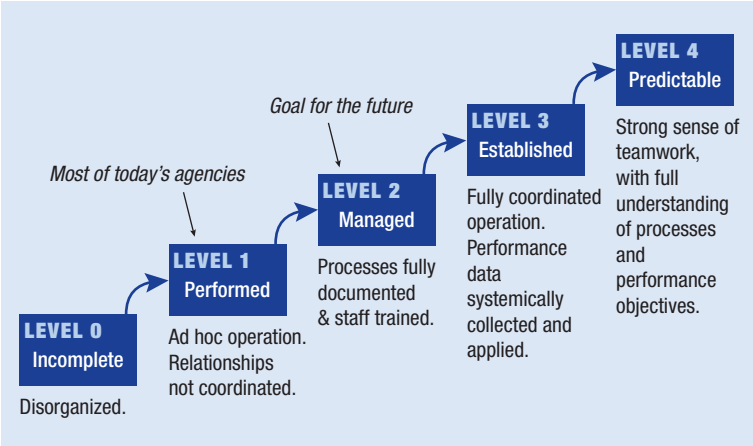
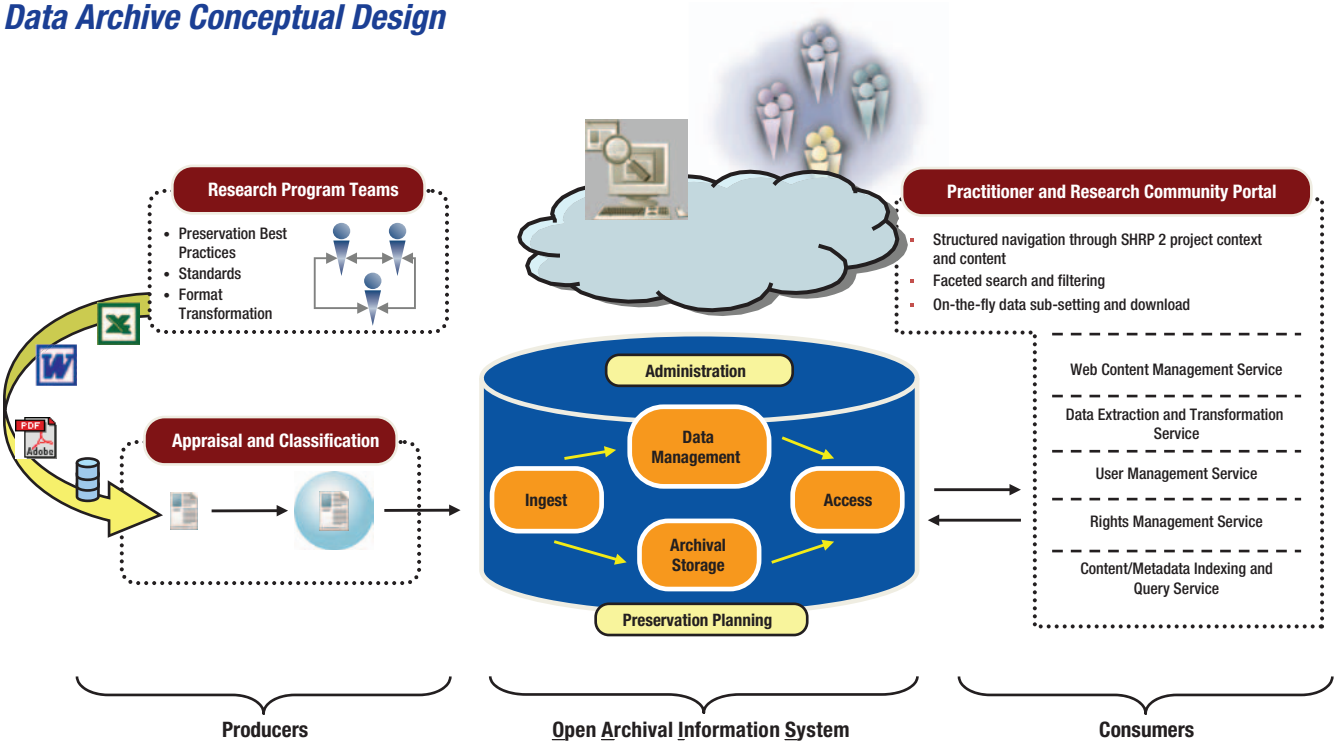
Levels of the Capability Maturity Model



Pilot test of training course in Gwinnet County, Georgia

Data Archive Conceptual Design



How can we preserve data from Reliability research?

SHRP 2 Reliability projects will generate a wealth of data. To ensure that this data remains accessible for decades, SHRP 2 is developing the Capstone Reliability Data Archive. The archive will make data from SHRP 2 Reliability projects and other related projects readily available to researchers and practitioners for more than 25 years.

The archive has two groups of target audiences:

- University faculty, staff, and students in civil engineering, transportation planning, and logistics/supply chain management who conduct research on travel time reliability and closely related topics
- Researchers from private consulting firms and other private enterprises involved in analyzing and modeling travel time reliability and closely related topics

A feasibility study was conducted, which determined that creating such an archive is feasible and recommended three alternative methods of creating the archive. A follow-on project will create the actual archive and help researchers archive their data. The project team is currently reexamining the findings of the feasibility study to determine the best way to proceed in creating the archive.

SHRP 2 Report S2-L13-RW-1: *Requirements and Feasibility of a System for Archiving and Disseminating Data from SHRP 2 Reliability and Related Studies* is available as an Adobe PDF document. The expected completion of the archive is June 2014.

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How can we improve overall systems operations and management?

Travel time reliability is not a stand-alone topic, but an integral part of SO&M. To facilitate the use of products from SHRP 2 Reliability research to improve overall SO&M, SHRP 2 is creating the Knowledge Transfer System (KTS) in project L17: A Framework for Improving Travel Time Reliability. The KTS will integrate products from SHRP 2 and other sources of SO&M information into a web-based product, but information will also be shared through workshops, peer exchanges, blogs, forums, and other social media. The KTS will provide the umbrella structure needed to incorporate the many individual elements of SO&M. It will transfer both explicit and anecdotal information. It will include content in the form of documents, reports, and other published information.

The KTS will support the development of a more reliable transportation system. It is being created for four principal audiences: policy makers, practitioners, researchers, and travelers. The first version of the KTS is expected to be complete in February 2012. Products from the SHRP 2 Reliability program will be integrated into the KTS as they are completed.

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