Disseminating Traveler Information on Travel Time Reliability

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16. Abstract

Travel time variability is that characteristic of the transportation system that means a traveler's trip will vary from what is normally expected and will potentially take longer than planned. By helping travelers make travel choices that take into account travel time variability, agencies have the potential to reduce roadway congestion.

Travel Time Reliability (TTR) information includes static data about traffic speeds or trip times that capture historic variations from day to day and enable individuals to understand the level of variability in traffic. A key component to addressing the reliability issue related to urban mobility is conveying this TTR information to system users so that they can make informed decisions about their travel. The challenge for transportation professionals lies in selecting the best means of conveying that information so that it is usable and effective to the traveler and other stakeholders.

The Strategic Highway Research Program (SHRP2) Reliability Project L14 established a preliminary set of suggested terminology and guidelines for conveying TTR information to road users so that they may make optimal travel choices from their point of view, such as whether to take a trip or not, departure time, mode choice, and/or route choice. Specifically, a Lexicon of phrases was developed for each of eight TTR terms, which contained detailed guidelines for TTR information that would most likely be understood and used by travelers. To help agencies and other transportation-related entities better deploy and use the recommended Lexicon terminology, a field study was conducted to test the phrases to demonstrate the technical and institutional feasibility of their use and determine the potential costs and benefits of using these products of L14.

Overall, the field study found that the particular Lexicon phrases tested performed similarly. Only one survey question resulted in statistically significant differences between the Lexicon phrases. The biggest finding of the field study was that dissemination of TTR information via the 511 information channel was less preferred than via the Web or App access channels. In a few instances, the App access demonstrated superior responses over both the Web and 511 access.

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EXECUTIVE SUMMARY

Travel time variability is that characteristic of the transportation system that means a traveler's trip will vary from what is normally expected and will potentially take longer than planned. This transportation system characteristic is important for travelers and shippers. It also is a component of the congestion problem for which transportation agencies can make significant and measurable gains, even as travel demand grows. By providing the means to help travelers make travel choices that take into account travel time variability, agencies have the potential to reduce roadway congestion. This reduced congestion has the added benefit of reducing primary and secondary crashes, vehicle emissions, and fuel use, as well as yielding other benefits.

One measure of travel time variability is Travel Time Reliability (TTR). Transportation professionals describe TTR in terms of historical average travel times calculated over periods of a year or longer. TTR information includes static data about traffic speeds or trip times that capture historic variations from day to day and enable individuals to understand the level of variability in traffic. TTR information is considerably different from real-time travel time information and may have different uses. A traveler can use reliability information to plan and budget in advance for a trip rather than simply react to current conditions. A key component to addressing the reliability issue related to urban mobility is conveying this TTR information to system users so that they can make informed decisions about their travel. The challenge for transportation professionals lies in selecting the best means of conveying information so that it is usable and effective to the traveler and other stakeholders.

The Strategic Highway Research Program 2 (SHRP2) Reliability Project L14 established a preliminary set of suggested terminology and guidelines for conveying TTR information to road users so that they may make optimal travel choices from their point of view, such as whether to take a trip or not, departure time, mode choice, and/or route choice. Specifically, a Lexicon of phrases was developed for each of eight TTR terms, which contained detailed guidelines for TTR information that would most likely be understood and used by travelers. To help agencies and other transportation-related entities better deploy and use the recommended Lexicon terminology, a field study was conducted to test the phrases to demonstrate the technical and institutional feasibility of their use and determine the potential costs and benefits of using these products of L14. Two Lexicon assemblies and three dissemination platforms were tested in the field study.

Overall, the field study found that the particular Lexicon phrases tested performed similarly. Only one survey question resulted in statistically significant differences between the Lexicon phrases. The biggest finding of the field study was that dissemination of TTR information via the 511 information channel was less preferred than via the Web or App access channels. In a few instances, the App access demonstrated superior responses over both the Web and 511 access.

Agencies considering dissemination of TTR information to their system users should consider various scenarios in which travelers and other stakeholders might find that information valuable. Some of these scenarios are individual trip planning for familiar trips, individual trip planning

for unfamiliar trips, individual trip changes, alternate route comparisons, employment center locations, and overall system reliability. Agencies also will need to obtain historical traffic datasets as a source for determining the TTR calculations. These calculations can then be utilized by information dissemination platforms so that travelers can make informed decisions about their trip.

If an agency determines that TTR information will be valuable to its system users, it is important to clearly explain to them the difference between real-time information and TTR information. It is highly likely that system users will be familiar with existing real-time traveler information for the region from the plethora of sources available to them across providers and information dissemination platforms. They may not intrinsically understand what TTR information is telling them, so an explanation is important for comprehension. Furthermore, providing examples of how travelers might use TTR information for trip planning (e.g., unfamiliar trips, familiar trips at unusual times, etc.) may help increase awareness and overall use of the information by travelers. If the transportation agency already provides real-time traveler information, then comparing the two types of information in a side-by-side comparison might help with comprehension and usage.

CHAPTER 1. OVERVIEW

Travel time variability is that characteristic of the transportation system that means a traveler's trip will vary from what is normally expected and will potentially take longer than planned. This transportation system characteristic is important for travelers and shippers. It also is a component of the congestion problem for which transportation agencies can make significant and measurable gains, even as travel demand grows. By providing the means to help travelers make travel choices that take into account travel time variability, agencies have the potential to reduce roadway congestion. This reduced congestion has the added benefit of reducing primary and secondary crashes, vehicle emissions, and fuel use, as well as yielding other benefits.

THE CONCEPT OF TRAVEL TIME RELIABILITY

Transportation professionals typically describe Travel Time Reliability (TTR) in terms of historical average travel times calculated over periods of a year or longer, as shown in Figure 1. A typical definition for TTR would be the following:

The consistency or dependability in travel times, as measured from day to day and/or across different times of the day.[1]

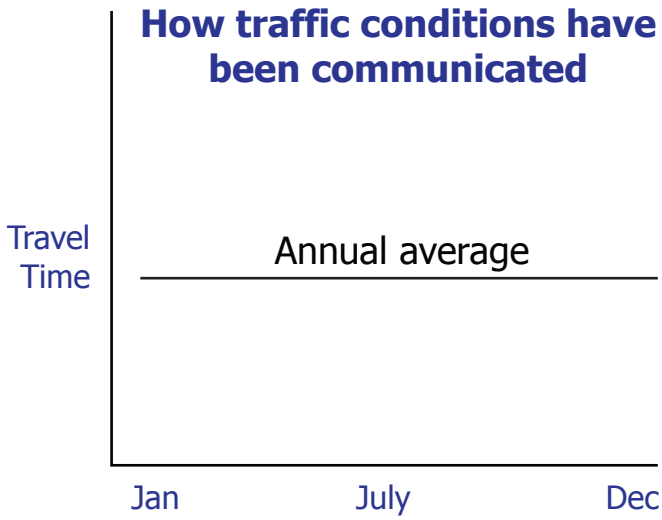


Figure 1. Graphic. Average travel time used by professionals.[1]

Source: http://ops.fhwa.dot.gov/publications/tt_reliability/brochure/index.htm#fig1m

However, most system users do not experience the same average travel time each day. Rather, they experience and remember something much different than the average throughout a year of commute trips (see Figure 2). Their travel times vary greatly from day to day, and they are more likely to remember a few bad days during which they suffered longer-than-typical travel times than a good day or a typical day.[1] Research has shown that TTR information can provide

transportation system users with a more complete picture of expected travel times along a particular route. The challenge is how to communicate that reliability information effectively to system users so that they understand it clearly and respond appropriately to improve their trip experience.

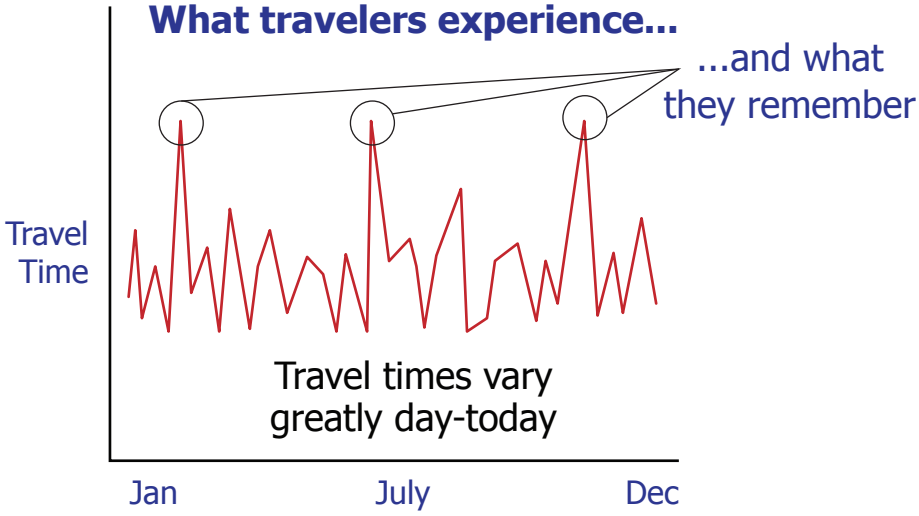


Figure 2. Graphic. Traveler travel time experiences.[1]

Source: http://ops.fhwa.dot.gov/publications/tt_reliability/brochure/index.htm#fig1m

Real-time travel time messages have been in use in the U.S. since traffic monitoring and integration systems became reliable more than a decade ago. Typically, the most commonly used media for these messages are Dynamic Message Signs (DMSs) and transportation agency websites. However, the widespread use of cell phones and other mobile devices has resulted in an explosion of new mechanisms for transportation agencies and third-party providers to offer real-time updates on transportation conditions and options via e-mails, text messages, mobile application push notifications, and Twitter feeds.[2]

Real-time travel time estimates are most often provided for a particular roadway segment, facility, or transit route based on recent travel speeds or conditions. Some agencies also provide travel time comparisons among two or more routes/roadways to help travelers make decisions about the route or transportation mode to take. More recently, agencies are beginning to provide TTR information for facilities: the likelihood that the estimated travel time for a particular trip or trip segment will be dependable.

As discussed previously, travel time variability describes how a traveler's trip will vary from what is normally expected. One measure of travel time variability is travel time reliability. TTR information includes static data about traffic speeds or trip times that capture historic variations from day to day or over a specified period of time and enable individuals to understand the level of variability in traffic.[2] TTR information is considerably different from real-time travel time

information and may have different uses. A traveler can use reliability information to plan and budget in advance for a trip rather than simply react to current conditions.

Typically, travelers might want to access TTR information for such purposes as: (a) trip planning for habitual trips such as commutes, or when new to an area and unfamiliar with routes and typical travel times; (b) pre-trip planning immediately prior to departure, to make decisions about departure time and/or mode based on real-time and historical travel time trends, especially if traveling at a time or to a destination that is not typical; and (c) changing their trip while in progress prior to a route or mode choice point (again based on both real-time and historical information regarding particular routes at particular times of the day).[1]

A key component to addressing the reliability issue related to urban mobility is conveying this TTR information to system users so that they can make informed decisions about their travel. Furthermore, transportation agencies can use TTR information to assess system performance and use that information to inform local decision makers about congestion challenges and/or needs in the region. The challenge for transportation professionals lies in selecting the best means of conveying that information so that it is usable and effective to the traveler and other stakeholders.

CHAPTER 2. COMMUNICATING TRAVEL TIME RELIABILITY

Cognitive science has demonstrated that most people are not good at understanding complex statistical concepts, which is the foundation of Travel Time Reliability (TTR) information. As with other forms of traveler information communication like traffic signs, a Lexicon of phrases to convey TTR information should accomplish the following:

- Communicate a useful message.
- Improve on-time performance.
- Encourage trust in the message.
- Communicate the "riskiness" of a route.
- Distinguish TTR from real-time traveler information.[2]

Based on the results of the initial human factors studies conducted as part of the Strategic Highway Research Program 2 (SHRP2) L14 project and on current traffic engineering practices regarding communication to drivers, recommendations were presented regarding the use of various terms related to TTR concepts. This document is based on that original research, along with additional research funded by the Federal Highway Administration (FHWA) that validated the initial findings of the L14 project and fine-tuned the Lexicon of TTR terms to better represent motorists' understanding and preference for various terms and access method.

The report, *A Lexicon for Conveying Travel Time Reliability Information*, developed as part of the SHRP2 Reliability Project L14—*Effectiveness of Different Approaches to Disseminating Traveler Information on Travel Time Reliability*—established a preliminary set of recommended terminology and guidelines for conveying TTR information to road users and stakeholders to reflect reliability conditions.[2,3] Specifically, a Lexicon of phrases was developed for each of the eight TTR terms:

- 95th percentile.
- Arrival time.
- Average travel time.
- Buffer time.
- Departure time.
- Recommended departure time.
- Recommended route.
- Reliability.[2]

Each Lexicon contained detailed guidelines for TTR information that would most likely be understood and used by the travelers. The Lexicon terminology and guidelines developed in L14 were based on a series of laboratory studies, and none of the terms were tested in a field environment.

To help agencies and other transportation-related entities better deploy and use the recommended Lexicon terminology, a field study was conducted to test the phrases to demonstrate the technical and institutional feasibility of their use and determine the potential costs and benefits of using these products of L14. The overall project objectives were to:

- Convey TTR information from theory to reality.
- Better understand travelers' perceived value of TTR information.
- Better understand the current and future dimensions of the TTR information marketplace.
- Better understand what network travel and TTR information travelers require.
- Develop and implement a plan to test and evaluate the preliminary design guidelines and Lexicon phrases for disseminating TTR information.
- Develop guidelines based on the outcome of the test and evaluation.
- Lay out the barriers to communicating TTR information to travelers and steps to overcome barriers.
- Outline how different travelers will use TTR information differently (e.g., one-time visitor vs. regular commuter).
- Recommend and develop outreach activities in order to encourage use and adoption of the recommended Lexicon phrases and guidelines.
- Outline clear steps that agencies need to take to start getting the TTR information into travelers' decision processes.

The field study was conducted in three different metropolitan areas—Houston, Texas; Columbus, Ohio; and Raleigh-Durham, North Carolina. At each of the three study locations, two separate assemblies of Lexicon terms for TTR information were delivered using three distinct methods: agency website, mobile smartphone application, and a traditional keypad response 511 system. The study was intended to assess the effectiveness and utility of TTR information to travelers in these three different areas of the United States and to help develop guidelines for agencies to disseminate this information in their jurisdictions.

FIELD STUDY RESULTS

The results of the field study are briefly summarized in this section. A complete discussion and presentation of the study results can be found in the final report from the study.[4]

Local partners from each study location provided historical traffic datasets as a source for determining the TTR information that was provided to study participants in the field study. Using a custom Smartphone application, study participants collected Global Positioning System (GPS) and travel characteristic data for all trips made over a four-week period along specific travel corridors in each study location. The travel period was divided into two equal phases. Only travel data was collected during the first phase. In addition to collecting travel data during the second phase, TTR information was provided to participants according to their randomly assigned Lexicon assembly (A or B) and dissemination platform (i.e., App, Web, 511).

Baseline and exit surveys were administered to study participants to obtain their typical travel patterns and perceptions of the provided TTR information. The data collection for the field study occurred during multiple rounds between April 2015 and April 2016. Depending on the round, participant recruitment was conducted in various manners, including targeted postcard mailings to randomly selected households in zip code areas near the study corridors, flyers and newsletter advertisements at major university campuses within the study corridor, and postings on social media and local partner websites.

A total of 762 participants across the three metropolitan areas completed the field study. Their aggregate information for the Baseline Survey, Phase 2 trip diaries, and Exit Survey were utilized to conduct an analysis for determining if TTR information dissemination Lexicon (A, B) or channel (App, Web, 511) generated a significant impact on the utility or satisfaction of trip planning and execution. The Baseline Survey results were analyzed to assess any preexisting differences between treatment groups, while the Exit Survey results were analyzed to establish the response probabilities associated with the TTR information dissemination channel and lexicon as a function of demographic and travel characteristic data.

Analysis of the baseline survey data found that there were no statistically significant associations between treatment group and demographic and travel characteristics variables. Given this result, subsequent differences between the treatment groups could be interpreted to be associated with the testing and not possibly reflective of an *a priori* bias in the panel composition.

Only one survey question resulted in statistically significant differences between the Lexicon assemblies. Those that were provided Assembly A were more likely to change their trip plans for a familiar trip than those provided Assembly B. However, it should be noted that across all the questions evaluated, no multiple comparison adjustments were made to the statistical test results. Therefore, each "statistically significant" result has a potential to have been reached in error. Across a large number of such results, it becomes likely that one or more of the significant results really represent only random variability in the responses. As such, this one result should be evaluated with caution.

Throughout the survey responses, there were several instances showing lower utility or satisfaction for the 511 information channel than either the Web or App access channels. In a few instances, the App access demonstrated superior responses than 511 or the Web.

Statistical models accounted for several exogenous factors, and this clearly seemed important to properly interpreting the results of interest for the Lexicon assemblies and information channels. The city of the participants only rarely appeared as a significant factor in the models, suggesting that location was not an important differentiator in the outcomes. Among other exogenous variables, education level and the number of Phase 2 trips taken with the TTR information were found to significantly correlate with responses for multiple questions. Specifically, participants with college degrees and those taking more trips in the TTR phase were less likely to report that they had made changes to either a familiar or unfamiliar trip as a result of the information. This finding was reinforced by the fact that in subsequent survey questions, these two groups were identified as finding TTR information less useful and reliable, and disagreeing that it reduced their travel time or their travel stress.

CHAPTER 3. A LEXICON FOR COMMUNICATING TRAVEL TIME RELIABILITY

As a result of the field study, the Lexicon tables presented in the original Strategic Highway Research Program 2 (SHRP2) L14 report were refined to better represent traveler preferences.[3] Only nominal changes were made, because in most cases those terms noted as "best" remained so and if one of the "best" terms performed better than the other, the other term was moved to "adequate." The one table that was modified (Table 4) is noted below as being adapted from the original report.

Each Lexicon entry in the following tables includes a technical Travel Time Reliability (TTR) term; the definition of the term/concept within the reliability framework; a description of when or for what purpose an agency might use the term; and recommendations for terminology, phrases, or graphics to be used, in order of preference. In some cases, alternate terms or phrases suitable for selected technology platforms also are provided. Finally, the Lexicon entries identify appropriate media and technology interfaces for each listed term, phrase, or graphic. However, it is important to note that graphical representations of the TTR data were not tested in either the original SHRP2 or follow-up Federal Highway Administration (FHWA) research. Additionally, the phrases were not tested on Dynamic Message Signs (DMSs) within the travel corridors for en-route access. The information for these presentations remains the same for all phrases based on the original guidance developed in the SHRP2 L14 project. Thus, these dissemination formats need additional research to confirm their usefulness to system users.

As noted previously, the goals for establishing a Lexicon to convey TTR information were the following:

- Communicate a useful message.
- Improve on-time performance.
- Encourage trust in the message.
- Communicate the "riskiness" of a route.
- Distinguish TTR from real-time traveler information.[2]

LEXICON FORMAT

The key elements of a Lexicon entry that are considered necessary to completely present each term are as follows:

- *Technical Term*—the formal TTR term to be defined.
- *Definition*—a definition of the term within the reliability framework.
- *Usage*—a general description of when an agency might use the reliability term or for what purpose it would use the term in the traveler information system.

- *Recommendation*—the ranking of the messages and/or terms to be used in order of preference.
  - *Best*—represents the term(s), phrase(s), and/or format(s) that performed the best and will most likely yield the desirable behavioral results when conveyed to system users or other stakeholders.
  - *Adequate*—represents term(s), phrase(s), and/or format(s) that performed reasonably well and will not likely present significant comprehension problems for system users or other stakeholders.
  - *Avoid*—represents terms(s), phrase(s), and/or format(s) that did not perform well or are recommended to avoid for noted reasons.
- *Alternate Phrase*—an alternative term or phrase of different length that is likely to be more easily understood than the technical term.
- *Information Technology Platforms*—identification of appropriate media and technology interfaces for each alternative. This list of technology platforms could continue to evolve as new media are introduced. These might include portable navigation devices, connected vehicle on-board equipment, and advanced car stereo or satellite radio systems. An initial list includes:
  - *Web*—intended to mean full website format viewed from a full-sized personal computer screen in a full-featured Internet browser.
  - *Mobile Web*—intended to mean a website format viewed from mobile devices such as smartphones and tablet computers.
  - *Text*—includes short message service (SMS) text messages and social network text messages, such as Twitter™, viewed on a mobile device.
  - *Mobile Application*—specially designed user interfaces optimized to work on a specific smartphone operating system. These apps include user input and output screens and data entry mechanisms, such as drop-down text boxes and scrolling menus, specifically designed for the touchscreen or keyboard supported by that operating system.
  - *Dynamic Message Sign*—roadside dynamic message sign.

TRAVEL TIME RELIABILITY LEXICON

The alternate phrases from the original SHRP2 research that were tested in this project are provided in Table 1. The Lexicon alternate phrases were tested for the following TTR terms:

- 95th percentile.
- Arrival time.
- Average travel time.
- Buffer time.
- Departure time.
- Recommended departure time.
- Reliability.

Table 1. Assemblies of travel time reliability lexicon alternate phrases for testing.

Travel Time Reliability Phrase	Alternate Phrase	
	Assembly A	Assembly B
95th Percentile	Majority of the time*	Most of the time**
Arrival Time	Arrive by*	What time do you want to get there?**
Average Travel Time	Estimated travel time*	Approximate travel time*
Buffer Time	Extra time*	Recommended cushion**
Departure Time	Departing at*	What time will you start your trip?**
Recommended Departure Time	Recommended departure time*	Suggested departure time**
Reliability	Predictable*	Reliable**

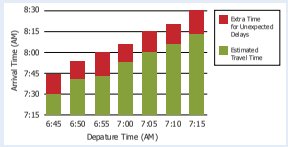
*Alternate phrase originally identified as "best" in SHRP2 L14 Lexicon.
**Alternate phrase originally identifies as "adequate" in SHRP2 L14 Lexicon.

The SHRP2 L14 report identified only one "Best" phrase for six of the eight technical TTR terms.[3] For these cases, the two TTR assemblies tested in the field study were determined by selecting the "Best" phrase to be Assembly A and an option from the "Adequate" category to be Assembly B. A phrase from the "Adequate" category was selected that was somewhat different from the "Best" phrase, though with multiple options, this was not always the case. It was impractical to test all of the "Adequate" options because of the number of subjects that would be required to participate in order to get a statistically significant sample of responses. For the other two TTR terms (i.e., "Average Travel Time" and "Departure Time"), slightly different methods were used to determine Assembly A and Assembly B. Both of the "Best" phrases were tested for "Average Travel Time", while one of the "Best" phrases and one from the "Adequate" list that was considerably different from the "Best" phrase were tested for "Departure Time". The reason for the difference with "Departure Time" was that the two "Best" phrases were so similar in nature.

Table 2 through Table 9 present the specific Lexicon of phrases for each TTR term tested in the original SHRP2 L14 project through various human factors studies as well as in the succeeding field tests. The evaluation of the effectiveness of various messages was based in part on the improvement of travelers' outcomes (reduction of early and late schedule delay, better on-time performance, and reduced delay) and preferences in the exit surveys. Because the Lexicon phrases were tested on a 511 platform in the field study, 511 was added to the tables as part of the Text information technology platform given that the messages were identical. Furthermore, the Mobile Web and Mobile Applications noted on the tables do not include auditory messages.

Only one table (Table 4) was changed from what was presented in the SHRP2 L14 report based on the findings of the field study. This change was the demotion of "Approximate travel time" from "Best" option to "Adequate" option for "Average Travel Time".

Table 2. Travel time reliability Lexicon for *95th PERCENTILE*.[3]

Technical Term	**95th Percentile**						
Definition	The point on a travel time frequency distribution at which 95% of the trips made would be at or less than the identified time.						
Usage	To describe the longest time a driver can expect a trip to take.						
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**				
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	**Majority of the time**	*"The majority of the time, your trip will take X minutes or less."*	√	√	√+	√+	**X**
		MAJORITY OF TIME TRIP TO [DESTINATION] X MIN OR LESS	√	√	√	√	√>
		Graphical representation of the average and 95th percentile.	√	√	**X**	√	**X**
Adequate	**Most of the time**	*"Most of the time, your trip will take X minutes or less."*	√	√	√+	√+	**X**
		MOST OF THE TIME TRIP TO [DESTINATION] X MIN OR LESS	√	√	√	√	√>
	Travel time for planning	*"Travel time for planning is X minutes or less."*	√	√	√+	√+	**X**
	95th percentile trip time	*"The 95th percentile trip time is X minutes or less."* Provide description such as "19 out of 20 days."	√	√	√+	√+	**X**
Avoid	**Maximum trip time**	Transportation Agency concerns regarding liability and credibility.	N/A	N/A	N/A	N/A	N/A
	Most common trip time						
	Worst-case trip time						

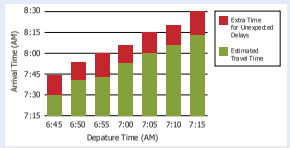
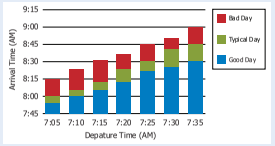
^ Mobile Web and Mobile Applications did not include auditory messages.
+ Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.
> The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.

Table 3. Travel time reliability Lexicon for *ARRIVAL TIME.*[3]

Technical Term	Arrival Time						
Definition	The time at which a traveler would arrive after a trip.						
Usage	To tell the driver when he/she can expect to arrive at his/her destination.						
Recommendation	Alternate Phrase	Wording Context/Additional Information	Information Technology Platforms				
			Web	Mobile Web^	Text / 511	Mobile Application^	Dynamic Message Sign
Best	Arrive by	*"Arrive by X:XX am/pm"*	√	√	√	√	X
		ARRIVE BY X:XX AM/PM	√	√	√	√	√>%#
Adequate	Arrive at	*"Arrive at X:XX am/pm"*	√	√	√	√	X
		ARRIVE AT X:XX AM/PM	√	√	√	√	√>%#
	What time do you want to get there?	This question would be used by a traveler to enter a preferred arrival time into a travel time calculator to receive a recommended departure time.	√	√	X	√	X
	What's the earliest you can arrive	This question would be used by a traveler to enter a preferred arrival time into a travel time calculator to receive a recommended departure time.	√	√	X	√	X
	What's the latest you can arrive?	This question would be used by a traveler to enter a preferred arrival time into a travel time calculator to receive a recommended departure time.	√	√	X	√	X
Avoid							

^ Mobile Web and Mobile Applications did not include auditory messages.
> The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.
% Term may present ambiguity to the viewer, as he/she would not see a specific destination.
# Term is not a complete message and cannot stand alone in this platform. It needs to be anchored to specific destination information.

Table 4. Travel time reliability Lexicon for *AVERAGE TRAVEL TIME (Adapted from* [3]*).*

Technical Term	Average Travel Time							
Definition	An average of historical travel times calculated over a specified time interval for a specified trip or roadway segment.							
Usage	To describe the typical travel time a driver can expect a trip will take.							
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**					
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	**Estimated travel time**	*"Estimated travel time is X minutes."*	√	√	√+	√+	**X**
		"It is estimated that your trip will take X minutes."	√	√	√+	√+	**X**
		EST THAT TRIP TO [DESTINATION] WILL TAKE X MIN	√	√	√	√	√>
Adequate	**Approximate travel time**	*"It will take approximately X minutes to make your trip."*	√	√	√+	√+	**X**
		APPROX X MIN TO [DESTINATION]	√	√	√	√	√>
	Typical travel time	*"Typical travel time is X minutes."*	√	√	√+	√+	**X**
		Graphical representation of the average and 95th percentile (typical day and bad day).	√	√	**X**	√	**X**
		Graphical representation of the 20th percentile and average and 95th percentile (good, typical, and bad day).	√	√	**X**	√	**X**
	Average travel time	*"Average travel time is X minutes."*	√	√	√+	√+	**X**
	Expected travel time	*"Expected travel time is X minutes."*	√	√	√+	√+	**X**
Avoid	**Historical Travel Time**	Difficult to determine relevance with no comparison to real-time information.	N/A	N/A	N/A	N/A	N/A

^ Mobile Web and Mobile Applications did not include auditory messages.
+ Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.
> The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.

Table 5. Travel time reliability Lexicon for *BUFFER TIME*.[3]

Technical Term	**Buffer Time**						
Definition	The average travel time multiplied by the buffer index.						
Usage	To describe how much extra time a driver should plan for a trip he/she wishes to take.						
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**				
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	**Extra time**	*"Extra time for trip is X minutes."*	√	√	√+	√+	**X**
		EXTRA TIME TO [DESTINATION] IS X MIN	√	√	√	√	**X**
Adequate	**Added time**	*"Added time for trip is X minutes."*	√	√	√+	√+	**X**
		ADDED TIME TO [DESTINATION] IS X MIN	√	√	√	√	**X**
	Recommended cushion	*"Recommended cushion for trip is X minutes."*	√	√	√+	√+	**X**
Avoid	**Cushion**	Preference shown for other terms.	N/A	N/A	N/A	N/A	N/A
	Buffer time						
	Departure window						
	Leeway						

^ Mobile Web and Mobile Applications did not include auditory messages.
+ Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.

Table 6. Travel time reliability Lexicon for *DEPARTURE TIME.*[3]

Technical Term	**Departure Time**						
Definition	The time at which a traveler would depart for a trip.						
Usage	To indicate the time a traveler departs for a trip. For DMS applications, message would need to be set in context with other information, such as destination, travel time, or route.						
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**				
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	Departing at	*"Departing at X:XX am/pm"*	√	√	√	√	**X**
	Leave at	*"Leave at X:XX am/pm"*	√	√	√	√	**X**
Adequate	What time will you start your trip?	This question would be used by a traveler to enter a start time into a travel time calculator to receive an arrival time.	√	√	**X**	√	**X**
	Leave by	*"Leave by X:XX am/pm"*	√	√	√	√	**X**
	Departing by	*"Departing by X:XX am/pm"*	√	√	√	√	**X**
	What's the earliest you can start your trip?	This question would be used by a traveler to enter a start time into a travel time calculator to receive an arrival time.	√	√	**X**	√	**X**
	What's the latest you can start your trip?	This question would be used by a traveler to enter a start time into a travel time calculator to receive an arrival time.	√	√	**X**	√	**X**
Avoid							

^ Mobile Web and Mobile Applications did not include auditory messages.

Table 7. Travel time reliability Lexicon for *RECOMMENDED DEPARTURE TIME.*[3]

Technical Term	Recommended Departure Time						
Definition	A time of departure displayed to a traveler that is calculated by a traveler information system and would ensure an on-time arrival for a given level of added delay.						
Usage	To indicate the time a driver should depart for a trip to ensure he/she arrives at his/her destination on time.						
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**				
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	**Recommended departure time**	*"Recommended departure time is X:XX am/pm"*	√	√	√+	√+	**X**
Adequate	**Suggested departure time**	*"Suggested departure time is X:XX am/pm"*	√	√	√+	√+	**X**
	Estimated departure time>>	*"Estimated departure time is X:XX am/pm"*	√	√	√+	√+	**X**
	95th percentile departure time	*"The 95th percentile departure time is X:XX am/pm"* Provide description such as "19 out of 20 days."	√	√	√+	√+	**X**
Avoid							

^ Mobile Web and Mobile Applications did not include auditory messages.
+ Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.
>> Can be used if term is NOT being used to mean average trip time.

Table 8. Travel time reliability Lexicon for *RECOMMENDED ROUTE.*[3]

Technical Term	Recommended Route						
Definition	A route between two points calculated by a traveler information system that would provide the best probability of on-time arrival to a specific destination.						
Usage	To describe the route a driver should take for a planned trip to ensure he/she arrives on time to his/her destination.						
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**				
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	**Best route**	*"Best route is via [facility]."*	√	√	√+	√+	**X**
		BEST ROUTE TO [DESTINATION TAKE [FACILITY]	√	√	√	√	√>
Adequate	**Forecasted trip**	*"Forecasted trip is via [facility]."*	√	√	√+	√+	**X**
		FORECASTED TRIP TIME VIA [FACILITY] X MIN	√	√	√	√	**X**
	Most reliable trip	*"Most reliable trip is via [facility]."*	√	√	√+	√+	**X**
		MOST RELIABLE TRAVEL TIME TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√>%
	Most predictable trip	*"Most predictable trip is via [facility]."*	√	√	√+	√+	**X**
		MOST PREDICTABLE TRAVEL TIME TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√>%
	Most consistent trip	*"Most consistent trip is via [facility]."*	√	√	√+	√+	**X**
		MOST CONSISTENT TRAVEL TIME TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√>%
Avoid	**Historical trip conditions**	Difficult to determine relevance with no comparison to real-time information. Preference shown for other terms.	N/A	N/A	N/A	N/A	N/A
	Least variable time						

^ Mobile Web and Mobile Applications did not include auditory messages.
+ Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.
> It is unknown whether drivers will understand this message if displayed on a DMS. Field testing needed to assess comprehension.
% The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.

Table 9. Travel time reliability Lexicon for *RELIABILITY*.[3]

Technical Term	Reliability						
Definition	A consistency or dependability in travel times between two points, as measured from day to day or across different times of day.						
Usage	To describe the variability of travel times to drivers so they can plan their trip with more robust information.						
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Information Technology Platforms**				
			Web	**Mobile Web^**	**Text / 511**	**Mobile Application^**	**Dynamic Message Sign**
Best	**Predictable**	*"Most predictable trip."*	√	√	√	√	**X**
Adequate	**Reliable**	*"Most reliable trip."*	√	√	√	√	**X**
	Consistent	*"Most consistent trip."*	√	√	√	√	**X**
	Vary	*"Trip varies."*	√	√	√	√	**X**
Avoid	**Differ**	Preference shown for other terms.	N/A	N/A	N/A	N/A	N/A
	Fluctuate						
	Change						
	Go up or down						
	Increase or decrease						
	Deviate						

^ Mobile Web and Mobile Applications did not include auditory messages.

CHAPTER 4. DEPLOYMENT OF THE TRAVEL TIME RELIABILITY LEXICON

This chapter provides information to transportation agencies with respect to use cases, data needs, delivery platforms, and other important considerations when assessing the potential use of Travel Time Reliability (TTR) information in their jurisdiction.

USE CASES FOR TRAVELERS

As discussed previously, travelers might find TTR information useful in a variety of situations related to trip planning. As agencies consider disseminating TTR information to their system users, they could consider various scenarios in which travelers and other stakeholders might find that information valuable and present it as such for ready use. These scenarios, which are by no means exhaustive, include the following:

- **Individual Trip Planning – Habitual:** Travelers may find TTR information valuable when planning habitual trips, such as daily commutes. TTR information may be particularly valuable when an individual is new to an area and unfamiliar with routes and typical travel times. They may also find it beneficial when moving to a new neighborhood or corridor within a community and need to assess commute times in new corridors. Explaining the potential use of the information for these habitual trips could be beneficial to the traveler and increase the overall value of the information to the target audience.

- **Individual Trip Planning – Unfamiliar**: Travelers may find TTR information useful for pre-trip planning immediately prior to departure or to make decisions about departure time and/or mode based on real-time and historical travel time trends, especially if traveling at a time or to a destination that is not typical. Explaining the value of TTR information for unfamiliar trips and how someone might use the information could help increase the overall value and usage of the information by the target audience.

- **Individual Trip Change:** Travelers may find TTR information helpful en-route and consider changing their trip while in progress prior to a route or mode choice point (again based on both real-time and historical information regarding particular routes at particular times of the day). However, it is important to note that the traveler should not be encouraged to access the information in a moving vehicle as this increases distraction in the driving environment.

- **Alternate Route Comparison:** Travelers may need to decide between alternate routes for either familiar or unfamiliar trips. Making TTR information available for facilities with alternate routes might improve the usability of the information by the target audience.

- **Employment Center Location:** Corporations or large employers could utilize TTR information when considering employment center locations within corridors with reliable travel times for employees. Presenting TTR trends for facilities along with comparisons of regional facilities can make this information useful to these stakeholders.

- **Overall System Reliability:** Agencies can use TTR information and the Lexicon phrases to provide stakeholders and decision makers with valuable information on system reliability. This information can be used to assess the priorities of future projects as well as to assess the impacts of projects and operational strategies for corridors and the system as a whole. The target audiences for this information presentation could include, but not be limited to, regional planning organizations; transportation agency decision makers; local chambers of commerce; economic development organizations; travel and tourism organizations; local entities such as school districts and universities; and more.

DATA NEEDS

For an agency to present TTR information to system users, it will need to have historical traffic datasets as a source for determining the TTR calculations. These calculations are then utilized by information dissemination platforms so that travelers can make informed decisions about their trip. To ensure compatibility across all platforms and to provide information that can be easily understood by system users, historical traffic datasets benefit from the following:

- Average segment-based travel time data with origins and destinations corresponding to the majority of entry/exit points along each corridor by direction. These average values are used as the "typical" travel time for display in the traveler information applications.

- For each of the segments in a corridor and for each aggregation period, the 95th percentile travel time for use in determining the worst-case travel times.

- Travel time data aggregated by day of week in at least hourly intervals for a 6-month period or more. The aggregation time (e.g., 15 minutes, hourly) limits the resolution of the departure and arrival times in the traveler information applications.

- The most recent historical dataset possible in order to reflect the current traffic conditions as accurately as possible.

Based on the availability of data, as well as source, timeframe, and format, agencies likely will need to manipulate the data to generate a dataset that can be mined to calculate TTR information and disseminate that information to the traveling public. To illustrate the type of data manipulation that might be necessary, the manner in which the project team handled travel time and speed data from Houston is described below. It is important to note that the volume and type of data available in Houston is not typical, given that the region collects and manages its own flow data. Many other locations obtain flow data from third-party sources, which may have

different levels of granularity. The manipulation and summary of those data likely will differ considerably from that in Houston; however, the format of the final resulting dataset would be similar.

The Houston region has an extensive deployment of Intelligent Transportation System (ITS) based sensors installed throughout each of the study corridors, which provide speed and travel time information through the region's traffic management center, Houston TranStar®. The source of the Houston study data was the information collected by these sensors that utilize either Bluetooth or toll-tag-based re-identification for estimating travel times. The sensors are operated by the Texas Department of Transportation, which provided the data for the study's usage for the I-10 Katy, I-10 Katy Managed Lanes, Westpark Tollway, I-45 North, I-45 North High-Occupancy Vehicle (HOV), and Hardy Toll Road study corridors.

The origins and destinations for each travel time segment were based on the locations of the roadside sensors. In most cases, the sensors were located near major entry and exit points along the corridors with 1- to 3-mile spacing. The software internal to Houston TranStar® collects and processes the travel time data in both real-time and historically, and aggregates the data into 15-minute summaries by day of week. For each 15-minute period and for each day of the week, the dataset contained a location identifier (including the roadway name, direction of travel, origin cross street, and destination cross street), a timestamp indicating the time of the summary, an average travel time, and a 95th percentile travel time.

Delivery Platform Data Interface Technical Description

There are a variety of approaches to disseminating TTR information to travelers depending on the delivery platform that an agency intends to use for the dissemination or which they already manage. For example, a backend architecture for a pre-existing traveler information website can provide a data interface framework for any of the three information delivery platforms included in the Lexicon. Additionally, a web Application Programming Interface (API) can be developed to allow other applications to query the historical datasets that are developed for a region. Typically, the delivery platform (e.g., a traditional website, mobile application, 511 system) can make queries to a web interface to obtain the traffic conditions data.

To initiate a query to the web service, a client makes a call to a web address with the following parameters included:

- Starting Location ID.
- Ending Location ID.
- Time of Day.
- Date of Travel.
- Departure or Arrival Calculation.
- Lexicon Phrase Selection.

Based on the information passed via the parameters, the web service queries the appropriate historical dataset and returns a string of text containing the approximate travel time, buffer time, and predicted arrival or departure time. The different information channels are then able to relay this information in an appropriate format (e.g., webpage via the website and mobile application, via 511). A diagram of a typical web service architecture is shown in Figure 3. This particular architecture was used in the research study, but can be replicated for a particular location.

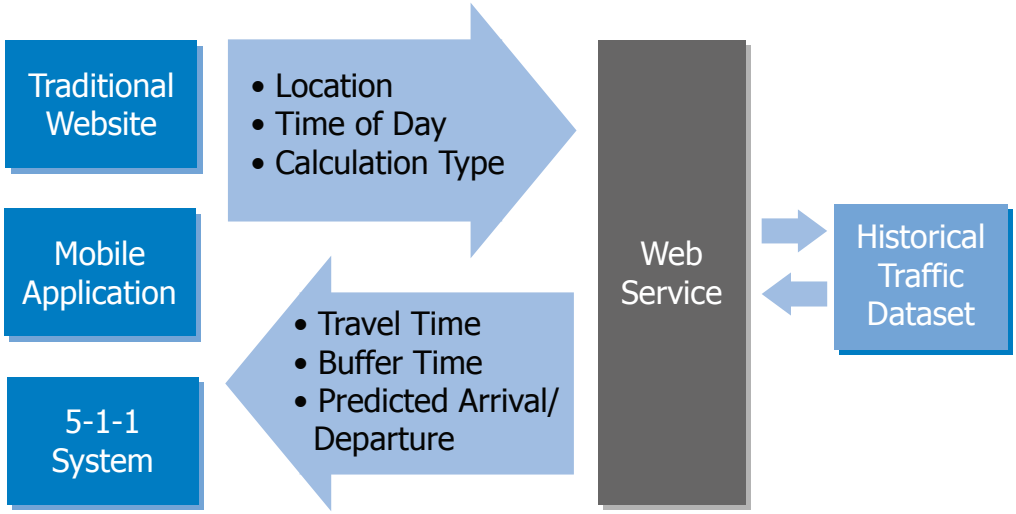


Figure 3. Graphic. Web service architecture.

Note that this web service architecture may vary depending on the traveler information website or service currently operated by an agency.

INFORMATION DELIVERY PLATFORMS

The research study tested three information platforms: a mobile application provided via smartphone, a traditional website, and a 511 telephone service.

- The **mobile application** was the platform most preferred by users in the study. This format can be the most convenient option for users to find TTR information at the point when they may be most likely to want it (i.e., just as they are beginning a trip). Designing the application so that users can enter and save personalized information such as their most-used departure point can help to maximize utility of this platform. Drivers should be encouraged to not enter any information while operating a vehicle.

- A **traditional or mobile website** may offer more options for customizing user inputs and/or output formats. This information platform ranked second in preference among study participants.

- The **511 telephone service** was least preferred by study participants. It is therefore not recommended that an agency develop a 511 system solely for the purpose of providing TTR information. However, if an agency already has a 511 system for travel information and develops other platforms (e.g., mobile application, mobile website, traditional website) for deploying TTR information, the mechanism for transferring that TTR information to the 511 system is fairly straightforward.

COMBINING REAL-TIME AND RELIABILITY INFORMATION

The original research conducted in the Strategic Highway Research Program 2 (SHRP2) L14 research project indicated that travelers consider real-time travel time information to be valuable and even necessary in addition to historical data when planning trips. However, this project did not assess the viability and/or best approach to combining those sources of information. Thus, additional research is needed to determine how best to combine real-time and historical travel time information to provide the most useful and accurate information to travelers. Some regions are beginning to provide this comparison information and future research could benefit these and other regions in ensuring that these two forms of information are combined in an effective manner to optimize the user travel experience.

If an agency determines that TTR information will be valuable to its system users, it is important to clearly explain to them the difference between real-time information and TTR information. It is highly likely that system users will be familiar with existing real-time traveler information for the region from the plethora of sources available to them across providers and information dissemination platforms. They also are highly likely to be very familiar with the roadway network in the region, especially for their regular commute route. They may not intrinsically understand what TTR information is telling them, so an explanation is important for comprehension. Furthermore, providing examples of how travelers might use TTR information for trip planning (e.g., unfamiliar trips, familiar trips at unusual times, etc.) may help increase awareness and overall use of the information by travelers. If the transportation agency already provides real-time traveler information, then comparing the two types of information in a side-by-side comparison might help with comprehension and usage.

CHAPTER 5. FINAL REMARKS

The field study was beneficial in better refining the information originally developed as part of the Strategic Highway Research Program 2 (SHRP2) L14 research project. However, only one survey question resulted in statistically significant differences between the Lexicon terminologies. Overall, the particular Lexicon terminologies tested performed similarly. The biggest finding of the field study was that dissemination of Travel Time Reliability (TTR) information via the 511 information channel was less preferred than via the Web or App access channels. In a few instances, the App access demonstrated superior responses over both the Web and 511 access.

However, some questions remain unanswered regarding the dissemination of TTR information to travelers across a broad spectrum of delivery platforms. These limitations are discussed below.

WEBSITE / MOBILE APPLICATION DESIGN

The research study assessed the use of the Lexicon in three different dissemination platforms: website, mobile web application, and 511. In all three cases, the information presented was identical across all three platforms. However, the actual user interface of the website and mobile web application was not assessed. User interface best practices should be utilized to develop a website and mobile application that will be easy to use and minimize access time.

GRAPHICAL MESSAGES

Two graphical formats were tested in the original SHRP2 L14 study as alternatives for presenting reliability information to drivers. These two formats were rated by participants as being "more complex" and therefore less easy to use than the same information presented in a text format. However, other graphical formats may prove useful as alternative or supplemental methods for communicating reliability information to drivers. These graphical formats were not tested in this study, so further research is still necessary to assess the potential usefulness and usability of "star" ratings, Harvey Balls, and other graphical formats for conveying reliability information.

AUDITORY MESSAGES

While the research study assessed the use of the Lexicon in a 511 auditory platform, it did not test auditory messages in the vehicle. Auditory messages were included as one format for communicating reliability messages in the original SHRP2 L14 project, but future research should further examine auditory options for both message delivery and, potentially, verbal inputs by system users.

DYNAMIC MESSAGE SIGN MESSAGES

As indicated in the Lexicon tables, sample messages for Dynamic Message Signs (DMSs) are provided. It is important to note that the studies conducted in SHRP2 L14 and in this project did not test these phrases as being displayed on a DMS and as en-route information. Those phrases suggested for display on DMSs were developed by the original SHRP2 L14 research team based on the results discussed for the related terminologies.[3] The team developed these phrases using the general guidance for DMS message development provided in the *Manual on Uniform Traffic Control Devices*. It is important to note that the formatting of these TTR messages is very different from the standard messages used by state transportation agencies on DMSs. For many of the TTR terms, their use on a DMS would present various challenges to the traveler including:

- Drivers are conditioned to see real-time travel information displayed on DMSs on freeway corridors, and reliability information may confuse them when placed on a DMS.
- Any reliability information displayed on a DMS would need to be relative to the specific location of the sign on the freeway facility, as drivers would have begun their trips from various locations in the region's transportation network.
- Messages providing departure time or buffer time information are not appropriate for DMSs since travelers would need to see these messages prior to starting their trip, not en-route.[3]

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