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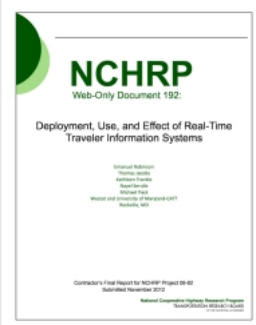

Deployment, Use, and Effect of Real-Time Traveler Information Systems

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AUTHORS

Robinson, Emanuel; Jacobs, Thomas; Frankle, Kathleen; Serulle, Nayel; and Pack, Michael

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Matthew Coogan, New England Transportation Institute
Gene Glotzbach, Florida DOT
James Hogan, P.E., New Jersey DOT
David Kinnecom, P. E., Utah DOT
Lee Nedervold, Michigan DOT
Dr. Pravin Varaiya, University of California, Berkeley
Scott M. Sauer, California Department of Transportation
Matthew Hardy, AASHTO Liaison
Dr. David Luskin, FHWA Liaison
Richard Cunard, P. E., TRB Liaison

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ABSTRACT

This report presents the results of a study on the deployment, use, and effect of real-time traveler information (TI) systems. The main goals were to understand agency dissemination practices, assess the potential effectiveness of TI systems as it relates to traveler perception and use, and suggest best practices for facilitation. It also provides several key outputs to be used by stakeholders: a) survey/interviews of agency representatives, b) surveys and focus groups with travelers to better understand the public's perception/use of TI, c) database of survey responses, d) comparative analysis of agency and public perceptions, e) recommendations of methods for assessing TI, including a "toolbox" of low-cost approaches, f) guidance for features of an ideal TI system, g) discussion of future TI, including cutting edge technologies. Agencies and the public agree that TI should be targeted, easy to use, relevant, clear, trustworthy, reliable, and accurate. Interestingly, there was a call for simple information that can be accessed by most people in a variety of locations (e.g., radio). We recommend features of an effective TI system. First, there should be a provision of TI focusing on non-recurring events. Second, a wide array of dissemination methods should be implemented. Finally, TI should align with needs and wants of the public. The report also includes guidance on how agencies can facilitate TI in the future, taking advantage of new technologies, new dissemination methods, and public-private partnerships.

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SUMMARY

Traveler information (TI) systems are diverse and rapidly evolving. It will be important for agencies and TI vendors to align development with the needs and expectations of the traveling public. The National Cooperative Highway Research Program (NCHRP) Project 08-82, Deployment, Use, and Effect of Real-Time Traveler Information Systems concerns: developing a better understanding of agency practices and rationales for disseminating real-time TI, assessing the effectiveness of these real-time information systems as it relates to traveler perception and use, and suggesting best practices for future facilitation of this information.

Many studies of real-time TI effectiveness focus on user satisfaction (e.g., *"NCHRP Synthesis 399: Real-Time Traveler Information Systems"* by Deeter, 2009). The current approach goes beyond this limited assessment approach, instead using a variety of methods to not only understand satisfaction, but also behavioral outcomes (through self-report logs) and other low-cost methods. This combination of methods creates a better assessment of effectiveness in real-time TI systems and practices, while also providing better information from which to develop guidance for future approaches to real-time TI.

The Westat-CATT team believes that the most critical aspects of this research, from a practitioner perspective, are the "gaps" between the agency's processes for disseminating travelver information and the public's expectations and needs. Another critical output of this research: Agencies are in dire need of guidance on how to measure the performance/impact of their TI programs. In addition, the project is providing a public use database of survey data collected throughout the effort for use by agencies in assessing the public's views on TI.

Research Approach

The research approach used in this study closely parallels the overall research objectives: to analyze the deployment, perception, and use of real-time TI systems. First, the research team identified how and why agencies disseminate real-time TI. This involved developing and conducting an extensive web-based survey and several followup phone interviews to collect public agency TI provider information around three interrelated themes:

1. Determine agency perceptions regarding the rationale for why TI is provided and the mechanisms by which the information is delivered;
2. Determine what evaluation/assessment techniques are used by agencies to support the rationales for TI provision mechanisms; and
3. An attempt to identify impediments to evaluation assessment, unique practices in existing TI programs, and agency perspectives on the future outlook of TI.

After focusing on how and why agencies disseminate TI, the research team used a variety of methods to explore outcomes from a traveler perspective including access to, perception of, and need for real-time information. This approach allowed us to not only understand TI user satisfaction and perception, but also behavioral outcome proxies (through self-report logs and recent timeframe surveys).

Several questions of interest were identified:

- What access do travelers have to real-time TI and what is their awareness of that access?
- What is the public perception of real-time TI?
- What characteristics do travelers need in real-time TI?
- What are the gaps between what agencies provide and what travelers feel is important and need?

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- How do agencies use real-time data in planning and operations activities and are these uses reaching the public with the intended effect?
- What are the reasons travelers do not use available real-time TI?
- Are there any self-reported behavioral changes due to real-time TI? If so, what are the most effective information type and medium to be used in changing traveler behavior? How do pre-trip and en-route patterns of using real-time TI differ?
- How frequently do these changes occur?
- In what ways do the changes occur (e.g., leave earlier, later, change route)?
- If behavior does not change, then why not? Is it a system constraint (e.g., lack of alternative routes/transit options, unreliable information) or personal constraints (inability to adjust trip time due to appointments, etc.)?

A particular area of interest for transportation managers and engineers is changing traveler behavior based on information disseminated. Ideally, one would like to have extensive empirical data on the actual changes in traveler behavior as a function of various types and sources of TI to directly measure the effect (and relative effectiveness) of TI. This is in fact quite difficult to do, particularly with a limited set of project resources. Our approach is to learn what we best can about multiple aspects of TI effects from a diverse set of sites. We believed the best approach to understanding travelers' use, perception, and response to real-time TI was the combination of a variety of low-cost methods that have proven successful in the past. This "toolbox" consists of several components which can be inexpensively adapted to a particular site. This approach also has the advantage of not being cost prohibitive for agencies who would like to develop their own evaluation process and use some of the same tools.

The detailed TI user assessment focused on four sites: a) Washington DC metro area (Rockville, Maryland), b) Orlando, Florida, c) San Francisco, California, d) New York City commuting area (Teaneack, New Jersey). Each site contained the following data collection approaches and was used in forming a comprehensive profile of traveler behavior and perceptions in the area (in this order):

- Reference to agency interviews and surveys, as well as use of Geographical Information Services to target optimal corridors that contained heavy traffic and potential for alternate routing.
- Web-based surveys with participants primarily targeted through zip codes in corridors of interest.
- Two focus groups at each location: one group of real-time TI frequent or heavy users and one group of non-users or light users.
- Traveler logs: Participants in each group were given a seven-day traveler log at the completion of each focus group, along with instructions for its completion.

To supplement the more detailed assessment sites, there were two additional sites where the research team did not visit in person but collected data remotely utilizing web-based surveys. The two remotely assessed (survey only) areas were: Detroit, Michigan and Salt Lake City, Utah.

Finally, after summarizing the information received from agency providers of TI and TI users, the information was compared to identifiy any gaps between what agencies perceive as effective TI practices and what travelers perceive as effective. The public was also asked to help define an ideal TI system and their detailed responses are included in Chapter 3. The research team also examined TI trends and the future of TI access such as having information integrated into our daily lives in such a way that requesting TI becomes virtually unnecessary.

Summary of Key Findings

This summary of key findings is based on the outputs of the research approach presented in the previous section and presented here in the order the research was conducted. Details of all research findings can be found in Chapter 3 and related appendices.

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Findings from Agency Surveys: From the agency perspective, approximately 98 percent believe that information allows the traveling public to make better travel decisions. This emphasizes the concern that agencies have about how to provide sufficient information to travelers in order to enhance individual and system performance. However, only 30 percent of the agencies reported having evaluation data that demonstrate the benefits of providing information to the traveling public, and only 40 percent have an ongoing program for evaluating the provision of TI. Finally, there was a strong desire/need of the agencies to take advantage of smartphones and new social media (e.g., apps, Twitter, mobile webpage, etc.) in order to enhance the range and rapidness of information dissemination. While detailed findings on agency perception and use of TI are provided in the Appendix, selected highlights are shown below:

- 90 percent of the interviewed agencies disseminate information on non-recurrent events (i.e., incidents and roadwork) and over 85 percent of them provide CCTV and interactive maps illustrating roadway travel conditions.
- The most popular modes of dissemination are variable message signs (VMS), webpage (including mobile accessible), social media outlets, and 511 systems.
- Agency perception of most the important information to provide to travelers includes CCTV video, roadway travel conditions (e.g., maps with speed/incident info), traffic incidents, travel times, parking availability, special events, weather, and roadwork.
- The manner in which agencies disseminate information to the public is generally perceived as very effective with the exception of highway advisory radio (HAR). Agencies consider HAR the least effective TI dissemination technique even though 70% of the agencies surveyed use it.
- Agencies mostly depend on 511 call statistics and, to a lesser extent, some form of traveler survey, to evaluate their systems.
- While roughly 90 percent of surveyed agencies provide information on traffic conditions (e.g., roadway status, CCTV video, incidents, construction zones), less than 35 percent provide alternate route information (which is perceived as somewhat less important than other information provided to travelers).
- Agencies express concerns regarding availability of funds and what they can do with the limited funds available, particularly in support of TI program evaluation. When asked about funding in the followup interview, common comments of the agencies included “there is never enough” and “we need more.”
- Agencies support the notion that new social media and technology must be seized. In followup phone interviews with six agenecies, all indicated that they have a mobile device app and/or Twitter account. The latter was the most popular in some cases, but not necessarily perceived as the most effective.
- When asked if there is any type of TI that they feel is effective but are not currently providing, agencies mentioned statewide travel times, detailed construction lane status information, and multimodal and route trip planning.

Findings from Public TI Users: The traveling public is generally satisfied and uses numerous sources and types of TI (see Figures A and B). It is also clear that there are areas where travelers are calling for improvements (e.g., HAR), highlighting concerns (e.g., smartphone apps in the face of distracted driving concerns/laws), or unaware of available services (e.g., 511). Surprisingly, although travelers generally seek more detailed and complex information that often requires the latest technology, there was a common call for simple, reliable information that can be accessed by most people in a variety of locations (e.g., AM/FM radio).

A supplemental survey was also deployed across all six cities to investigate recent trip changing behavior. The survey found that trip changes were rare; only 14 percent of respondents reported changing a trip in the past three days. Among those who did report changing a trip, the most popular information sources used when making trip changes included radio, smartphone apps, and VMS. Note that

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smartphone app use was reported at a much higher percentage than the earlier survey asking about typical use, possibly due to better memory retrieval now when asked about most recent trips within the last three days. The least popular sources included arterial electronic roadway signs, social media, and on-board devices (possibly reflecting the lack of availability of these systems). Travelers reported the most used information types were traffic incident reports, travel times, and alternate routes. The least used were safety information, special events, and parking availability.

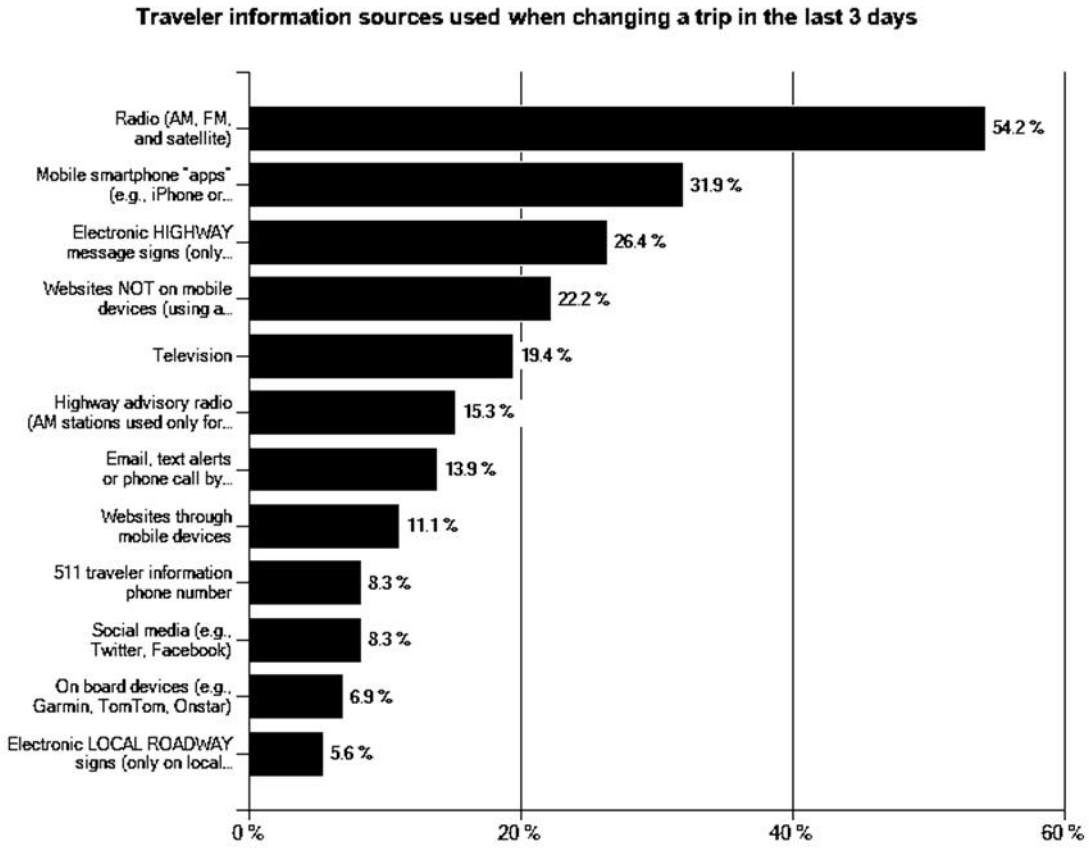

Figure A. Information sources used when changing a trip in the last 3 days.

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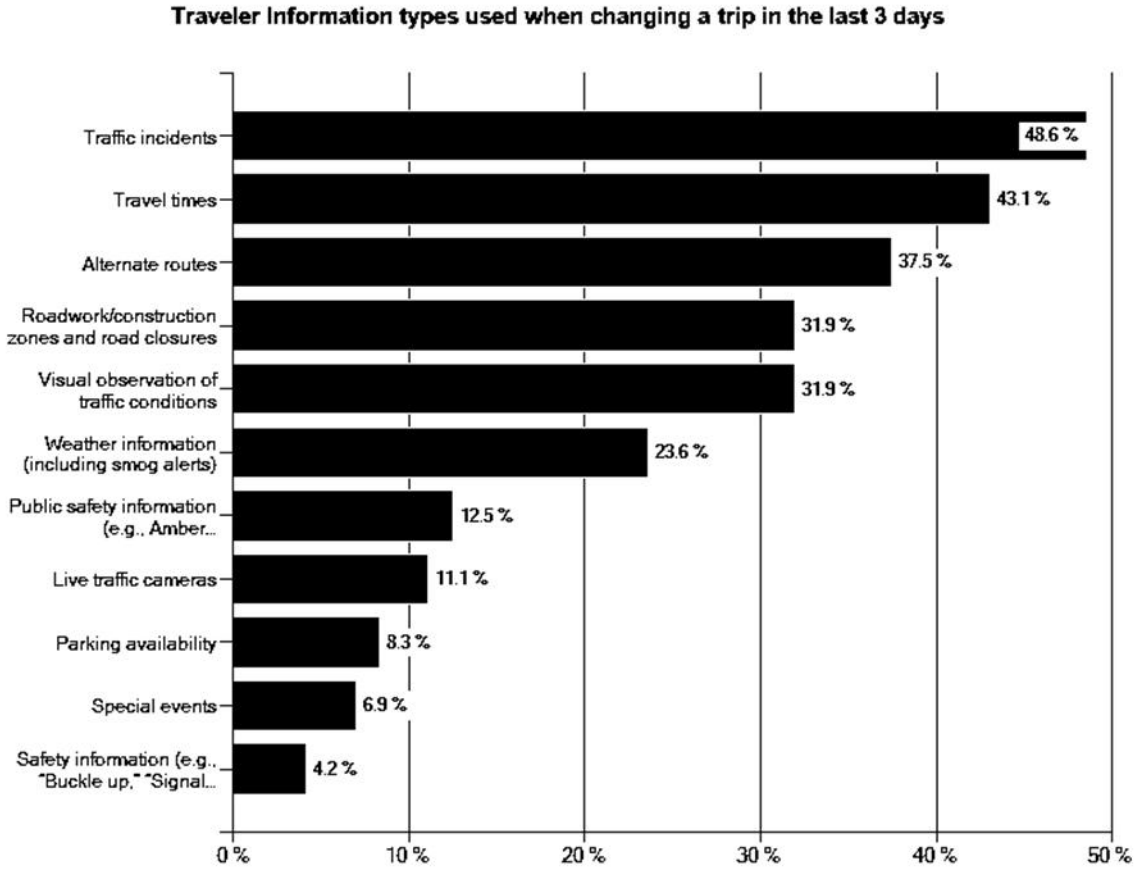

Figure B. Information types used when changing a trip in the last 3 days.

Participants were asked a direct question about **features of an ideal real-time TI system**. These were the main themes that emerged across all cities:

- Reliable, real-time, and accurate information
- Local and tailored to the travel corridor of interest and living area based on location (possibly GPS enabled), filtering irrelevant information
- Detailed information such as specific lane closures, video images of traffic conditions, etc.
- Time-stamped information so that the "freshness" is known
- Automated alerts based on route or location of traveler
- Accessible from a variety of sources ("universal means of accessing information"). Similarly, bundled suite of information types that one can choose from via most sources (e.g., traffic, road closures, construction, weather, public transit)
- Alternate route and transportation information to improve decision-making
- Radio as a mode should be included because it is accessible to almost everyone and more reliable in emergencies or places with cell signal obstructions
  - Including continuous updates on a dedicated station that clearly transmits information
- Multimodal information, including transit
- Information provided at key decision points (e.g., before entering a highway)
- Dedicated apps, radio stations, and television stations
- Integrated information regardless of jurisdiction for the traveler from Point A to Point B

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Agency TI Providers and Public TI Users – Do Perceptions Match? One of the more compelling aspects of this research project is having the ability to match agency and public perceptions of effective TI features. The research analysis reveals considerable consistency between agencies and the public in terms of what features are considered effective and which are considered less effective. Agencies and the public agree that TI should:

- be targeted, local, and relevant to the consumer;
- be easy to access and use, including when en-route;
- be clear, concise, trustworthy information that is accurate and reliable;
- include special event, construction/maintenance, or emergency information; and
- use technologies that are widely available to everyone and easily implemented (e.g., radio).

While there is general agreement in agency and public perception as to the effectiveness of TI and how it should be provided to the public, there are some notable examples of where these perceptions do NOT match. It is these instances (agreement on ineffectiveness and disagreement on effectiveness) that are of interest as they point to features where resources are needlessly being expended or where features might need considerable improvement. Some examples of perceived limited effectiveness and disagreements about effectiveness are:

a) Highway Advisory Radio—This TI program feature is a good example of a dissemination method where both agencies and the public agree as to its limited effectiveness as implemented,
b) Social Media and Apps—TI program features using social media and smartphone apps are receiving increased attention from agencies as they are considered both effective and a technology trend that must be taken into account. From a TI program perspective, these features are perhaps the most "cutting edge" in terms of state of the practice and the long term viability remains to be seen. From a public perspective, very few people are using social media and apps to receive TI
c) 511 Phone Systems—Many agencies have implemented or are moving toward 511 phone systems as they are considered to be highly effective, but at the same time, state legislatures are moving to ban cell phone use while driving (and the public's mindset is changing in the same direction). This may explain why a review of survey results indicates that making a 511 phone call is not deemed a particularly effective method of getting en-route TI. This may be the result of a conflict between developing state laws and public perceptions targeting cell phone use and the desire for en-route TI.

Application to Practice

Based on the findings of this study, several overall features of an effective TI system are recommended. First, there should be provision of real-time TI with a focus on non-recurring events. Second, a wide array of information dissemination methods should be implemented and used effectively. Finally, TI should align with demands of the public. Details of effective TI programs include:

- Provision of real-time information concerning transportation system status focusing on non-recurring events—It is apparent that non-recurring events (including those that are unplanned such as traffic incidents or planned such as special events) are very important in terms of the type of information needed by travelers to make better decisions. In an effort to focus on the randomness of incidents and their impact on the consistency (or lack thereof) of trip travel times, the concept of travel reliability is becoming an increasingly important feature amongst TI providers. The challenge with travel reliability is conveying measures (e.g., buffer and planning indices/times) that are easily consumable by the traveling public.
- A wide array of information dissemination methods are implemented and used effectively—When it comes to dissemination, TI cannot be too accessible. Not every traveler has the same needs and not every traveler will find value in every dissemination mechanism so an important feature of any

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effective TI program is a diversity of dissemination methods. Also, it is not critical that an agency be responsible for all dissemination mechanisms. Many agencies focus on providing a usable website with timely and reliable information, but also provide data to third parties (at no cost) so that additional outside resources, ideas, and capabilities can be used to create new and innovative dissemination mechanisms. Effective use of a dissemination method is also important. For example, when using websites, it is important to keep clutter to a minimum so that uses can quickly find the information they need. Many websites include extensive headers, footers, and menus with extraneous links that can distract from the primary information that users seek.

- A TI program should be evaluated for its effectiveness—The definition of effective is "successful in producing a desired or intended result." Desirable results may include benefits to transportation network performance, and improved trip decisions, travel times, and satisaction levels for individuals. Evaluating a TI program to determine if it is successful in producing desired or intended results is not a straightforward proposition. While agencies expend a great deal of effort determining transportation system performance (see Appendix for a list of evaluation measures), they typically do not use these measures to determine the specific contribution of their TI program to overall transportation system performance. There are many components of a TI program, some of which are more easily evaluated than others. Agencies today evaluate their TI programs using data collection techniques such as 511 call statistics, website hit statistics, and a variety of traveler input survey methods using their 511 systems, web and e-mail forms, and to a lesser extent, traveler focus groups. These collection techniques are being used, to some extent, to evaluate effectiveness of TI content including information timeliness, accuracy, availability, accessibility, and decision-making. While information helps with decisions regarding departure time, destination choice, mode choice, etc., there is also benefit to travelers of just knowing why they might be in a delay and what the impact may be to their trip. Not knowing, for example, why they are stuck in congestion adds to driver frustration or anxiety (especially in some locations where they may be in a tunnel or fear an emergency event). TI should align with demands of the public—The traveling public has certain demands and expectations regarding an effective TI system. When there is alignment between the public's desires and goals, and the agency's information services, the system can be optimized and the public can be satisfied.

Facilitating TI in the Future: Agencies are already providing a wide array of TI systems, but new technology, particularly in the private sector, provides opportunities to substantially advance the effectiveness of TI systems. Agencies can facilitate providing TI in the future. Readily attainable facilitation topics include:

- ***Data Accessibly***—Data collected but not used can be a waste of good resources. It can also be an inefficient use of resources to develop an application internally that can be done cheaper by someone else. In order to enhance an agency's ability to provide accurate and reliable TI, they should allow easy access to the data they collect so that developers, media outlets, universities, the private sector, and others can obtain success without severe bureaucratic navigation. A process should be put in place that has the required steps to access agency data. This would assist both internal staff as well as external agencies. Access agreements should be kept as simple as possible. The data should be made available with little or no access fees. When agencies design their databases, it should be done with a focus on using technologies and standards that will make the data more easily accessible.
- ***Private Sector Partnering***—As discussed above, sometimes providing TI can be accomplished more effectively through a public-private partnership that includes the added potential benefit of obtaining free services or even revenue generation. It is imperative that agencies keep an open mind about partnership opportunities with the private sector. Every state has its own laws about what can and can't be accomplished through private sector partnering but many states have been able to receive free 511 services through private sector partnerships. Agencies can also partner for the development of a mobile app. Private sector partnerships will also benefit by making agency data easily accessible.

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- ***New Data Sources***—Agencies should consider using outside sources such as having an outside organization provide probe data to supplement agency data sources. This third-party data combined with the agency's own data could be used to support their TI activities as well as other management, operations, and planning functions. The costs of internally adding and maintaining additional cameras or sensors should be compared to the cost of having a third party provide the additional data. If additional data is contracted by an outside party, the agency should maintain open dialog because technology changes so rapidly.
- ***Partnering with Other Agencies***—In order to provide the most complete informational picture to users, agencies should endeavor to work with neighboring agencies to fuse data from multiple sources. It is especially important in regions where multiple state and local jurisdictions exist.
- ***Evaluation***—Since the traveling public is the ultimate consumer of TI, it is important for agencies to measure the effectiveness of their TI programs. Most agencies provide TI to the public but don't measure its effectiveness. How will an agency know how to manage their TI program if they do not know how effective it is? Therefore, it is important to actually program specific funding to evaluate the TI program. The evaluation should focus on the users' experience and use of TI. This will allow the agency to actively manage and evaluate their TI program from the user's perspective. One reason that thorough evaluation of a TI program is rarely undertaken is a lack of efficient, scienticially derived techniques to quantify operational impacts of TI programs. A research effort to develop such techniques could benefit transportation agengies nationwide. Research could also be conducted to assess how to mitigate driver distraction that is associated with users receiving TI while driving.
- ***Distribution Mechanisms***—Each user gathers TI in a different way so it is important that agencies provide the information in a variety of ways. Agencies should support a wide range of distribution mechanisms/opportunities in order to reach the maximum amount of users. As discussed earlier, because technology changes so rapidly, it is important that agencies also have the ability and flexibility to provide new types of TI as the environment demands.
- ***Improve Existing Traveler Information***—TI provided to users can always be better. Agencies should strive to continually improve the reliability, timeliness, coverage, and quality of its existing TI and the resources used to disseminate the information (e.g., highway advisory radio, VMS, etc.).

Facilitation goals with longer time horizons are also discussed in the report, as well as future TI technologies. Smartphones and other mobile devices are the current favorite for advancements in TI primarily due to the ease at which new applications can be deployed to powerful networked devices. As soon as new data sources become readily available, developers can innovate and create new applications that are quickly vetted by hundreds of thousands of users. Advancements in these mobile platforms come quickly. Smaller, increasingly powerful devices, with more accurate GPS, higher quality cameras, longer battery life, and more brilliant displays are developed every few months. Yet, the advancements in TI will be less reliant on hardware, but rather on tighter integration between other services including personal calendars, entertainment, education, and automatic analysis of our travel behavior—estimating our every need without making a single request. For example, the next "killer app" won't be an app at all, but rather an integrated calendar service that 1) knows where you are, 2) knows where you need to be, 3) knows what the conditions are along the way, 4) alerts you when it's time to leave—showing you the best route to take, and 5) automatically reroutes you along the way as conditions change. It should be noted that several of these technologies operate within the smartphone space. While the research team notes limitations in utilizing smartphone apps, the reader should be mindful of the usefulness of smartphones if the technology allows for safe deployment (e.g., in-vehicle docking with central stack information displays and voice controls).

It should be recognized that, while smart phones will continue to play an increasing role in TI dissemination in the future, radio-based TI dissemination will continue to play a major role. Components of agency TI systems, such as surveillance/detection systems continue to be needed for non-TI related

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operational reasons (e.g., for volume monitoring, ramp metering, etc.). VMS will also continue to be needed to meet a range of TI needs. At the same time, agencies may need to re-evaluate continued investment in what they and the public perceive to be less effective TI delivery mechanisms like HAR. While traditional agency-run systems will continue to be required, private industry will continue to deliver effective, personalized products to better meet real-time TI needs and this provides transportation agencies more flexibility to focus resources on other TI components or operational needs. While industry has not developed the ideal, personalized TI system quite yet, this evolution is occurring, and should be part of agency considerations in their own TI and traffic surveillance investments. In short, transportation agencies can benefit from advances made in the private sector and need not be threatened by them.

Assessing the Effects of TI on Trip Behavior: Assessing the effects of TI on trip behavior requires alternative approaches used in combination with more traditional methods. We propose a "toolbox" method. This approach combines a variety of focused, targeted, and low-cost methods that evaluate different aspects of a TI program. It is also a desirable approach due to the variety of dissemination methods, traveler characteristics, and information types. The toolbox should consist of several components which can be inexpensively adapted to a particular site and can provide insight into the effectiveness of a TI program. The list below describes basic approaches:

- Focus groups targeting certain travelers
- Traveler logs
- Targeted surveys
- Interviews
- Use available data where possible

Summary of Research Results & Products: The results of this research project provide an important glimpse into the decision-making and opinions of agencies and the public with respect to real-time TI systems in cities across the country. It also provides several important products that can be used by stakeholders in the TI domain. These are discussed in more detail in this report, but include:

a) national survey and targeted interview of agency dissemination practices and beliefs,

b) large scale surveys and focus groups with the traveling public in several locations across the country to gain a better understanding of the public's perception and use of TI,

c) a public use database of survey responses for future analysis,

d) analytical discussion of the match between agency and public perceptions, along with identification of gaps for policies,

e) recommendations for methods to use in assessing a TI system,

f) guidance for features of an ideal TI system and how agencies can facilitate information dissemination,

g) discussion of the future of real-time TI, including cutting edge technologies and deployment approaches.

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CHAPTER 1

Background

Introduction

Traveler information (TI) systems are diverse and rapidly evolving. It will be important for agencies and TI vendors to align development with the needs and expectations of the traveling public. The National Cooperative Highway Research Program (NCHRP) Project 08-82, Deployment, Use, and Effect of Real-Time Traveler Information Systems has the main objectives of (1) developing a better understanding of agency practices and rationales for disseminating real-time TI, (2) assessing the effectiveness of these real-time TI systems as it relates to traveler perception and use, and (3) suggesting best practices for future facilitation of this information.

Do travelers use real-time TI systems to make decisions that will result in improved operational efficiency, decreased congestion, mode shifts, and increased throughput? The majority of real-time TI system evaluations conducted to date, particularly those related to 511 systems, focus on outputs rather than outcomes (e.g., Swan, Baker, Hintz, & Trimble, 2004). For example, 511 systems are typically evaluated based on call volumes and patterns, call frequency, call durations, system menu selections, etc. In the instances where attempts are made to evaluate outcomes, they are based on levels of "satisfaction" with the quality of information provided, but not necessarily the specific decisions or actions that were made as a result of the TI provided. This research explores outcomes from a traveler perspective including access to, perception of, and need for real-time information. It also addresses outcomes from an information provider standpoint. Recurring and non-recurring congestion are significant problems in many areas where the construction of new or expanded roadways is not feasible. Therefore, it is of great interest to traffic management agencies to better manage demand to maximize system efficiency, reduce congestion, and increase driver satisfaction.

Critical to the successful implementation of real-time TI systems is: (1) the collection of real-time transportation system status data and (2) the delivery of this data in the form of information that can influence traveler decision making and hence, impact system demand (e.g., Wang, Khattack, & Fan, 2009). Over time, the development and deployment of real-time TI systems has evolved from an entirely public-sector role to the point where the private sector has become an increasingly pivotal player. From a data collection perspective, real-time TI systems today make significant use of privately installed traffic monitoring devices in public rights-of-way. Most recently, private companies are becoming involved in the collection of real-time data using non-infrastructure based techniques such as vehicle probe technology. From a delivery perspective, the private sector continues to strive towards the creation of successful TI dissemination-based business models. The expanding role of the private sector in existing and future real-time TI systems is a key aspect of this research initiative.

To assess the effect of real-time information on traveler behavior, we must first understand traveler behavior. Traveler behavior is the process of individual decision making about what trips to make, where to visit, when to depart, what mode of travel to utilize, and what route to follow (Schofer, Khattak, & Koppelman, 1993). In a constantly changing environment, individual needs and trip purposes change at a day-by-day/week-by-week basis. One could even argue that they change at a minute-by-minute/hour-by-hour basis. Pre-trip information is frequently available for most of the different modal alternatives. The challenge for real-time TI systems is to intervene in these behavioral processes both pre-trip and en-route,

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providing information that is desired, used, and contributes to improved travel experience for individuals and their community. When en-route information is provided, then the travelers could implement as many of the following strategies as they deem necessary: route change, change of schedules, change of activities, and change in activity locations (Anderson & Souleyrette, 2002; Adler, 2001; Chen & Jovanis, 2003; Dia, 2002; Levinson, 2003; Mahmassani & Liu, 1999; Thakuriah & Sen, 1996).

The TI system can be separated into two key parts, the user (i.e., the traveler) and the information. Attributes of travelers themselves, their households, and their situational constraints, are likely to affect the utilization of real-time traveler information systems (RT-TIS) and/or their effects. Similar to all kinds of information, RT-TIS could be evaluated by their content (e.g., parking availability at destination, congestion levels, etc.), type (e.g., qualitative vs. quantitative), format (e.g., map-based versus text messages), reliability (i.e., credible, accurate, and relevant), and prescriptive characteristic (i.e., whether it advises on alternate routes, modes, etc., or just provides information on current conditions). Several studies have evaluated the influence of each component of TI. Schofer et al. (1993) and Casas & Kwan (2007) provide a more detailed review of the literature in this area.

As in any project evaluation, the go-to methodology is the cost/benefit analysis. Results from a study performed in Washington, DC showed that if RT-TIS deployments are evaluated purely on time-savings, the benefits of TI will likely be grossly underestimated (Wunderlich, Hardy, Larkin, & Shah, 2001). In addition, an evaluation of Utah's RT-TIS showed that there was a higher level of awareness and use associated with en-route TI sources such as VMS and HAR, when compared to pre-trip TI sources such as the 511 phone system and the CommuterLink website (Martin, Lahon, Cook, & Stevanovic, 2005). DC's case study showed that TI users improved their on-time travel reliability. The value of improved on-time reliability is not easily nor directly monetized, but it is clear that many types of travelers can benefit from RT-TIS. Commercial vehicle operations rely on just-in-time deliveries and manufacturing processes, decreasing inventory size, and therefore cost. Commuters who have jobs with firm arrival time requirements are also likely to benefit from more consistent arrival times and reduced stress. From this perspective, it can be argued that the benefit of improved travel reliability and predictability from RT-TIS may outweigh whatever returns are generated from the monetization of aggregate in-vehicle travel time reductions.

Three approaches have been generally implemented to measure the effect of RT-TIS (Kristof et al., 2005; Hu, 2009): observational studies (e.g., measuring the differences in travel times between drivers with and without RT-TIS), surveys (e.g., survey studies that poll RT-TIS users to determine what qualitative and quantitative benefits they perceive) or a combination of both (e.g., simulation). Observational studies can provide more accurate accurate results compared to surveys because they present test subjects with real information and observe their responses. However, these studies are performed at a higher cost and most likely with a smaller sample size. In contrast, surveys and other exploratory studies have shown promise as effective, relatively inexpensive, and fairly accurate methodologies to evaluate hypothetical alternatives/products. Finally, simulation combines the best of observational and exploratory studies (i.e., show the potential benefits that could occur if RT-TIS were used at a certain location), but tends to demand a lot of computational effort making it a less desirable approach. Today, with the availability of GPS, Bluetooth, and other technological advancements, it is possible to examine the behavior of travelers in a more reliable and accurate manner, obtaining the level of granularity, accuracy, and timeframe needed to assess change at the individual level in real-time over a considerable period of time.

The literature on methodologies to evaluate TIS does not suggest any universal methodology. Besides traditional methods (i.e., surveys and data collection), several numerical simulators have been developed: IDAS (ITS Deployment Analysis System), DynaMIT (Dynamic Network Assignment for the Management of Information to Travelers), VISSIM and HOWLATE (Heuristic Online Web-Linked Arrival Time Estimator). IDAS is a sketch planning tool created for the FHWA. It calculates the benefits and costs of deploying the specified ITS alternatives and reports outputs in terms of the incremental

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change in performance measures (e.g., vehicle-miles traveled, vehicle-hours traveled, volume-to-capacity ratios, and vehicle speed) and the annual benefit/costs. VISSIM is able to assess TIS options such as VMS effects in a network by applying dynamic assignment features. Martin et al. (2005) stated, regarding VISSIM, that "the benefit of this approach is in the integration of off-line planning information and information derived from the physics of traffic flow, in addition to the detector data. This system, when calibrated and fully deployed, will make TIS evaluations more valuable." DynaMIT combines real-time data from a surveillance system with historical travel time data in order to predict future traffic conditions and provide travel information and guidance through a TIS. HOWLATE uses simulated yoked pairs traveling between specified origin and destination (O-D) pairs, one of which has a TIS and one that does not, from which the method measures travel time reliability. As technology and computer performance advances, simulation exponentially grows in demand and potential for answering key questions. Its ability to assess different alternatives and provide reliable outputs based on limited data makes it, in all likelihood, the next step in project evaluation techniques. For examples on how simulation has been used, and improved, in the past two decades, the reader is referred to Jayakrishnan et al. (1993), Florian (2004), Kristof et al. (2005), and Chorus et al. (2007).

Furthermore, the density of traffic data to support TIS as well as the impact of TIS is ever growing. Objective measurements of the impact of TIS were once highly improbable due to the level of data collection and coordination needed. This is rapidly changing. A case-study from the Maryland-DC metropolitan area is a good example. In 2010, enabled by the successful proliferation of outsourced traffic data, the Maryland SHA activated statewide travel times on signs on its network VMS, providing travelers with route travel times at key decision points in the network. In 2011 a full network of Bluetooth™ sensors was deployed in multiple corridors in the DC metro area providing some overlap between the TIS and high-resolution measurement with Bluetooth traffic monitoring (BTM) deployment. In 2010, researchers at the University of Maryland began experiments at isolated locations to measure the impact of TIS delivered via the VMS on route diversion. Though in its infancy, the data assets to objectively measure the network impact of TIS (in this example delivered by a VMS system) are beginning to be deployed. For example, a VMS placed prior to the diversion of I-95 east and west on the DC beltway provides travelers information to best assess whether the inner loop (eastbound signed with I-95) or the outer loop (westbound signed strictly as I-495) is the best route for through trips. Currently, the VMS sign at this location provides TIS based on the outsourced data feed. The BTM deployment provides an indication of the travel time and percent diversion eastbound or westbound at any time period, providing the opportunity to measure the impact of TIS. A systematic study utilizing systems of similar combined capability provides an opportunity to objectively assess TIS impact to a level of granularity not previously achievable.

As for the data needed for assessment, the U.S. Department of Transportation (USDOT) proposed six goals for ITS so that the benefits of the technologies can be measured (U.S. Department of Transportation, 2004). The metrics for these goals are listed in Table 1. As can be seen, these goals encompass a vast variety of metrics, some of them could be perceived as complex and costly to obtain. Furthermore, FHWA's Office of Operations (2005) defined congestion performance measures that could be transposed to RT-TIS evaluation, incuding metrics for reliability, delays of various types, travel time, and throughput. Some overlap can be seen between these programs, which indicate an expected relationship between using RT-TIS and diminished congestion levels. Finally, 23 CFR 511, Subpart C – Real Time Systems Management Information Program (Section 511.309) provides the minimum requirements for traffic and travel conditions made available by RT-TIS by type of information (e.g., construction activities, lane blocking incidents, weather observations, etc.). This regulation also states that the establishment of a real-time information program for traffic and travel conditions on the Interstate highways system shall be completed no later than November 8, 2014 and on the State-designated metropolitan area routes of significance by November 8, 2016.

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Table 1. USDOT benefit metrics.

ITS Goal	Related Metric
Increase Transportation System Efficiency and Capacity	Traffic Flows/Volumes/Number of Vehicles Lane Carrying Capacity Volume to Capacity Ratio Vehicle Hours of Delay Queue Lengths Number of Stops Incident-related Capacity Restrictions Average Vehicle Occupancy Use of Transit and HOV modes Intermodal Transfer Time Infrastructure Operating Costs Vehicle Operating Costs
Enhance Mobility	Number of Trips Taken Individual Travel Time Individual Travel Time Variability Congestion and Incident-related Delay Travel Cost Vehicle Miles Traveled Number of trip end opportunities Number of Accidents Number of Security Incidents Exposure to Accidents and Incidents
Improve Safety	Number of Incidents Number of Accidents Number of Injuries Number of Fatalities Time Between Incident and Notification Time Between Notification and Response Time Between Response and Arrival at Scene Time Between Arrival and Clearance Medical Costs Property Damage Insurance Costs
Reduce Energy Consumption and Environmental Costs	NO_X Emissions SO_X Emissions CO Emissions VOC Emissions Liters of Fuel Consumed Vehicle Fuel Efficiency
Increase Economic Productivity	Travel Time Savings Operating Cost Savings Administrative and Regulatory Cost Savings Manpower Savings Vehicle Maintenance and Depreciation Information-Gathering Costs Integration of Transportation Systems
Create an Environment for an ITS Market	ITS Sector Jobs ITS Sector Output ITS Sector Exports

Many studies of RT-TIS effectiveness focus on user satisfaction (e.g., *"NCHRP Synthesis 399: Real-Time Traveler Information Systems"* by Deeter, 2009). In a recent effort, we went beyond such measures by using a laboratory study to tie such subjective measures to what drivers actually report doing (e.g., "*Driver Use of En Route Real-Time Travel Time Information"* by Lerner, Singer, Robinson, Huey, & Jenness, 2009). Methods included measurements of response time and comprehension, and ratings of likelihood to divert in laboratory settings. In addition, driver logs were used to assess drivers' uses of real-time travel time information in daily commutes and supplemented by focus groups and questionnaires in three regions of the United States.

For the current effort, our approach uses a variety of methods to not only understand satisfaction, but also behavioral outcomes (through self-report logs) and other low-cost methods (including extant agency

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data on effectiveness). This combination of methods creates a better assessment of effectiveness in real-time TI systems and practices. It also provides a better pool of information from which to develop guidance for future approaches to RT-TIS.

The Westat-CATT team believed that the most critical aspect of this research, from a practitioner perspective, was to identify the potential "gaps" between the agency's processes for disseminating TI and the public's expectations and needs. In other words, is the information that an agency is providing to the traveler provided in a way that is actually useful to the traveler? If not, what are agencies doing wrong and what can be done to improve real-time TI gathering/delivering mechanisms? What gaps exist between what travelers say they really want and what is currently being delivered?

Another critical output of this research: Agencies are in dire need of guidance on how to measure the performance/impact of their TI programs. Currently, agencies base evaluations of system performance by measuring output data such as number of webpage hits, 511 call volumes, etc. Unfortunately, these approaches do not measure outcomes in terms of assessing the effect of information on trip behavior. How can this outcome-oriented approach be woven into their existing (if they exist) TI performance monitoring initiatives? This is becoming more and more critical as agency Administrators, Directors, and even high level politicians (e.g., Governors) are becoming more intent on measuring outcome-based performance to justify investments in their programs (including TI system programs).

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CHAPTER 2

Research Approach

The research approach of this study used a variety of methods to explore outcomes from a traveler perspective including access to, perception of, and need for real-time information. It also used interviews and surveys to understand the dissemination practices of agencies, as well as performance measurement of TI systems. Described in more detail below, the current study used a variety of low cost methods including interviews, surveys, focus groups, and traveler logs in addition to analytical tasks. This approach allowed us to not only understand satisfaction and perception, but also behavioral outcome proxies (through self-report logs and recent timeframe surveys). This combination (i.e., "toolbox") of methods creates a better, more thorough assessment of effectiveness of real-time TI systems and practices. It also provides a better pool of information from which to develop guidance for future approaches to real-time TI.

This section highlights several methods that were used in the project: interviews, surveys, focus groups, and traveler logs, along with analytical research for development and synthesis of information.

Questions and Variables of Interest

Several questions of interest were identified for the current study to explore:

- What access do travelers have to real-time TI and what is their awareness of that access?
- What is the perception of the public of real-time TI?
- What characteristics do travelers need in real-time TI?
- What are the gaps between what agencies provide and what travelers feel is important and need?
- How do agencies use real-time data in planning and operations activities and are these uses reaching the public with the intended effect?
- What are the reasons travelers do not use available real-time TI?
- Are there any self-reported behavioral changes due to real-time TI? If so, what are the most effective information type and medium to be used in changing traveler behavior? How do pre-trip and en-route patterns of using real-time TI differ?
- How frequently do these changes occur?
- In what ways do the changes occur (e.g., leave earlier, later, change route)?
- If behavior does not change, then why not? Is it a system constraint (e.g., lack of alternative routes/transit options, unreliable information) or personal constraints (inability to adjust trip time due to appointments, etc.)?

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In addition, several variables of interest with respect to traveler's perception of, access to, and need for real-time TI were selected for the current study:

- Traveler type (e.g., commuters, high and low TI users, different ages);
- Information type (e.g., travel time, congestion levels, incident information, weather, road closures);
- Media used (e.g., mobile device, computer, radio, TV);
- Temporal information need and use (e.g., pre-trip, en-route);
- Traveler perception of importance;
- Effect on traveler behavior;
- Likeability/satisfaction;

A particular area of interest for transportation managers and engineers is changing traveler behavior based on information disseminated. Ideally, one would like to have extensive empirical data on the actual changes in traveler behavior as a function of various types and sources of TI to directly measure the effect (and relative effectiveness) of TI. This is in fact quite difficult to do, particularly with limited project resources. Among a variety of reasons, the difficulty is associated with:

- Travelers may have available a broad range of pre-trip and en route information (websites, radio and television, mobile devices, on-board devices, roadway signs, commercial signing, direct observation of traffic, and, in the future, emerging new sources through programs such as Connected Vehicles). These various sources may be operated by different entities and may be continually evolving in an uncontrolled way. All may be contributing to behavior in some way, and this confound makes it very difficult to evaluate the behavioral effects of one particular source of information.
- The effects of real-time TI are not expected to be uniform over time or between locations. Changes in driver behavior may be meaningful only under certain conditions (e.g., only when an alternative route or mode is available), which limits when and how data are collected and analyzed and makes it difficult to quantify "driver response."
- The effects of real-time TI are also not expected to be uniform between individuals, or even between different trips for the same individual. This may be affected by route familiarity, personal characteristics, trip motivation, etc.
- The effects of real-time TI will be dependent on the characteristics of the local roadway network, as well as local options for other modes of travel.
- The effects of real-time TI may be expressed in a variety of ways: pre-trip route planning, en route diversion, trip timing, trip chaining, mode choice, cancelling the trip, vehicle occupancy, etc. Any given measure may in itself not fully capture the effects of the information.

The Westat-CATT team recognized these pragmatic concerns and our approach aimed at deriving maximum useful information and insights within the scope of the resources. We recognized that the objective of this project should not be a large-scale survey that devotes most of the project resources toward a narrow range of sites or practices. However nice a statistically precise large survey might be, it would overly limit the range of practices and conditions we could examine. Information at each site may come from traffic observation, small-scale surveys, commuter daily trip logs, driver focus groups, practitioner feedback, system performance statistics, system use, etc. Available information may vary from site to site. Our approach is to learn what we best can about multiple aspects of TI effects from a diverse set of sites.

Multi-modal considerations: For some applications of real-time travel time provision (e.g., changeable message signs), information relating to other modes is largely irrelevant in the United States (although we have seen European examples). For other applications (e.g., certain websites), information on additional modes may be appropriate and useful. The project focus was on the provision of real-time TI to drivers. We are fully aware of multi-modal considerations and attended to them as feasible, but they were not the focus.

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Target traveler: Many types of travelers may make use of real-time TI. In previous work with providers of TI, we have found that the needs of commuters are generally the operational agency's primary concern, particularly at those times when congestion is likely to occur (morning and evening peaks). However, in some areas tourists are a predominant concern, and for special events the target users might be quite different (e.g., rock concert, golf tournament). These various target users differ substantially in the information they need, willingness to change routes or modes, flexibility in travel options, local knowledge of the roads and transportation system, and ability to comprehend/use various messages and data. Consequently, while our assessments took into account the effectiveness of various TI provision practices across the range of users, the greatest emphasis was placed on commuter needs and behavior.

Materials and Methods

Because there is not a single best technique for a project of this size, the Westat-CATT team believed the best approach to understanding travelers' use, perception, and response to real-time TI was the combination of a variety of low-cost methods that have proven successful in the past. This "toolbox" consisted of several components which were inexpensively adapted to a particular site. Also, these components were tailored to the particular region/site and built on findings from agency interviews. This approach also has the advantage of not being cost prohibitive for agencies who would like to develop their own evaluation process and use some of the same tools.

Several types of instruments and materials were used for data collection, with selected draft sample documents included in Appendices C-F: a) focus groups including a moderator's guide, notes, and audio recording, b) traveler logs completed by participants, c) web-based surveys completed by participants through SurveyMonkey, d) telephone interviews of agency representatives. The following sections describe the basic approaches taken to ensure highest quality implementation.

Agency Survey

A draft web-based survey was disseminated to the Expert Panel members and comments were incorporated prior to its distribution. An e-mail with a link to the survey and a paragraph description of its importance was sent out to 50 contacts representing 40 state DOTs. See Appendix B for the survey questions and responses. On the same day, an e-mail was also sent out to the graduates of the Operations Academy Senior Management Program asking that they have someone in their office who works on their agency's TI program assist by completing the survey. Similarly, an e-mail with the survey information was sent out to the members of the 511 Coalition LISTSERV. A total of 28 fully completed and 14 partially completed surveys were obtained. Subsequently, the survey was sent out again with a request to those who had not initially filled out the survey to please do so. An additional six fully completed surveys were obtained.

Agency Interviews

Survey results were compiled and, based on this compilation, five follow-up phone interviews were held to gather additional detailed information from individuals who had filled out the web-based survey. The selection of individuals for follow up phone interviews was largely based on those whose agencies indicated efforts to evaluate the TI program activities and/or had interesting responses and comments related to their programs.

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Overall Traveler Assessment and Implementation Approach

The detailed assessment focused on four sites listed in detail below. Each site contained the following data collection approaches and used in forming a comprehensive profile of traveler behavior and perceptions in the area (in this order):

- Reference to agency interviews and surveys from earlier in the project, as well as use of Geographical Information Services to target optimal corridors that contained heavy traffic and potential for alternate routing.
- Web-based surveys with participants primarily targeted through zip codes (using online databases and postal mailouts) in corridors of interest.
- Two focus groups at each location: One group of real-time TI frequent or heavy users (~eight) and one group of real-time TI non-users or light users (~eight).
- Traveler logs: Participants in each group were given a seven-day traveler log at the completion of each focus group, along with instructions for its completion.

To supplement the more detailed assessment sites, there were two additional sites where the research team did not visit in person but collected data utilizing web-based surveys.

Site Selection

Site selection took into account a variety of factors, including roadway and regional characteristics, alternative routing opportunity (including public transportation), diversity of travelers, level of congestion, input from earlier agency data collection, panel member suggestions, etc. In order to optimize information gained from each location, we coordinated sites with those used in the agency dissemination survey and interviews, which will allowed us to develop a better picture of the RT-TIS from the users' and agencies' perspectives.

The four detailed assessment (surveys, focus groups, and traveler logs) sites were:

- Washington DC metro area (Rockville, Maryland)—This was the pilot site due to its geographical convenience, research team familiarity, and diversity of travelers/commuters/tourists
- Orlando, Florida—Particularly attractive for potential tourist issues
- San Francisco, California—Constrained commuting corridor options and highly developed TI services
- Teaneack, New Jersey (New York city commuting area)—Strong public transportation options

The two remotely assessed (survey only) areas were:

- Detroit, Michigan
- Salt Lake City, Utah

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Figure 1. Site locations and data collection methods.

These sites were selected due to the commuting characteristics, including a mix of daily commuters and tourists in some areas and the systems in place that are available for receiving TI. See Appendix A for a listing of TI sources and types by city. They also all had high levels of congestion, which was important because that could provide an impetus for trip changing behavior and also allow us to ask about TI use during non-peak times (which may mimic less congested and more rural areas). Taken together, they provide a variety of characteristics, regions, user types, traffic patterns, transit options, and real-time TI approaches.

Sample Characteristics and Size

The sample size and characteristics for each methodological approach follows:

- Focus groups/traveler logs—there were 74 total travelers in the focus groups, and 61 individuals completed and retured traveler logs.
- Participants were selected to balance gender and distribute ages across a range from 21-78 years of age.
- Both drivers and non-drivers (e.g., transit commuters and carpool passengers) were included.
- Smartphone users were oversampled and included in both groups for each city.
- Both drivers and transit commuters were included in groups, with the NY metro area and San Francisco metro areas having more public transit users represented.
- Traveler surveys—there were a total of 1021 travelers over the age of 21 who lived in the six sites who responded to the surveys.
- There were 194 complete responses for the Salt Lake City, UT and Detroit, MI sites.

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- There were a total of 317 complete responses for the survey targeting Orlando, FL, San Francisco, CA, Teaneck, NJ, and Rockville, MD.
- A third survey focusing specifically on recent trip changing behavior was deployed in all six metro areas. There were a total of 522 respondent who completed this survey (with 72 qualifying for the trip changing questions of interest).
- Agency surveys—Forty-three agencies responded to a web-based survey regarding TI practices. Twenty-eight surveys were fully completed and 14 were partially completed. Survey respondents were recruited from existing state DOT contacts, colleagues of graduates of the Operations Academy Senior Management Program, and members of the 511 coalition LISTSERV.
- Agency interviews—five follow-up phone interviews were held to gather additional detailed information from individuals who had filled out the agency web-based survey.

Focus Groups

A total of eight focus groups, consisting of eight to ten travelers in each, were conducted in the four metro areas outlined below. Each focus group was facilitated by a trained moderator and lasted for approximately two hours. Focus groups were held during evening hours as commuters were the target population.

Two groups were conducted in each city – one group of non- or light users of TI and one group of heavy users of TI. Also, smartphone users were oversampled and included in both groups for each city. Both drivers and transit commuters were included in groups, with the NY metro area and San Francisco metro areas having more public transit users represented. Public transit options were less utilized in the Orlando area. Focus groups were held at equipped facilities in the following cities:

- Rockville, MD (Washington, DC metro area)
- Teaneck, NJ (New York City metro area)
- Orlando, FL
- San Francisco, CA

Facilities were selected based on recommendations from others who had used focus group facilities in the areas studied as well as based on location being in the metro area of interest. Facilities were also chosen that were equipped with recording capabilities as well as respondent databases to select the participants.

Participant recruitment was completed through two channels depending on the focus group location. For all locations, the same telephone screener was administered to potential participants. For the focus group pilot location in the Washington, DC metro area, recruitment of participants took place through an ad placed within Westat. The ad excluded Westat employees but allowed family and friends of employees to participate. Participants who called in or emailed were administered a telephone screener to determine demographic criteria and commuting habits. Eligible participants were selected to include groups with a balanced gender and age distribution across the lifespan. In the New York City metro area, San Francisco and Orlando metro areas participants were recruited from participant databases through the facility being used to hold the group. Westat provided the telephone screener to the facility as well as detailed information as to demographic criteria and commuting habits criteria for recruitment. The facility administered the screener and eligible participants were selected to include groups with a balanced gender and age distribution across the lifespan. Once participants were identified and selected, Westat received a list and checked to ensure that the participants met the provided criteria. The recruitment screener administered included but was not limited to questions regarding daily commute characteristics including distance traveled, AM and PM rush hour commuting, smartphone use for TI and TI sources used prior to or during a trip (i.e., websites, freeway signs and news).

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Participants signed informed consent forms upon arrival at each of the groups. The facilitator followed the moderator's guide to direct the discussion (see Appendix C for the sample guide). In addition, the sessions were recorded for data analysis and reporting. Notes were cleaned and compiled following each focus group session (see Appendices G-K for note summaries). At the end of the focus group session, participants were asked to complete brief trip logs for seven days following the session (see section 2.2).

Trip Logs

Focus group participants were asked to complete trip logs for seven calendar days following their focus group session. Participants were asked to complete the logs for trips of at least five miles of travel and were asked to complete the logs immediately following each trip if possible. The trip logs collected basic information such as weather, trip start time, and end time. Trip logs also contained questions regarding TI sources used both pre-trip and en route (i.e., TV, radio, 511 call, smartphone application, navigation device, or electronic travel time sign) and questions regarding the behavioral effect of receiving that information (i.e., did they change their route, change trip time or cancel a trip stop or the trip altogether, change trip destination, use a different type of transportation or let someone know expected arrival time). A sample trip log is presented in Appendix D. At the end of the seven days participants mailed in completed trip logs to the researchers using the pre-addressed, postage paid return envelopes received upon exiting the focus group session. The return rate for completed trip logs was approximately 83%.

Traveler Surveys

A survey was developed through SurveyMonkey that targeted travelers in the Detroit, MI and Salt Lake City, UT metro areas. There were 194 complete responses for this survey. A second identical survey was administered to travelers in the focus group cities of Orlando, FL, San Francisco, CA, New York City metro area, and the Washington, DC metro area. There were a total of 317 complete responses for the second survey. A third survey focusing specifically on recent trip changing behavior was deployed in all six metro areas. There were a total of 510 respondents who completed this survey (with 71 qualifying for the trip changing questions of interest). Prior to launching the surveys they were piloted among staff for time and suggestions to increase clarity. The surveys took approximately 10 minutes to complete and paralleled many of the questions asked as part of the focus groups. Also, there were opportunities for open-ended responses for certain questions, and some of those responses are incorporated below. See Appendices E and F for the survey questions.

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CHAPTER 3

Findings and Applications

The findings are separated into three sections that parallel the main goals of the current project—deployment, perception, and use of RT-TIS. The first section focuses on a national survey and several interviews that gathered information about deployment practices from agency representatives. The second section provides findings from the public's perspective on their perception and understanding of real-time TI. These findings are from a large scale web survey of six cities and focus groups in four cities. The third section focuses specifically on the topic of use by the public—from surveys and travel logs, data are presented that describe the ways that people report use of real-time TI in decision-making and trip behavior. Finally, the public was asked how they would define an ideal TI system and a summary of responses are presented at the end of Chapter 3.

Section 1 - Deployment: Summary of Agency Surveys and Interviews

A complete compilation of agency survey data can be found in Appendix B. Provided here is a summary of the web-based survey data and the follow up phone interviews from various agencies. The objective of the survey was to obtain the necessary information to compare agencies' perceptions and rationale as to why they provide TI with their efforts to collect and evaluate data in support of this rationale. The survey can be broken down into three general themes: 1) what are the agency perceptions regarding the rationale for why TI is provided and the mechanisms by which the information is delivered; 2) what are agencies doing to measure the impact of TI and its benefits, and what are some impediments to evaluation assessment; and 3) what are some unique practices in existing TI programs and agency perspectives on the future outlook of TI. A total of 43 agencies responded the survey, either partially or completely. A total of 28 agencies completed the entire survey.

Agency perceptions regarding the rationale for why traveler information is provided and the mechanisms by which information is delivered

Approximately 98 percent of the agencies believe that information allows the traveling public to make better travel decisions. This emphasizes the concern that agencies have about how to provide sufficient information to travelers in order to enhance individual and system performance. In order to address their concern, around 90 percent of the interviewed agencies disseminate information of non-recurrent events (i.e., incidents and roadwork) and over 85 percent of them provide CCTV and interactive maps illustrating roadway travel conditions. The most popular modes of dissemination are VMS, webpage (including mobile accessible), social media outlets and their 511 system (see Figure 2).

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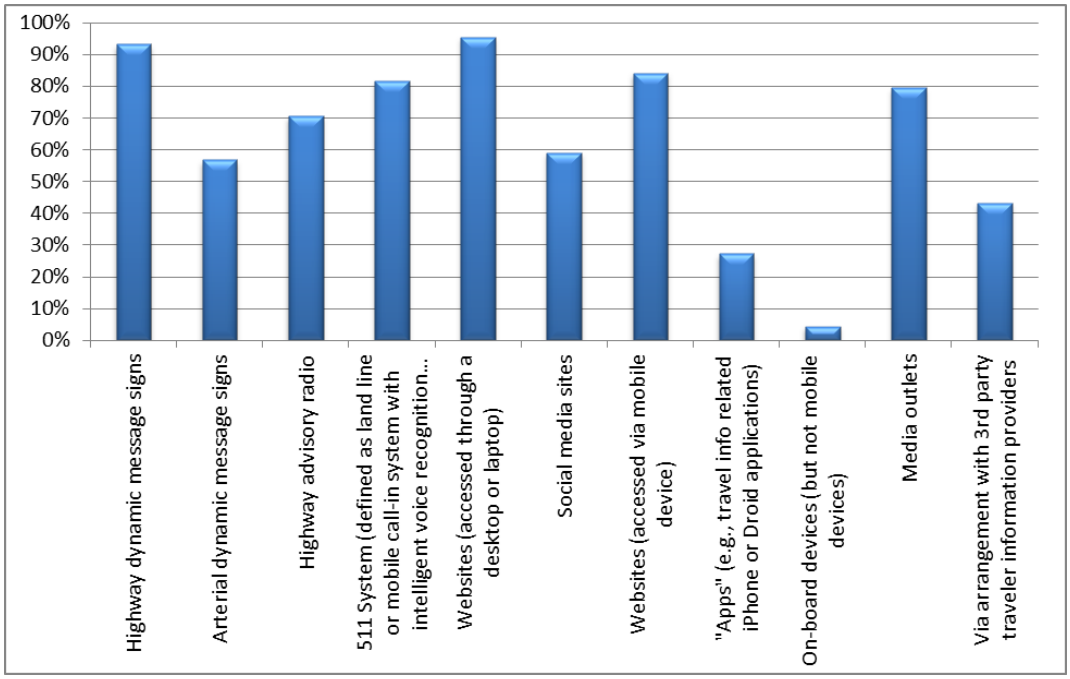

Figure 2. Percentage of agencies disseminating TI by various methods.

In general, agencies feel that TI systems are effective in fulfilling their objectives. On a scale from 1 to 4, 1 being "not important" and 4 being "very important", different types of TI averaged 3.24, excluding "Safety Information" and "Transit Alternatives" which scored around 2.5 each (see Figure 3).

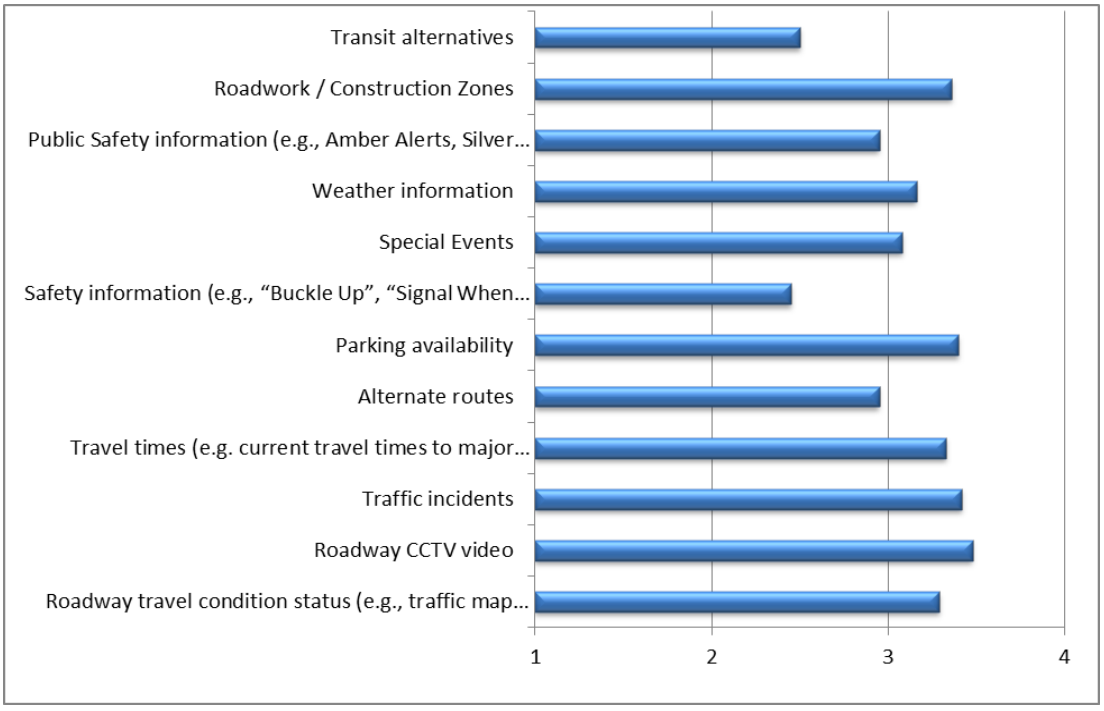

Figure 3. Perceived traveler information system effectiveness in meeting agency goals.

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Figure 4 illustrates how this information is being disseminated to the public. Approximately 95 percent of the agencies use highway VMSs and computer accessible websites. In addition, over 80 percent of them rely on a 511 system, mobile accessible webpage and media outlets.

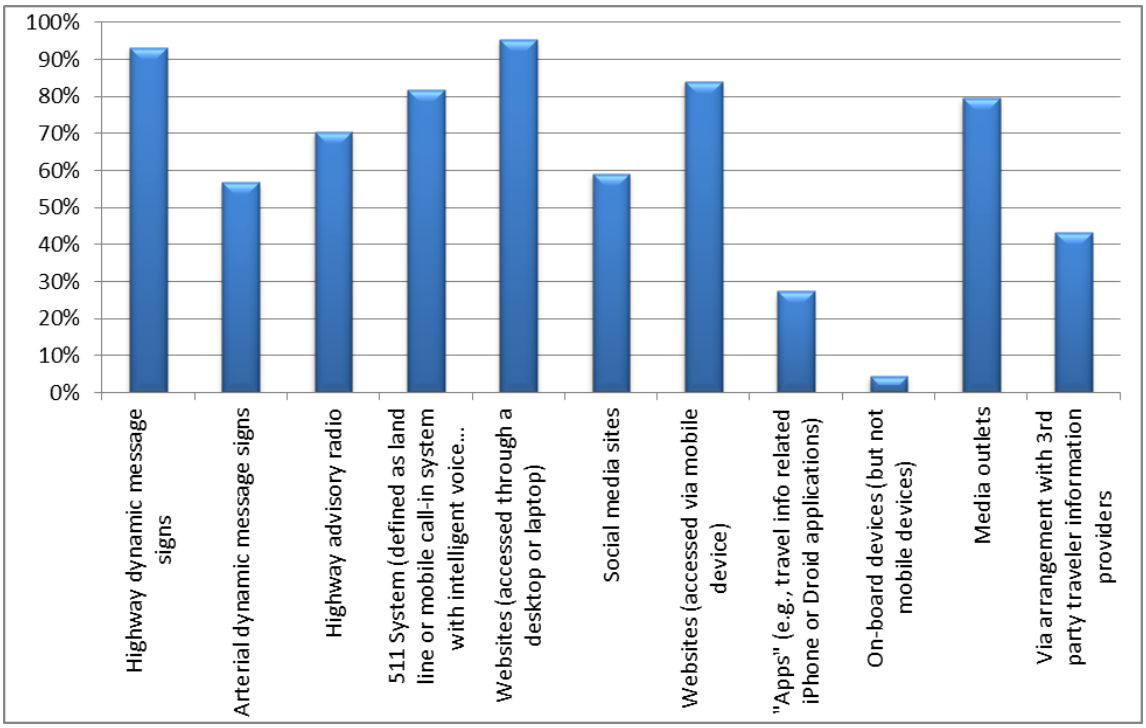

Figure 4. Deployment of traveler information systems.

As for why they are selecting these dissemination mechanisms, most of the agencies (84 percent) believe they are taking advantage of the latest information dissemination technology/technologies, while around 60 percent are basing their decision on literature reviews, lessons learned from other agencies and FHWA guidance and encouragement. Furthermore, based on their perceived effectiveness, different types of dissemination mechanisms averaged 1.73 on a scale from one to four, one being “very effective” and four being “not effective”, excluding “Highway Advisory Radio” which scored 2.5. To see the complete list of TI systems please go to Question 6 of the survey, which is shown in Appendix B.

Measuring the impact of traveler information and traveler information’s benefits and impediments to evaluation assessment

Agencies employ a variety of methods to reach different travelers. However, only 30 percent of the agencies reported having evaluation data that demonstrates the benefits of providing information to the traveling public, and only 40 percent have an ongoing program for evaluating the provision of TI (Figure 5). The survey shows that agencies mostly depend on 511 call statistics and, to a lesser extent, some form of traveler survey, to evaluate their systems. Moreover, around 63 percent of the agencies focus their evaluation on three TI components: roadway travel conditions, traffic incidents and travel times. When evaluating, 80 percent of the agencies assess the performance of their 511 system and webpage, while less than 30 percent focus on their TI system trip characteristics components, such as departure time, destination choice, pre- and en-route route choice (see Question 7B).

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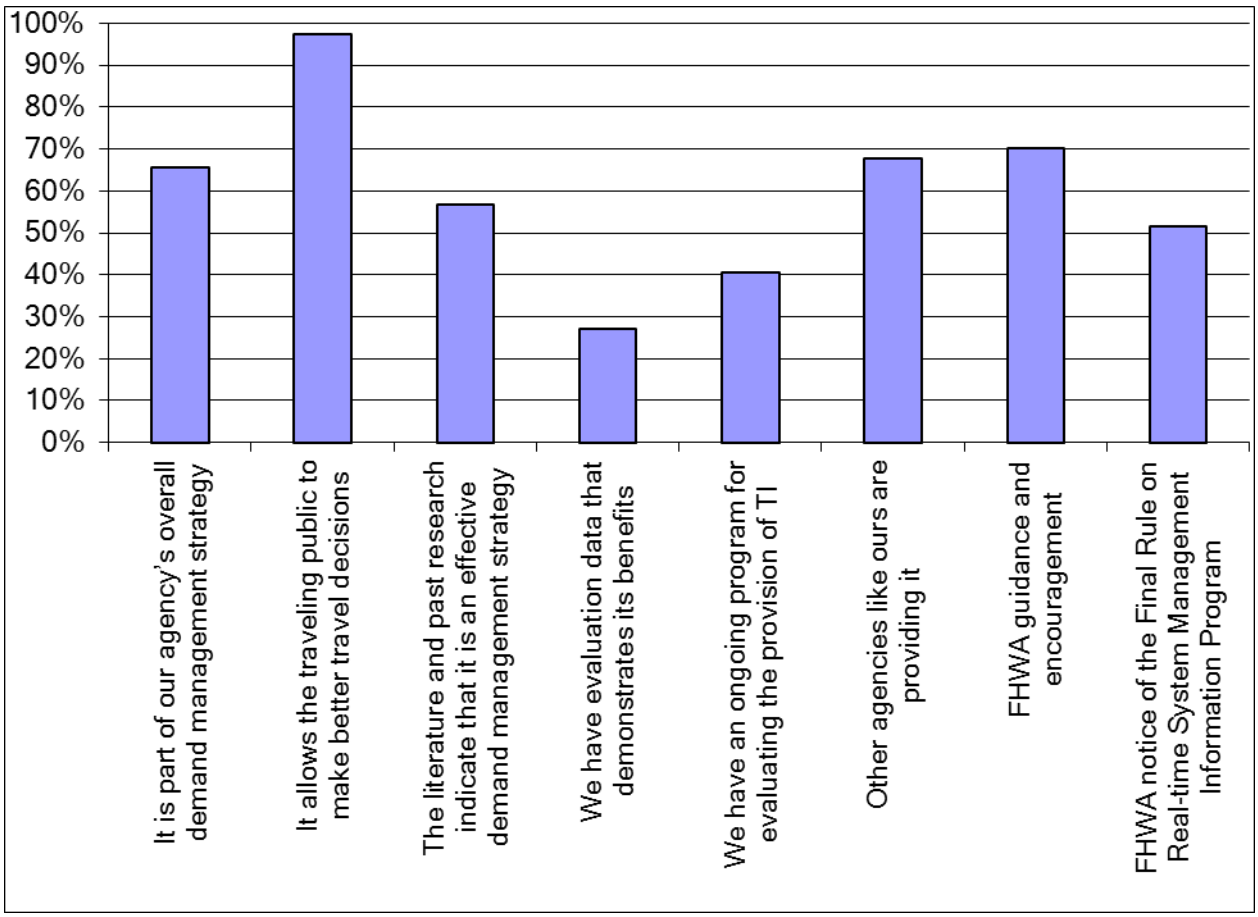

Figure 5. Reasons for disseminating real-time traveler information.

In general, most of the agencies limit themselves to measure travel time, mainly because of the difficulty/cost of measuring actual operational impacts and determining how best to evaluate the many components of their program (see Figure 6). This might explain why less than 20 percent of the agencies do not believe their TIS methods are unique, and around 60 percent of them do not feel they are more effective than other agencies (see Questions 9 and 11, respectively). This might also explain the 60 percent of the agencies that indicated the reason for providing TI is because other agencies like them are providing information to the traveling public. Hence, one can expect that agencies attempt to provide the same type of information as other agencies and don't necessarily feel the need to evaluate the impact of this information.

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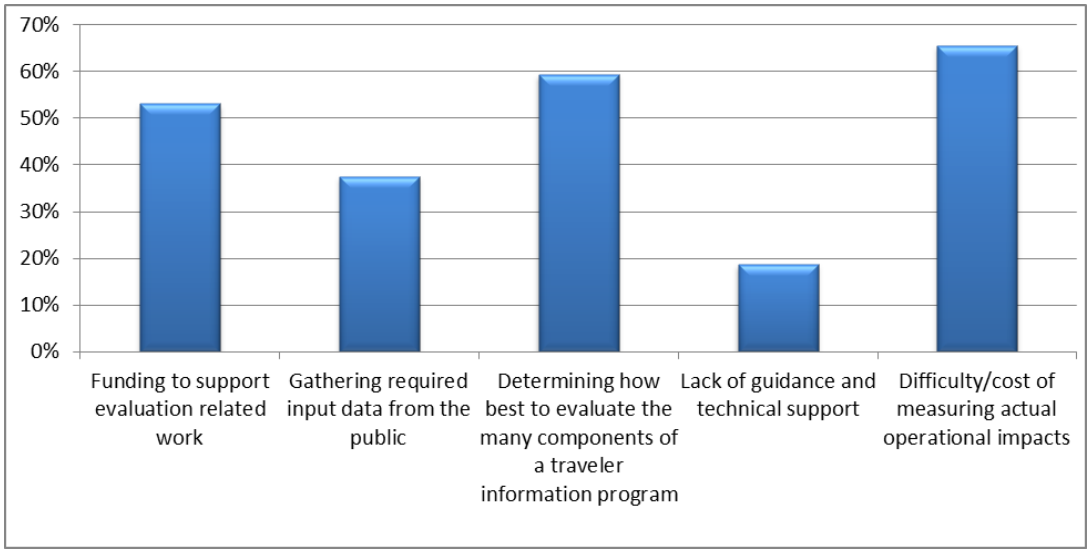

Figure 6. Factors hindering agencies' abilities to effectively evaluate traveler information programs.

Unique practices in existing traveler information programs, and agency perspectives on the future outlook of traveler information

As technology advances (e.g., communication, sensor, internet accessibility), so does the possibility of new TIS applications and measuring techniques. As previously stated, fewer than 20 percent of the agencies believe their TI systems methods are unique. Nevertheless, the agencies that do believe they provide unique information/service offer TI systems in one of these two forms:

- Pinpoint location-based information accessed from smartphones (i.e., apps or mobile accessible webpage) or 511 systems.
- Maintaining a higher level database (in quality and quantity) allowing a more effective action evaluation process. One agency's database is publicly accessible, providing access to developers, media outlets, and others without much bureaucratic navigation.

In general, when asked about the future of TI systems (see Question 14), agencies' responses can be summarized as:

- Partner more with the private sector. In this manner, the private sector is proving to be a strong ally (43 percent of the agencies have some form of relationship with it) and even stronger in the near future (78 percent of agencies admitted possibility of alliance) (see Questions 4 and 13, respectively). In the follow up interview, NYSDOT stated that: "Currently, they contract out for everything."
- Take advantage of smartphones and new social media (e.g., Twitter, Facebook, apps). This new technologies enable more rapid real-time information dissemination.
- Make sure funding is available for expansion.

Additional information

- Highway advisory radio is considered the least effective dissemination technique ; nevertheless 70 percent of the agencies use it and only 27 percent of them take it into account in their evaluation.
- While roughly 90 percent of agencies provide information on traffic conditions (e.g., roadway status, CCTV video, incidents, construction zones), fewer than 35 percent provide alternate routes.

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- While 98 percent of the agencies believe that TI enhances traveling experience, only 30 percent of them have performed studies to demonstrate the benefits of TIS.
- While 59 percent of the agencies indicated they provide TI because other agencies like them are doing it, perhaps not surprisingly, 60 percent of the agencies do not feel they are more effective than other agencies.
- Safety and transit alternatives information are indicated to be the least important types of TI.
- Agencies express concerns regarding availability of funds and what can they do with the limited funds have available. When asked about funding in the follow up interview, the common comment of the agencies could be summarized as "there is never enough" and "we need more."
- Agencies support the notion that new social media and technology need to be seized. In this manner, in the follow up phone interview all six agencies indicated that they have an app and/or Twitter account. The latter being the most popular in some cases, but not necessarily the most effective.
- INRIX's real-time data is being used in 15 States and its app has over 1 million downloads.
- When asked if there is any type of TI that they feel is effective but are not currently providing, agencies responded with: statewide driving time, detail post construction lane status information, and multimodal and route trip planning. However, only 59 percent focus on travel time as a research topic, around 47 percent do research on construction zones, and fewer than 21 percent of the agencies sponsor research on alternate transit and routes (see Question 7A).

Section 2 - Use/Perception: Summary of Traveler Focus Groups and Surveys

Several topics of interests were discussed and surveyed through focus groups in four metro areas (New York City, Washington, DC, San Francisco, and Orlando) and surveys in the same four metro areas, plus Detroit and Salt Lake City. The data collected from these two approaches are organized into a high-level overview for each topic of interest. The goal of this section is to address the major findings for each topic from findings across selected cities.

For organizational purposes, topics are separated into two categories—information sources and information types. Information sources are the places and media where individuals find TI (e.g., 511 phone system, websites, electronic messages signs, radio, television). Information type is composed of the TI content that individuals use media and other modes to access (e.g., traffic incident information, alternate routes, travel times, parking availability).

Each of these will be briefly discussed with the main respondent feedback summarized. See Appendices L and M for detailed graphs and data summaries. In some cases, there is a fair amount of detail that varies from city to city, and will be discussed within each context and the city specifically mentioned. In other cases, either due to low usage or familiarity, some sources or types may not have had much discussion and will be treated accordingly. Finally, a section is provided that summarizes participants' responses to questions of what features they would like to find in an ideal real-time TI system.

Information sources

There is a burgeoning amount of sources available to individuals who are seeking real-time TI. See Appendix A for a list of information sources that are available in each city. The following list is not exhaustive, but provides the major categories of information sources in alphabetical order:

- 511 phone system
- Electronic highway message signs
- Electronic local roadway signs
- Email, text messages that are subscription based

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- Highway advisory radio
- Mobile smartphone “apps” (e.g., iPhone or Droid-based apps)
- On board devices (e.g., Garmin, TomTom, Onstar)
- Radio
- Social media (e.g., Twitter, Facebook)
- Television
- Websites (using a laptop or desktop)
- Websites via mobile devices
- Other information sources

These range from the basic and readily accessible (e.g., radio and television) to the more cutting edge and less available (e.g., smartphone apps). Also, some methods lend themselves to only pre-trip or en-route use and others can be used both pre-trip and en-route. Each will be briefly discussed below.

Across all of the information sources surveyed in the four focus group cities, we see that the most commonly accessed sources before taking a trip were television, radio, and websites (Figure 7). In contrast, very few travelers used the 511 phone system, received alerts, or utilized social media. A similar pattern held for en route information sources, with the exception of the popularity of roadway signage (Figure 8). Figure 8 also shows that nearly one in four respondents reported using information from television to make a trip change en route. This result might suggest that participants saw relevant traffic information on television, but did not act on that information until they were already en route, perhaps in response to corroborating information from another source or visual confirmation of congestion.

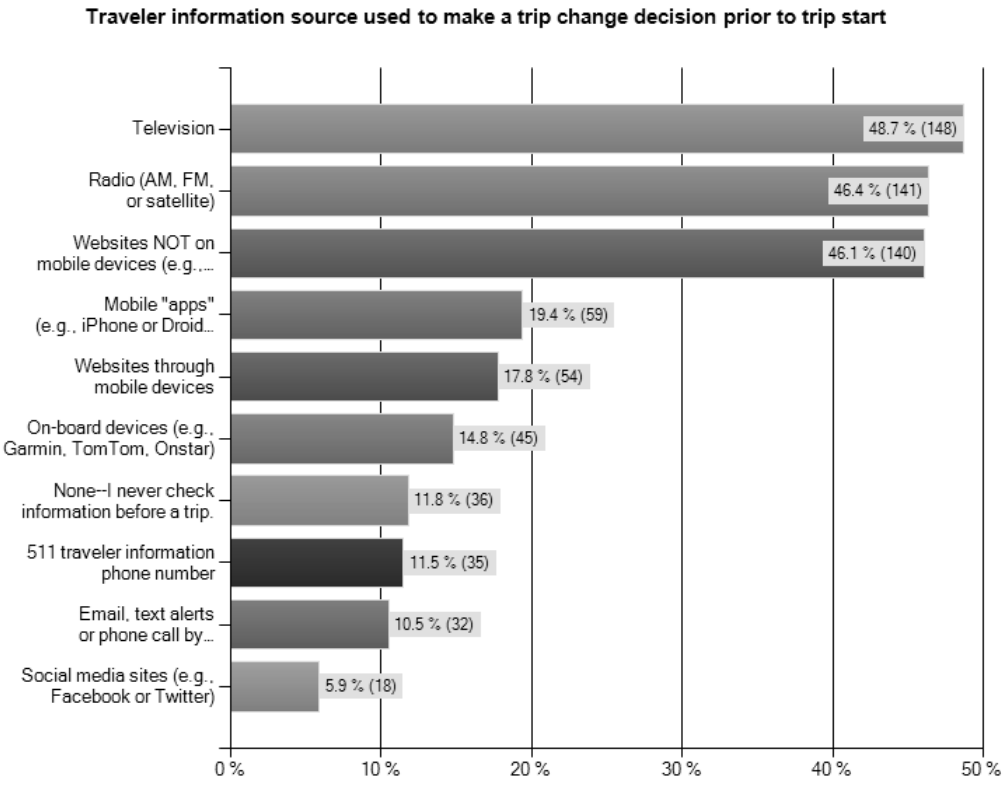

Figure 7. Information source used to make a trip decision prior to start (web survey data).

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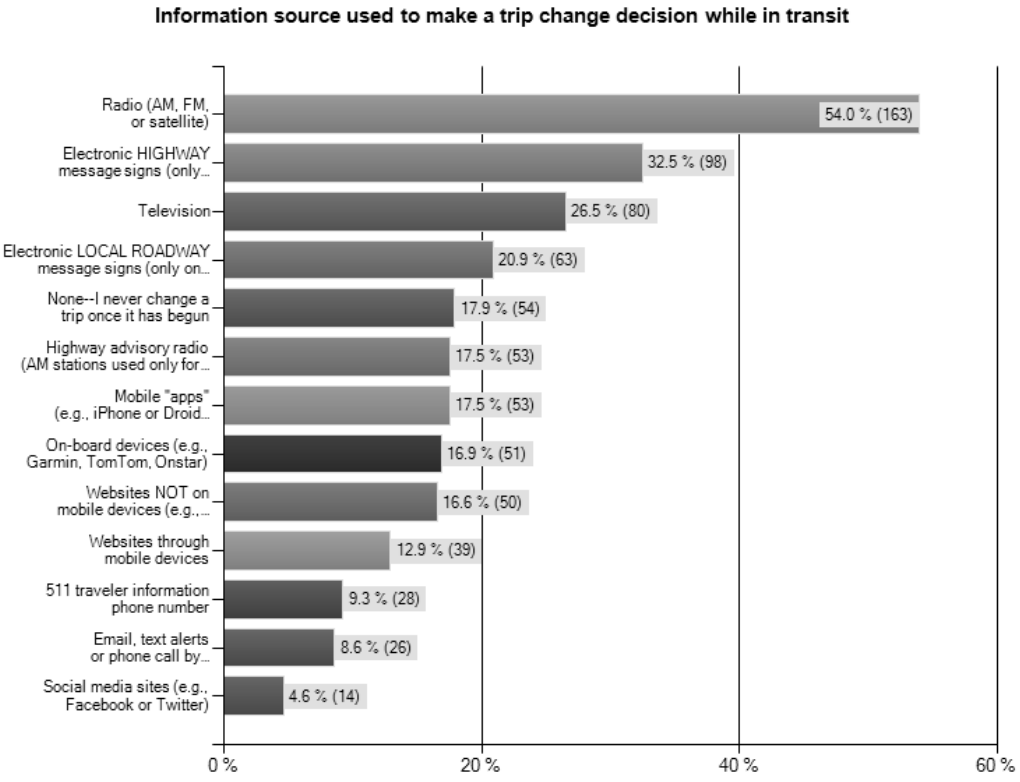

Figure 8. Information source used to make a trip change decision while in transit (web survey data).

511 phone system

Although 511 can have a website associated with it, for the present purposes we focused on the 511 telephone system for feedback from respondents. The main findings were:

- In almost every city investigated, with the exception of San Francisco, the 511 phone system was almost completely unheard of in the area. The trip logs corroborate this, with very little use before or during a trip.
- At the time of the Washington, DC/Maryland focus group, there had recently been a large informational campaign to educate the public about 511 as a new service in the area. Surprisingly, no one in the focus groups was aware of its existence.
- Consistently rated as near lowest importance of any source, and the highest non-applicable rating due to perceived lack of availability across almost all cities.
- There is an overall concern about using the cell phone while driving to call 511 due safety and legal reasons.
- Travelers mentioned the desire to have 511 coverage expanded to local roadways and for there to be a simplified menu.
- Travelers in the San Francisco area were aware of the 511 service, and used it with mixed results:
- 25.9% of San Francisco travelers found it not at all important as a source of TI.
- Interestingly, those that do use 511 (61%), found it relatively accurate (29.8 % reporting close to extreme or extremely accurate).
- In general, travelers used 511 before or during a trip much less than many other sources (and San Francisco was the high water mark for 511 use across the various cities).

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- One of the disappointments reported by travelers is that the 511 system had limited starting points and destinations, and was only applicable on major roadways. They also wanted to see destinations farther away from San Francisco.
- Most travelers learned about 511 via roadway signs.
- Users complimented the voice recognition and usability of the system.

Electronic highway message signs

This section focuses on electronic highway message signs only. Electronic local roadway signs are treated separately below. The main findings were:

- Overall favorable response and travelers prefer to have the information.
- Trust in accuracy of signs (for example, 27.5% of respondents in the focus groups cities rated them extremely accurate).
- Travelers would like to see:
  - More signs
  - Time stamp to indicate how recently the information was posted
  - Description of traffic (e.g., "heavy congestion" or "moderate")
  - Better placement of signs before decision points (e.g., before entering the highway—arterial roadway signs with indications of highway traffic conditions)
- Helpful for adjusting trip while en-route, especially when events are occurring.
- More than 32% of those who responded to a question about en-route use in the focus group cities report typically using them when deciding to change a trip. That number was even higher in the two non-focus group cities (40.9%).
- Some travelers felt signs caused traffic delays due to drivers slowing down to read the signs.
- Preference to have the information provided on highway signs, even if it is just an indicator of delays without many alternate routes to choose from ("a stress reliever").

Electronic local roadway signs

A distinction was made between electronic highway message signs and electronic local roadway signs. Electronic local roadway signs are becoming more common and provide a variety of options for more specific traffic information, special events, etc. The following were the main findings:

- Travelers would like to see more of these signs in places where they can maximize decision options (e.g., on the roadway approaching a major highway).
- Travelers who did encounter these signs reported levels of trust and favorability similar to electronic highway signs.
- These signs were reported to be effective in making a decision about adjusting a trip when en-route (~21% of respondents who answered a question about use while en-route).

Email, text messages (via subscription services)

In some locations, travelers can subscribe to alert services for information about roadway conditions, emergencies, etc. These messages can arrive via email and/or text messages. The following were the main findings:

- In focus groups, some individuals were aware of these services and spoke favorably. Interestingly, those who were not aware of them asked how to subscribe.
- Similarly to several other sources, there were safety and legal concerns about receiving text messages while driving.

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- One participant in a focus group stated (and several agreed) that she "will not risk her life or anyone else's to check her phone while driving." (Orlando)
- In Orlando, most travelers felt that the service would only be useful if there was a hands-free in-vehicle device or if there was a passenger.
- Some travelers in the New York metro area voiced a desire for route specific email or text alerts (similar to what is available for transit systems in the area).
- Travelers in the Orlando area seemed to be familiar with several options that provided traffic information, construction alerts, and incident information (e.g., Orlando Sentinel alerts, Florida Sun Pass).
- Across both surveys, emails and text messages were rated as low importance and the majority of respondents did not use them (for those who did use these options, the service was perceived as fairly accurate).
- There was also very low use (~5%) reported for making a decision about trip diversion pre-trip or en-route.

Highway advisory radio

Highway advisory radio (HAR) has a long history and general awareness by the public. The following findings were universal across cities:

- Extremely negative response about the sound quality, usefulness, and timeliness of information.
- Many travelers never tried HAR because they have heard such negative comments from others who have tried it.
- Others have only tried HAR once and found the quality to be so lacking that they never tried it again.
- Interestingly, several individuals mentioned HAR having potential as a very useful medium ("everyone has a radio") to reach travelers with important information while on the roadway, but the implementation was severely lacking.
- The surveys indicate that a fair number of travelers (~18%) across the 6 cities reported trying to use it en-route as part of their typical decision process. Note that this may be some confusion from other radio outlets (which had a very strong showing) or a reference to using highway advisor radio only in extreme cases.

Mobile "apps" (iPhone or Droid)

Mobile apps are increasing in popularity along with the availability of smartphones. The market for mobile apps is still rather fragmented and there are a variety of vendors and agencies using these tools to supply the public with TI. The main findings were:

- Overall, individuals using the apps really liked them, and those in the focus groups who were not aware of a particular app seemed eager to learn more about it. In fact, participants were eager to demonstrate an app for the group.
- The surveys also see a parallel to this, where apps are rated either extremely important or not at all important (approximately 20-25% for each).
- There seemed to be difficulty discovering apps—travelers either were not sure how they learned about an app they were using, or where to find apps if they wanted to use a new one.
- Similar to all of the mobile device media, there were concerns about using a smartphone while driving for both safety and legal reasons. This seemed to be particularly strong in the New York City area were enforcement seems to have been stronger (for example, one participant received a ticket for operating his phone to get TI while at a stop light).
- The use of apps seemed to correspond with more high frequency users of TI.
- Approximately 18% of respondents who responded to the pre-trip and en-route decision questions reported the use of apps in their typical trip decision process.

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- Transit users seemed to have more options and be more knowledgeable about agency provided apps (in the New York City and New Jersey areas—e.g., NYEmbark and NYCMate).
- WAZE was mentioned in the NY groups, and given a favorable evaluation because it was interactive and provided information in real-time.
- Orlando and the Washington, DC area groups mentioned the use of TeleNav GPS and also Beat the Traffic (in the latter, there was a concern that the app does not have a voice option).
- In Orlando, there was a perception by some that apps were for the "young."
- Favorable apps seemed to be those that:
  - Had a voice option for use while driving
  - Were interactive and allowed for customization
  - Were GPS enabled and provided local, relevant information to a traveler
  - Provided real-time information

On-board devices (e.g., Garmin, TomTom, Onstar)

- Most travelers with on-board devices did not have real-time traffic information as an option (often individuals were not aware of this option or seemed uninterested due to a paid subscription requirement for some devices).
- Overall, travelers found the systems to be reliable and provided valuable information regarding alternate routes and traffic congestion. In the surveys, respondents generally rated on-board devices either not at all important or extremely important.
- Limitations to on-board devices included the need to program them and that they do not provide all of the features of a smartphone app.
- A Ford and a Lexus (Lexus Link) system were both specifically mentioned, coupling traffic information with directions. In both cases, a positive was the ability to have directions read to the driver and hands free operation.
- Travelers generally found on-board devices to be accurate.

Radio

Radio is ubiquitous in vehicles, and was discussed in a variety of contexts for its benefits across all of the cities (and was reportedly heavily used en-route). It is the most highly used source as noted in the trip logs and surveys. The main findings were:

- Favorable opinion across all cities.
- Individuals also mentioned a trust in radio being accurate and reputable. Travelers discussed a strong bond formed growing up listening to the radio for traffic information.
- Regularly rated in the surveys near the top for typical use in trip decisions (overwhelmingly most popular for en-route decisions—approximately 55%), importance, and accuracy. Trip logs also corroborate the use of radio.
- Travelers felt that it was the ideal medium to be used for information dissemination ("not everyone has a smartphone, but everyone has a radio"), especially in case of emergencies with the possibility of the cellular network being overloaded. This was particularly the case in the New York City region and Washington, DC.
- Radio was seen as more reliably available than cell phones due to reception and signal strength.
- Regularity of updates was favorable, and travelers felt there were numerous options across stations.
- Travelers wanted a dedicated traffic radio station that transmitted clearly.
- Some travelers mentioned it is difficult to follow road updates, especially if not familiar with the area and there are numerous roads discussed.

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- Several participants were able to mention specific radio stations and when traffic updates were given ("on the 3s", etc.). Satellite radio (Sirius/XM) was also discussed in the context of free over-the-air radio.

Social media (e.g., Twitter, Facebook)

Social media contains a plethora of options for agencies and vendors to provide TI to, and receive feedback from, travelers within targeted interests, demographics, and regions. The main findings were:

- Although a cutting edge of information dissemination, social media was not often used for TI. Occasional mention was made of social media sites like Waze or Trapster, but not as a primary source of TI.
- Regardless of the city, social media was not a heavily used avenue for gathering TI.
- In the New York City area, some travelers mentioned following Facebook friends who used the same travel corridor to share information with each other through updates. But this was an isolated case and even these individuals were not actively searching through social media sites for traffic information.

Television

Television is another source of information that is ubiquitous and has low technological barriers to entry for a potential user. It is one of the more commonly used sources of information for pre-trip planning. The main findings were:

- The common complaint about television across all of the cities was its datedness for incident information and that it cannot be used en-route. If individuals checked the television news reports before leaving, the information is likely not accurate by the time one arrives at the reported incident location.
- Similar to radio, individuals were dedicated to certain television stations and knew the routine of updates, expressed trust in the reports, and had an overall favorable impression (even if aware of the timeliness limitation due to accessing television reports pre-trip only).
- Television was one of the top three most highly used pre-trip decision sources (~45% of respondents used it as a source).

Websites (e.g., using a laptop or desktop)

There were a variety of findings related to websites:

- In focus groups, most travelers check for traffic conditions through websites of local news stations or newspapers.
- San Francisco travelers had a variety of websites to use and offered several opinions:
  - www.511.org—travelers liked the color and thought the maps were easy to understand. The zooming feature was considered helpful to explore the map. Participants felt a weakness was the limited points on the map, and at times it was not accurate.
  - Other websites mentioned were Bing, Google, SF navigation, and SF Chronicle.
  - BART and Muni were websites used to find public transportation information.
- Color maps on websites were seen as favorable, along with the ability to manipulate the map to focus on certain areas of interest (via zooming, for example). Color codes may correspond to congestion, road closures, average speed, delays, etc.
- Some travelers in the New York City area mentioned the need for maps to have an option of color layout for individuals with color blindness.
- Travelers in the Washington, DC area mentioned the desirability of lane closure information due to roadwork (including tree trimming) to be displayed on websites (e.g., on a website such as www.montgomerycounty.gov).

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- Websites were one of the three most popular sources to check information pre-trip (~46% of respondents).

Websites through mobile devices

There was very little discussion or reported use of websites through mobile devices. What was mentioned focused on the difficulty with viewing webpages on smaller screens of mobile devices. Some individuals mentioned using Google maps with traffic, but that was limited. Surveys also indicated this is not a commonly used source of TI.

Other information sources

No additional sources of information were mentioned.

Information Types

There is a wide variety of information types and content available to individuals who are seeking real-time TI. See Appendix A for a list of information types that are available in each city. The following list is not exhaustive and is likely being updated as new sensors or information types are being developed. It provides the major categories of information types in alphabetical order:

- Alternate routes
- Live traffic cameras
- Parking availability
- Public safety information (e.g., Amber alerts, Silver alerts)
- Roadwork/construction zones
- Safety information (e.g., “Buckle up,” “Signal when changing lanes”)
- Special events
- Traffic incidents
- Travel times
- Weather information
- Other information types

These information types range from those that are more cautionary but not necessarily intended for route decisions (e.g., safety information messages) to those that can be critical in improving travelers’ decision-making (e.g., alternate route information, travel time, special events). Each will be briefly discussed below.

Across all of the information types surveyed in the four focus group cities, we see that the most commonly accessed types before taking a trip were weather, traffic incidents, roadwork/construction and road closures, and travel time (Figure 9). In contrast, very few travelers used public safety information, live traffic cameras, or parking availability. A similar pattern held for en route information types, with the exception of the popularity of visual inspection of traffic (Figure 10).

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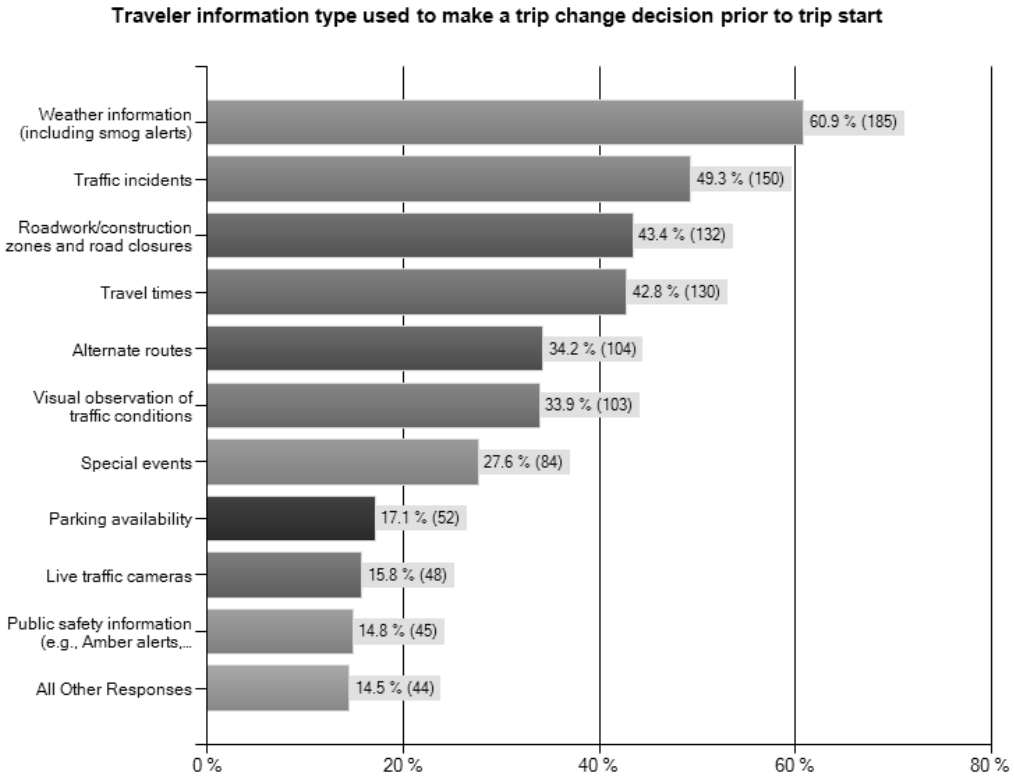

Figure 9. Traveler information type used to make a trip decision prior to trip start (web survey data).

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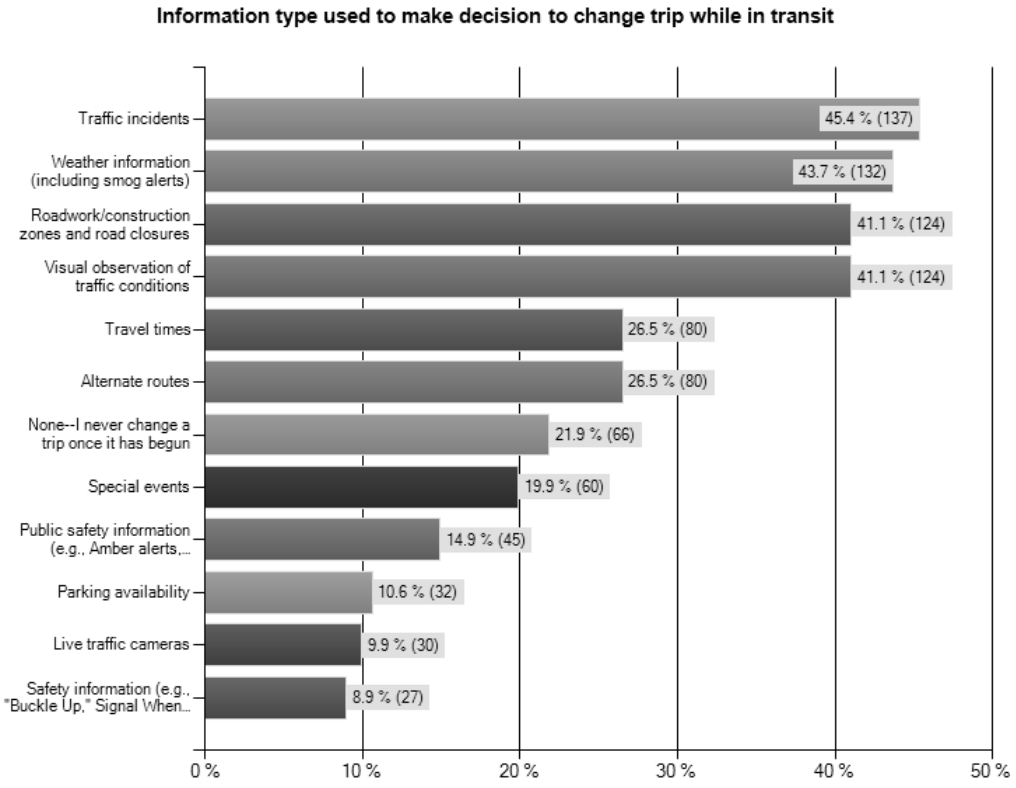

Figure 10. Information type used to make a decision to change trip while in transit (web survey data).

Alternate routes

Alternate route information is usually a complement to travel times/incidents, special event information, construction zones, and weather. It can be a critical aspect of a traveler's decision-making process. It can also be constrained by the environment. For example, in San Francisco travelers repeatedly said that options into the downtown area were limited, so alternate route information was not useful. But, in many other locations, it can be the one type of information that can convince a traveler to divert. Several themes of responses regarding alternate routes were found:

- Travelers wanted more detail about an alternate route when one is given—the type of roadway, for example.
- Related to the above findings from electronic message signs, travelers want to know as soon as possible about alternate routes (to maximize utility in making a decision and before they are committed to the primary route).
- Very highly rated on importance and somewhat highly rated on accuracy in both surveys.
- Interestingly, it is not one of the main types of information reported in surveys for pre-trip or en-route decisions. It is possible alternative route information is only sought after another type of information impacts trip plans.

Live traffic cameras

Live traffic cameras offer the opportunity for travelers to judge the density of traffic at a particular location. Most travelers seemed to view these favorably, and mentioned a higher level of trust in this type

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of information than most others. Several main themes emerged in the findings related to live traffic cameras:

- Travelers liked and trusted traffic cameras because they allow for the traveler to judge the traffic themselves.
- Travelers wanted more availability and flexibility in selection of live traffic cameras (with sections of roads highlighted).
- Also, integration into traffic maps was seen as desirable.

Parking availability

Parking availability is a type of information that is useful for particularly dense areas where parking spaces are hard to find. There can be valuable savings in time and fuel that are gained by knowing where there are parking options available. The main points discussed were:

- Travelers in densely populated urban areas (especially the New York City area) were very interested in having parking availability information. Regardless, parking availability was not often reported as heavily used in the surveys.
- Some travelers in the New York City area felt it would only be useful for parking garages, and that city streets would be too fluid in availability for the information to be useful. But several other participants were familiar with smartphone apps that provided parking availability and felt it reliable and useful for finding street parking in a timely manner.
- In San Francisco, travelers discussed parking availability smartphone apps for garages, and found them reliable (they learned about the app in the San Francisco Chronicle).
- Travelers would like parking information that included:
  - Garage prices
  - Free parking locations
  - Parking spots that are in no parking or tow-away zones
  - Time a street changes to no parking

Public safety information (e.g., Amber alerts, Silver alerts)

Public safety information was separated from safety information in general, with the belief that public safety information was more active and urgent. Travelers are being asked to attend to something (e.g., a missing child last seen in a certain type of vehicle) or do something in this context. Several themes emerged:

- There was a lack of familiarity with certain types of alert systems including silver alerts (which are issued for a missing person with cognitive impairment).
- Travelers mentioned that the information was useful and that they helped actively look for a vehicle, but in the surveys there was a low reporting of actual use in trip decisions.
- Travelers mentioned a desire for evacuation information, which may fall into this category.

Roadwork/construction zones

Information related to roadwork (including tree trimming) and construction zones was seen as very important and useful for avoiding a particular area (or adjusting traveling times). Approximately 40% of respondents in the surveys rated it extremely important. It is also one of the more highly sought after types of information typically used in trip decisions. Travelers wanted information about which lanes would be closed, but also the start and end dates/times of construction.

The San Francisco area had the Bay Bridge closure around the time of the focus groups, and participants praised the breadth of sources that this information was transmitted on (e.g., billboards,

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television, radio, etc.). This provides an example of a major roadwork disruption and the type of information that is vital to get to every traveler (even if multiple sources are necessary).

Safety information (e.g., "Buckle up," "Signal when changing lanes")

Safety information was a topic that was not discussed or highlighted in detail any of the cities. The response seemed to be indifference to the messages and travelers questioned the usefulness.

Special events

Special event information can range from street closures due to a fair or marathons, diverted traffic as a result of a football game, or increased traffic volume due to a concert or festival. These types of events can be most disruptive and can cause the greatest inconvenience (especially if there are street closings and detours), yet TI about them seems to be the least organized. Consequently, travelers expressed several issues:

- Frustration with knowing what is going on and when, with a lack of a cohesive website or source to provide this information. For example, in the New York City area, when asking a group of travelers where they would direct a new neighbor to the area (where street closures are common and can disrupt the ability to park in your buildings garage), the response was a collective "you'll just have to learn like we did."
- One interesting suggestion was to provide a list of special event websites that may impact the area as part of a move-in welcome package (along with what is provided regarding utility information).
- Travelers also noted the need to go to individual event websites to find out schedules of fairs and street closings, for example (in the New York City area).
- There was a clear desire to have a central location, possibly managed by the local DOT where a person could find information about special events that may disrupt traffic or contain street closures
- Special event information was rated extremely important by a large portion of respondents (~20%), but ratings of accuracy were more mixed.
- Interestingly, the reported use of special event information was rather low for both pre-trip and en-route trip decisions. This may be due to lack of $_{\text{available}}$ sources that travelers can use to make trip decisions.
- Travelers wanted to know:
  - Date and time of the event
  - When will the traffic disruption (e.g., street closure) end
  - What specific roads are closed or potentially impacted
  - What are the high density areas

Traffic incidents

Traffic incident information was rated as extremely important by approximately 39% of respondents in the surveys, but it was not emphasized in the focus groups. This type of information was also the top one typically used for making decisions about trips. Traffic incident information was discussed more in terms of what characteristics were desirable. Travelers listed several features:

- Time when incident occurred and time when it was cleared.
- Number of lanes affected.
- Type of incident.
- When will affected lanes be reopened.

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Travel times

Travel time information was not discussed in as much detail as many other types of information. This may be a function of availability on highway signs in some areas, and also other ways of presenting the information (e.g., relative to normal traffic via color coded maps on websites or descriptions on radio reports). Overall, travelers indicated a desire for the information, and it was rated as highly important and relatively accurate. Travel time information was used relatively frequently in trip decisions. Travelers also expressed a need for congestion information, specifically how many lanes and what areas of the roadway are affected by congestion. One interesting criticism was that travel time information is not that useful when in unfamiliar areas. Travelers would much rather a description of what the travel is like relative to normal traffic—e.g., "heavy traffic" or "moderate traffic."

Weather information

Weather is another type of information that can have major impacts on roadways and traveler decisions. The main themes that emerged related to this type of information were:

- Weather information should include road closures (planned or unplanned), severity of weather, evacuation routes, and alternative routes.
- It is considered extremely important (~32% of respondents rated it extremely important) and relatively accurate.
- Weather information is the most highly used type for pre-trip decisions and one of the most highly used types of information for en-route trip decisions.
- Specifically in the Orlando area and related to hurricanes, travelers wanted to know:
  - What roads were closed
  - When tolls were lifted for evacuation
  - Which roads were inaccessible
  - Alternate routes
  - Signs that provide distance ahead for severe weather (e.g., "severe weather 2 miles ahead")
  - Tornado warnings or other weather events that can appear unexpectedly

Other information types

Public transportation information was considered highly desirable in some areas (e.g., San Francisco). This information could be used to support mode switching decisions.

Section 3 - Effect: Summary of Traveler Log Information and Supplemental Survey

A key question from the study focused on the effect of TI sources and types. Without the benefit of resources to do an on-road naturalistic driving study, the approach consisted of traveler logs (i.e., "diaries") and surveys. The larger web-based survey asked about typical use, which was discussed earlier. This had limitations due to mis-remembering by respondents, and varying time frames. The research team felt it was necessary to focus specifically on TI use and to minimize memory degradation or confusion in reporting. Consequently, information was gathered via traveler logs shortly after trips, and also with a targeted web-survey that asked about TI use in the recent past (3 days).

One of the difficulties of gathering data about trip changing behavior is that it does not occur often, as noted in the surveys where the vast majority (80%+ of all cities) noted that they change trip plans one day a week or less. This was also shown by the small sample of individuals who responded to the effect survey who had a recent (3 days or less) trip change to report. Of the 522 who completed the survey, only

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72 (13.8%) reported changing a trip in the last three days. That is consistent with the low reported trip changing rate in the traveler logs. See Appendix N for additional detailed graphs and data summaries.

The clearest and most accurate reporting will be found in traveler logs that are completed shortly following a trip. Based on traveler log reports of sources used before and during a trip, we see that the majority of trip changes were based on information gathered from television (pre-trip only), radio, and navigation devices (Figures 11 and 12). The use of 511 was almost non-existent, and smartphone apps were also relatively lightly used (although a decent proportion of pre-trip use was found).

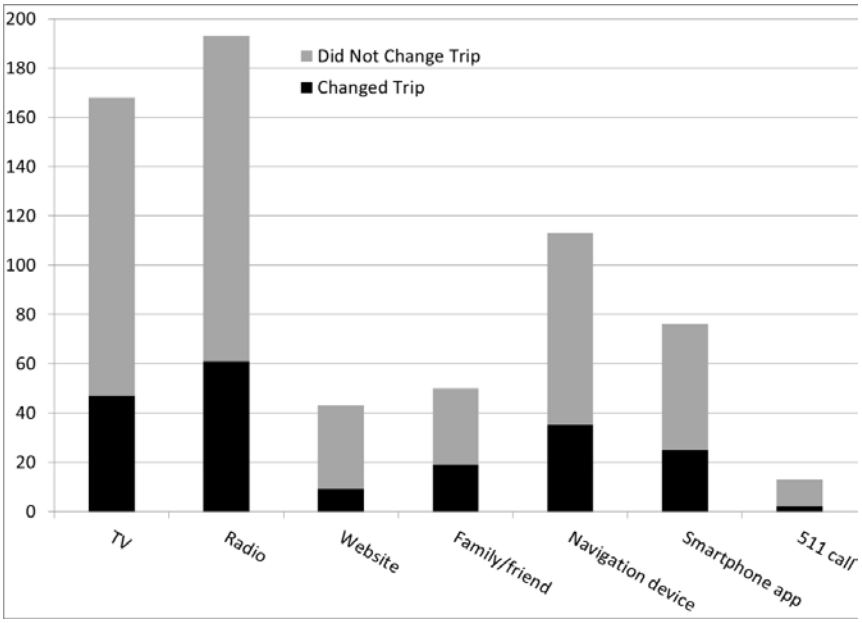

Figure 11. Trip changes by pre-trip traveler information source (traveler log data).

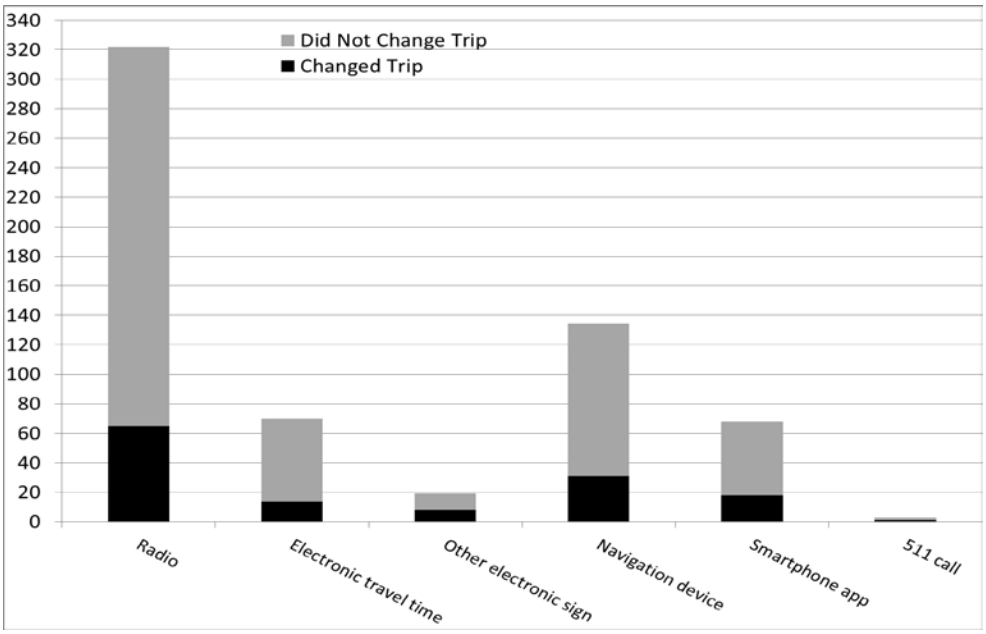

Figure 12. Trip changes by en-route traveler information sources (traveler log data).

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A supplemental survey was also deployed across all six cities to investigate recent trip changing behavior. This was based on the small number of reported trip changes from the traveler log and because a key interest of the study was to understand the effect of information types and sources on trip changes. A similar pattern was found, with TI sources and types. The most popular sources used included radio, smartphone apps, and electronic highway signs (Figure 13). Note that smartphone apps were reported at a much higher percentage then the earlier survey asking about typical use, possibly due to better memory retrieval now when asked about most recent trips within three days. The least popular sources included local roadway signs, social media, and on-board devices (all possibly reflecting the lack of availability of these systems). As for information types, travelers reported the most used to be traffic incidents, travel times, and alternate route information (Figure 14). The least used were safety information, special events, and parking availability.

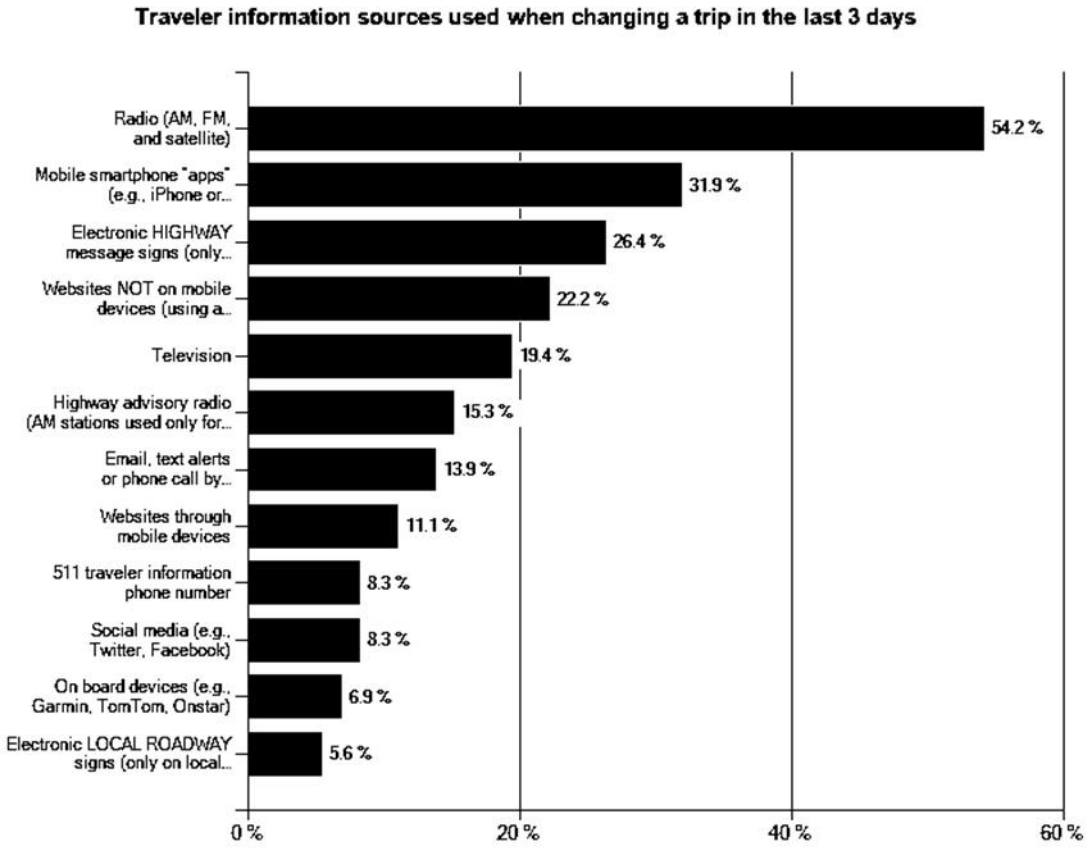

Figure 13. Traveler information sources used when changing a trip in the last 3 days.

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We also asked travelers what were the most influential types of TI used when making trip changes. Participants listed traffic incidents, travel times, alternate routes, visual observation of traffic conditions, and roadwork/construction zones and road closures as the most influential types of information used in typical trip changing decisions.

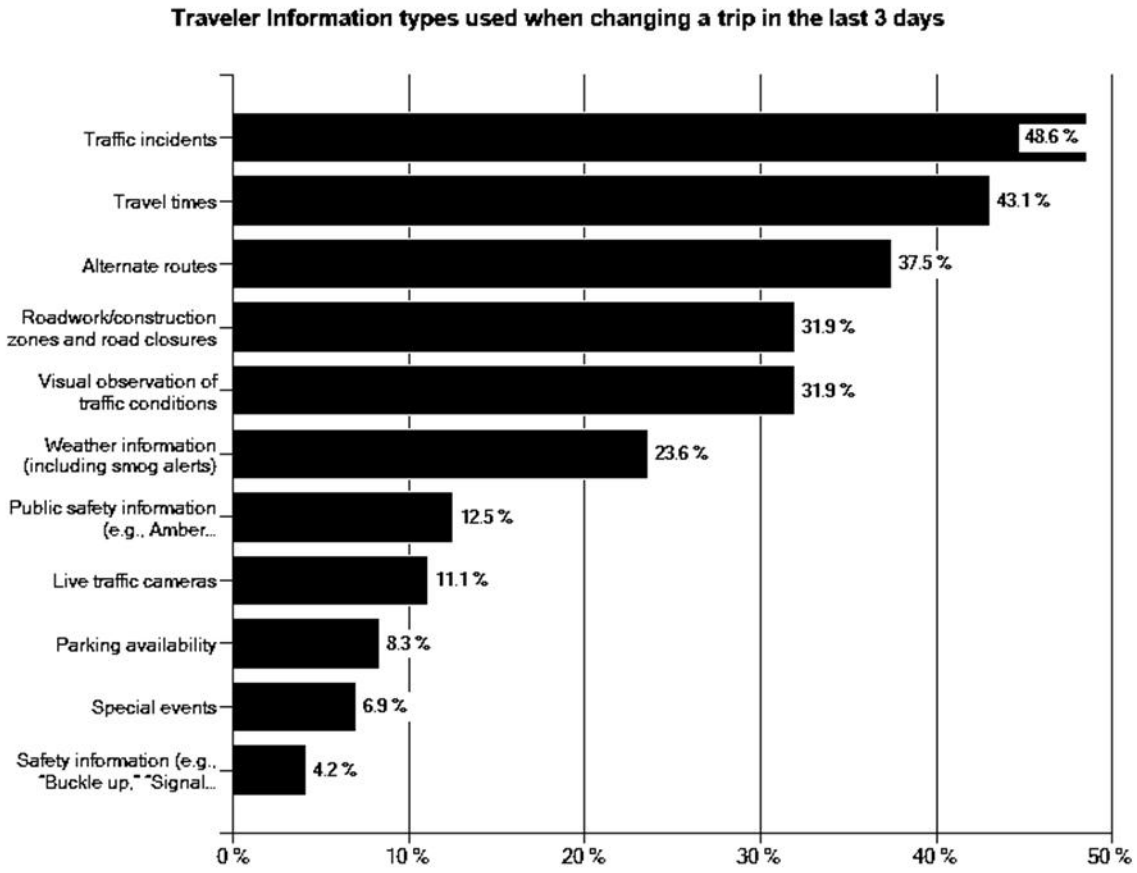

Figure 14. Traveler information types used when changing a trip in the last 3 days.

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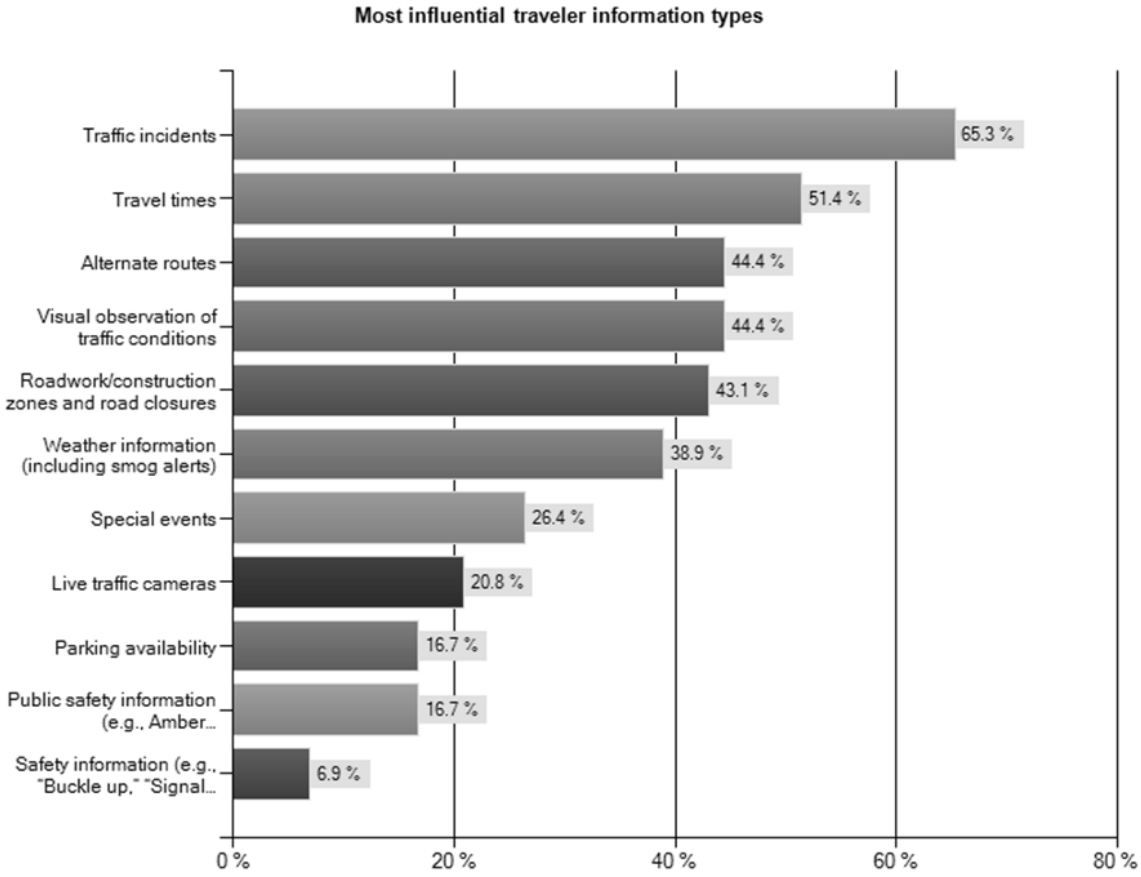

Figure 15. Most influential traveler information types.

Features of an ideal system

In focus groups and surveys across all cities, participants were asked a direct question about features of an ideal real-time TI system. They were asked to pretend that they could design a TI system in the area, and what features would make it an ideal system. These were the main themes that emerged across all cities:

- Reliable, real-time, and accurate information
- Local and tailored to the travel corridor of interest and living area based on location (possibly GPS enabled), filtering irrelevant information
- Detailed information such as specific lane closures, video images of traffic conditions, etc.
- Time-stamped information so that the "freshness" is known
- Automated alerts based on route or location of traveler
- Accessible from a variety of sources ("universal means of accessing information"). Similarly, bundled suite of information types that one can choose from via most sources (e.g., traffic, road closures, construction, weather, public transit, etc.)
- Alternate route and transportation information to improve decision-making
- Radio as a mode should be included because it is accessible to almost everyone and more reliable in emergencies or places with cell signal obstructions
  - Including continuous updates on a dedicated station that clearly transmits information
- Multimodal information, including transit

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- Information provided at key decision points (e.g., before entering a highway)
- Dedicated apps, radio stations, and television stations
- Integrated information regardless of jurisdiction that is for the traveler from Point A to Point B

As noted earlier, some types of TI sources and types are not available in all areas (see Appendix A). Consequently, we asked individuals in the supplemental use survey (all six cities) who had recently changed a trip to select the source and type of information they would have preferred to have when making their decision. In other words, what types and sources of TI would a traveler want to have access to when deciding to change a trip? Interestingly, for sources the two that were most frequently named were radio and smartphone apps. Radio has been consistently rated highly in all phases of the study, but smartphone apps have not received as much attention (likely due to lack of availability in many areas). Also, highway message signs were a popular request, and the least popular were 511 phone systems and social medial. As for information types, overwhelmingly travelers wanted information about incidents, alternate routes, travel times, and construction zones/road closures. Safety information and parking availability were the least desired types of information for travelers.

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CHAPTER 4

Conclusions and Suggested Research

TI systems are diverse and rapidly evolving. It will be important for agencies and TI vendors to align development with the needs and expectations of the traveling public. The current project provides a glimpse into the decision-making and opinions of the public with respect to real-time TI systems in various cities across the country. It also provides several important outputs that can be used by stakeholders in the TI domain. These will be discussed in more detail, but include: a) national survey and targeted interview of agency dissemination practices and beliefs, b) large scale surveys and focus groups with the traveling public in several locations across the country to gain a better understanding of the public's perception and use of TI, c) a public use database of survey responses for future analysis, d) analytical discussion of the match between agency and public perceptions, along with identification of gaps for policies, e) recommendations for methods to use in assessing a TI system, f) guidance for features of an ideal TI system and how agencies can facilitate information dissemination, g) discussion of the future of real-time TI, including cutting edge technologies and deployment approaches.

The traveling public is satisfied and uses numerous sources and types of TI. It is also clear that there are areas where travelers are calling for improvements (e.g., highway advisory radio), highlighting concerns (e.g., smartphone apps in the face of distracted driving concerns/laws), or unaware of available services (e.g., 511). Surprisingly, although travelers generally seek more detailed and complex information that often requires the latest technology, there was a common call for simple, reliable information that can be accessed by most people in a variety of locations (e.g., the use of radio). Based on these findings, there are numerous readily attainable goals that agencies can adapt to improve a real-time TI system. Further discussion of these findings and guidance for system improvement are presented below.

The conclusions and implications presented in these sections are drawn from the research tasks performed in this project, as well as agency input and recommendations gained during interviews and informal discussions. In addition, the research team and project panel are composed of experts in domains related to TI implementation, data fusion and information technology, and research methods who provided their expert opinions on guidance for TI system development and behavioral data collection methods.

Agency and Public Perception

One of the more compelling aspects of this research project is having the ability to match agency and public perceptions of effective TI features. Analysis reveals considerable consistency between agencies and the public in terms of what features are considered effective and which are considered less effective. For example, both agencies and the public seem to agree on the value of real-time TI that helps the public make better decisions. Agencies and the public agree that TI should:

- be targeted, local, and relevant to the consumer—possibly based on GPS enabled cell phones or vehicles so that relevant, location-based information is provided;
- be easy to access and use, including when en-route;
- be clear, concise, trustworthy information that is accurate and reliable;

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- include special event, construction/maintenance, or emergency information that can drastically affect routes; and
- use technologies that are widely available to everyone and easily implemented (e.g., radio).

Surprisingly, features that are considered less effective by both agencies and the public are still in wide use (e.g., highway advisory radio). There are also some notable examples of where these perceptions do NOT match. It is these instances (agreement on ineffectiveness and disagreement on effectiveness) that are of interest as they point to features where resources are needlessly being expended or where features might need considerable improvement. Some examples of perceived limited effectiveness and disagreements about effectiveness are presented below.

- ***Highway Advisory Radio***—This TI program feature is a good example of a dissemination method where both agencies and the public agree as to its limited effectiveness. Of the methods used by agencies, this was deemed the least effective method of getting TI to the public. The public agrees as focus groups and surveys indicated that an overwhelming majority of people do not trust or use highway advisory radio. Most felt the information was on a loop and, therefore, not timely and they all thought the radio stations were mostly "crackly" or "fuzzy" to hear. Despite these negative impressions, HAR is widely available to en route drivers using their car radios and may be considered worthwhile as part of a TI toolbox, particularly if some improvements are made (e.g., more frequent information updates, timestamp to indicate how recently the message was updated).
- ***Social Media and Apps***—TI program features using social media and smartphone apps are receiving increased attention from agencies as they are considered both effective and a technology trend that must be taken into account. From a TI program perspective, these features are perhaps the most "cutting edge" in terms of state of the practice and the long term viability remains to be seen. From a public perspective, very few people are using social media and apps to receive TI. Some of this can be attributed to not knowing that the feature exists and some relates to, again, use of a mobile device in a car. Of course, this area is developing rapidly, and there may be advances for safely using smartphones as part of an integrated vehicle system with appropriate mounting.
- ***511 Phone Systems***—Many agencies have implemented or are moving toward 511 phone systems as they are considered to be highly effective, but at the same time, state legislatures are moving to ban cell phone use while driving (and the public's mindset is changing in the same direction). This may explain why a review of survey results indicate that making a 511 phone call is not deemed a particularly effective method of getting en-route TI. This may be the result of a conflict between developing state laws and public perceptions targeting cell phone use and the desire for en-route travel information. See Figure 16 for a comparison of state laws targeting texting or cell phone use (note Chapel Hill temporarily banned all cell phone use, including hands-free until a court recently overturned the law). The overall aim for an effective TI system should be alignment between the agency's goals and the public's needs/wants.

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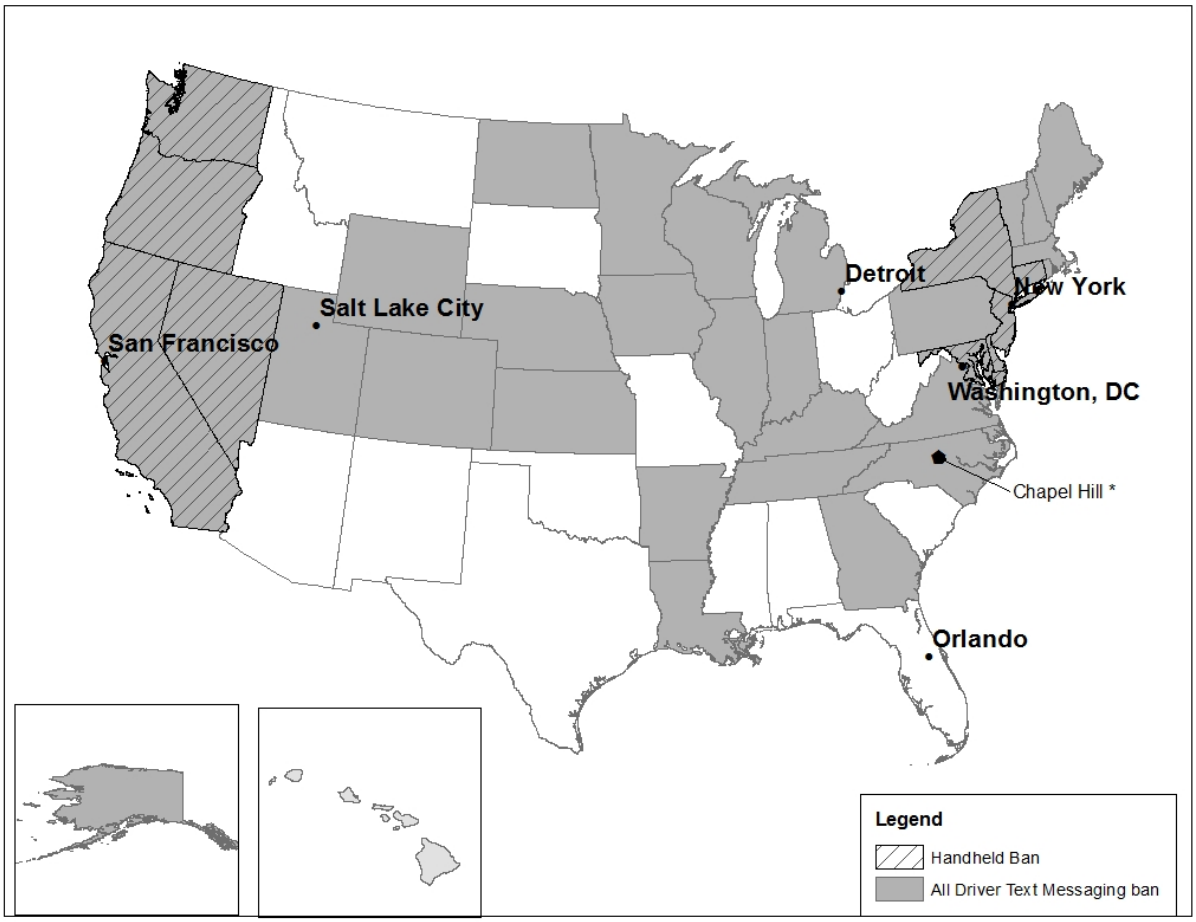

Figure 16. Cell phone and texting bans by state.

Effective TI Program Features

From an agency perspective, it is clear from the agency surveys conducted in this project that the prevailing goal of any TI program should be to provide information that allows the traveling public to make better decisions. Hence, the underlying features listed below and in the Appendix O (left column) are those that support this goal and that are deemed effective by TI providers and by the public. The information is largely based on results of the agency surveys and the traveler focus groups and surveys.

Following is a summary overview of effective features:

- Provision of real-time information concerning transportation system status focusing on non-recurring events—It is apparent that non-recurring events (including those that are unplanned such as traffic incidents or planned such as special events) are very important in terms of the type of information needed by travelers to make better decisions. In an effort to focus on the randomness of incidents and their impact on the consistency (or lack thereof) of trip travel times, the concept of travel reliability is becoming an increasingly important feature amongst TI providers. The challenge with travel reliability is conveying measures (e.g., buffer and planning indices/times) that are easily consumable by the traveling public.
- A wide array of information dissemination methods are implemented and used effectively—When it comes to dissemination, TI cannot be too accessible. Not every traveler has the same needs and not every traveler will like every dissemination mechanism so an important feature of any effective TI

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program is a diversity of dissemination methods. Also, it is not critical that an agency be responsible for all dissemination mechanisms. Many agencies focus on providing a usable website with timely and reliable information, but also provide data to third parties (at no cost) so that additional outside resources, ideas, and capabilities can be used to create new and innovative dissemination mechanisms. Effective use of a dissemination method is also important. For example, when using websites, it is important to keep clutter to a minimum so that uses can quickly find the information they need. Many websites include extensive headers, footers, and menus with extraneous links that can distract from the primary information that users seek.

- An effective TI program is one that is evaluated for its effectiveness—The definition of effective is "successful in producing a desired or intended result." Evaluating a TI program to determine if it is successful in producing a desired or intended result is not a straightforward proposition. While agencies expend a great deal of effort determining transportation system performance (see the Appendix O for a list of evaluation measures), they typically do not use these measures to determine the specific contribution of their TI program to overall transportation system performance. There are many components of a TI program, some of which are more easily evaluated than others. Agencies today evaluate their TI programs using data collection techniques such as 511 call statistics, website hit statistics, and a variety of traveler input survey methods using their 511 systems, web and e-mail forms, and to a lesser extent, traveler focus groups. These collection techniques are being used, to some extent, to evaluate effectiveness of TI content including information timeliness, accuracy, availability, accessibility, and decision-making. While information helps with decisions regarding departure time, destination choice, mode choice, etc., there is also benefit to travelers of just knowing why they might be in a delay and what the impact may be to their trip. Not knowing, for example, why they are stuck in congestion adds to driver frustration or anxiety (especially in some locations where they may be in a tunnel or fear an emergency event).
- TI should align with demands of the public—The traveling public has certain demands and expectations regarding an effective TI system. When there is alignment between the public's desires and goals, and the agency's information services, the system can be optimized and the public can be satisfied.

Guidance on Assessing the Potential Effect of Information on Trip Behavior

There are a variety of methods to assess the public's use, perception, and the effect of TI systems. The second column in the Appendix O table provides guidance on assessment methods. Traditional methods have included call statistics, website hits, and satisfaction surveys. Although helpful, these methods have limitations regarding understanding the effect of TI on travel behavior. For example, 511 calls may spike if an incident occurs, but may not result in many people adjusting their travel route, especially if there is low confidence in 511 accuracy or operation. Similarly, a satisfaction survey may provide information about the overall likeability of information sources, but not overall use or effects on travel behavior. In a previous study on real-time travel time signs, Westat found that individuals liked having the signs present, but generally did not use them to adjust their trip behaviors (often due to lack of alternative route options or information) (Lerner, Singer, Robinson, Jenness, & Huey, 2009; Robinson, Lerner, Singer, Jenness, & Huey, 2011). Consequently, assessing the effect of TI on trip behavior requires alternative approaches used in combination with these more traditional methods.

Based on prior experience and finding of the current project, we propose a "toolbox" method. This approach combines a variety of focused, targeted, and low-cost methods that evaluate different aspects of a TI program in a particular area. It is also desirable to use a combination of methods due to the large variety of dissemination methods, traveler characteristics, and information types. Findings from these

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methods can then be combined to generate a profile of overall system effectiveness, especially with respect to its effect on trip behavior.

The toolbox should consist of several components which can be inexpensively adapted to a particular site and can provide insight into the effectiveness of a TI program. The list below describes basic approaches and provides a sample of steps taken to ensure the highest quality implementation:

- ***Focus groups targeting certain travelers*** (e.g., heavy/light users of TI, older adults, smartphone users)—Questions should be tested and developed on populations of interest; detailed moderator's guide; audio and video recording; question path should be developed based on information gathered via other evaluation methods of real-time TI.
- ***Traveler logs***—Pilot testing and formatting checks are necessary; focus on effects on actual travel behavior; look for shifts in planned route/mode, trip characteristics (e.g., occupancy, chaining), pre-trip and en-route behavior, outcomes, and perceived benefits. This method should be used in a limited manner to supplement focus group findings. In fact, focus group participants can also be invited to participate in a traveler log study.
- ***Targeted surveys*** (including web-based)—Deployed with off-the-shelf software for web-based surveys; cognitive interviewing and item development should be performed, with questions being refined; recruitment from mail-outs and pre-existing survey panels; target census tracts and corridors of interest to send mail-out invitations to participate. A combination of web-based survey panels and mail-outs should be used.
- ***Interviews***—Use trained interviewers; pilot testing and question path optimization is necessary; interview script question path should be piloted and constructed based on survey and focus group questions; due to the resource intensive nature (one interviewer per participant at a time), should be used for a focused follow-up to some responses or statements in earlier phases.
- ***Use available data where possible***—Examples include traffic and congestion data, surveys, and usage data already being collected.

The methods described above should be used in combination to gather a variety of information. Some methods are more suitable for certain types of information—for example, interviews and focus groups are useful for gaining insight into particular issues the public may have with a type or source of information, hypothetical systems or test implementations, and traveler logs can be a validity check on how frequently people really change trips (and based on what type of information source they decide to change trips).

In order to develop a profile of TI effects on trip behavior and TI usage in an area, the following should be collected (via combination of methods described above):

- Traveler type (e.g., commuters, elderly, frequency of TI use, technology use)
- Information type (e.g., travel time, congestion levels, incident information, weather)
- Information source or media used (e.g., mobile apps, websites, radio, TV, highway signs)
- Temporal information need (e.g., pre-trip, near trip, en-route)
- Traveler perception of quality, accuracy, reliability, availability
- Information comprehension
- Effect on travel behavior
- Likeability/satisfaction
- Frequency of use
- Traveler perception of risk (e.g., distraction of mobile devices)

How Transportation Agencies Can Facilitate Traveler Information in the Future

There are many ways in which agencies can facilitate providing TI in the future and many provided some ideas through the agency survey discussed above. Below is a description of their ideas along with a

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few that were developed during the course of this research based on insight gained from the public. It should be noted that they are separated into two categories: “Readily Attainable” and “Looking Further into the Future.”

Readily attainable

- ***Data Accessibility***—Data collected but not used can be a waste of good resources. It can also be an inefficient use of resources to develop an application internally that can be done cheaper by someone else. In order to enhance an agency’s ability to provide accurate and reliable TI, they should allow easy access to the data they collect so that developers, media outlets, universities, the private sector and others can obtain success without severe bureaucratic navigation. A process should be put in place that has the required steps to access agency data. This would assist both internal staff as well as external agencies. Access agreements should be kept as simple as possible. The data should be made available with little or no access fees. When agencies design their databases, it should be done with a focus on using technologies and standards that will make the data more easily accessible.
- ***Private Sector Partnering***—As discussed above, sometimes providing TI can be accomplished more effectively through a private partner that includes the added potential benefit of obtaining free services or even revenue generation. It is imperative that agencies keep an open mind about partnership opportunities with the private sector. Every state has their own laws about what can and can’t be accomplished through private sector partnering but many states have been able to receive free 511 services through private sector partnerships. Agencies can also partner for the development of a mobile app. Private sector partnerships will also benefit by making agency data easily accessible.
- ***New Data Sources***—Agencies should consider using outside sources such as having an outside organization provide probe data to supplement agency data sources. This third-party data combined with the agency’s own data could be used to support their TI activities as well as other management, operations, and planning functions. The costs of internally adding and maintaining additional cameras or sensors should be compared to the cost of having a third party provide the additional data. If additional data is contracted by an outside party, the agency should maintain open dialog because technology changes so rapidly.
- ***Partnering with Other Agencies***—In order to provide the most complete informational picture to users, agencies should endeavor to work with neighboring agencies to fuse data from multiple sources. It is especially important in regions where multiple state and local jurisdictions exist.
- ***Evaluation***—Since the traveling public is the ultimate consumer of TI, it is important for agencies to measure the effectiveness of their TI program. Most agencies put the information out there but don’t measure its effectiveness. How will an agency know how to manage their TI program if they do not know what the ultimate users think about it effectiveness? Therefore, it is important to actually program specific funding to evaluate the agency’s TI program. The evaluation should focus on the users experience and use of the TI that is available. This will allow the agency to actively manage and evaluate their TI program from the user’s perspective.
- One aspect of evaluation that could be done is to conduct and sponsor research to develop effective techniques to quantify operational impacts of TI programs. This could be done nationally rather than via a single agency. Research could also be conducted to assess how to mitigate driver distraction that is associated with users receiving TI while driving.
- ***Distribution Mechanisms***—Each user gathers their TI in a different way so it is important that agencies provide the information in a variety of ways. Agencies should support a wide range of distribution mechanisms/opportunities in order to reach the maximum amount of users. As discussed earlier, because technology changes so rapidly, it is important that agencies also have the ability and flexibility to provide new types of TI as the environment demands.

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- ***Improve Existing Traveler Information***—TI provided to users can always be better. Agencies should strive to continually improve the reliability, timeliness, and quality of its existing TI and the resources used to disseminate the information (e.g., highway advisory radio, DMS, etc.).

Looking further into the future

When looking to the future of TI, it is challenging to make any specific predictions that will help guide agency TI programs given the environment of rapidly advancing computer and communications technology. However, there is work underway to identify a framework for TI in the future. USDOT's Dynamic Mobility Applications (DMA) Program is looking ahead into a future operational environment that will enable advanced TI services. Enabling Advanced Traveler Information Systems (EnableATIS) is the TI component of USDOT's DMA Program. EnableATIS has drafted a number of "potentially transformative aspects" of TI such as:

- Truly integrated multisource and multimodal data on a regional level;
- Intuitive, location and mode option specific information to enable real-time decision making by travelers;
- Anticipation of traveler's specific information needs based on location, time of day, typical individual historical travel patterns and other parameters such as weather conditions;
- Improved agency operations with robust and comprehensive data about how the transportation network is functioning in real time and how users are reacting within those travel conditions;
- Benefit from real-time user updates about travel conditions or impacts; and
- Daily travel decisions which result in a noticeable positive impact on transportation network mobility, safety and overall transportation system operations across modes.

It should be emphasized that aside from USDOT's DMA efforts, the results of this research seem to point to a future where there will be a continued need to solve the paradox of the public's desire for good in-vehicle TI, but without the distraction (and in some jurisdictions illegal use) of mobile phones/devices. This will impact the future of telematics which terminology used to describe enhancements to the driver's experience (e.g., GPS navigation, information listings, vehicle performance diagnostics, traffic conditions, etc.) in an automobile by efficient managing information among diverse sources and using wireless communications between the vehicle and a location-based service. Telematics is becoming increasingly sophisticated with ongoing advancements in voice-recognition technology that allows improved hands free interaction with in-vehicle systems. This is one concept that most users could readily embrace. It would be the development of one in-vehicle device that, besides having the standard navigation from point A to point B, would incorporate real-time data for: roadway congestion, road conditions due to weather events (ice, flooding, etc), and planned events that would affect road congestion (construction, road closures, football games, car races, etc.). The users would only have to attend to one information source that provided all the information they needed. The device would also have voice recognition so it would be completely hands free. The goal is to have a single device that would provide the user with a complete picture of road conditions and the user would know that the data was reliable, accurate and timely. This can be provided within an in-vehicle system interface, or as part of a dedicated mounting unit for a smartphone device brought into the vehicle.

Smartphones are becoming widespread, and provide many of the features from a variety of sources that users seek. Manufacturers and the USDOT (through such programs as Connected Vehicles and related vehicle design evaluations) have been increasingly concerned with ways to present a variety of travel information in a safe, minimally distracting way. One example is development of integration methods for nomadic devices brought into the vehicle which may provide an array of real-time TI. The limitations and concerns about using smartphone apps mentioned earlier may be alleviated in vehicles that allow for "docking" of a smartphone which is then accessed through the in-vehicle system.

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Potential for Innovative and New Traveler Information

In addition to future trends in TI from an agency deployment perspective, we found it useful to briefly review trends in future technologies and innovations for TI. These technologies are on the horizon and can provide agencies with tools to implement the recommendations discussed above. Although not exhaustive, the following discussion attempts to be forward-looking and detailed enough to provide insight into technological trends that can impact TI systems in the future.

In a world driven by telecommunication, continuously changing and improved technologies in this field break barriers that limit the potential of social interaction. The most prominent examples of this are smart phones and the newest technology trend, the tablets. This reality highlights the need to adapt any future development to these new indispensable pieces of technology such as "apps", push notifications, service locators, integrated GPS, real time users input, etc. VMS, 511 services, and GPS services, among others, need to evolve to a more precise, adaptive, prescriptive, in-vehicle, and en-route modes of RT-TIS. One example of this evolution is a smart phone that can learn the user's routines and adapt to them, automatically changing any settings to the ones preferred by the user in a specific scenario or time of day. This technology should be developed for private vehicles using GPS systems that automatically determine your most common routes, evaluate their condition when you start traversing through them and suggest other alternatives in case of severe congestion. Future developments would need to implement this technology to all modes of transportation by communicating with the user through phones or tablets. At the same time, all the information available should be gathered by a centralized control system from which each personalized device would download the necessary information to provide real-time and expected conditions in the user's common routes.

The next step in this evolution is accepting real-time input from the most important component of the network, the users. Online social media such as Facebook and Tweeter have revolutionized the way people communicate with each other. Furthermore, they have opened a new chapter in real-time information transfer to the masses. Webpages like waze.com have implemented this idea and allow the users to be the ones that provide real-time traffic information through a "fun, community-based GPS traffic and navigation app". DOTs can benefit from real-time user updates about travel conditions or impacts in the network. For example, operators responsible for real-time transportation situational awareness in the Washington, D.C. metropolitan region monitor waze.com and even upload user provided pictures of congestion and incidents to a system that shares the information with regional DOT and transit agency operations personnel. However, the real dilemma comes from the fact that providing en-route and more importantly in-vehicle real-time information most likely contradicts the initiative of "zero distractions when driving" that many states pursue. One solution is enhancing the telematic capabilities of the vehicles, allowing for standardized smart phone docking along with voice recognition commands. Even more promising is the combination of this technology with the ongoing partially- and fully-autonomous vehicle initiative. This could yield the most beneficial result, as it could help unify real-time data collection efforts and bypass the distraction-related limitations of hands-on devices. We noted earlier that there were concerns and limitations to smartphone deployments, but some of these approaches can make them safe to use and compatible with the ultimate goal of providing reliable, useful, and effortless TI in a responsible manner.

The future of traveler information

TI in the future will be completely integrated into our lives in such a way as to make requests for information virtually unnecessary. While today's TI is primarily "search and discover" with some more generic personalization becoming available, tomorrow's TI will be provided directly to you—and it will be highly personalized, targeted, and preemptive. Unlike today's "personalized" TI, tomorrow's technology integration efforts will mean that users are simply delivered timely information without ever "subscribing" to a particular service or taking valuable time to set up specific alerts and routes into a

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cumbersome system. This section describes various technologies and efforts that are in the visioning phase, in development, and in some cases, very near to deployment.

Dissemination technologies and applications

The future of TI depends on several factors including 1) the availability of ubiquitous data (both infrastructure and real-time situational awareness), 2) the dissemination platform/technology, and 3) the applications themselves. See Table 2 for a summary.

Table 2. Prevailing dissemination technologies.

Today	+2 Years	+5 Years	+10 Years
• Television • Radio • Web sites • Smartphones • VMS • Nav Systems • 511	• Radio • Smartphones • Nav Systems • Web sites • 511 • Integrated Calendar Systems • Television	• Predictive Integrated Calendar Systems • Nav Systems • Personalized Mobile Web • Radio • 511	• Augmented Reality Devices • Heads-up In-vehicle Displays & Audio • Multi-modal in-Route Decision Systems • Radio

Navigation Systems

The future of standalone navigation systems is limited. Most consumers now have access to smartphones that are readily equipped with free or nearly-free navigation aids. These smartphone navigation apps are sophisticated with voice input, voice directions, maps, real-time traffic, etc. Newer apps are even beginning to explore augmented reality—a topic covered later in this document.

Standalone navigational aids are typically not networked, which means that map and point-of-interest updates are manual (and usually costly.) The only advantage of the standalone navigation system is that they do not require a network connection to function, which means they can be more effective in remote areas. The future of these standalone navigation aids will depend greatly on the future of ubiquitous networking, cell reception, etc.—the greatest challenge to their continued existence.

In-vehicle Navigation Systems

Most smartphones have voice input, voice search, and auto rerouting capabilities based on traffic conditions. Many new built-in vehicle navigation systems have these capabilities, too. The failing of built-in systems is their lifespan and their abilities to keep pace with other more rapidly changing technology platforms. The lifespan of a vehicle and its electronics can easily be longer than 10 years. Smartphones, tablets, and other mobile devices, however, are replaced usually every two years, on average. Even if the device isn't swapped out or upgraded during those two years, operating systems are updated frequently, and new apps are always being developed, and they can be downloaded, often for free, in just a few minutes.

In-vehicle electronics, as they exist today, are fighting a losing battle. They will always be perceived as old. Users don't appreciate having to pay for multiple data and service plans (one for their phone, one for their home, one for the laptop while in the road, and a final one for the vehicle navigation system). To keep pace with rapidly evolving user demands and technology advancements, it is expected that the more successful vehicle manufacturers will adopt sophisticated docking stations that allow smartphones,

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tablets, and other devices to become the vehicle's infortainment system, providing audio, video, gaming, internet access, and navigation.

SmartPhones, Tablets, and other Mobile Devices

Smartphones and other mobile devices are the current favorite for advancements in TI primarily due to the ease at which new applications can be deployed to powerful networked devices. As soon as new data sources become readily available, developers can innovate and create new applications that are quickly vetted by hundreds of thousands of users.

Advancements in these mobile platforms come quickly. Smaller, increasingly powerful devices, with more accurate GPS, higher quality cameras, longer battery life, and more brilliant displays are developed every few months. Yet, the advancements in TI will be less reliant on hardware, but rather on tighter integration between other services including personal calendars, entertainment, education, and automatic analysis of our travel behavior—estimating our every need without making a single request. For example, the next "killer app" won't be an app at all, but rather an integrated calendar service that 1) knows where you are, 2) knows where you need to be, 3) knows what the conditions are along the way, 4) alerts you when it's time to leave—showing you the best route to take, and 5) automatically reroutes you along the way as conditions change. It should be noted that several of these technologies operate within the smartphone space. While we earlier noted limitations in utilizing smartphone apps, the reader should be mindful of the usefulness of smartphones if the technology allows for safe deployment (e.g., in-vehicle docking with central stack information displays and voice controls).

This type of predictive and personalized information is what we can and should expect in the near future. Imagine the devices in your home (television, alarm clock, coffee maker, bathroom mirror, etc.) all knowing your typical morning ritual. Each knows when you wake up, when you brush your teeth, when you drink your coffee, and when you usually leave for work. Now imagine each of those devices can talk to each other. They share information. They know where you are in your home, if you're running according to your usual schedule, and they even know what the conditions are out on the roads that you'll be driving later that morning.

Imagine this scenario. As you sleep, your devices all become aware of several major accidents along your normal commuter route. Your alarm clock goes off 15-minutes early, knowing that you'll need a little extra time to make it to that meeting on your schedule. As you brush your teeth, your day's itinerary pops up on your bathroom mirror—reminding you of that meeting you have downtown. Your television automatically tunes to a news station that's covering one of the major accidents along your route. Your coffee maker automatically turns itself on early to make sure you're caffeine fix isn't what makes you late. Your phone/nav system keeps monitoring conditions and plans an alternative route that will help you make it on time, even reserving a parking spot for you ahead of time to ensure you don't have to walk in the rain too far given that the weather is forecasting an extra strong thunderstorm in the afternoon. All of this happens without you needing to hit a button, type in a URL, or do any sort of searching/decision making whatsoever. It is all effortless and integrated into your daily life. The technology adjusts to your life, not the other way around.

Augmented Reality

Augmented reality (AR) has been gaining ground recently—mainly as a result of geospatially and directionally aware device proliferation in the marketplace. While AR has often been used for entertainment and educational purposes, there are significant applications for its use within the TI domain that will likely continue to gain traction in the coming years.

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Locating transit stations

The San Francisco transit agency, Bay Area Rapid Transit (BART), is using adopting an AR application provided by Junaio to help improve the experience of its travelers. Transit riders can use the application to navigate their way to stations by holding up their camera phone, pointing it in a direction, and seeing the transit station entrances highlighted on their screens. Similar applications have cropped up in the United Kingdom and in other areas around the United States. Google and Yelp have similar applications for mobile devices that let users locate businesses, restaurants, and other points of interest.

Google, along with many other innovators, is actively developing the next generation of augmented reality devices. Google Glasses ® is a product that that can be worn over one of more eyes that will allow the user to see their surroundings while overlaying additional information on the scene. These wearable devices could provide navigation aids to users while alerting him or her of impending hazards, points of interest, and other relevant information. Most of these wearable AR devices will be integrated with other mobile devices, like phones, so that users will be able to take advantage of calendar integration, voice commands, processing power, etc.

Live data that streams directly in front of your eye via devices like Google Glasses may seem futuristic, but researchers are working on ever more incredible wearable and discreet technology a reality. Linglea (2011) tested out a small contact lens like device that could be inserted into the eye—meaning the user wouldn't even need to wear bulky glasses. The UW researchers demonstrated how such a device could be worn safely by testing it in the eye of a rabbit. Although the prototype contained only a pixel of information, this proof of concept could lead to superimposed TI and AR-like applications in your line of sight.

In-vehicle Head-up Displays

Vehicle manufacturers have been working to develop the types of next-generation head-up displays typically found in the cockpits of sophisticated military airplanes and embed them in passenger vehicles. The technology turns an ordinary windshield into an AR information dashboard. Such systems could improve safety by visually alerting the driver to important objects in physical space such as road signs, pedestrians or animals, and even edges of the road hidden by poor visibility. They could even bring navigation and sophisticated TI directly into the windshield.

These innovative head-up display windshields would use night vision, navigation, and camera-based sensors to gather data relevant to the driver's surroundings, databases of points of interest, and then project corresponding images onto the windshield surface.

Future Driver Interfaces Using AR

How will TI change when vehicles drive themselves? The Aeon Project is a futuristic exploration into the world of augmented reality. A conceptual design and visioning project, Aeon speculates as to what could be the future of automated transportation systems.

One component of the Aeon project is a fully immersive AR system incorporating a navigation overlay which updates itself in real time. The Aeon system brings a unique visual experience to transportation systems. It even allows users to learn about the history and important details of surrounding objects. It is an excellent example of what AR could really mean for the transportation community of tomorrow.

Information backbone

To realize the many visions of future TI systems, various government, private sector, and university partners must work to solidify and make available the various information sources that will be needed to drive advanced applications (See Figure 17). While many private sector entities are working to generate

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their own crowd-sourced speed and incident data sources, these entities view these data as highly proprietary because of the time and energy that was put into collecting it for their own applications.

True innovation and competition will only begin to rapidly expand TI options if and when government entities pool their resources to collect and/or pay for the integration of these many disparate data sources—making these data publicly and freely available to developers. Doing so will spur innovation, business opportunities, growth, and further the government's mission of providing timely and accurate information to the public and business for the purpose of increasing safety and mobility—ultimately creating significant economic benefits for all involved.

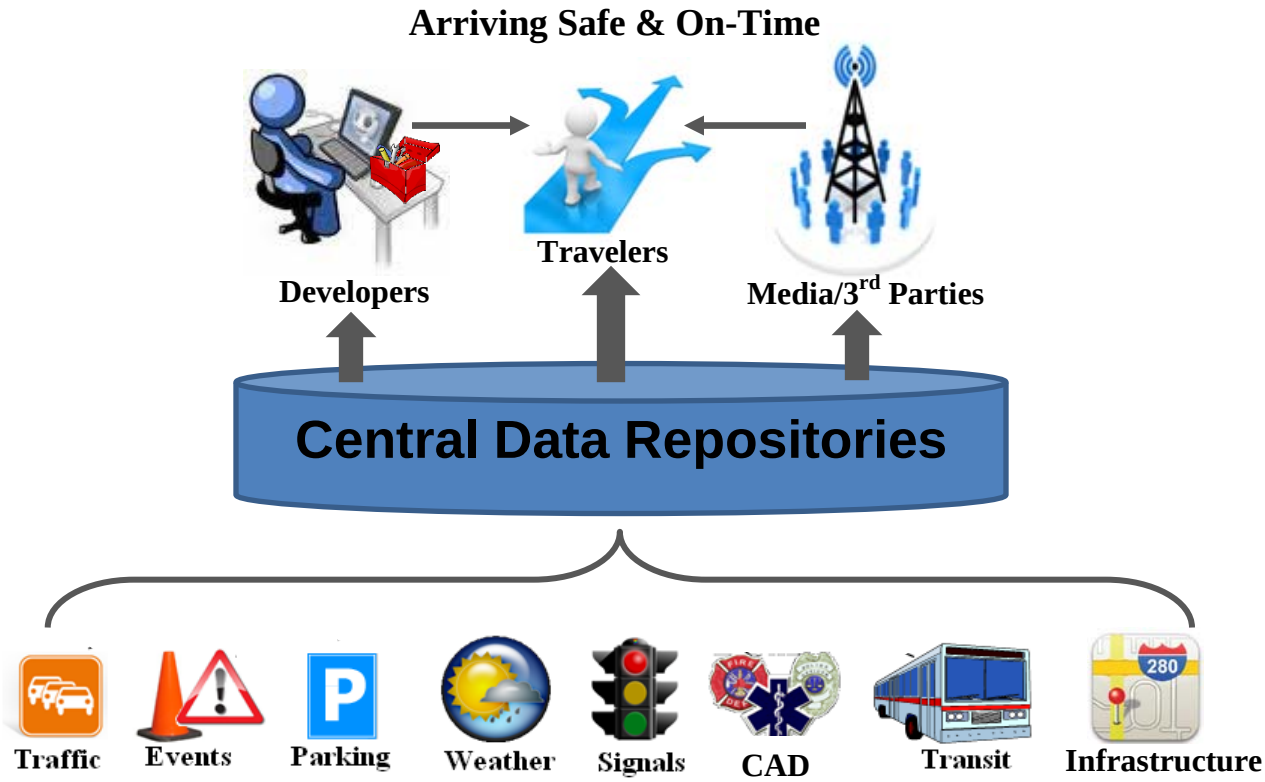

Figure 17. Information infrustructure and real-time traveler applications.

Many transit agencies are working towards a national repository of real-time transit AVL and schedule information through their adoption of the Google Real-time Transit Feed. As agencies conform to this standard, 3rd party developers can more easily tap into each of these independent feeds in a uniform manner—making it significantly easier to deploy applications to large audiences across the entire country. The highway system, however, has no such standard or central repository system which makes it exponentially more difficult to develop regional and national traveler applications.

Researchers at the University of Maryland are working hard to create the information backbone of just such a national system. They are slowly making the business case for better data collection, integration, and open access to each and every state and local DOT or related transportation agency. The data they are collecting is being integrated into an open access 3rd party developer toolkit. This toolkit will allow independent application developers and other businesses to tap into a national data warehouse of real-time TI. Though still in development with only about 35% of the country being covered, the system is gaining traction and popularity among the business community.

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References

Adler, J. 2001. "Investigating the learning effects of route guidance and traffic advisories on route choice behavior." *Transportation Research Part C, 9,1,* 1-14.

Anderson, M., & Souleyrette, R. 2002. "Pseudo-dynamic travel model application to assess traveler information." *Transportation, 29,3,* 307-319.

Cambridge Systematics, Inc. 2005. *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation.* Washington, DC: Federal Highway Administration.

Casas, I., & Kwan, M. 2007. "The impact of real-time information on choices during the commute trip: Evidence from a travel simulator." *Growth and Change, 38,4,* 523-543.

Chen, W., & Jovanis, P. 2003. "Analysis of driver en-route guidance compliance and driver learning with ATIS using a travel simulation experiment*." Presented in the Annual Meeting of the Transportation Research Board*, Washington, D.C.

Chorus, C., Molin, E., Arentze, T., Hoogendoorn, S., Timmermans, H., & Wee, B. 2007. "Validation of a multimodal travel simulator with travel information provision." *Transportation Research Part C, 15,3,* 191-207.

Dia, H. 2002. "An agent-based approach to modelling driver route choice behaviour under the influence of real-time information." *Transportation Research Part C, 10,5,* 331-349.

Florian, D. 2004. *Simulation-Based Evaluation of Advanced Traveler Information Systems (ATIS).* Massachusetts Institute of Technology.

Hu, H. 2009. *Measuring the Effectiveness of Advanced Traveler Information Systems (ATIS).* Raleigh: North Carolina State University.

Jayakrishnan, R., McNally, M., & Cohen, M. 1993. "Simulation of Advance Traveler Information System Strategies to Reduce Non-Recurent Congestion from Special Events". *Publication of: California University, Irvine* .

Kristof, T., Lowry, M., & Rutherford, G. 2005. "*Assesing the benefits of traveler and transportation information systems."* Washington State DOT.

Lerner, N., Singer, J., Robinson, E., Huey, R., and Jenness, J. 2009. "Driver use of en route real-time travel time information: Final report" (Prepared for Federal Highway Administration). Available at: http://tmcpfs.ops.fhwa.dot.gov/index.cfm

Levinson, D. 2003. "The value of advanced traveler information systems for route choice." *Transportation Research Part C, 11,1,* 75-87.

Lingley, A.R., Ali, M., Liao, Y., Mirjalili, R., Klonner, M., Sopanen, M., Suihkonen, S., Shen, T., Otis, B.P., Lipsanen, H., & Parviz, B.A. 2011. "A single-pixel wireless contact lens display." *Journal of Micromechanics and Microengineering, 12,12.*

Mahmassani, H., & Liu, Y. 1999. "Dynamics of commuting decision behaviour under advanced traveler information systems". *Transportation Research Part C, 7,2/3,* 91-107.

Martin, P., Lahon, D., Cook, K., & Stevanovic, A. 2005. *Evaluation of UDOT's ATIS Technologies.* Salt Lake City: Utah Department of Transportation.

Robinson, E., Lerner, N., Singer, J., Jenness, J., and Huey, R. 2011. "En route real-time travel time information: Experimental evaluation of display characteristics." *Proceedings of the 18th World Congress on Intelligent Transport Systems (Paper No. 3037),* Orlando, FL.

Schofer, J., Khattak, A., & Koppelman, F. 1993. *Behavioral Issues in the Design and Evaluation of Advance Traveler Information Systems.* Great Britain: Pergamon Press Ltd.

Swan, N., Baker, S., Hintz, R., & Trimble, T. 2004. *511 Virginia evaluation*. Prepared for Virginia Department of Transportation. Blacksburg, VA: Virginia Tech Transportation Institute.

Thakuriah, P., & Sen, A. 1996. "Quality of information given by advanced traveler information systems". *Transportation Research Part C, 4,5,* 249-266.

U.S. Department of Transportation. 2004. *Welcome to the U.S. Department of Transportation Intelligent Transportation Systems.* USDOT.

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Wang, X., Khattak, A., & Fan, Y. 2009. "Role of dynamic information in supporting changes in travel behavior." *Transportation Research Record, 2138,* 85-93.

Wunderlich, K., Hardy, M., Larkin, J., & Shah, V. 2001. *On-Time Reliability Impacts of Advanced Traveler Information Services (ATIS): Washington, DC Case Study*. Washington, DC: Federal Highway Administration.

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APPENDIX A

Traveler Information Availability

SOURCES	Detroit	Teaneck, NJ	Orlando	Salt Lake City	San Francisco	Washington, DC (Rockville, MD)
511 phone call		x	x	x	x	x
Electronic highway message signs	x	x	x	x	x	x
Electronic local roadway message signs			x	x		
Email, text messages (subscription based)	x	x	x	x	x	x
Highway advisory radio	x	x	x	x	x	x
Mobile Smartphone "apps" (Iphone or Droid)	x	x	x	x	x	x
On-board devices (e.g. Garmin, Tom-Tom, Onstar)	x	x	x	x	x	x
Radio	x	x	x	x	x	x
Social media sites (e.g. Twitter)	x	x	x	x	x	x
Television	x	x	x	x	x	x
Websites (using a laptop or desktop)	x	x	x	x	x	x
Websites via mobile devices	x	x	x	x	x	x

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TYPES	Detroit	NYC (Teaneck, NJ)	Orlando	Salt Lake City	San Francisco	Washington, DC, (Rockville, MD)
Alternate routes						
Live traffic cameras	x	x	x	x	x	x
Parking availability		x	x		x	x
Public safety information (Amber or Silver alerts)	x	x	x	x	x	x
Roadwork/ construction zones	x	x	x	x	x	x
Safety information ("Buckle-up", "Signal when changing lanes")	x	x	x	x	x	x
Special events		x	x	x	x	x
Traffic incidents	x	x	x	x	x	x
Travel times	x	x	x	x	x	x
Weather information	x	x	x	x	x	x

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APPENDIX B

Public Agency Survey

Deployment, Use, and Effect of Real-Time Traveler Information Systems Public Agency Web-based Survey

Question 1. What real-time traveler information does your agency disseminate to the traveling public? (Please check all that apply and provide additional information as necessary in the space provided.)

Answer Options	Response Percent	Response Count
Roadway travel condition status (e.g., traffic map of current speeds)	85.1%	40
Roadway CCTV video	87.2%	41
Traffic incidents	91.5%	43
Travel times	68.1%	32
Alternate routes	29.8%	14
Parking availability	2.1%	1
Roadwork / Construction Zones	93.6%	44
Transit alternatives	34.0%	16
Special Events	70.2%	33
Weather information	74.5%	35
Public Safety information (e.g., Amber Alerts, Silver Alerts, etc.)	80.9%	38
Safety information (e.g., "Buckle Up", "Signal When Changing Lanes", etc.)	59.6%	28
Other (please specify) or Comment		15
answered question		**47**
skipped question		**0**

Other:

1. Roadway CCTV is disseminated to the media by subscription. They make it available to the public; however, the entire state is not necessarily covered.
2. Ferry schedules, Mountain Pass Closures and winter driving conditions, Active Traffic Management System on select corridors.
3. Weather information is limited to weather conditions affecting traffic. Parking availability is forthcoming later this year and will include real-time availability.
4. You don't specify the method of data sharing: internet, phone or roadside devices. I am assuming you mean all three and have answered accordingly.

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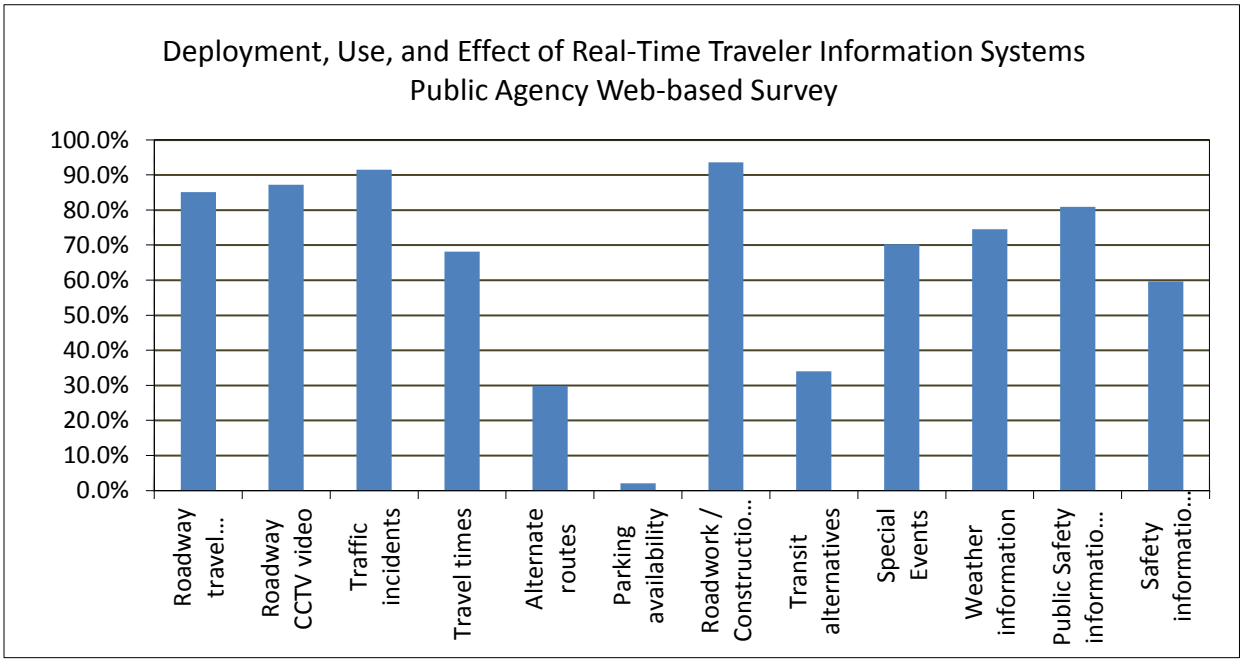
5. Not all of this information is available in all formats. For example; Travel Times are disseminated via our DMS. Access to Transit information is available only through a 511 transfer. But those checked above are disseminated to the public via one system or another.
6. AASHTO leads the 511 Deployment Coalition, which is a group of states deploying and operating real time information systems through the web, message signs and personal devices such as cell phone.
7. We provide transfers through our 511 system to public transportation, ferry, and rail agencies. We also provide real-time ferry information.
8. Homeland Security Messages.
9. CMS info.
10. Road conditions and chain requirements - Travel services.
11. Winter Road Conditions-by specific roadway and segment, Dynamic Message Sign messages, and Customized emergency alerts, specific to traffic impacts
12. We also provide transfers/links to information on seaports, airports, commuter services, tourist agencies and other 511 systems. We provide congestion information and disseminate emergency information regarding road closures, evacuation routes, and shelter openings and closings.
13. We also provides links to and/or transfers to seaports and airports, commuter services, tourist agencies and other 511 systems. We provide an emergency information page on our web site to provide information to the motorists on road closures, evacuation routes, alternate routes and shelter openings and closings. We also provide information on congestion over what a motorist can glean from the travel time/speed information provided.
14. In the next few months we'll be adding Travel Times, but currently do not do this. DMS messages, and winter road conditions
15. Safety information only as requested and funded by the Governor's Safety Office



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Question 2. Please indicate why your agency disseminates this real-time traveler information to the traveling public (check all that apply):

Answer Options	Response Percent	Response Count
Providing this information is part of our agency's overall demand management strategy	72.3%	34
This information allows the traveling public to make better travel decisions	97.9%	46
The literature and past research indicate that providing this information to the traveling public is an effective demand management strategy	57.4%	27
We have evaluation data that demonstrates the benefits of providing this information to the traveling public	29.8%	14
We have an ongoing program for evaluating the provision of traveler information to the public	40.4%	19
Other agencies like ours are providing this information to the traveling public	63.8%	30
Federal Highway Administration guidance and encouragement	66.0%	31
Federal Highway Administration notice of the Final Rule on Real-time System Management Information Program	46.8%	22
Other (please specify)		4
answered question		**47**
skipped question		**0**

Other:

1. Safety for the traveling public is our #1 reason; the Final Rule has not been a reason in the past, but will become a reason in the future.
2. Helping the public make informed travel decisions
3. Traveler information system puts the power of knowledge in the "hands" of the motorist so they can avoid problem areas and help reduce congestion. This knowledge allows the motorist to assess their travel before leaving to better plan their commute by providing them the information they need to plan what route to take, time to leave and mode to take. Getting information en route limits the motorist's options.
4. It keeps our first responders safer if the public knows about traffic incidents to avoid or winter road conditions.

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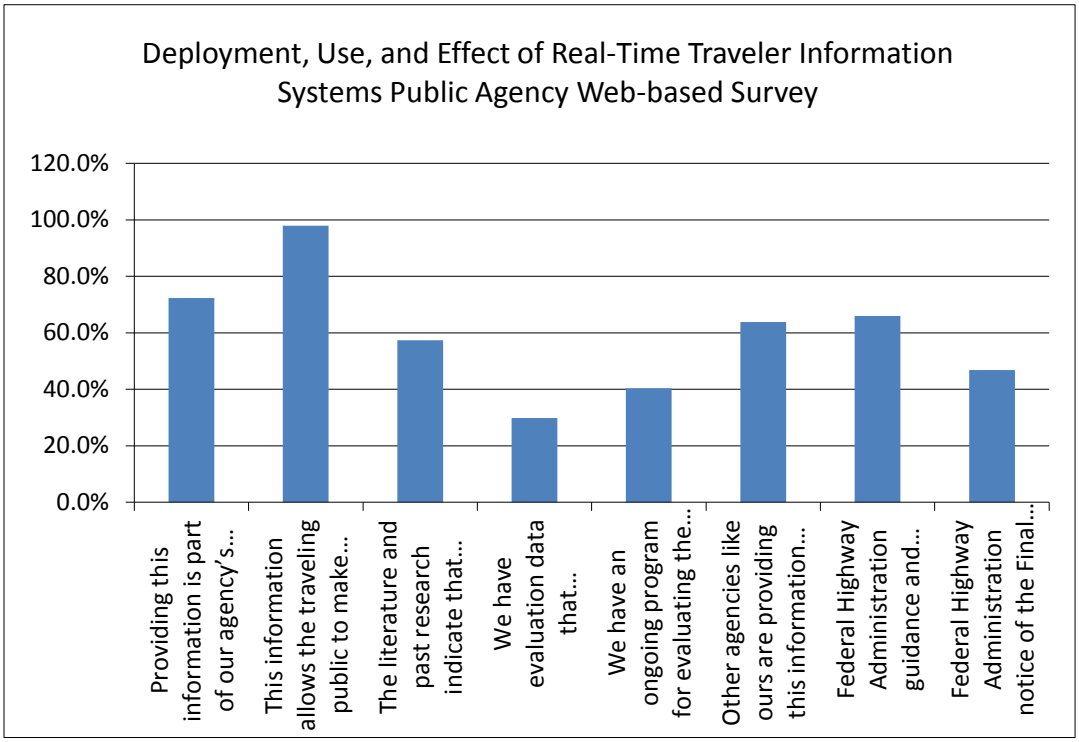

Question 3. Please indicate your perceptions of the importance of each type of traveler information your agency provides to the public in terms of meeting agency program goals. (Note: Please rate only those you selected in Question 1, select N/A if not used.):

Answer Options	Very effective	Effective	Somewhat effective	Not effective	N/A	Rating Average	Response Count
Roadway travel condition status (e.g., traffic map of current speeds)	17	20	5	0	4	3.29	46
Roadway CCTV video	25	16	2	1	2	3.48	46
Traffic incidents	22	20	3	0	0	3.42	45
Travel times (e.g. current travel times to major destinations or interchanges)	13	18	2	0	11	3.33	44
Alternate routes	7	6	6	1	16	2.95	36
Parking availability	2	3	0	0	27	3.40	32
Safety information (e.g., "Buckle Up",	3	8	17	1	12	2.45	41

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"Signal When Changing Lanes", etc.)							
Special Events	10	20	7	0	5	3.08	42
Weather information	13	18	7	0	5	3.16	43
Public Safety information (e.g., Amber Alerts, Silver Alerts, etc.)	10	18	10	1	3	2.95	42
Roadwork / Construction Zones	19	23	3	0	0	3.36	45
Transit alternatives	4	5	8	3	16	2.50	36
Other (please specify)							1
answered question							**47**
skipped question							**0**

Other:

1. In California we rely on regional 511 agencies, media and the private sector

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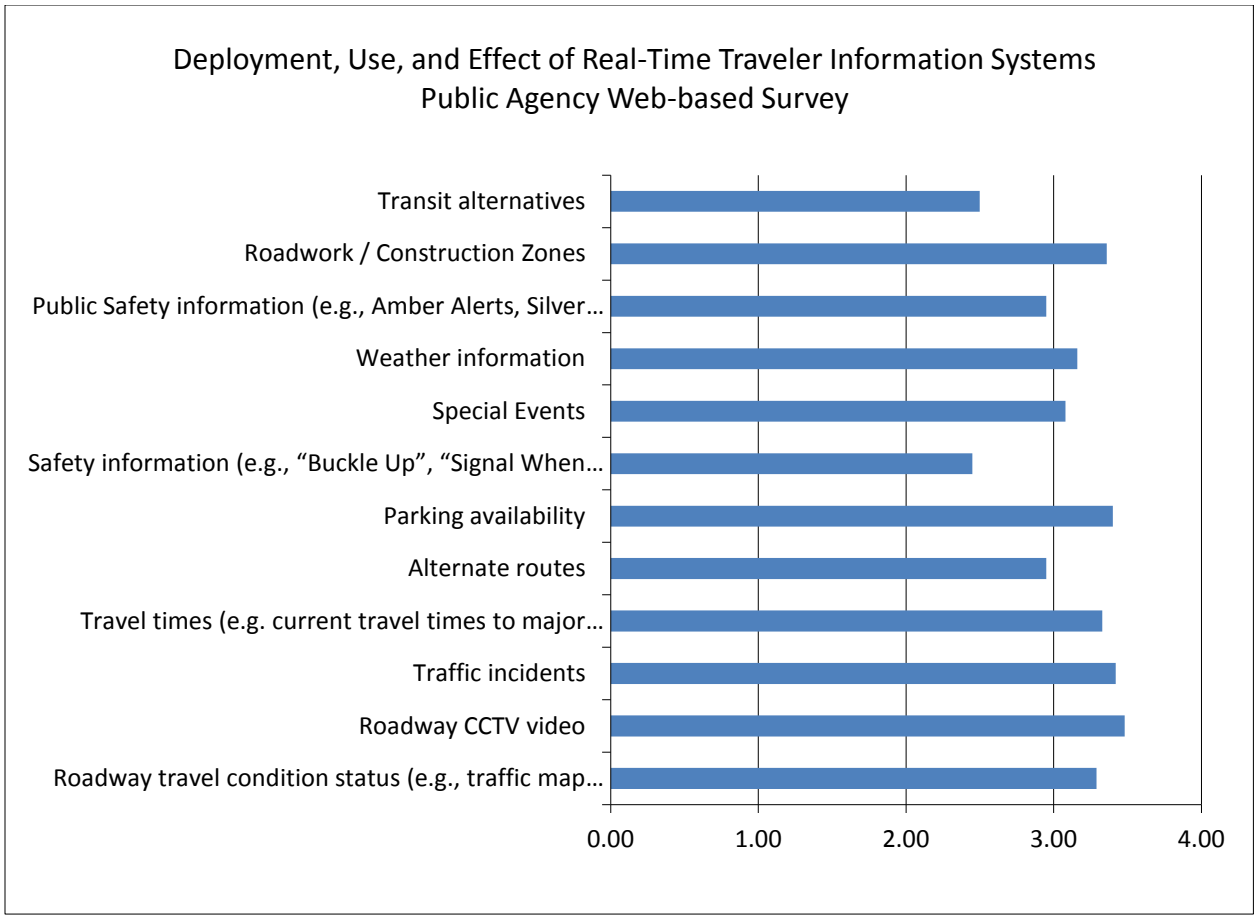

Question 4. How is this information disseminated to the traveling public? (Please check all that apply)

Answer Options	Response Percent	Response Count
Highway dynamic message signs	93.2%	41
Arterial dynamic message signs	56.8%	25
Highway advisory radio	70.5%	31
511 System (defined as land line or mobile call-in system with intelligent voice recognition (IVR) that allows menu driven access to real-time traveler information)	81.8%	36
Websites (accessed through a desktop or laptop)	95.5%	42
Social media sites	59.1%	26
Websites (accessed via mobile device)	84.1%	37
"Apps" (e.g., travel info related iPhone or Droid applications)	27.3%	12

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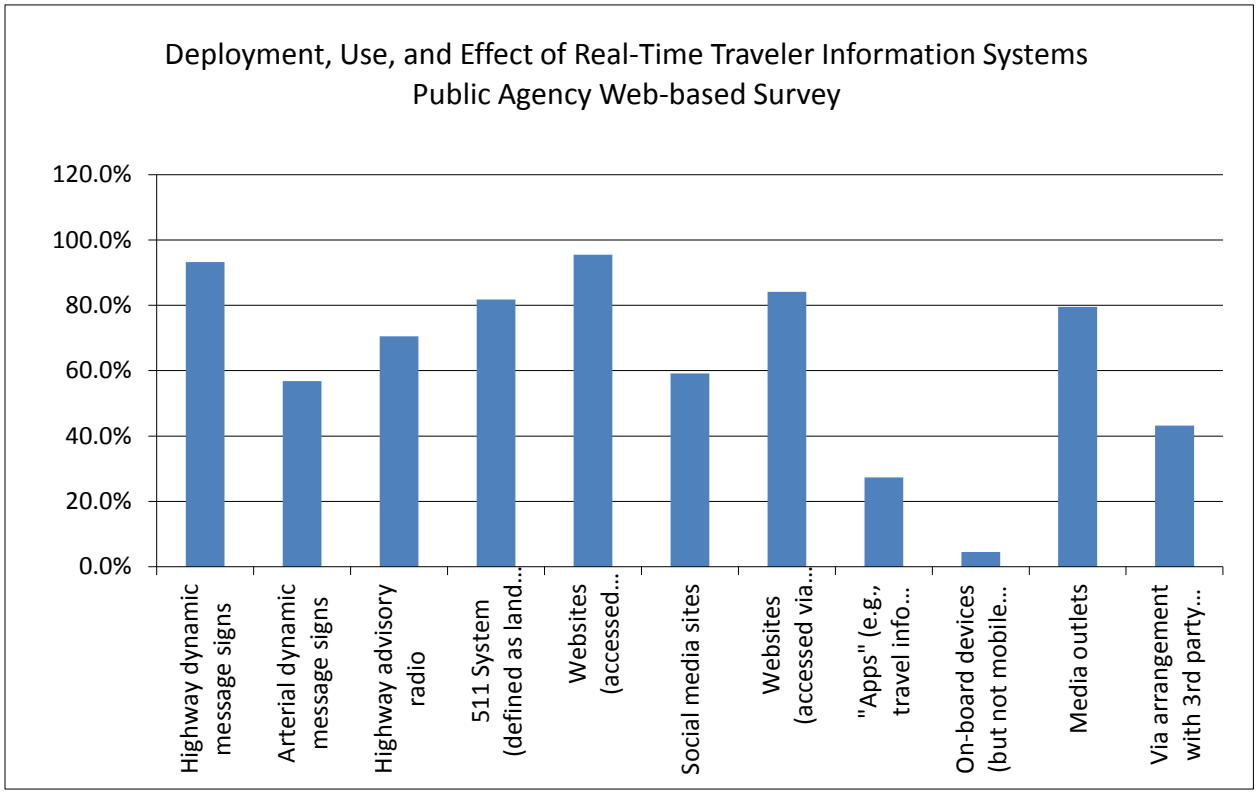
On-board devices (but not mobile devices)	4.5%	2
Media outlets	79.5%	35
Via arrangement with 3rd party traveler information providers	43.2%	19
Other (please specify)		3
answered question		**44**
skipped question		**3**

Other:

1. Our 511 will be online in a couple of months, Our information is also disseminated via third party which address those items not checked.
2. We have a data feed we make available to third party traveler information providers. We are in the process of developing the use of social media to provide traffic information and to market our system. We also will be deploying an iPhone application to provide location based information.
3. In the next month or so we'll be launching our 511 events on Twitter.



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Question 5. Please indicate why your agency has chosen the dissemination methods listed under Question 4 (Please check all that apply):

Answer Options	Response Percent	Response Count
We are taking advantage of the latest information dissemination technology/technologies	84.1%	37
The literature and past research indicates that these are effective dissemination methods	63.6%	28
We have evaluated the effectiveness of these information dissemination methods	36.4%	16
We have an ongoing program for evaluating effectiveness of these information dissemination methods	29.5%	13
Other agencies are providing traveler information via these dissemination methods	59.1%	26
Federal Highway Administration guidance and encouragement	61.4%	27
Federal Highway Administration notice of the Final Rule on Real-time System Management Information Program	40.9%	18
Other (please specify)		7
answered question		**44**
skipped question		**3**

Other:

1. As in previous question, the FHWA Final Rule on RTMIP has not been why in the past but will be in the future.
2. Cost-effectiveness is a factor in deciding which dissemination mechanisms to use. We have hesitated to develop apps because they are expensive to develop and maintain.
3. Skip.
4. We are currently undergoing a study to evaluate the effectiveness of our information dissemination.
5. That's as far as we have been able to get with the funding available
6. It is important for us to reach as many people with our information as possible so we look to utilizing as many dissemination methods as are available.
7. We do what we do as it has shown that it gets the information out. We are in need of adapting to new "push" mechanisms, which we are now evaluating.

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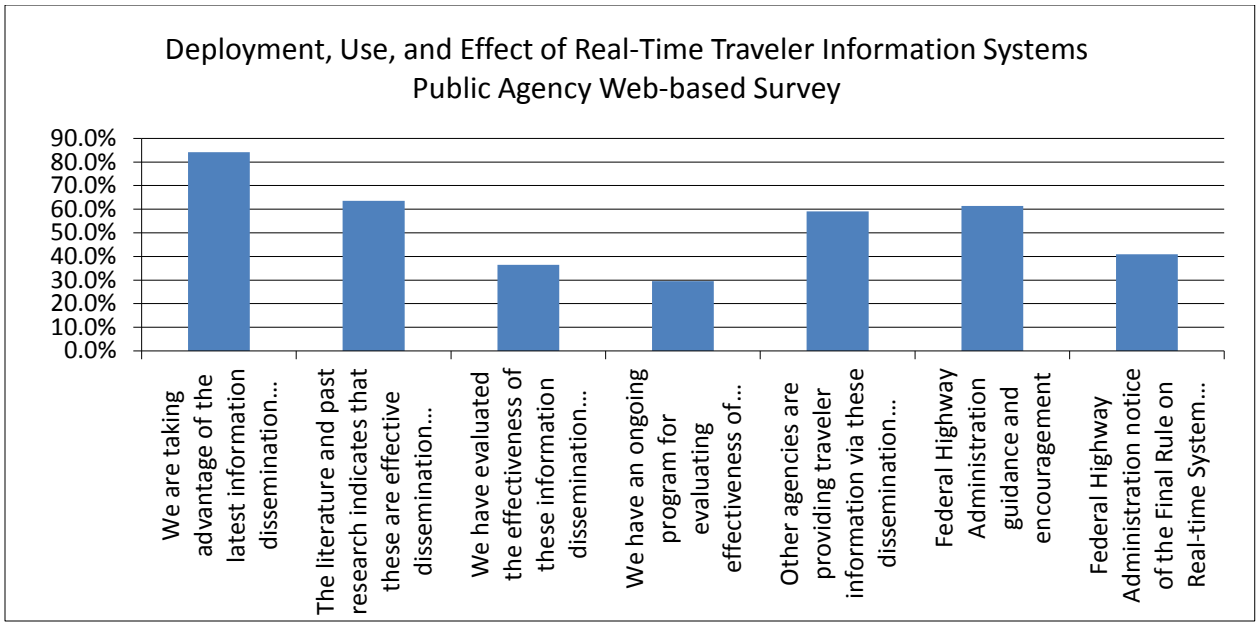

Question 6. Please indicate your perception of the overall effectiveness of each of the following methods for disseminating traveler information to the public in terms of providing benefits to the traveling public (Note: Please rate only those you selected in Question 4, select N/A if not used):

Answer Options	Not effective	Somewhat effective	Effective	Very effective	N/A	Rating Average	Response Count
Highway dynamic message signs	1	2	7	32	1	1.33	43
Arterial dynamic message signs	1	1	13	12	13	1.67	40
Highway advisory radio	2	19	11	4	8	2.53	44
511 System (defined previously)	1	3	17	18	1	1.67	40
Websites (accessed through a desktop or laptop)	2	1	11	27	0	1.46	41
Via arrangement with 3rd Party traveler information providers	1	2	9	14	12	1.62	38
Social media sites	3	5	14	9	9	2.06	40
Website access via mobile device	2	5	14	18	3	1.77	42
"Apps" (e.g., travel info related iPhone or Droid applications)	2	3	5	9	17	1.89	36
On-board devices (not mobile)	2	2	5	4	22	2.15	35
Commercial radio and TV	1	3	13	17	3	1.65	37

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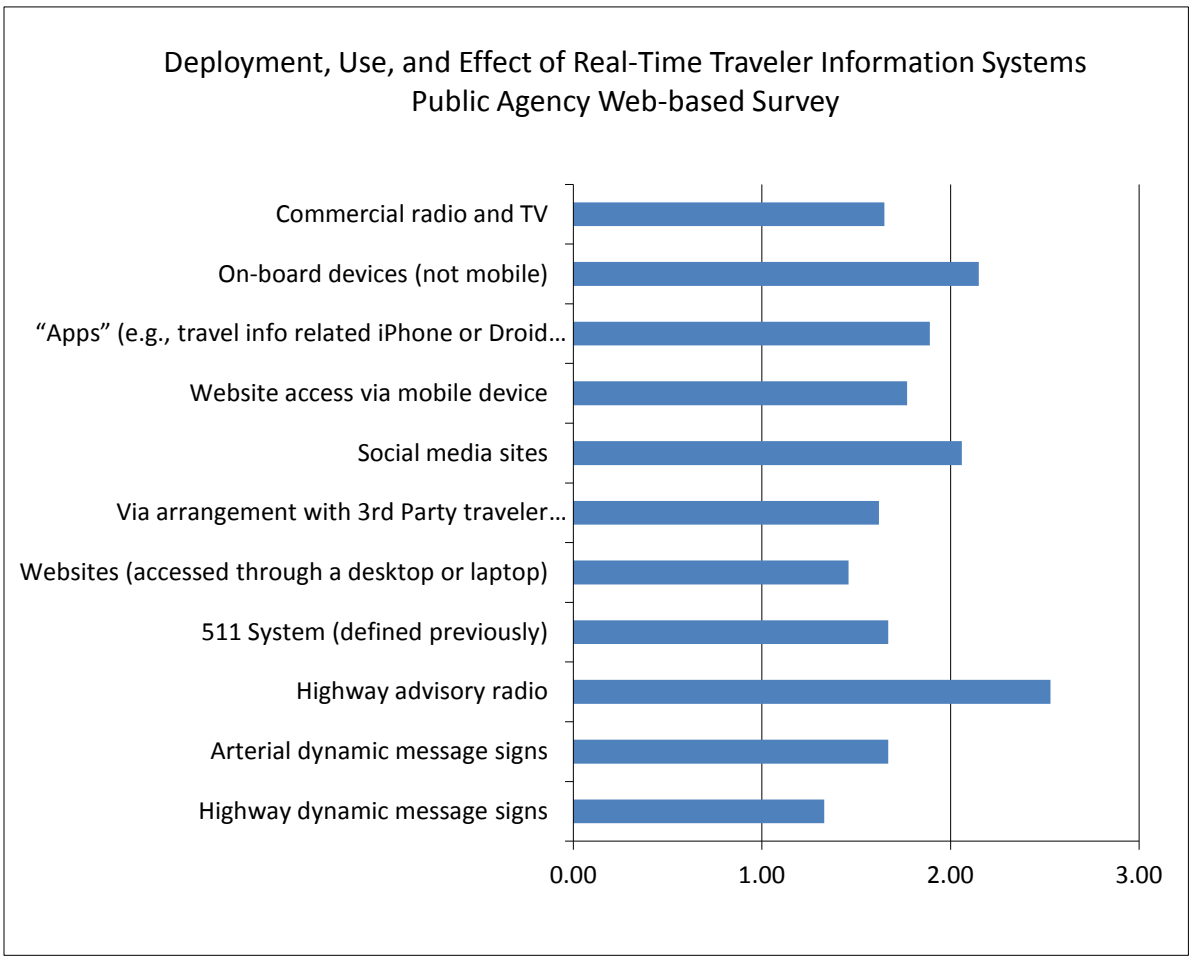
Other (please specify)	1
answered question	44
skipped question	3

Other:

1. See comments above related to boxes unchecked



Question 7. Part A. Please indicate the evaluation techniques and/or inputs used by your agency (Please check all that apply):

Answer Options	Response Percent	Response Count
Traveler surveys (If you select this option, please also select an applicable italicized option below.)	61.5%	24

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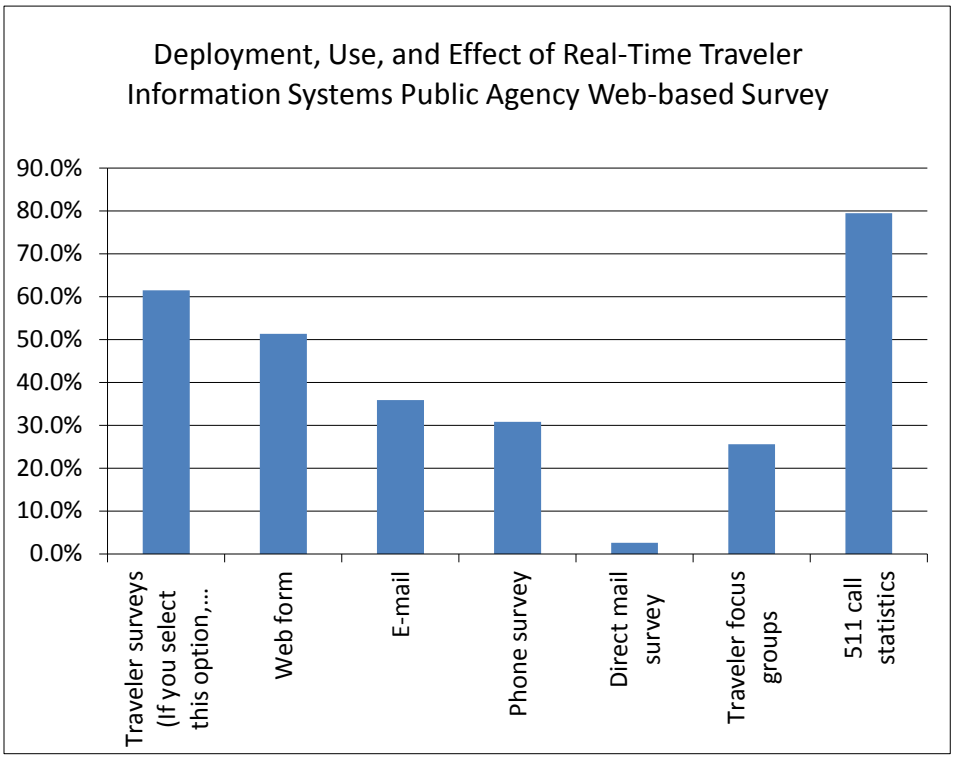
Web form	51.3%	20
E-mail	35.9%	14
Phone survey	30.8%	12
Direct mail survey	2.6%	1
Traveler focus groups	25.6%	10
511 call statistics	79.5%	31
Other (please specify)		6
answered question		**39**
skipped question		**8**

Other:

1. We have U of M currently conducting studies using various evaluation techniques.
2. We will be implementing a survey shortly. We also allow user feedback on the phone and web without an actual survey.
3. 511 web statistics.
4. Our system has a feedback function where callers can leave feedback on how the system is working and to report traffic. This function is well used and we have made some modification to how the system operated based on this feedback.
5. Use of Twitter for public input. Web use tracking and statistics. Use of web surveys and focus groups is not done on a regular basis.
6. Website traffic via Google Analytics.



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Question 7. Part A Continued. Agency specific sponsored research initiatives (please indicate any/all specific types of traveler information that have been or are being evaluated by your agency):

Answer Options	Response Percent	Response Count
Roadway travel condition status (e.g., traffic map of current speeds)	64.1%	25
Roadway CCTV video	43.6%	17
Traffic incidents	66.7%	26
Travel times	59.0%	23
Alternate routes	20.5%	8
Parking availability	17.9%	7
Roadwork / Construction Zones	46.2%	18
Transit alternatives	17.9%	7
Special Events	25.6%	10
Weather information	38.5%	15
Public Safety information (e.g., Amber Alerts, Silver Alerts, etc.)	23.1%	9
Safety information (e.g., "Buckle Up", "Signal When Changing Lanes", etc.)	30.8%	12
Other (please specify)		10
answered question		**39**
skipped question		**8**

Other:

1. Not clear on what is being asked
2. 511 system at a high level, general level
3. http://www.ncdot.org/doh/preconstruct/tpb/research/download/2006-13FinalReport.pdf
4. None
5. None
6. At this point, evaluation is limited to statistics available for call volumes, web stats, and Twitter followers. No formal information content evaluation is currently being done.
7. Dynamic Truck Parking Info research project
8. We don't have any formalized research efforts going, but we do track and categorize the feedback we receive and utilize that information to improve the operation of the system, which provides information on the checked boxes above.
9. I am not clear if your perspective of "being evaluated" refers to rigorous analysis or ongoing performance reporting. My responses are based on what we do related to ongoing performance reporting.
10. None

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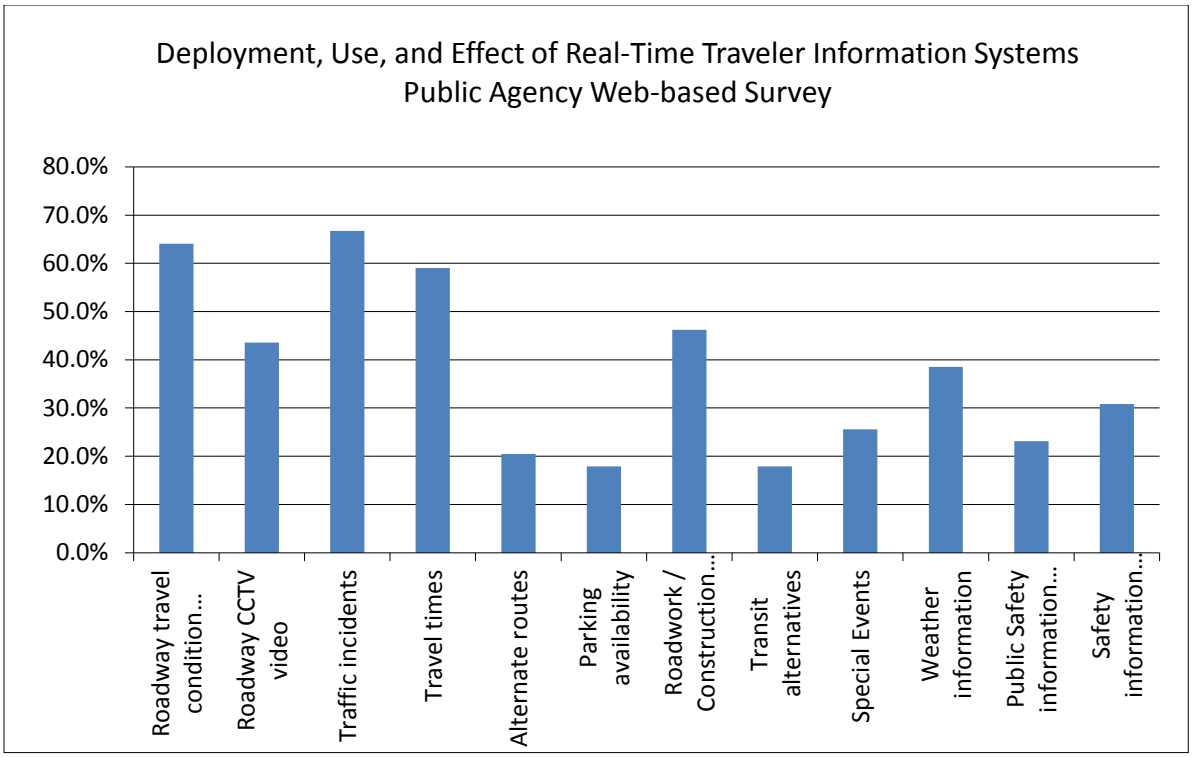

Question 7. Part B. Please indicate the traveler information components that are assessed when your agency evaluates the public's use of the information it disseminates (Please check all that apply).

Answer Options	Response Percent	Response Count
Type of information	69.4%	25
Information quality [Note: specific criteria have been established in the Final Rule for establishment of a Real-time System Management Information Program] (If you select this option, please also select an applicable italicized option below.)	66.7%	24
Information Timeliness	66.7%	24
Information Accuracy	75.0%	27
Information Availability	66.7%	24
Information Accessibility (If you select this option, please also select an applicable italicized option below.)	72.2%	26
Dynamic Message Signs	47.2%	17
Highway Advisory Radio	27.2%	10

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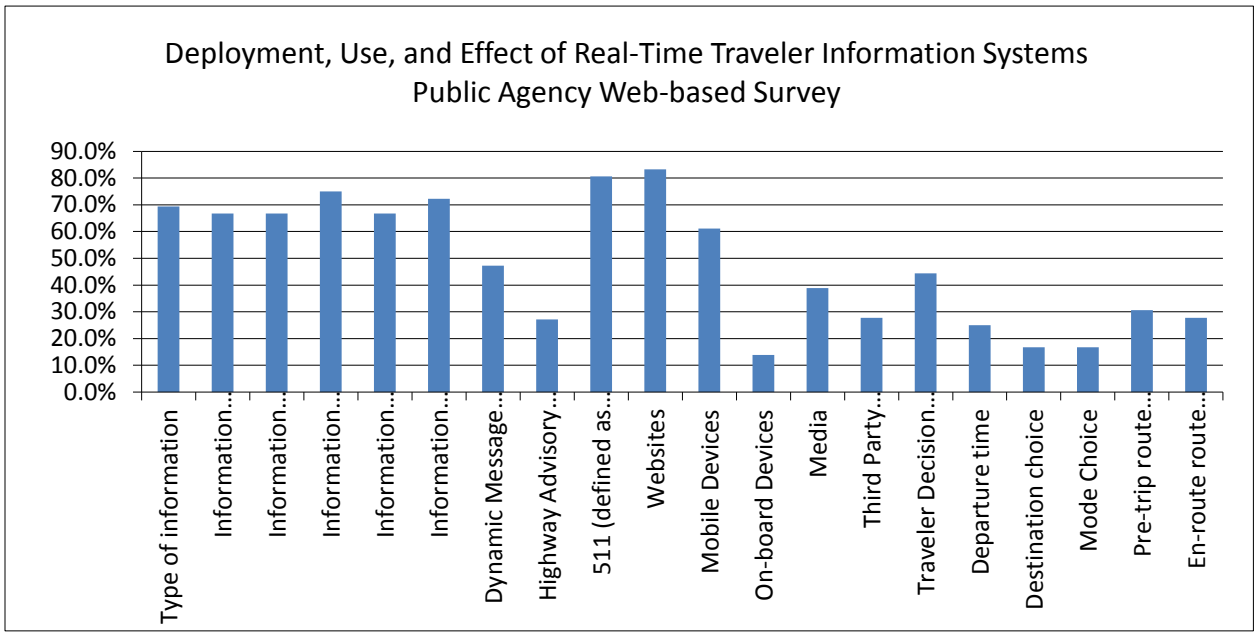
511 (defined as land line or mobile call-in system with Intelligent Voice Recognition that allows menu driven access to real-time traveler information)	80.6%	29
Websites	83.3%	30
Mobile Devices	61.1%	22
On-board Devices	13.9%	5
Media	38.9%	14
Third Party Providers	27.8%	10
Traveler Decision Making (If you select this option, please also select an applicable italicized option below.)	44.4%	16
Departure time	25.0%	9
Destination choice	16.7%	6
Mode Choice	16.7%	6
Pre-trip route choice	30.6%	11
En-route route choice	27.8%	10
Other (please specify)		3
answered question		**36**
skipped question		**11**

Other:

1. Route choice.
2. We track what the traveler is asking for, that is what facilities gets the most calls to check on travel conditions, what time of day are peak periods, what area of the state gets the most calls, etc.
3. For Traveler Decision Making we also assess and provide travel reliability information.



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Question 7. Part C. Please indicate the performance measures that have been or are currently being used to assess the impacts of your traveler information program on the operational efficiency of your transportation system. In particular, please identify any specific evaluations you have conducted on the effectiveness of the real-time information you disseminate and how those results may be accessed. (Please check all that apply and provide additional information as necessary in the space provided):

Answer Options	Response Percent	Response Count
Vehicle-hours of delay	34.4%	11
Person-hours of delay	3.1%	1
Travel time	65.6%	21
Speed	43.8%	14
Throughput	25.0%	8
Travel time index	21.9%	7
Planning time index	6.3%	2
Buffer index	6.3%	2
Duration of congestion	40.6%	13
Cost-benefit or return on investment	40.6%	13
Other (please specify) or Comment		9
answered question		**32**
skipped question		**15**

Other:

1. N/A
2. Ignore checked box, but I had to check something to continue....we have no existing performance measures and are currently working on them.
3. Incident Duration
4. Currently, there are no performance measures in place for traveler information program. However, we are working on using Travel Times, Travel Time Index, and Cost-Benefit for prioritization of projects (all types). The goal is to assess if the assumed result (i.e. reduce travel demand by 5 percent for DMS placement) is an actual result.
5. While we use some of these measures, we haven't tried to tie them to traveler information
6. None at this time, but plan to in future.
7. We don't have any performance measures that we can turn to that will indicate what benefit (what part of the total benefit) can be attributed to traveler information in improving operational efficiencies.
8. Please disregard this answer. The survey is requiring an answer for me continue, but you did not offer a "none of the above" option.
9. None

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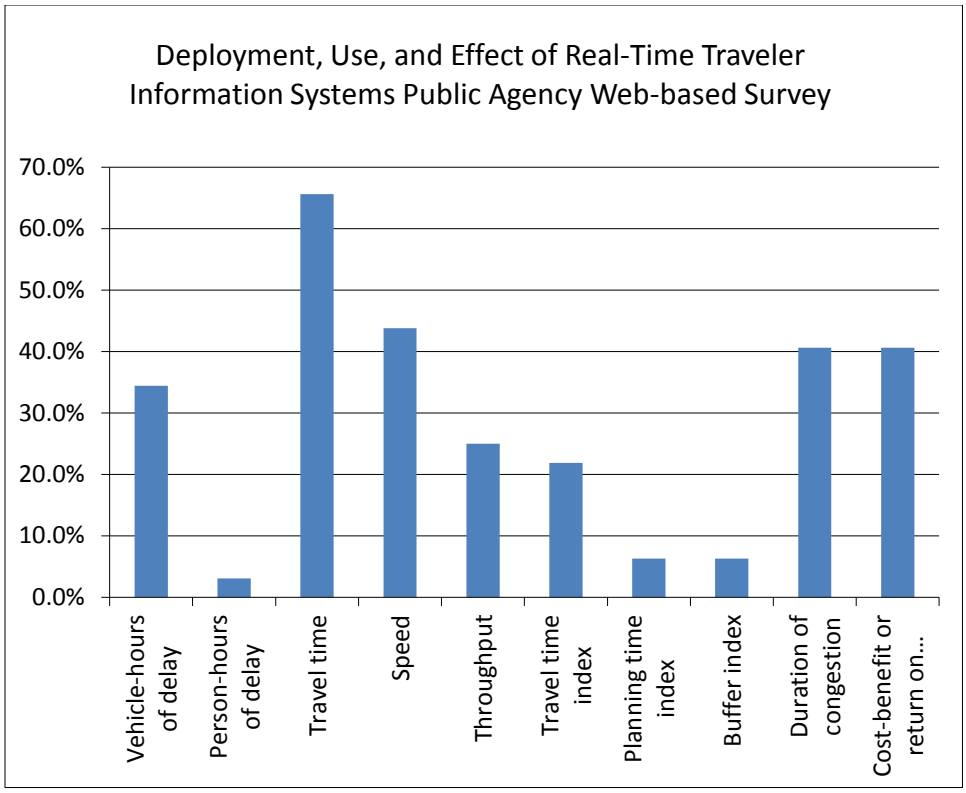

Question 8. What are the two biggest factors hindering your agency's ability to effectively evaluate your traveler information program?

Answer Options	Response Percent	Response Count
Funding to support evaluation related work	53.1%	17
Gathering required input data from the public	37.5%	12
Determining how best to evaluate the many components of a traveler information program	59.4%	19
Lack of guidance and technical support	18.8%	6
Difficulty/cost of measuring actual operational impacts	65.6%	21
answered question		**32**
skipped question		**15**

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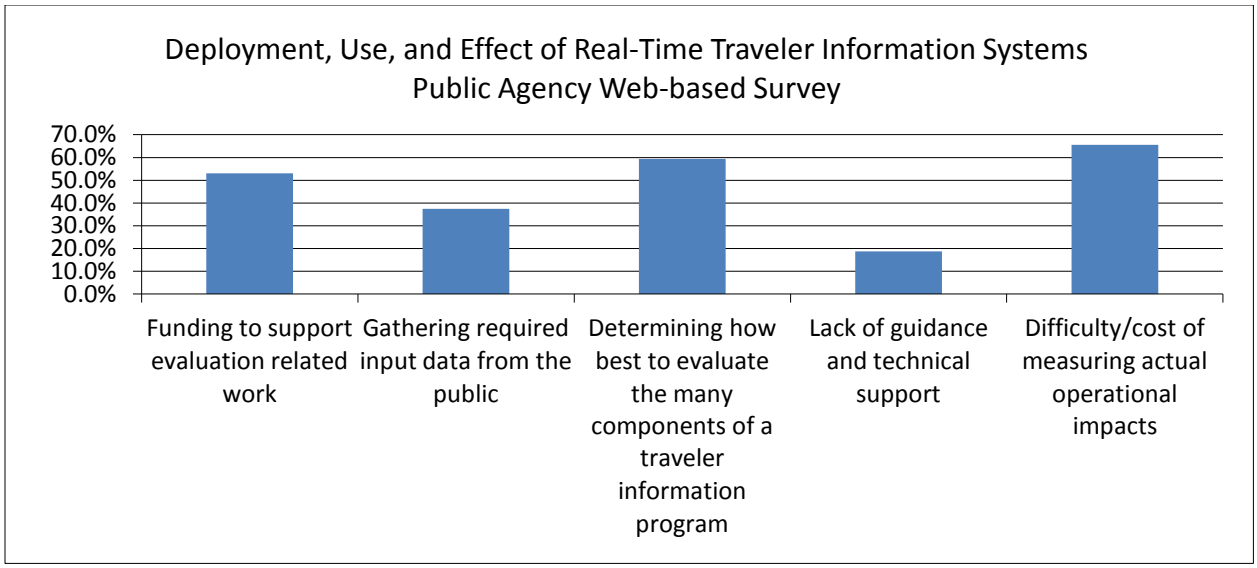
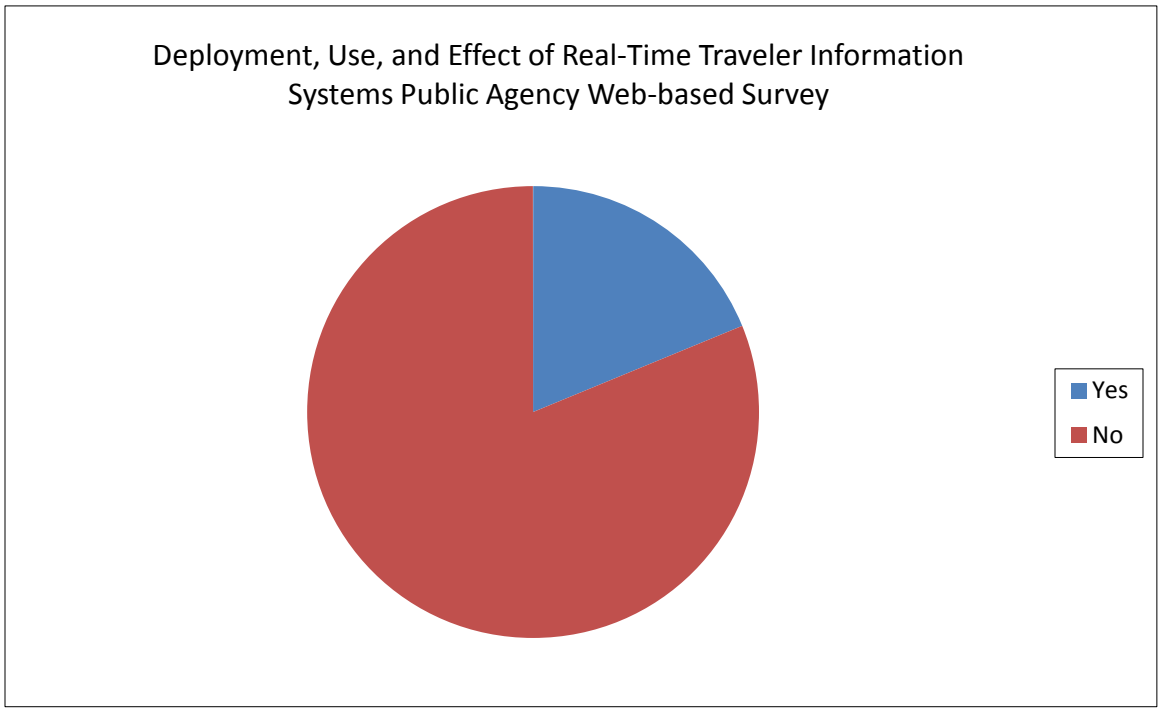


Question 9. Is there any way in which you feel the practices of your agency are unique compared to typical practices with respect to providing traveler information?

Answer Options	Response Percent	Response Count
Yes	18.8%	6
No	81.3%	26
answered question		**32**
skipped question		**15**



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Question 10. If you answered yes, please describe the practice(s) and what makes it (them) unique.

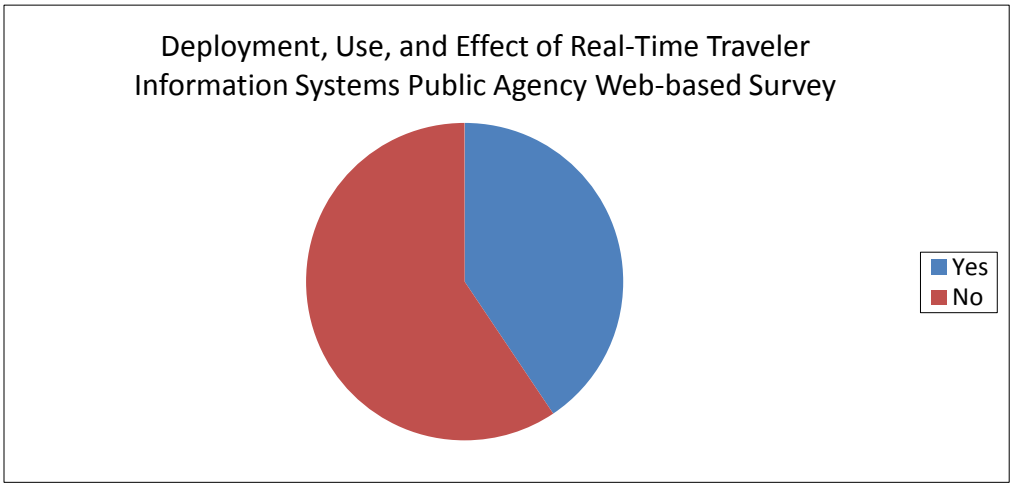
Answer Options	Response Count
	6
answered question	**6**
skipped question	**41**

Answers:

1. Please reference our annual comprehensive congestion report here: http://www.wsdot.wa.gov/Accountability/Congestion/2010.htm And our quarterly performance measures with information about travel information starting on page 22: http://www.wsdot.wa.gov/Accountability/GrayNotebook/navigateGNB.htm
2. We can target specific counties, metro areas, and roadways with floodgate messages on 511.
3. Recently deployed a Smartphone, hands-free, audible, location-relevant solution - Trumpit - on the iPhone, Android and BlackBerry platforms.
4. I feel that our agency maintains a higher level database then most allowing us to more effectively evaluate our actions
5. We're one of the few public agencies that provide all of our traveler information in XML feeds for developers, media outlets, and others without a lot of bureaucratic navigation. We provide transit schedule data, highway incident, construction and special event data, CCTV camera feeds, Commercial Vehicle files (restricted and posted bridges and bridge height clearances). We actively communication with Navigation device providers too to ensure the information is in their devices to avoid truck/bridge hits.
6. Please see: http://www.wsdot.wa.gov/accountability/

Question 11. Do you feel the practices of your agency, with respect to providing traveler information, are more effective compared to typical practices?

Answer Options	Response Percent	Response Count
Yes	40.6%	13
No	59.4%	19
answered question		**32**
skipped question		**15**



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Question 12. If you answered yes, please describe the practice(s) and what makes it (them) more effective.

Answer Options	Response Count
	12
answered question	**12**
skipped question	**35**

Answers:

1. Generally speaking I believe we provide a wider range of products and services then most other agencies.
2. Rural long distance travel time is implemented on I-70 and I-25 up to 100 mile segments
3. Focus on the customer experience and ROI related to new technologies.
4. Regardless of the platform you receive traveler information; it is IDENTICAL as it all gets populated instantaneously from a single database. This is also the identical information that we push out via our free XML feed.
5. We try to stay on the cutting edge of technology.
6. I believe that we provide a higher level of information
7. We have implemented XML feeds, created mobile applications, a mobile device friendly website (for those without Smartphones), phone information including call transfers, web based services with a transit trip planner (multi-operator) and customizable My511 services. We are trying to cover every medium a user may need/use.
8. Comprehensive, statewide approach.
9. Florida has been affective in deploying ITS in the state and have significant deployments of ITS (DMS, Sensors, CCTVs) in our urban areas. What make Florida more affective is that we have a good range of means of dissemination information to the public.
10. The use of our web pages, our 511 phone system, our social media efforts, our downloadable apps, and our subscription email alerts are some of the highest in the country.
11. we collect and use our own data from different collection methods (loops, etc.)
12. (not requested) We're missing "push" of data and social media usage.

Question 13. Technology is changing rapidly, and the private sector is becoming more involved (e.g. generating and delivering its own congestion information through mobile devices). How do you think your agency may adapt its real-time traveler information system in response to these changes? (Please check all that apply, and elaborate in the space provided)

Answer Options	Response Percent	Response Count
Don't envision much change	15.6%	5
May drop components of our traveler information program	12.5%	4
May expand our program to include additional components	68.8%	22
May partner more with the private sector	78.1%	25
Other (please specify)		3
answered question		**32**
skipped question		**15**

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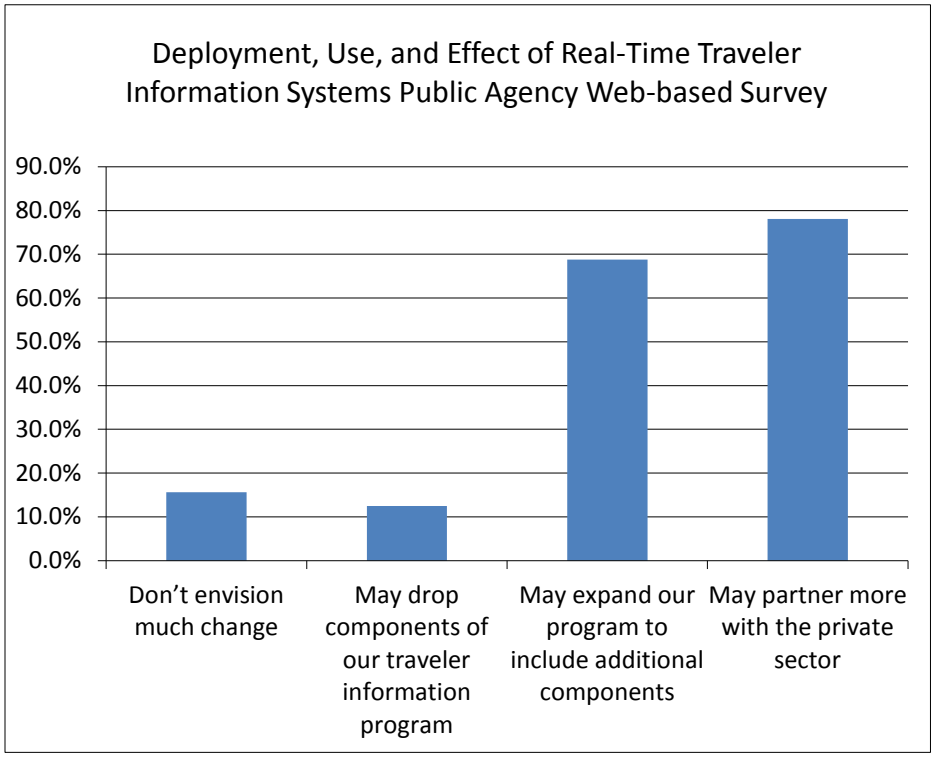
Other:

1. The FDOT will probably continue to provide traveler information, but we are turning more to the private sector to provide information (data) in the areas where we are not instrumented to supplement our data collection efforts.
2. NOTE: I chose Don't envision much change on this question since the survey required a box be checked to move to the next page, however, my response to this question is below: Change will come, hard to know how at this point.
3. We need to begin to "push" data and will look into social media.



Question 14. Please elaborate on how you think your traveler information program may change. What will you do differently in the next five years?

Answer Options	Response Count
	26
answered question	**26**
skipped question	**21**

Answers:

1. Make certain we meet the requirements of the FHWA RTMIP. More than likely, this could mean we partner more with the private sector as well as expand our existing program components. Additional metro information will be added.
2. Moving program to multimodal information based on GPS based Smartphones using voice recognition technology. In process of expanding traveler advisory radio system statewide with addition of synchronized WTMC 1380 AM repeaters to expand coverage of primary licensed WTMC 1380 AM.
3. Add travel time to the mix

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4. The quality and availability of data is increasing allowing us to consider alternative approaches to data collection.
5. Public is demanding more, quicker and diverse data in various formats. We'll have to try to keep up and pick the most effective tools.
6. it may be more cost effective to buy the data or sell the current data?
7. we are just about to develop an RFP for a second generation 511 system and we will likely have changes to our system at that time.
8. Work to integrate Intellidrive into our system.
9. Use private sector to process the data we are currently collecting.
10. Currently, we have an ATMS advertised that will integration many of our data source, automate incident management response protocol/plans, automate travel time, etc. This new tool will result in more reliable real-time information to the public.
11. Rely less on physical communication infrastructure and more on driver-provided consumer electronics.
12. States are including social networking to reach consumers and several states are trying privatization models
13. We have a core mission to manage our highways. That is the primary purpose and reason for the development of our database. We capture all the information in that database. The design effort put into this database will allow future development costs of new applications to be low. In addition, by making the data available to third parties, we can potentially work with them to develop future applications that are not around today.
14. Provide TI Apps for motorists.
15. We are looking to add a mobile web and mobile app to our service. Travel Times will be added to our service in a few months.
16. We will have 511, we are also keeping up with technology advancements to provide the public the best information we can and technology advancements are also helping us to have better information
17. if funding is available, we hope to provide more expansive information, including travel times in more areas of the state, bridge and border crossing information, etc.
18. More sources of information (911) will be processed in real time and sent to more outlets (pda's etc..) Probe data will become more common as will Itellidrive.
19. May make use of private sector data as a supplement to DOT data.
20. At this point I don't envision us disseminating less traveler information. To enhance the information we have, we would look to the private sector for assistance. We currently provide our traffic information at no cost.
21. Develop 511 mobile apps and look to partner with industry to leverage emerging in-vehicle devices. Also possibly seek out revenue sharing opportunities within the limits of state law.
22. We are looking to shift to a revenue generation business model to get a free system or at least a system supplemented with revenue generated by the commercialization of our assets.
23. We are following the use of the 511 phone system to measure impacts on use.
24. A lot will depend on the direction of technology. Do we want to put the information out there (e.g. via XML feed) and let the 3rd parties develop apps for its use, or do we develop it in-house? This is where we are right now.
25. In California, rely on "others". We will never do trip generation.
26. Push, push, push. Attempt to reduce those that have to call into our telephone system.

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Question 15. Please provide the following information.

Answer Options	Response Percent	Response Count
Name:	100.0%	29
Title:	100.0%	29
Agency:	100.0%	29
Phone number:	96.6%	28
E-mail:	100.0%	29
answered question		**29**
skipped question		**18**

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APPENDIX C

Focus Group Question Path

RTTIS Focus Group Question Path

1) Introduction [5 MINUTES]
    a. Moderator introduces self and project staff.
    b. The purpose of this focus group is for us to learn how you use **various types of traveler information**.
    c. This work is being done for the National Cooperative Highway Research Program, which is part of the Transportation Research Board of the National Academies. My company, Westat, is conducting these focus groups on their behalf. [City] is one of three locations in the country where we are conducting these groups. States sponsor this research and are really interested in learning about your uses, likes, and dislikes of real-time traveler information being provided.
    d. Focus group etiquette
        i. How many of you have taken part in a focus group?
        ii. Need to hear about your feelings. We are not here to reach consensus, but to hear and discuss a range of views. **There are no right or wrong answers**.
        iii. Cross talk among group, not to/from moderator; moderator guides the discussion to cover the topics we need to hear about
        iv. If the group gets off topic the moderator will step in to guide the group back to the topic.
        v. Give everyone the opportunity to speak
        vi. Inform of being audio-taped and possibly video-taped for offline analysis
        vii. Rest rooms, breaks
        viii. Please turn off and put away phones
    e. This focus group is just the first phase of a two-phase procedure. You have volunteered to take part in both phases, for which we will pay you $100 (125 in other cities). Today's focus group will take up to 2 hours and we will pay you the first $50 (75 in other cities) as soon as the session is over. The second phase is where you will keep a record of your driving trips over the next 7 days. I'll go over that procedure with you at the end of the session. After you complete the driving logs, we will send you an additional check for $50. It is very important that you continue through both phases of the procedure.

2) Ice breaker [5 MINUTES]
    a. Let's start with introductions. **Moderator: Go first to set an example of brevity**. Going around the table, I would like each of you to tell us your first name and the town or neighborhood you live in. Then briefly tell us about a recent trip where you changed your route before or during the trip (or wished you had).

WHERE

3) Sources of traveler information [35 MINUTES]
    a. Today we are going to talk about the sources and types of information that you use for your driving trips. We're interested in a wide variety of information and sources that you

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might use before or during a trip to find out what kind of conditions you can expect on your trip, or to help plan your trip.

b. First, let's start with sources of traveler information. That is, where do you get your traveler information (e.g., news, website, etc.)? **Moderator: Let someone name each source and ask to describe briefly (especially for light users group), then probe on**:
    - **i.** What types of information do you access from this source? **Moderator: ONLY list and then tell come back to information types later.**

c. Use of traveler information sources (ASK FOR EACH SOURCE AS IT IS DISCUSSED)
    - **i. What do you like about sources types of information? *(discuss each source individually as they come up)***
        1. **How many of you are aware of each source of information? Moderator: Record number of the group who is aware of each type of information as it is discussed (ask question as soon as a new type of information is discussed).**
    - **ii. What made you decide to use this source of information? How did you find out about it?**
    - **iii. Do you look for this source of information pre-trip or during trips?**
    - **iv. What effects do these information sources have on your trip?**
        1. **Probe: frequency of changed route choices, route choice, travel time expectation, aborted/delayed trips**
    - **v. Are there any other benefits of this source?**
        1. **Probe: Peace of mind? Calling ahead to someone?**
    - **vi. What limits the usefulness of traveler information sources for you?**
        1. **Probe: What could be done better? What keeps you from using some sources?**

d. Features of traveler information sources and types (Possibly asked about each, but don't emphasize—depends on time for each and many may come up naturally in discussing each).
    - **i. How credible/accurate is the type and source of information?**
    - **ii. What is confusing or ambiguous?**
    - **iii. Importance in making a trip change?**
    - **iv. Quality/reliability?**
    - **v. Convenience?**
    - **vi. Ease of use?**

<u>WHERE</u>

e. Probe on **(if not familiar, ask them to say what they think it means)**:
    - i. Electronic highway message signs
    - ii. Electronic local roadway message signs
    - iii. Highway advisory radio (usually a short range AM radio station dedicated to reporting traffic/traveler information)
    - iv. Phone call to 511 traveler information phone number
    - v. Websites NOT on mobile devices (e.g., using a laptop or desktop)
    - vi. Social media sites (e.g., Twitter)
    - vii. Websites through mobile devices
    - viii. Receive email, text message, phone call by subscription service (either free or paid)
    - ix. Mobile "apps" (e.g., travel info related iPhone or Droid applications)
    - x. On-board devices (but not mobile devices) (e.g., Garmin, TomTom, Onstar)
    - xi. Television

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xii. Radio
xiii. Other?—e.g., plan of action and evacuation routes

POSSIBLE BREAK [10 MINUTES]

WHAT

4) Traveler information type [30 MINUTES]
   a. Earlier we discussed the different ways you may get traveler information. We also discussed some of the types of information you may get from each source. Now, let's come back and focus on the information itself.
   b. What sort of traveler information do you make use of (e.g., incidents)? Probe as necessary to reveal additional sources.
   c. Use of traveler information types (ASK FOR EACH TYPE AS IT IS DISCUSSED)
      i. What do you like about these types of information? *(discuss each type individually as they come up)*
         1. How many of you were aware of each type of information before today? Moderator: Record number of the group who is aware of each type of information as it is discussed (ask question as soon as a new type of information is discussed).
      ii. What made you decide to use this type of information?
      iii. Do you look for this type of information pre-trip or during trips?
      iv. What effects do these information types have on your trip?
         1. Probe: frequency of changed route choices, route choice, travel time expectation, aborted/delayed trips
      v. Are there any other benefits of X traveler information type?
         1. **Probe:** Peace of mind? Calling ahead to someone?
      vi. What limits the usefulness of traveler information sources for you?
         1. Probe: What could be done better? What keeps you from using some sources?
   d. Features of traveler information type (Possibly asked about each)
      i. How credible/accurate is the type of information?
      ii. What is confusing or ambiguous?
      iii. Importance in making a trip change?
      iv. Quality/reliability?
      v. Convenience?
      vi. Ease of use?
      vii. What are the benefits?

WHAT

   e. Probe on **(if not familiar, ask to describe what they think it means)**:
      i. Traffic map (showing speeds, incidents, etc.)
         1. If yes, then what sources?
            a. Agency website; other website; smartphone app
         2. If no, then why not?
         3. Information not applicable to my trips; inconvenient to access; information is unreliable or inaccurate; don't know how to access this information; information not available in my area; don't have computer/internet; other (please specify)___
      ii. Live traffic cameras (video or pictures of current traffic conditions)
      iii. Traffic incidents (reports of collisions, lane closures, etc.)
      iv. Travel times (reported current times to get from one location to another)
      v. Alternate routes

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vi. Parking availability
vii. Roadwork / construction zones
viii. Special events
ix. Weather information
x. Public safety information (e.g., Amber Alerts, Silver Alerts, etc.)
xi. Safety information (e.g., "Buckle Up", "Signal When Changing Lanes", etc.)
xii. Other?

5) Features of traveler information sources and types [10 MINUTES]. **Moderator: This question will summarize or rank order some of the things discussed.**
   a. What is the most credible/accurate type of information? Source?
      i. What is the least?
   b. What is confusing or ambiguous type of information? Source?
   c. What is the most important piece of information in making a trip change? What source do you use the most to get that information?
   d. What is the most reliable source? Type of information?
   e. What is the most convenient source of information?
   f. What is the easiest source to use? Most difficult?
   g. What is the most beneficial type of information? Least?

6) Now that we've spent a while talking and thinking about different aspects of traveler information, let's put it all together. If you were in charge of [city's] traveler information program, what would you do to improve the information currently available to drivers? [5 MINUTES]
   a. Probe: You can be as creative as you like, remember that technologies are developing rapidly and what seems like science fiction today could be possible in just a few years.

7) What do you see as the overall value of traveler information? Can you summarize how useful it is to you? [5 MINUTES]

8) Final suggestions: are there any specific recommendations you would like to make for how [City] might improve traveler information to make it more useful? [5 MINUTES]

9) Driving log procedure [5 MINUTES]

10) Pay participants for first phase, have them sign receipts.

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APPENDIX D

Trip Logs and Figures of Results

8897 NCHRP 08-82 Driver Log – Participant # __

Date: _____

******Complete this section for EACH trip taken during the day******

TRIP:

1. At what time did you start this trip? _____ am pm

2. At what time did you end this trip? _____ am pm

3. Did you encounter congestion or delays on this trip? Yes No

4. What was the primary purpose of this trip? ___work commute ___scheduled appointment ___leisure/errand/shopping

5. From what sources did you receive traveler information before starting this trip? *(check all that apply)*:

___TV ___Radio ___DOT Website ___Other website ___Family/friend ___Navigation device ___Smartphone app ___511 call Other

(specify):_____

6. Based on the pre-trip information you received, did you... *(check all that apply)*

___ let someone know when you expected to arrive at your destination?

___ choose to take the trip at a different time?

___ change your driving route?

___ use a different type of transportation (walk, bike, transit, carpool, taxi, etc.)?

___ choose a different destination or cancel a stop on your trip?

___ cancel your trip?

7. From what sources did you receive traveler information during this trip? *(check all that apply)*:

___Radio ___Electronic travel time sign ___Other electronic sign ___Navigation device ___Smartphone app ___511 call Other *(specify)*:

_____

8. Based on the information you received during your trip, did you... *(check all that apply)*

___ let someone know when you expected to arrive at your destination?

___ change the driving route of a trip?

___ switch to a different type of transportation (walk, bike, transit, carpool, taxi, etc.)?

9. Please rate how strongly you agree or disagree with each of the following statements about the traveler information you received before or during your trips today:

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a. The traveler information influenced my route choice. *Strongly disagree* → 1—2—3—4—5 ← *Strongly agree*

___not applicable

b. The traveler information was accurate. *Strongly disagree* → 1—2—3—4—5 ← *Strongly agree*

___not applicable

c. Making use of the traveler information saved me time. *Strongly disagree* → 1—2—3—4—5 ← *Strongly agree*

___not applicable

d. I am confident that I made the best decisions about my routes. *Strongly disagree* → 1—2—3—4—5 ← *Strongly agree*

___not applicable

e. Overall, I liked having traveler information for these trips. *Strongly disagree* → 1—2—3—4—5 ← *Strongly agree*

___not applicable

10. Of all the traveler information you saw or heard today, what information was the most useful to you?

Specify the information source and the information it provided:

_____

_____

_____

_____

11. What information that you did not receive before or during your trips would have been useful to you?

_____

_____

_____

12. Describe the weather you encountered while driving today (*check all that apply*): ___ Clear ___ Rain ___ Road wet ___ Fog

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APPENDIX E

Survey Questions

Traveler Information Survey

Westat, a professional research firm, is conducting this survey under contract with the National Cooperative Highway Research Program (NCHRP). It will take approximately 15 minutes to complete. We want to understand travelers' access to, perception of, and need for real-time traveler information, and your responses will lead to improvements. There will be no personal identifiers, so your responses to the web survey will be kept completely anonymous. Your responses will be shared only with the project team and NCHRP, but otherwise kept confidential. By choosing "next" you are providing consent and agreeing to participate in the survey which will begin on the next page.

1) Typically, how often do you take vehicle trips where you are the driver and the purpose is to travel to a regular location, such as a job, school, etc.?
   - Less than 1 day a week
   - 1 day a week
   - 2-3 days a week
   - 4 or more days a week

2) Typically, how often do you take vehicle trips where you are the passenger?
   - Less than 1 day a week
   - 1 day a week
   - 2-3 days a week
   - 4 or more days a week

3) Typically, how often do you take trips via public transit (for example, bus, train, subway)?
   - Less than 1 day a week
   - 1 day a week
   - 2-3 days a week
   - 4 or more days a week

4) Please rate the IMPORTANCE of the following sources of traveler information that you use for your travel goals. If a source is not available in your area, then please choose "N/A" or skip that option.

   1= Not at all important --- 7 = Extremely important

   Radio (AM, FM, or satellite)
   Television
   Websites through mobile devices
   Electronic highway message signs
   511 traveler information phone number
   Social media sites (e.g., Facebook or Twitter)

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Mobile "apps" (e.g., iPhone or Droid applications)
Websites NOT on mobile devices (e.g., laptop or desktop)
Email, text alerts or phone call by subscription service
On-board devices (e.g., Garmin, TomTom, Onstar)

5) Please rate the ACCURACY of the following sources of traveler information that you use. If you do not use a source, then please choose "N/A" or skip that option.

1 = Not at all accurate --- 7 = Extremely accurate

Electronic highway message signs
Websites through mobile devices
On-board devices (e.g., Garmin, TomTom, Onstar)
Email, text alerts or phone call by subscription service
Mobile "apps" (e.g., iPhone or Droid applications)
Social media sites (e.g., Facebook or Twitter)
511 traveler information phone number
Websites NOT on mobile devices (e.g., laptop or desktop)
Television
Radio (AM, FM, or satellite)

6) Please rate the IMPORTANCE of each type of traveler information that you use for your travel goals. If a type is not available in your area, then please choose "N/A" or skip that option.

1= Not at all important --- 7 = Extremely important

Public safety information (e.g., Amber alerts, Silver alerts, etc.)
Special events
Weather information (including smog alerts)
Travel times
Parking availability
Roadwork/construction zones and road closures
Alternate routes
Live traffic cameras
Traffic incidents

7) Please rate the ACCURACY of the following types of traveler information that you use. If you do not use a type, please choose "N/A" or skip that option.

1 = Not at all accurate --- 7 = Extremely accurate

Roadwork/construction zones and road closures
Live traffic cameras
Travel times
Weather information (including smog alerts)
Parking availability
Alternate routes
Special events
Traffic incidents
Public safety information (e.g., Amber alerts, Silver alerts, etc.)

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8) How often do you change (including delaying or cancelling) a trip based on traveler information before the trip has begun?
   - Less than 1 day a week
   - 1 day a week
   - 2-3 days a week
   - 4 or more days a week

9) When preparing to leave for a trip, where do you typically look for information when deciding whether to change (including delaying or cancelling) the trip? Please check all that apply.

   - On-board devices (e.g., Garmin, TomTom, Onstar)
   - Radio (AM, FM, or satellite)
   - 511 traveler information phone number
   - Social media sites (e.g., Facebook or Twitter)
   - Websites NOT on mobile devices (e.g., laptop or desktop)
   - Email, text alerts or phone call by subscription service
   - Television
   - Mobile "apps" (e.g., iPhone or Droid applications)
   - Websites through mobile devices
   - None--I never check information before a trip.
   - Other (please specify)

10) When preparing to leave for a trip, what information do you typically use when deciding whether to change (including delaying or cancelling) the trip? Please check all that apply.

   - Special events
   - Traffic incidents
   - Traffic cameras
   - Weather information (including smog alerts)
   - Parking availability
   - Travel times
   - Alternate routes
   - Roadwork/construction zones and road closures
   - Public safety information (e.g., Amber alerts, Silver alerts, etc.)
   - Visual observation of traffic conditions
   - None--I never check information before a trip.
   - Other (please specify)

11) How often do you change (including delaying or cancelling) a planned trip once the trip has begun?

   - Less than 1 day a week
   - 1 day a week
   - 2-3 days a week
   - 4 or more days a week

12) What information source do you typically use when deciding to change (including delaying or cancelling) a planned trip once the trip has begun?

   - Electronic HIGHWAY message signs (only on major highways)
   - Electronic LOCAL ROADWAY message signs (only on local roads or surface streets)

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- Highway advisory radio (AM stations used only for providing bulletins to travelers along a highway)
- 511 traveler information phone number
- Websites NOT on mobile devices (e.g., laptop or desktop)
- Social media sites (e.g., Facebook or Twitter)
- Websites through mobile devices
- Email, text alerts or phone call by subscription service
- Mobile "apps" (e.g., iPhone or Droid applications)
- On-board devices (e.g., Garmin, TomTom, Onstar)
- Television
- Radio (AM, FM, or satellite)
- None--I never change a trip once it has begun
- Other (please specify)

13) What information do you typically use when deciding to change (including delaying or cancelling) a planned trip once the trip has begun?

- Live traffic cameras
- Traffic incidents
- Travel times
- Alternate routes
- Parking availability
- Roadwork/construction zones and road closures
- Special events
- Weather information (including smog alerts)
- Public safety information (e.g., Amber alerts, Silver alerts, etc.)
- Safety information (e.g., "Buckle Up," Signal When Changing Lanes," etc.)
- Visual observation of traffic conditions
- None--I never change a trip once it has begun
- Other (please specify)

14). If you were in charge of your area's traveler information program, what would you suggest to improve the information currently available to drivers? Where would you like to find travel information, how would you like it provided to the traveler, and what information should be provided? - Open-Ended Response

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APPENDIX F

Supplemental Survey Questions

1) What city do you live in or near?

   Detroit metro area
   New York City metro area (including New Jersey suburbs)
   Orlando metro area
   Salt Lake City metro area
   San Francisco metro area
   Washington, D.C. metro area (including Maryland and Virginia suburbs)
   Other (please specify)

2) Have you taken a trip to or from WORK in the last 3 days?

   Yes
   No

3) How often do you typically change (including delaying or cancelling) a trip to or from WORK based on traveler information? This can happen either before a trip has begun or during a trip.

   Never
   1-2 times a month
   3-5 times a month
   5 times a month

4) Have you changed a trip (including delaying or cancelling) to or from WORK based on traveler information in the last 3 days?

   Yes
   No

5) For the most recently changed WORK trip, were you a

   driver of a vehicle?
   passenger in a vehicle?
   traveler using public transportation (e.g., train, bus)?
   other (please specify)

6) Thinking about this most recent work trip ONLY, what sources of traveler information did you use when deciding to change (including delaying or cancelling)? Check all that apply.
   - 511 traveler information phone number
   - Electronic HIGHWAY message signs (only on major highways)

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- Electronic LOCAL ROADWAY signs (only on local roads or surface streets)
- Email, text alerts or phone call by subscription service
- Highway advisory radio (AM stations used only for providing bulletins to travelers along the highway)
- Mobile smartphone "apps" (e.g., iPhone or Droid-based applications)
- On board devices (e.g., Garmin, TomTom, Onstar)
- Radio (AM, FM, and satellite)
- Social media (e.g., Twitter, Facebook) %
- Television
- Websites NOT on mobile devices (using a laptop or desktop)
- Websites through mobile devices
- Other (please specify)

7) Thinking about this most recent work trip ONLY, what types of traveler information did you use when deciding to change (including delaying or cancelling)? Check all that apply.
   - Alternate routes
   - Live traffic cameras
   - Parking availability
   - Public safety information (e.g., Amber alerts, Silver alerts)
   - Roadwork/construction zones and road closures
   - Safety information (e.g., "Buckle up," "Signal when changing lanes")
   - Special events
   - Traffic incidents
   - Travel times
   - Visual observation of traffic conditions
   - Weather information (including smog alerts)
   - Other (please specify)

8) Thinking about this most recent work trip ONLY, what sources of traveler information would you have liked when making your decision to change the trip? Note that even if some of these are not available in your area, we want to know what you would have liked to be available. Check all that apply.
   - 511 traveler information phone number
   - Electronic HIGHWAY message signs (only on major highways)
   - Electronic LOCAL ROADWAY signs (only on local roads or surface streets)
   - Email, text alerts or phone call by subscription service
   - Highway advisory radio (AM stations used only for providing bulletins to travelers along the highway)
   - Mobile smartphone "apps" (e.g., iPhone or Droid-based applications)
   - On board devices (e.g., Garmin, TomTom, Onstar)
   - Radio (AM, FM, and satellite) Social media (e.g., Twitter, Facebook) Television
   - Websites NOT on mobile devices (using a laptop or desktop)
   - Websites through mobile devices
   - Other (please specify)

9) Thinking about this most recent work trip ONLY, what types of traveler information would you have liked when making your decision to change the trip? Note that even if some of these are not available in your area, we want to know what you would have liked to be available. Check all that apply.
   - Alternate routes

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- Live traffic cameras
- Parking availability
- Public safety information (e.g., Amber alerts, Silver alerts)
- Roadwork/construction zones and road closures
- Safety information (e.g., “Buckle up,” “Signal when changing lanes”)
- Special events
- Traffic incidents
- Travel times
- Visual observation of traffic conditions
- Weather information (including smog alerts)
- Other (please specify)

10) Thinking about typical work trips, what types of traveler information influences your decisions the most? Note that even if some of these are not available in your area, we want to know what would influence your decision. Check all that apply.
    - Alternate routes
    - Live traffic cameras
    - Parking availability
    - Public safety information (e.g., Amber alerts, Silver alerts)
    - Roadwork/construction zones and road closures
    - Safety information (e.g., “Buckle up,” “Signal when changing lanes”)
    - Special events
    - Traffic incidents
    - Travel times
    - Visual observation of traffic conditions
    - Weather information (including smog alerts)
    - Other (please specify)

11) Gender

    Male
    Female

12) Age
    < 18
    18-29
    30-44
    45-60
    > 60

13) Education
    Less than high school degree
    High school degree
    Some college
    Associate or bachelor degree
    Graduate degree

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APPENDIX G

Focus Group Summary: Overall

- Everyone wants travel information that is clear, concise, and trustworthy
  - How often it is being updated
  - Where the information is coming from
- Information that is trustworthy is the most important when making travel decisions
  - All of the focus groups felt that TV and radio are constantly being updated and find it to be a reliable source of information
    - Between TV and radio the majority felt that radio provided the best information because you were receiving the information while driving
      - Everyone has a radio, whereas not everyone has a Smartphone
      - Radio does not distract the driver, and does not break any distracted driving laws
    - The drawback to TV, is that you don't have the information in the car with you and it can be out of date, by the time you start driving
    - Most individuals also relied on the internet for reliable traffic information
      - Google maps/MapQuest- for directions and alternate routes
      - Local newspapers or local news channels- for road closures and major incidents
- Travel information that people don't know where the information is coming from or how often the information is being updated they do not trust
  - Most people didn't trust or use the highway advisory radio station
    - When most people tried the stations they felt the information was on a loop and not being updated
    - The radio stations did not provide a clear signal, everyone thought the radio stations were mostly "crackly" or "fuzzy" to hear
- Highway traffic signs
  - People liked the signs, and thought the travel information was accurate
  - People liked when the sign had miles associated with travel time
    - e.g. 17 miles to exit x – travel time 20 minutes
  - Want to see more signs on the highways
  - Most people wanted signs before they merge on the highway, so they make better decisions about travel routes
  - Some people thought the signs were distracting and slowed traffic
- All of the focus groups had concerns about travel information coming to their phones
  - Most people did not like to use their phone while driving
  - Most people did not want to receive texts while driving
  - Most people were concerned about state laws and using their phones while driving
  - In every state but California, people were not aware that 511 was a travel phone number they could call.
    - People were concerned about calling 511 because they didn't want to use their phone while driving
    - Users of 511 seemed to like the system but wished it covered a broader area
- Social Media and Apps
  - Very few people were using social media to receive travel information

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        - The few people who used Twitter followed local news, they would only know traffic updates if it was a major traffic incident
        - Facebook users would see friends updates, occasionally on traffic but would not go to look for traffic information on the site
    - Most were not using their smart phones for travel information
        - Most were using the default "map" or "navigation" apps for directions or alternate routes
        - When people learned from the few who were using travel information apps they were excited and wanted to learn more
            - They liked the idea of receiving information that was specific and tailored to them
            - Concerns for travel apps, you need at least two people in the car to use the app
            - Older adults expressed concerns about apps and mentioned that apps are for "young people"
        - When looking for travel information everyone wanted the information to be accessible and to be relevant to them (local and targeted)
- Overall people wanted to see a traffic map with easy to read information
    - Color maps, with green, red, and yellow easy to understand
- Traffic congestion was a major concern
    - Where traffic congestion started and ended
    - What type of congestion
        - Normal rush hour congestion
        - Accident or road construction
            - What time the accident happened
            - When the accident was cleared
            - How many lanes are affected
- They wanted to know travel times and alternate route travel times
    - Types of roads for alternate travel
        - Limited access highway, major arterial, minor arterial, or local roads
- Almost everybody wanted to know weather conditions with traffic since it often plays a role in traffic delays
- In some areas, displaying special event information that adversely affects roadways was viewed as vital (street closings, emergencies, etc.)

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APPENDIX H

Focus Group Summary: New York City (Teaneck, NJ)

New York City metro area – Light Users Group – February 16, 2012

Introductions and responses to where they receive travel information

- GPS; radio; smartphone; news; radio; looking out window, internet (hop stop)

Sources of travel information

- Radio
  - Most people like the radio because it gives you ahead's up about what is going on. Listening to the radio is easy because you are already doing it, it gives you quick information and is not distracting when you are driving, like the phone. Most people feel nostalgic about the radio; the radio has always been around. Certain areas are talked about more than other areas on the radio. Most people think the radio relies on the public to call into the radio stations.
  - Most use it once they are in the car. Only a few people listen to the radio before they leave
  - Satellite radio doesn't appear to update often**.**
- TV/News
  - Instead of radio, most people will watch TV before they leave the house. They like when the news shows traffic cameras, especially during inclement weather. They also like the cameras because they can see exactly where the traffic incident is occurring. The news will also tell you what roads are blocked. The TV gives you more detail than the radio.
- Apps
  - GPS is heavily used on the phones. People will check their phones before they leave, so they can judge the time they need to make the trip.
  - Waze – Interactive with other drivers near them. It works best if more than two people in the cars. It will constantly up date you if traffic stops and is updating in real-time. Does not like to use it by themselves in the car. They heard about it from word of mouth.
  - Trapster
- Internet
  - Hopstops for travel
  - Google is used to identify the building they are going to, they like to see the street view option
  - Telamap – is great for speed limits.
  - Local county websites are used for looking at information on the Tappan Zee Bridge. The website is extremely accurate because you can see the street cameras. People aren't using other DOT sites.
- GPS

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  - They like if you make a mistake, it will still give you directions for the wrong turn. People said that you can get traffic information if you subscribe but most people aren't paying for that service. They like that the GPS will update arrival time.
- GPS/Navigation
  - Cars beep when you go over the speed limit; it is good to know when the speed limits changes.
- Highway advisory radio
  - A few people have tuned in but the system is very mundane, the information is on a loop, and the station does not come in clear. They wished that the stations would update more often.
- Highway message signs
  - The signs will say "accident ahead" most people feel that there is nothing you can do once you see the sign, you are committed to the road you are on, you must "tough it out". The signs are helpful if you know the area.
  - Some signs will say use the alternate route, but the alternate route is still congested.
  - Some though that the signs are not accurate, especially when it says "7 minutes" to get across the bridge but in reality it takes "45 minutes".
  - The signs were accurate when they listed road closures and construction.
- 511
  - No one in the group was familiar with it.
- Local message signs
  - People have seen the signs and information would be posted about major events and list alternate routes. The signs are helpful and people will adjust their trip.
- Social media
  - People will see it if their friends update. People have posted themselves that traffic is better. One person follows twitter for train information.
  - They find it accurate because people are on the ground and collecting the information.
  - It would be nice if there was a place that people could send in updates.
- Brake lights in traffic
  - As soon as people see red lights and traffic they will change their patterns.
- Emails or text alerts
  - People receive alerts for weather but not about roadways.
- Public transportation
  - MTA Twitter is followed to look at train information.
  - Check the agencies websites for train times.
  -

What type of information?

- Parking
  - The app tells about parking and you can make a reservation at a parking lot and get a discount.
  - Best Parking app – it will highlight where on street parking is parking lots and it will give you the price of parking. You just need to enter an address.
  - People would find it very useful and they would use it if they aren't using it yet.
  - People thought that app was useful, but for the most part it still comes down to timing.
  - Certain parts of the city this is more useful than other parts of the city.
- Travel maps
  - Some of the people are visually oriented so they find the maps more useful, and like it communicate information. People like to see the maps so they can understand where they are going, more than just the turn by turn directions, they can be familiar with the area and then pick alternative routes.
  - Traffic cameras on the maps and congestion and camera's not as helpful when you are sitting at home and before you enter traffic.

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- Speed Cameras
  - It is nice to know where the cameras are located.
- Road Closures
  - People are not aware how to find this information; they would like to have access to this information.
- Emergency advisories
  - They would like to receive an alert stating that there is a major police presence; they don't need to know the details but want to know something is going on.
- Amber and Silver Alerts
  - Most people will pay attention to the information and are impressed on how well they work.
- Traffic incidents
  - The group would like to know how many lanes are closed. The only time they see information is at night when nobody is on the bridge.
- Travel time information
  - They like to see the travel time on the signs; people like to see the time and like to make a game out of it some have coined the game as "beat the time".
- Special event information
  - They find the information about special events on the radio. It would be helpful if this was on a smart phone app, so you can find out what streets are closed.
  - If you are new to the city and roads are closed most feel that people have to learn as they go, this is something that comes from experience.
  - They would like to see a text alert about events.
- Weather
  - Weather channel and weather bug will give updates on road conditions.
- Text alerts
  - There is a concern that they could get too many text alerts, they think an app would be more reasonable than text alerts. Too many texts could be bothersome.
- Other
  - You have to know what time to leave; most people think that traffic is like a "game" that you have to beat.

What is most accurate ?

- You have to base travel on experience, they like the radio because it appears to be closest to real-time updates. They would trust most sources if they were giving real-time.
- Radio is better, than an app because nothing is more frustrated when you lose a signal.

What is the least accurate?

- Websites - because they don't take into account construction or accidents. The information is not real-time.

What is the one piece of information that makes you change your trip ?

- Special events, accident information, heat advisories when heading to the beach

Overall value of traffic information?

- Everyone felt that travel information is valuable because it lets you know why you are sitting in traffic. Knowing what is going reduces stress level of sitting in traffic.

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What would be your ideal traffic information?

- They want constancy, up-dates; local information e.g. when the local news stations are on the streets with bad weather such as snow; they would like an app with a news feed where you can start with you zip code and find out the information that you need. Most want local, but our concerns that the local information wouldn't necessarily sink up nationally; they constantly want to be updated on what is going on; tailoring the information to where people are located; emergency information; sub categories with additional information, such as toll information, the information has to be current; the system should be voice activated; agencies should share information a seamless way to get information; some think every car should have a GPS that can receive alerts, but concerns about "big brother".

Final suggestions

- Construction should be done at night.

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New York City metro area – Heavy Users Group – February 15, 2012

Introductions and responses to where they receive travel information

- TOM-TOM, Google Maps, Mentioned spouse having a tracking device where you can look online at location, etc, radio-traffic on the 8's, Sirius radio, channel 12 in past, phone apps

Sources of travel information

- Radio
  - One participant likes Sirius
- TV/News
  - Mentioned specific station NJ 12 which they like because traffic and weather in a loop-"know before you go." Can only access on certain providers (Optimum). This station did not have news.
- Apps
  - Use for public transportation. NYEmbark, NYCMate are two public transportation apps. Also use WAZE-easiest to use, shows accidents. Also, radio station 1010 wins up to date. Mentioned not being able to use phone while driving defeats purpose of having an app.
- Internet
  - Google maps-like using for directions. Like that it is an actual map. Feels it provides options.
  - MapQuest-not always reliable
- GPS/Navigation
  - Have to update software which was a dislike. Like that GPS with cell phone automatically updates, Sounded like one person allows traffic info through GPS to be enabled but do not seem to like and cannot silence because want directions.
- Highway advisory radio
  - Have tried to use it and have gotten signal but mostly can't get a signal. Would expect to get the signal when you see the sign for the radio channel but can't. Should test the system.
- Highway message signs
  - Some people do not like using the exit number. Another participant likes that they can tell about special events day before, e.g. Giants or Jets game and finds it helpful for travel planning, e.g. leave early. Sometimes too late to make decision from sign. Thinks placement of sign is important. Also, feel not as updated as frequently as far as delays. Like knowing about repair work. Real time for signs that say 4 minutes to X highway was a question one participant asked.
- 511
  - One participant mentioned it is confusing, difficult to navigate. Only want to know specific locations not all of NJ. Used website. Have never called except for one person who mentioned calling and not liking.
- Local message signs
  - One participant mentioned that they see them and are up to date pretty much but signs are usually off even if there is traffic. Mentioned route 3 specifically.
- Social media
  - WAZE app is interactive, can use to send Twitter alerts. Feels WAZE is up to date compared to other sources but it's on the phone so cannot check when moving. Up to date as far as what people are experiencing. Will use WAZE at a gas station, etc. not when moving.

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- Emails or text alerts
  - Have used PATH alerts for public transportation, subscriber services. Thinks it's helpful. Would like for specific routes e.g., 109, turnpike.
- Public transportation
  - Apps for public transportation. Metro North, Path, etc. Two apps mentioned NYEmbark and NYCMate

What type of information?

- **Alternate routes/modes**
  - Might like a sign with that information but do feel that many alternates are not available. Gridlock alert days.
- **Construction**
  - Would like to see alerts. Do not know about it earlier, it just converges on you.
- **Public safety information**
  - Think blinking lights are more attention getting.
- **Amber and Silver Alerts**
  - Would like to know definitions of alerts. Also, really have to know cars to be aware. Thinks you would need paper to write info down. Difficult to catch this information.
- **Special event information**
  - Sports stadiums near each other. Like the signs because you can plan an alternate route. Websites tell about certain events. Need to know especially in NY.
- **Weather**
  - Never know what roads are open. Some channels show you but not always accurate. Use TV and radio. For snow emergencies or weather emergencies can find out through emails, town telephone system, etc.

Other

- Mentioned color blindness and issue of app and websites using red/green. Like the idea of some vehicles allowing texts, emails through radio. Think that would be good if it did not affect driving.
- Took a long time to find something helpful, spend lots of time looking online.
- New to area may have to check newspaper.

What would be your ideal traffic information?

- Would like information consolidated. Would like it through radio and something like an app that can be set to a location.

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APPENDIX I

Focus Group Summary: Orlando

Orlando - Light Users Group - March 7, 2012

Introductions and responses to where they receive travel information

- Radio; news; highway sign; radio; watches traffic patterns when driving; radio and watches traffic patterns; GPS with traffic conditions; news and calls friends; radio; highway signs and GPS.

Sources of traveler information

- Radio
  - The radio will state there is an accident but it doesn't tell you when the accident will be cleared up. Sometimes the radio speakers will speak to fast and you miss the information.
- TV/News
  - People watch the camera on the news, when they want to know about traffic, that way they can check to see if the accident was cleared. They think the cameras on the TV give more accurate information than the radio. And they like the visual component of the cameras. TV is very reliable before you get in the car, not helpful once you get in the car, most switches to radio.
  - Some people will watch the new, and then call their spouses or children and let them know the conditions they saw on the news.
- Text/email alerts
  - Orlando Sentinel traffic sends text messages about traffic information. The texts are sent to her phone daily about traffic information, just when there is an accident on the road.
  - Most thought texts were only useful if you had a car or device that would read the text message to you.
  - Florida Sun pass for toll roads will send emails, with nearby construction that will affect the toll roads. The one lady who receives the lady doesn't know how she got signed up for the emails.
  - One person said and several people agreed that she "will not risk her life or anyone else's to check her phone while driving".
  - People try to avoid traffic on their daily commutes, they know where to go, and they don't want to see traffic information all the time that doesn't apply to their daily traffic.
- Apps
  - One person in the group was using an app that works with the GPS it was very reliable when looking at traffic.
  - A few people in the group were using the default travel app on their phone; they are not using any extra features.
  - One person knew of a public transportation app, in Houston, that would alert you if the buses were running late.

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  - One person used their spouses phone and found it very accurate. A few people pointed out that it only works best when traveling with more than one person in the car.
  - TeleNav GPS – they found the app to be very reliable, a friend told them about the app.
  - Several people in the group noted that apps were for the "young".
  - Beat the Traffic app – it will send you an alert, like a text message. The app doesn't speak to you, which people were concerned about in the group.
- GPS/Navigation
  - Most were using their GPS for turn by turn directions. One lady's GPS information gives her traffic information; it gives traffic information in real time. Then she will take the alternate route that her GPS suggest.
  - People didn't like that you had to pay to get road updates in the GPS.
- Onboard devices
  - Lexus-link has real time traffic, one person has it but they have not used the traffic feature yet. He felt that he knew better than the car. Lexus-link, you can call hands free and the operator will download directions to the car or you can enter in the directions. The system will even make reservations for you.
- Highway Signs
  - The highway signs are very reliable and allow you to get out of certain lanes. Even if they can't take an alternate route, they can tell someone they will be late with the time delays.
  - Everyone thought the signs were large enough and easy to read. They felt the signs have become more reliable over the past few years. The signs scroll between two messages, they are easy to read – but they would like to see the same sign a little further down the road so they could read the sign again in case if they miss something that the sign says. They would not like to share the signs with the Amber alerts if it is taking away from traffic conditions.
  - They would like to see more signs in rural areas.
  - They would like to see the signs before you pass the exit and they would like to see more signs.
  - They would like to see the signs color coated, so you could understand the signs as you are driving quickly by them.
  - What is nice is that it will give you time per mile. So you know if traffic will be bad for the next mile or over the next ten miles.
  - Some signs are great about notifying people about traffic patterns.
- Highway advisory Radio Stations
  - The station can be reliable when there is a major accident. The few people in the group found it useful, but they don't use it often.
  - One person will check the advisory station when traveling out of state to see what is going on.
  - A few tried the station a couple of times but wouldn't try it again.
- 511
  - One member of the group tried the 511 system but found it difficult to use when he was driving. It was not user friendly.
  - Several in the group saw the signs but have never called the system.
  - Most people in the group weren't familiar with the system.
- Local Highway Signs
  - No local road signs.
  - They would like to see them on "feeder" roads.
- Construction signs – portable
  - Some felt that the signs gave accurate information, but not that useful. They thought the distance was too close to traffic events.
- Social media
  - People will post that they are in traffic but they don't seek out traffic on social media websites.
  - Most people will check face book at home, not checking it in the car.

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- Internet
  - People will go to the internet to check weather, so they can better plan their trip
  - Google and MapQuest – to check directions, they only check this when they are going out of town.
  - They would like to see traffic with the directions they are looking up to better plan their trips.
- Public Transportation
  - No one is using public transportation. The public transportation is not good and reliable.

What type of travel information?

- Weather
  - Weather advisories will sometimes be posted on the highway signs. They want to know how the weather will affect road conditions. They would like to see more information about weather associated with traffic, especially in rural areas, where there is heavy fog and bush fires. They want the weather information up-to-date.
  - It would be nice to see signs that say "severe storms 2 miles ahead" because the weather patterns in Florida are not regular.
  - Concerns about pop up weather like Tornado's – people would like an alert to know that there is a warning.
- Special Events
  - The group wants to know more about road closures. Small signs such as sandwich boards, will remind people of events, but you have to be on certain roads to know about the events.
  - TV and newspaper will inform people but they acknowledge that some people don't watch local news or read the newspaper.
  - They acknowledged that you can leave an event easily where there is a heavy police zone, but as soon as you get out of the zone it is hard to get around.
- Construction
  - Street closures and how many lanes will be closed. They also want to know what time construction is happening so they can avoid the roads when construction is happening. It would be nice to plan ahead instead of being surprised by construction.
- Travel times
  - They would want to know if all lanes are open. They like 10 miles, 15 minute it helpful because you can estimate your trip. You have to know the local roads to know which roads are congested to get the best travel times.
- Alternate routes
  - Most people would prefer to drive out there way instead of being on stop and go roads. They would like to maybe see this information and internet site.
  - People felt they need to know the amount of time it will take the alternate routes.
  - They don't like to take alternate routes that have many turns; they also will not take alternate routes if they don't feel the neighborhood is safe.
  - They want to know how many lanes and what type of road is the alternate route.
- Local road conditions
  - People need to know and understand when and how to make a left hand turn.
- Tourist
  - Inform them of traffic on roads and what to expect on the roads. They should inform tourist of construction. Tourist should be given information on main toads about congestion, and what to expect when driving in the area.
  - Tourist drivers should get a sticker on their car that says "Tourist Driver".
- Traffic Incident

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  - They want to know what type of accident is it a hazmat or a fender bender. They want to know if traffic is moving and how many lanes are open. They also want to know how far the backup is.
- Traffic Maps
  - They like that the maps show the location. People have concerns about how up-to-date the traffic maps. They like the ones on the news that are animated with the color dots. They like when it tells how long the traffic has been backed up.

If you were in charge what would you do?

- The system need to be real-time. Coordinate highways signs with apps. They need to have campaigns to let people aware of what systems are already out there, advertise more. Consider the fact that people do not have computers and apps and you have to make a system that is available to everyone. Most people thought that signs were the best solution to traffic, because you are getting information on the road that you are on. Signs are the best way to share information – bilingual signs are hard because what languages do you put up. It would be nice if your car could be tagged with language preference in car to send alerts, a custom app in the car that is user friendly. They would like a system that is voice activates.

Suggestions to Orlando

- Keep information current and reliable, more early warning, of signs at least 5 miles before an exit, more signs.

Other Orlando

- If the road is a toll road makes a major decision on which road they will take.
- Highways signs are most reliable, when it comes to travel time.
- It would be nice if you know traffic information as you travel outside of your area. People felt this information would have to be sent to cell phones or an onboard computer.
- An app should be on your phone that will alert your to weather and traffic anywhere that you go. Even if it is a signal that will tell you to turn to the radio, like and emergency broadcast.
- They would like the signs to show minimal information, but they would like to see more of them.
- Long distance traffic will more likely check weather because that will dictate traffic congestions.
- Most felt that the technology it out there to make traffic easier, they just need a clear and concise medium.
- People will pay the tolls to avoid I4 – they don't care how expensive it is worth it when travel is bad.
- Computer systems that control the lights
- Weather and time of day make a big difference in travel behavior.
- Signs – will tell you about Amber Alerts.
- Need more roads

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Orlando - Heavy Users Group - March 6, 2012

Introductions and responses to where they receive travel information

- News; prior knowledge; AM talk radio; overhead highway signs; overhead signs; internet sites such as MapQuest or Google maps; just sites in traffic; TV and radio

Sources of traveler information

- TV/ News
  - Several people in the group watched TV in the morning before they left for their trip. Most found that TV news travel information was reliable. They liked the fact that the TV news stations updated traffic every 10 minutes.
  - Some of the group felt that the major drawback of TV was that by the time you get in the car and start your trip, the accident you learned about on TV may already be cleared up. Some people thought that TV is a good source of information but they don't have time to watch it in the morning.
- Radio
  - Everyone in the group liked and uses the radio to receive travel information. Most people in the group thought that the radio was the most current source of travel information. They also liked that most stations update the traffic conditions every 10 minutes. One of the other reasons that people liked the radio is because people call in the accidents to the radio, so they know the information is current. People also found the radio easy to use when traveling to other cities.
  - What they don't like about the radio is that people don't call into the radio when the accident is clear. They also see a need for more information from the radio if a major accident just occurred.
  - A few people in the group have either tried or currently use FM Sirius Satellite Radio; they found the traffic radio station to be very accurate and up-to-date. They liked that you could set the radio station to the city you were in.
- GPS/Navigation
  - For the few people who had traffic information on their GPS they said that the traffic information is reliable and nice to have. Most noted that older GPS models only provided turn by turn directions, not traffic conditions.
  - Most people are using GPS for turn by turn directions, and they don't use their GPS for their daily commute, they only use it when traveling out of town.
  - Most thought that having traffic conditions on their GPS would be helpful.
- Highway overhead signs
  - Overall the group likes the information received on the highway signs. They thought the information was easy to read, and significantly easier to read than the portable highway signs
  - The major dislikes of the signs are when they give range of "3-8 minutes" not very useful. It would more useful to give a more precise travel time. It would also be more useful to just list "no congestion" instead of a message that says "3-8 minutes".
  - Some people were confused about messages on the signs, for instance several people did not know what a Silver Alert was. When the sign is blank they don't know what to expect and wonder what a blank sign means.
  - People are not aware of problems because there aren't enough signs especially when a road is closed because of bad accidents. Most people wanted to see more signs.
- Local road signs
  - No local road signs in Orlando.
- Highway advisory stations

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  - A few people in the group have used the AM advisory when they have traveled to other cities.
  - The major dislike of the advisory stations is that the information is robotic and on a loop, it makes you wonder how up to date it is. Everyone felt you aren't going to get instantaneous information on the channel.
  - Most thought that AM stations do not seem to reach young adults, only older people tune in. Everyone thought that AM stations seem to be "crackly".
  - Everyone felt other radio stations are better, because you also get other information such as news, while you are listening.
- 511
  - Nobody in the room has ever called the system; several people said they didn't even know what it was for.
  - Most said they won't use the system because they don't like to use their cell phone while they are driving.
- Phone Apps
  - Most people didn't know that there were travel information apps.
  - People like the idea of an app because they can go to the information when they want it; most thought they would prefer an app instead of being texted all the time.
- Internet
  - Most commonly used Websites:
    - Website for I-4 that is just for traffic for that road. Runs by the state, and is really up to date
    - MapQuest -most people preferred
      - Dislike lack of traffic information
      - Liked, when traveling in Las Vegas, that MapQuest updated congestion zones, but they never saw this feature in Orlando
- On Star and other onboard systems
  - Nobody in the group is using OnStar or any other system, in their car. One person once used it in a rental car, but they didn't see the system as something worth paying for.
- Social Media
  - Nobody is using social media for traffic information.
- Text messages or emails
  - Several people have heard about it, but they don't know how to access text or email alerts about traffic. A few people in the group received breaking news emails. Occasionally a traffic email is sent, in the breaking news emails but it has to be a major traffic incident.
  - People would sign-up for, text message of email alerts if it was a free service.
  - One person, received severe weather texts for Tennessee, but they didn't know how they were signed up for the service, they thought it would be nice if this included traffic information.
  - "Older adults don't do text", they try not to talk or text while they are driving.
  - One lady had an app, that doesn't allow her to get text or phone calls while she is driving. She doesn't know how she got it.
- Public transportation
  - No one in the group was using public transportation.
  -

What would you like to see in travel information?

- Traffic cameras
  - Link cameras that are on highways and major roads and make them accessible to the public, so people can see real-time information.

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  - They would like to see this information in several mediums such as an app, feed the information into the car's onboard computer, and/or add it to a website. It was noted that this could be distracting to the people in the car.
- Traffic maps
  - Set app to the city that you are traveling through, but if you are familiar with the city with basic information, show information on a map that is easy to read. Several people thought this would work best if you are traveling with someone so it is less distracting.
  - Maps need county name information, especially for emergency information.
    - Example of tornado's in Illinois in early March people didn't know what county they were traveling through, and did not know when to take cover mentioned on CNN and one lady thought this was important information.
- Major traffic Incidents
  - For major traffic incidents, like when the highway closed, there should be an emergency broadcast system. But this is only for severe traffic conditions, like when a highway is shut down.
- Update on road changes
  - When there are updates in road changes, most of the group felt that the highway signs were very accurate. They also looked for information on road changes in the newspapers, especially on new traffic patterns.
  - Most people in the group did not like getting traffic information updates from the portable highway signs. Several people in the group did not pay attention to the potable signs. Most felt they did not give accurate information and that the signs were very hard to read.
  - One person in the group saw a portable sign that read "trek ahead caution zombies" people were pulling off to take pictures; at least the signs were amusing.
- Weather
  - Hurricane related traffic information, everybody want to know what roads were closed, when tolls were lifted for evacuation, when both sides of the highways are used for evacuation out of the city, which local roads were not accessible, and which alternate routes they can use when a road it too congested. The major information for traffic information is the TV.
  - For an unexpected weather event, most thought that you have to find out the information from an AM/FM radio.
- Parking
  - Nobody in the group saw a need for parking information. The only place where parking was an issue was downtown Orlando.
- Special events
  - The most important information that people in the group wanted to know, was what time and when the event was happening. Radio is a good place to find out special event information. Everybody felt that it was hard not to know about major events if you lived in the area, because they are well advertised on TV and radio.
    - e.g., NBA All-star game - TV showed map of road closures, everybody felt that if they didn't need to be at the event they would avoid the area and traffic.
- Congestion
  - When there is traffic congestion everybody in the group wanted to know what type of congestion, expected time of opening of roads that were affected, and alternate routes.
- Public safety
  - An alert should happen when there are felons that have escaped from prison. You can be more aware when you are driving.
  -

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Overall traffic information

- Clear and concise information
  - What is going on – what type of traffic incident happened
  - What lanes and roads are affected
- Real-time information of what is going on the road
- Have information shared through a Bluetooth, if your car doesn't have an onboard computer.
- Most people in the group would pay for a travel app if they could find out information that is important to them:
- They want to know - when there is traffic congestion, what type of congestion, expected time of opening, alternate routes, fuel, rest areas, construction, gas station prices, gas station locations in relationship to the highway (how far), nearby food, important weather information such as smoke and fog.

Overall value of traffic information

- Nice to have because it avoids the hassle, saves time, creates less aggravation, energy saver, let you avoid congestion, let's you avoid construction, informs you of travel times
- Some felt that information valued differently depending on where you are, local vs. non-local. When you are local you hear information more often on news and TV, whereas for non-local traffic you are less informed of the area and need to know more.

Traffic information solutions

- Most thought that the best solution is an app that can be "On Demand" so that the user can seek out the information that you want.
- They liked the idea of an app because like the radio you have the choice to tune in or not.
- When developing an app, most people in the group thought that you need to be considerate to different demographics and age groups. The system needs to be universal to keep everyone informed.

If you were in charge, what would you do?

- Set up big screen TV screens with travel information
- Add highway signs to other major roads
- App that you could access "On Demand" so you could extract information that you want – no wasting time listening to information that doesn't pertain to you.
- Voice interactive information system so you can be hands free in the car
- They want additional information such as weather, construction, what is a good place to eat, a GPS like system that is either in the car that is interactive that is real-time information about your travel route and that is interactive about your route.
- They liked travel maps –easy to view, like on the GPS
- They also want to know if traffic is backed up how far it backed up.
- It helps to remind people not to look at accidents, signs should say maintain speed, keep right, people need to be reminded to keep moving.

Specific recommendation to Orlando

- Integrate what you have and make it more available to everyone; most felt that technology is being wasted by not sharing it.

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- They all wanted better signage and more signs further away from road, so people have more time to prepare and react to the signs.

Other

- Speed limit signs - the speed limit changes and you don't know what the speed limit is or when it changes.
- When you leave for work affect how badly traffic is.
- Key to traffic is timing.
- In Orlando, the roads have multiple names so it can be confusing on how to get around.
- Apps don't necessarily serve the entire population. The radio can't give you all but it can give a good overview of the most important information – but people have to know where to go to get the information. Broadcast the radio stations on the signs over the freeway.

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APPENDIX J

Focus Group Summary: San Francisco

San Francisco - Light Users Group – February 29, 2012

Introductions and responses to where they receive travel information

- Highway signs; SF Navigator to look for traffic information, radio and online; online for traffic conditions; news; personal knowledge, retired so is flexible; news for local traffic, internet for out of town travel; 511

Sources of traveler information

- 511
  - Most people in the group were familiar with 511 on the phone or website. People felt that the 511 phone system had a "reassuring voice". People who had used the system felt that the voice recognition on the system was very good. Everyone who used the system liked that the system gives you multiple routes. Everyone enjoyed the humor in the message "Exit was destroyed" the system said this after a tanker truck exploded on an exit ramp.
  - One of the major disappointments for the 511 system was limitations in the start trips and destinations. It only worked efficiently if you were starting or ending your trips on certain major roads.
- Internet Websites
  - 511.org – people liked the pictures of the maps and they thought the colors were easy to understand and it was easy to zoom in and explore the map. They didn't like that there were limited points on the maps, and at times not accurate.
  - SF navigation – likes the color maps
  - MapQuest
  - Google/Bing –likes the traffic maps, most thought the information varies on how reliable it was. Most the information on Google/Bing was always improving.

- Highway overhead signs
  - Most people that that time to travel destination was very reliable, but not helpful when looking for alternate routes. Most people liked the signs and they didn't think there were enough of signs.
  - A few people thought that signs can be confusing and not clear about the bridge. For example the bridge was only closed one way not both ways like the signs implied.
  - A lot of time the freeway signs give you information too late, most times you see the highway sign but it is too late you are already committed to the road you are on. Seeing the sign "makes you sad", because it is too late to change your trip.
- TV/News
  - Most people found the traffic reports on the news very reliable. Watching the news on TV in the morning is easy to use when you are getting ready in the morning.

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- Smart phones – websites or apps
  - Several people in the group use default map app on their smart phone. Many people relied on Google maps for traffic information and thought the traffic updates were very good.
  - Most people don't like using their phones when driving but most admit that they look at their phones if they are already sitting in traffic to see how bad traffic is.
- On Star and other onboard systems
  - One person in the group was using Ford directions. They liked the fact that car will use Bluetooth in car and that the system will read you turn by turn directions
  - Onstar, people like that the system gives you directions
- GPS/Navigation
  - Some people were using GPS systems with traffic layers. Most didn't think the traffic information was in real-time. And the systems that they were using were not very reliable and spotty in certain areas. When traffic is bad, there are not a lot of alternate routes to take; people will take out printed directions as a back-up to their GPS.
  - Most people don't use GPS on their daily commute because they understand and know the roads they are taking.
- Emails and text messages
  - No one was using emails or text alerts, most people want to know who sends the information and how reliable the information is.
- Social Media
  - A few people in the group have tweeted if they are in bad traffic. When traveling to major events, they will look at friends updates to monitor how bad traffic is.
  - No one is seeking out traffic information on social media. A few people follow local news channels on twitter and will occasionally see traffic information but they don't seek out the traffic information.
- Radio
  - Everyone likes radio as a decision making tool. They like stations that encourage listeners to call in and report the problems. A few people will switch to AM news stations when the traffic gets bad.
  - A dislike about the radio is that sometimes the information comes too quickly, you might miss the road that you are interested in.
- Traffic cameras
  - Some felt that they were helpful in major accidents.
- Highway advisory radio stations
  - Most people think the advisory radio station never works. A few people have said that they tune into the station when they travel to Lake Tahoe, through the mountains, they will mainly check to see if roads are closed or if they need to add chains.
- Other
  - People will call their friends to let them know not to go certain ways, when they are in bad traffic.
  - Check traffic from back window at her house, because she can see the highway and if it delayed.
- Public transportation
  - A few people call a 4 digit phone number to hear about bus times in Emeryville, and find the times to be very accurate.
  - They like apps for public buses.
  - Most people check for bus information before they travel. They will check to see if there are any delays. They will also look up bus schedules on the internet. If the travel time is wrong for the buses they will sometime drive because it is faster.
  - Most people will use public transportation if it is accessible to the event that they are going to. Most people thought that BART was very reliable; they thought the MUNI bus system was less reliable.

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Information about the San Francisco Bay Bridge closure

- The information was well advertised on the news, radio, highway signs, some even saw flyers posted at restaurants.
- They wanted to know more about train information when the bridge was closed, some people knew that extra trains were running but did not know a lot of information about it.
- When the bridge opened early they found out on the news and radio.

What would you like to see in travel information?

- Trip time
  - They like the highway signs with trip information. Most people like to see how long the trip should take. They also want to know if the traffic is heavy, or light especially if it is a road they don't typically travel, just stating highway time to next road isn't always helpful without extra information.
- Public Transportation
  - Most people thought that it was just most important to know what buses or trains were delayed.

- Traffic delays
  - People want to know what type of incident happened on the road, so they can adjust their trip. Most people like that 511 will tell you the incident on the road.
- Special events
  - Most of the time there are signs that let you know if a game is going on or a scheduled sporting event.
  - With parades most people want to know what streets are closed. They also want to know a good centralized place to get the information. It would also be nice to know where critical mass is gathering so they can avoid it.
- Parking
  - Most people would like to receive notifications of parking garages.
  - Some thought that parking meters notifications would be nice. They aren't using the app but they are aware that they are out there or that they are going to be created. The apps that they are using have very little reliability. Most people have no faith that the parking apps would be accurate.
- Construction zone
  - Most thought it would be nice for detours and alternate routes. They also want to know the length of the road closure. They also want to know how many lanes will be affected when there is construction.
- Alternate routes
  - It is nice to see alternate travel routes on their IPhones, they like that the app will give you three different options
  - When looking for alternate routes they would like a system that would give you route A and B are busy you should take route C. It would nice to know fastest route.
  - Most people just want to know major places to avoid.
  - Most people want to see how long the backup is going to be. Most people felt that the sign is too late, especially when traveling though the tunnels. Once they see that there is a delay you are there and you have to commit to the road.
- Weather
  - Weather is important information to have when traveling through the mountains.

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Which system is most reliable?

- Most people felt that TV Local News, 511, Radio, and Online 511were the most reliable.

What travel information is annoying?

- When you hear there is a traffic incident but once you get to the spot on the road it is cleared out. No one ever reports when the incident is cleared.

What disappointments to you have with travel information?

- People dislike that on the radio you have no control over the information you get. Missing data on some towns in the 511 area, the scope isn't wide enough. Inaccurate times and inaccurate routes on GPS, GPS isn't up to date in new developments.

If you were in charge, what would you do?

- They like to see maps online because they are in more control in travel information that pertains to them, they would like to see more of this. They would also like to see speed limits on maps that they are looking at online. They would also like to see HOV lane information. They want to see what type of accident it is, for example a tractor trailer takes longer to clean up and they would like to know how long the cleanup will take. Visual comments to the traffic conditions are very helpful. People also like traffic cameras, but no one is seeking them out.
- They want to know how backed up each freeway on ramp is; where to park for free, when meters run out, where tow away zones are, and how much the ticket is going to be; extreme weather; estimated time travel would be useful, real-time would be better. Average time would be good too; Gas prices, where to find cheap gas; Streets with timed light changes, because they are the streets that you want to be on during rush hour; crime statistics for an area traveling thought, something like Microsoft's recently announced walking navigation system that allows users to avoid high-crime neighborhoods.
- For public transportation they want to see bus and train times at stops on a running ticker and have it at every stop.

Concerns on travel information

- Everybody wants to know how accurate the travel information is. Most feel that false information is worse than no information.

Other

- Internet is the easiest information to need. The color maps are very clear. They would like to see if the line is red it would be nice to why it is red.
- Most information is easy to understand it has been dumbed down, and it is just limited.
- Most people want clear and concise signs. A few people suggested a rating system of the signs, maybe in color, so it is easy to understand what traffic conditions are and how long travel time should take.

Overall value of traffic information

- Time, peace of mind, avoid stop and go traffic, avoid frustration, safety issue – avoid accidents

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Specific recommendations to San Francisco

- San Francisco has limited routes
- Barrier to using apps, is the monthly service to provider.
- People compare different websites, especially in the city where there are often one way streets
- People already know the alternate routes because they have lived there so long.
- San Francisco doesn't have many alternate routes.

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Introductions and responses to where they receive travel information

- GPS used to changed travel information; Friend texted information; Looks at traffic patterns on internet; Received information from signs about weather; Internet before they leave home and GPS; Watches traffic patterns; Checks 511 voice activated system

Sources of traveler information

- 511
  - Some of the group is using 511; everyone who is using the system said that is very reliable. People like 511.org as well because it has links to everything.
  - The people that are using 511, learned about the phone number from signs on the road.
  - For the rest of the group that is not using 511 they don't think about using it, and they prefer other systems.
- Internet
  - Most people in the group that checked the internet for travel information checked more than one internet site.
  - Most people liked to look up travel information on the internet because most sites give alternate routes, they can choose a route that does not have tolls, and they can look up restaurants and other points of interest on the maps. Another major positive is that websites like Google give an option for walkable routes
  - Most commonly used Websites:
    - 511.org - Likes that it links to everything
    - Google Maps (used on occasion but not often by most) -Good because it gives alternate routes and people liked that you can drag the route, so you can pick your own roads
    - SF Chronicle –online newspaper
    - Other local TV or news web pages
    - MapQuest
    - BART – for public transportation
    - "Muni" – website for public transportation
    - Buses are equipped with GPS -even though the buses should give you real time information it doesn't work well and is not very accurate

- TV/News
  - Most people liked getting travel information from the news because it is detailed and can give you specific travel information.
  - The major dislike of travel information from the TV is that it is hard to get accurate information by the time you leave.
- Radio
  - A lot of people in the group used radio as a decision making tool, everybody that used the radio thought that it was a very reliable source to receive travel information.
- GPS/ Navigation
  - People mainly use their GPS for turn by turn directions; they find it accurate and very reliable. They like that the GPS will give an option of three different routes to take and the fact the GPS speaks to you.

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  - The major issue with the GPS systems is that they are hard to keep up to date, San Francisco has a lot of one way streets, and the GPS is not always current. Several people in the group thought that you should back up the GPS with paper maps. They thought the paper maps were kept more current and provided a good detailed map to use. Most printed out directions or carried a paper map in case there GPS doesn't work (especially when traveling near the mountains).
  - Most people felt that their smart phones, either Android or IPhone, had a more reliable GPS than the portable units that they place in their cars

- **A**pps
  - For the people in the groups that had smart phones, many of them have not loaded additional apps on their phones; they use the app that was provided, which is typically called navigation.
  - DriveSafe.ly is a free app that reads text messages through your Bluetooth, one person in the group is using this.
  - Everyone thought that voice commands are key to using phones when driving.
  - A few people are aware of public transportation apps, but nobody was using them.
- Social Media
  - No one is looking for travel information on social media. A few said that if a friend posts something on traffic they will acknowledge it but they will not actively look for information there.
- Text/Email Alerts
  - A few people in the group received text alerts. The people who received the text alerts found them to be very reliable.
  - The information from the text alerts came from San Mateo County Sheriff's office; it is also limited information for San Mateo County information. The San Mateo county alerts can come from either a text message or via email, and the service is free. One lady knew from a friend the other lady knew because her niece works in the sheriff's office. The service is not widely known. The service does not update often, but when it is updated it is very reliable.
- Highway overhead signs
  - Most people felt that highway travel signs are very accurate and reliable source of information.
  - The major dislikes of the highway travel signs are that once you see the signs in most areas it is too late to change your travel decision, and for the most part in San Francisco there aren't very many alternate routes to choose from. Most people felt that traffic slows down when the sign has information because people are slowing down to read the sign.
- On Star and other onboard systems
  - A few people in the group were using OnStar; they liked it because it was nice to talk someone to find alternate routes.
- Public transportation
  - Public transportation is often unreliable in the city. Better transportation information is needed.

What would you like to see in travel information?

- Parking
  - Most people thought that parking in the city was a problem. Some people had turned to an app to find parking spaces, which seems reliable. The app listed garages and told you how many spaces were left. They learned about the app in the San Francisco Chronicle.
  - In general, most people wanted to know where they could find free parking and when streets became tow away zones.
- Special Events
  - Watching TV and reading the newspaper was the best way to learn about special events.

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  - Most people in the group wanted more information on events, like a list of events in advance that were happening on a weekend. They also wanted to know the date and time, the main routes to event, alternate routes around the event, and traffic the day of the event with routes and alternate routes
- Additional information
  - People would like see information about the surrounding counties to San Francisco, because most travel isn't limited to the city or surrounding suburbs.
- Big alerts such as the Bay Bridge closure
  - Billboards had the notice, highway signs had the notice, TV, radio the information was everywhere. And it was given weeks in advance. Everyone in the group knew this event was going to happen and was prepared for it.
- Traffic congestion
  - "Traffic congestion is just something you have to deal with". For most places there are limited alternate routes. Everyone felt that if you want to avoid congestion leave earlier.
  - Everyone liked that the traffic congestion colors were consistent on all the maps that they looked at. It made it easy to understand.

Overall traffic information

- There is a lot of information already out there.
- We already receive too much traffic information.

What gives you the most piece of mind before you travel?

- Most people felt that the travel information didn't give them much peace of mind. Before they begin a trip most people prefer to map out the route to make their travel decisions. Everyone felt that it is just best to leave early.

If you were in charge, what would you do?

- It would be nice to have free apps, where you don't have to pay for the extra add ons. That is the one thing they did not like about current navigation systems, or certain apps. Everyone felt this information should be free
- Everyone wanted to see more accurate clear time of accidents; they understand that it takes time they just want to know how much time. Most people felt that by the time people find out about the accident they are already committed to the route.
- In emergencies they want to hear alerts on their phones, to learn about which routes are accessible. They felt this information is useful on the phone since they always have their phone with them.
- Most people felt that Apps and texts are dangerous to use when driving.
- People want more up-to-date information; More consistency in information, a one stop shop of information; display destination and time, to show traffic patterns; have free data sent to phones.

What is the most credible source of information that you are receiving?

- Signs credible when on highway; Google, changes with time, which is reliable; 511, very accurate whenever it is called

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Confusing information

- Streets not updated in maps where they are making travel decisions. Also, signs can be confusing, when the information is not clear, e.g. when you can make a left turn during rush hour.

Convenient sources of information

- Radio and GPS are most convenient driving. Internet and news before you leave for your trip.

Receiving travel information

- Many people thought that receiving travel information saves time and creates less stress.
- A few felt that all of the travel information makes you worry more.

What did you look at before you came to the focus group?

- Some people entered the address in the phone and allowed an extra few minutes
- Some took public transportation because it was convenient and they didn't have to worry about parking
- Check times of trains and buses before they left so they knew when to leave, checked on internet before they left.

Specific recommendation to San Francisco

- People just know that there are certain times to travel then other times
- Most of travel information is intuitive to the city
- Traffic is an everyday problem, best to just double your time
- San Francisco does not push public transportation, and public transportation doesn't connect, and very expensive, and not frequent
- Most of the group doesn't travel far on their daily commute.

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APPENDIX K

Focus Group Summary: Washington DC Metro (Rockville, MD)

Rockville - Light Users Group – February 8, 2012

Introductions and responses to where they receive travel information

- Radio or news on TV; alerts to phone, radio and signs; GPS – with traffic; TV or overhead signs; Phone and Sirius radio and Montgomery county dispatch information; Radio; Just knowing the roads and the road conditions

Sources of traveler information

- Radio
  - They like that traffic conditions are updated every 10 minutes so you can channel surf the radio and come back when you want traffic information. They like that you also get news updates with the radio. You are able to get a lot of information in a short amount of time.
  - Sirius radio – updates traffic on the "3's" so you know when to tune in. Sirius will give you an alert to know that traffic is happening so you know to switch to the traffic station.
  - They dislike, when the radio just says the exit number and not the name of the road.
- Overhead signs
  - They want to see reliable information; they would also like to post information about what is going on the road. Some people thought that the traffic signs slow down traffic. It can also be had to see when the sun is at certain angles. The signs can be distracting. People who see the boards everyday like that the signs are accurate and have become accustomed to viewing them. People who see the signs every day do change their routes based on information they see from the sign.
  - The amount of information that is currently on the signs is the right amount.
- Local road signs
  - There aren't any local signs around Montgomery County.
  - They would like to see them because any information can be useful.
- Highway Advisory Radio
  - They dislike that the information is on the loop, and the information isn't clear. Most people felt the information was old. People felt it was hard to tune into and once you found the station it was very grainy and hard to hear. Most people have tried to use it.
  - They would like to see the information on an FM radio station.
- GPS/Navigation
  - People like that the GPS talks to you to give you information. People prefer the information because they can seek it out and find it when they want it.
  - People like it when the GPS gives you different routes.

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  - People acknowledge that the best way to keep you updated is to constantly update your GPS. Some people get messages that they have to update their GPS. You have to pay to get either lifetime updates
  - Internet
  - MapQuest – to get an idea of the route
  - GoogleMaps for directions
  - Bay Bridge website for bridge information
- TV/News
  - Most people check the news in the morning before they leave. It won't influence the decision making for most people but it provides good information.
  - OnDemand on TV – you can look to see traffic and weather. This service is on both Comcast and Verizon. The people who use this found it very accurate.
  - Apps
  - TellaMap – gives good information – found out the information from her husband.
  - GoogleMaps or the default map on their phones is what is primarily used.
  - A few people weren't aware that their phones had GPS
- Text/emails
  - Montgomery county alert sends out emails that alert about traffic. The one person using it found out from their wife.
- Social Media
  - No one is seeking out traffic information on social media. The only information they see about traffic is if a friend posts something.
- 511
  - No one was aware of 511; a few have seen the signs. One person called it once never called it again, they thought it was confusing but they called years ago. They wanted to know how often the system was updated.
  - Concerns about it being cancelled, the weather number that they used to check is no longer in service
  - They would like to see a traffic phone number. Cautious about phone systems because most people thought that you shouldn't use your phone while driving.

What type of information?

- Alternate routes
  - It is hard to find out alternate routes; unless you have a GPS.
- Parking availability
  - They want to have a sign that would let them know how many parking spots are available, or before they pull into a garage, how many spots are left.
  - They also want to know when they can't park in certain areas, because they might get towed or ticketed.
- Construction
  - When construction starts and when it is going to end. Construction during the day is confusing; it should be done at night.
  - TV access channels would be a good place to find this information. Or display this information on an alert across all TV channels, to get people's attention that don't watch the news. It would also be good to find this on a website. They also need more information that is real-time.
  - It would be nice to know where there will be lane closures, not only for construction but also for things like tree trimming, and inform people what the alternate routes are.
  - They would like to see this information on a website like montgomerycounty.gov.
- Alerts

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- People liked them on the signs because they know they should stay alert.

What people would like to see?

- They are concerned if the apps are free or if they have to pay for them.
- They want information that is easy to use and is simple. You need to adjust to all levels not all people are computer friendly.
- They want information that is important to where they are traveling to, if they are not traveling to certain areas, they don't want to know about it.
- They like to see colors on map, they are easy to use. Red, yellow, and green are easy to understand.
- They want a graphic organization, where they can search for the information that they need.
- They want a free app.
- People would like an alert either to the radio or to the phone (which they can't use in MD) to let them know when traffic is bad.
- People would like to filter what information they don't need. Some systems already let you choose which information you want to receive.
- Several concerns about how to access the text while diving, some people don't look at their phone when they are driving because it is distracting. Some people responded that you do text to Bluetooth so the texts will be read to them as the solution.

What are you looking for when the weather is bad?

- Most people know to leave early, and they just assume that the traffic will be bad. Most people won't look for information if it is a short trip.

Emergency

- They would like to have a plan of action of where they can go to get information. They would like an app for emergency situation, so people didn't cluster on one road.
- Homeland Security should provide an app with safety information, alternate routes, congestion, and emergency evacuation routes.
  - Example of earthquake that happened last summer: People didn't know where to go for information. It would be nice to have information sent to their phones – people did note that the earthquake the phones systems did jam.Texts would be the best way to get the information.

Where would you want information if you were from out of town?

- People would rely on radio, and GPS.

Most credible source of information

- Radio was what most people felt was credible, followed by GPS, TV, road signs

Most confusing

- Some people thought that TV has confusing information, and not as accurate.

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Once you have started your trip

- Radio and traffic alerts, and highway signs.

Before your trip

- People watch TV to learn about traffic.

What is the most beneficial piece of information?

- Radio has the best explanation, because it often tells you what is happening. Like what type of accident or when events are happening or ending.

Overall value of traffic information

- Making informed decision; better judgment of time; real-time information is most important; knowing patterns of the area; how long it will take you; knowing traffic patterns.

Other

- Traffic camera's cause problems because people slow down when they see them.
- Time of day will make the most important decision when it comes to traffic.
- There was some confusion in the group about what defined a smartphone.

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Sources of traveler information

- Radio
  - Trusted when caller phones in, felt information more up to the minute and most people can access.
  - Cons were that may not know stations for certain locations and have to pay for satellite radio or similar services. Also, the information only provided at certain times, e.g. WTOP traffic on the 8's.
- Websites
  - Mentioned using Verizon Fios, able to see 20 incidents at a time. One participant mentioned looking for location to make decision Pros were that you could trust websites for route planning, especially in local area.
  - MapQuest/Microsoft Streets and Trips
    - Find a good suggestion maybe about an exit one had not thought to take previously
    - Sometimes MapQuest will take you on longer route
    - Like the side notes that tell you if you've seen X then you've gone too far
  - Cons to websites were if you look at information before leaving house it could change by the time you get to a certain route. Felt that it may be useful if leaving to go somewhere in the middle of the day. Do not seem to have as much trust for planning alternate routes when route planning, e.g., feel that others will be getting the same information and then alternate will be backed up. Less trust of websites if out of local area. Also, they were concerned about lack of access, e.g., everyone does not have computer access.
- Websites on Phone
  - Cons are that it is the same as being on the computer, cannot look at information unless a passenger is in the vehicle**,** have to constantly look at it. Also, lack of access.
- Phone Apps
  - Mentioned several phone apps that have been used. Like that phone apps provide information via voice.
  - TeleNAV
    - Really good data
    - Tends to be five minutes to a half mile behind traffic
    - When app says "red" it is really slow
    - One participant said "Like to see if I can get past the red before the traffic really breaks"
    - Same participant said about app "Pretty good, works up and down the East Coast accurately"
  - Beat the Traffic
    - Info about location of accidents
      - Uses icons to provide info about incidents/accidents
      - Red icon
    - Can click on it and get exact location
    - Provides alternate routes
    - Provides exact location
    - One participant liked that it lets you choose the best thing for you by providing a specific address not just the area
    - Free or can get a premium version
    - One participant felt it was a benefit over text alerts, such as Montgomery County Alerts because it provides specific locations but one still have to decide what the choices are for them
  - MotionX
    - Info about accidents, i.e. 5 miles down the road there is an accident

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    - Traffic updates every half hour
  - Cons to phone apps are lack of access as everyone does not have a Smartphone. Also, some are fee based, e.g., Motion X
- Social Media
  - Participants thought Twitter could be "ok" if source was not a friend, i.e. source was DOT
  - Cons to social media included being less trusting of other people's opinions**.** One participant said "opinions on how bad things are…are so different." Felt that the news would give more exact feedback. Felt that a caller on the radio mentioning a specific traffic incident more trustworthy than social media**.** Also, lack of access to social media mediums, e.g. smartphone or computer.
- Text messages or emails
  - Signed up to local info, e.g. Montgomery County, MD alerts**.** Thinks that the local alerts are pretty good. Like that you get information the entire day.
  - One con is that people felt you should not get text alerts when you are not traveling, i.e., 5am
- Highway Advisory Radio
  - One participant felt it could be a useful source because you do not have to play with a cell phone to use. Participant also said "idea that it is in your car would be more immediate
  - Cons were that it is hard to access clearly, fades in and out and can be days behind.
- 511
  - One participant has tried system on New Jersey turnpike**,** Punch numbers while driving**.** Group not aware of system in MD
- GPS/Navigation
  - Like that some systems, i.e. TOMTOM provide speed info and alerts
  - Cons to GPS are that you need to program info into it and it does not provide all the features that an app can provide.
- Highway overhead signs
  - Like that they are pretty accurate, e.g., Felt that for Dulles Toll Rd., sign more up to date than website. Also, pay attention to them, e.g., bright.
  - Felt that there are not enough signs.

What would you like to see in travel information?

- Congestion/Incidents
  - Would use another route if 270 was blocked. One participant feels that the radio usually knows where the nasty ones are. One participant felt that the issue is that it usually takes a while to get the information, confirm the info and disseminate the info with this info source (radio).
- Traffic Cameras/Hot Spots
  - Feel that they are a good info source when working. One participant mentioned website with cameras for information about Bay Bridge- like that you can pick section of the road. Use Traffic.Com and Fox 5 News or NBC 4.
- Construction
  - Areas to avoid. The **Beat the Traffic** shows an icon of construction cone indicates area where construction is and can click on it and get address where it is occurring.
- Route planning
  - Decisions about delay times**.** Mentioned that it may be easier to deal with a 10-15 minute delay than to change routes altogether.

Overall**- Information Sources**

- Some suggested one source/integrated source

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  - Source would need to be credible with a lot of info
    - "One of the key things would be collecting the data so it is accurate"
  - Want a source that is "seamless, easy and inexpensive"
  - "Just like cell phone companies they merge to make things better, come together to make things better"
  - One participant preferred single radio station throughout each state that would change as you got to the next state via the signal
    - Likened to watch changing when you fly
  - Want multiple sources so one can pick and choose which one is accurate
  - Something more ongoing, i.e. constantly cycling through the information
    - Local radio only updates on the 8's

Information Type-

- "More, faster, better"
- Customization of information types
  - Want to know about specific route applicable to them
- Want to see information about special events especially if traveling from another city to one not as familiar with
  - Could be a bulletin/sign
    - Would need to be close to an alternate so close enough to make a route decision
  - Something possibly as part of traffic app
    - Add an icon
    - Use zip code

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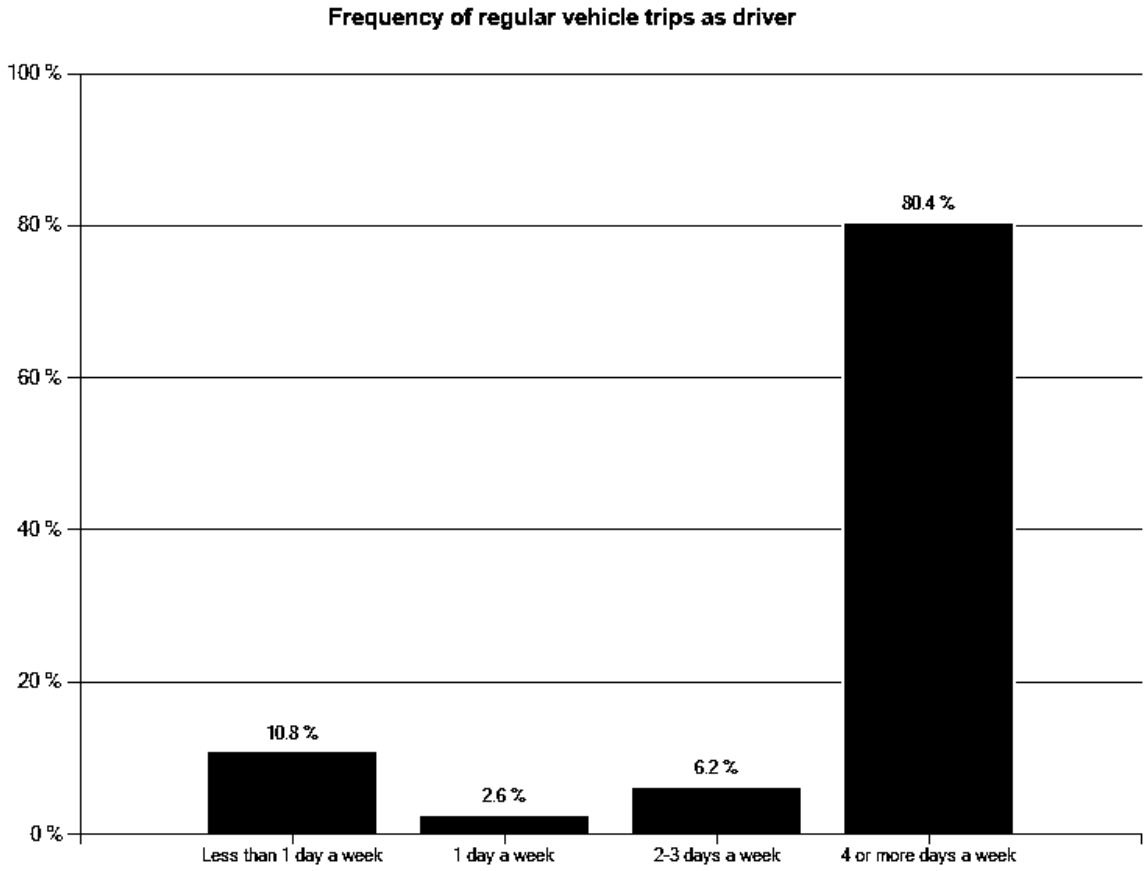
APPENDIX L

Results (combined): Detroit/Salt Lake City Metro Areas



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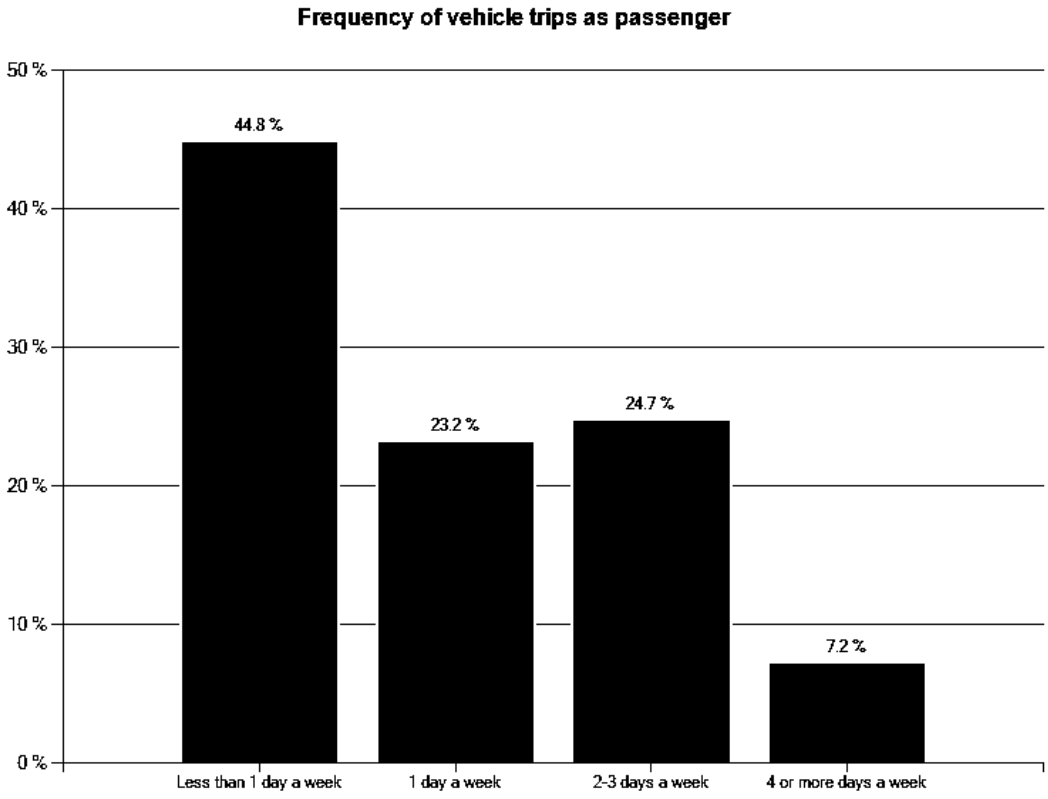

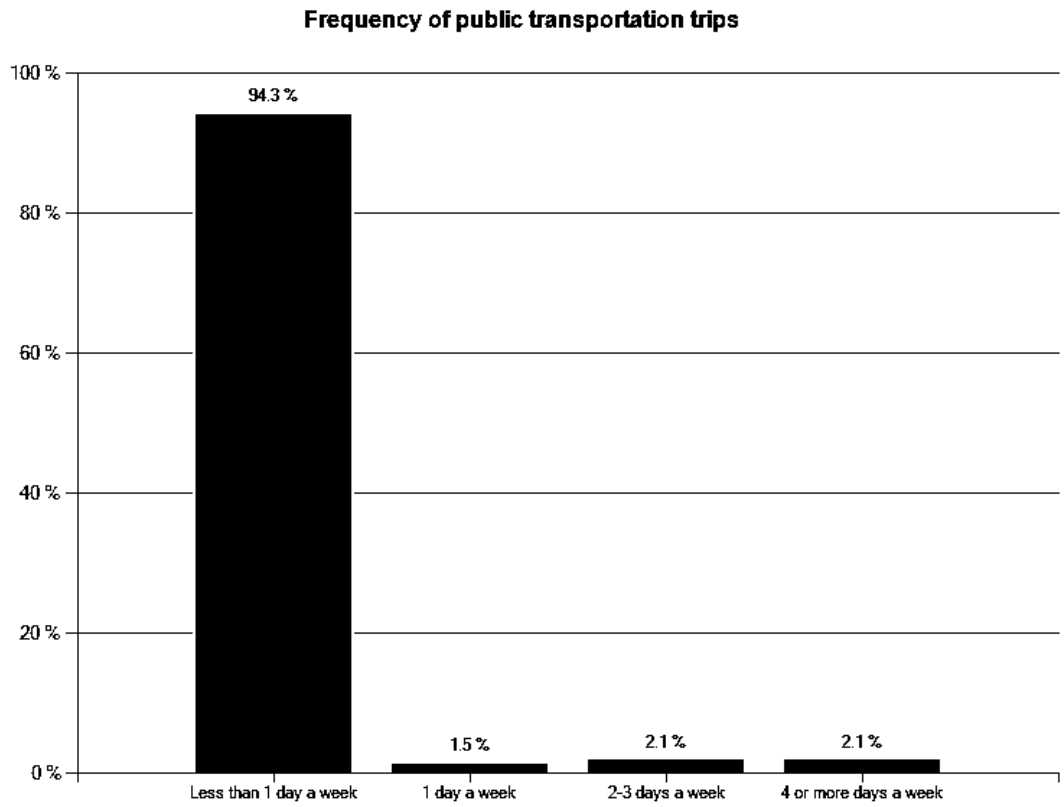

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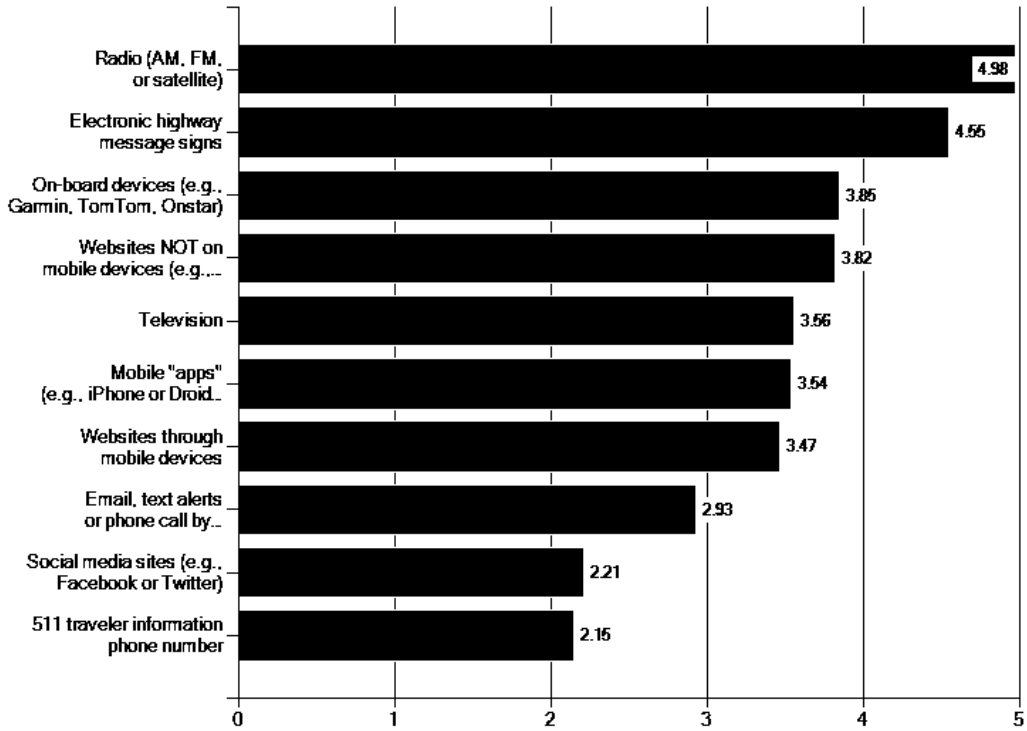
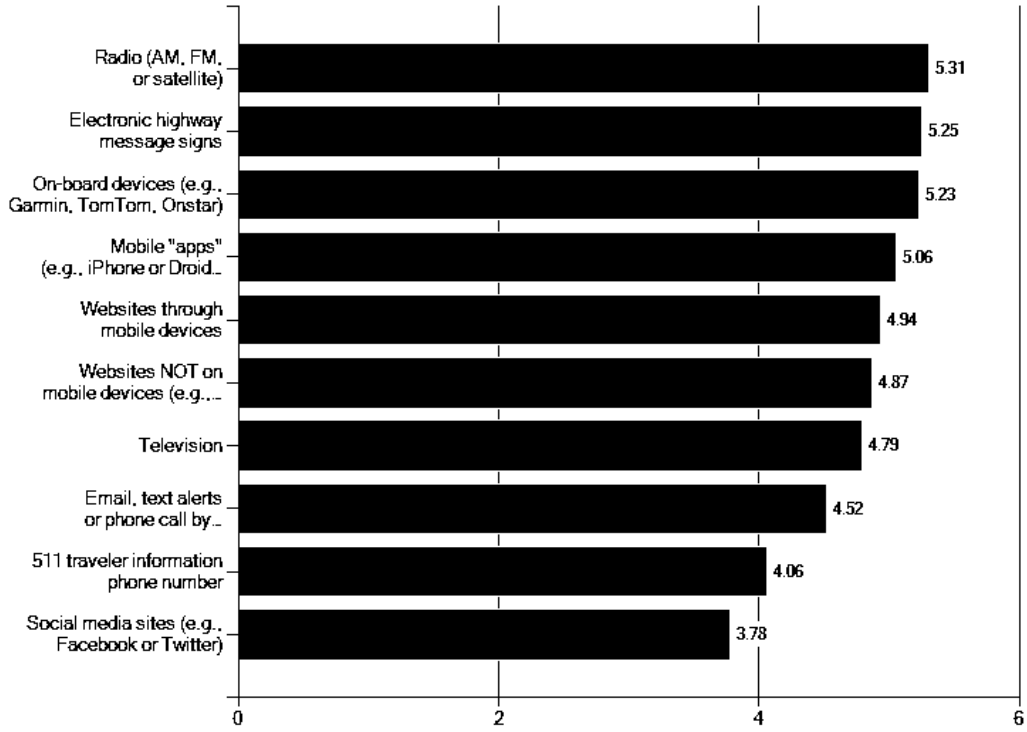
Importance of traveler information sources used



Accuracy of traveler information sources used



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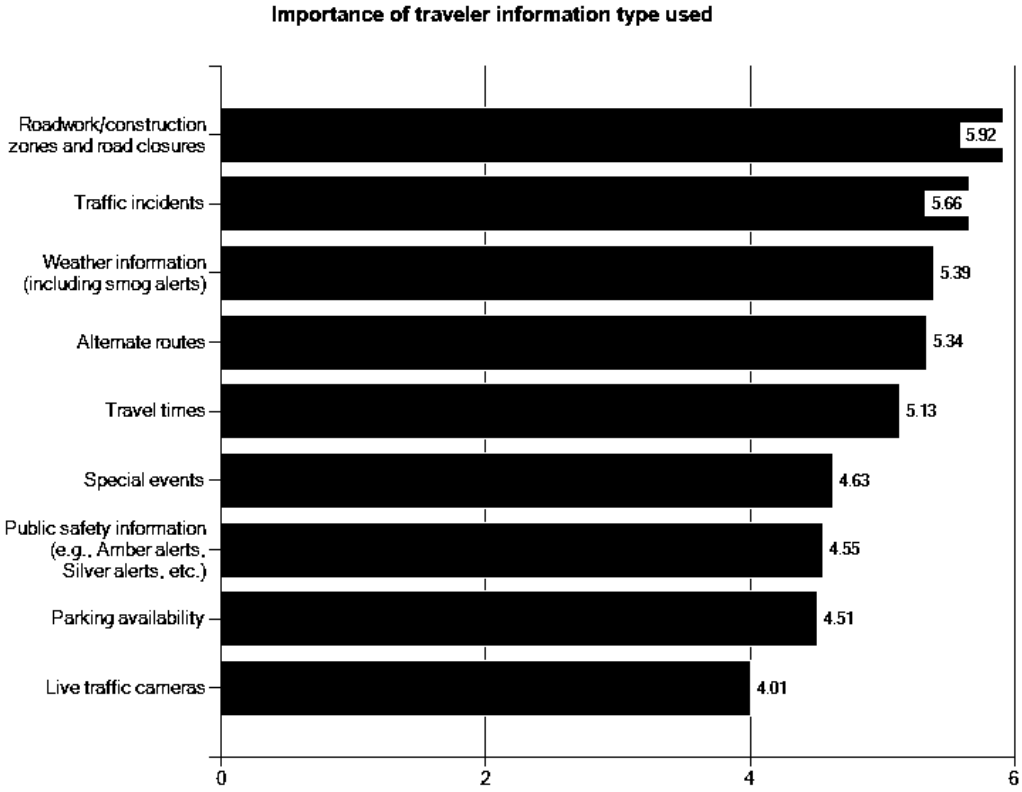

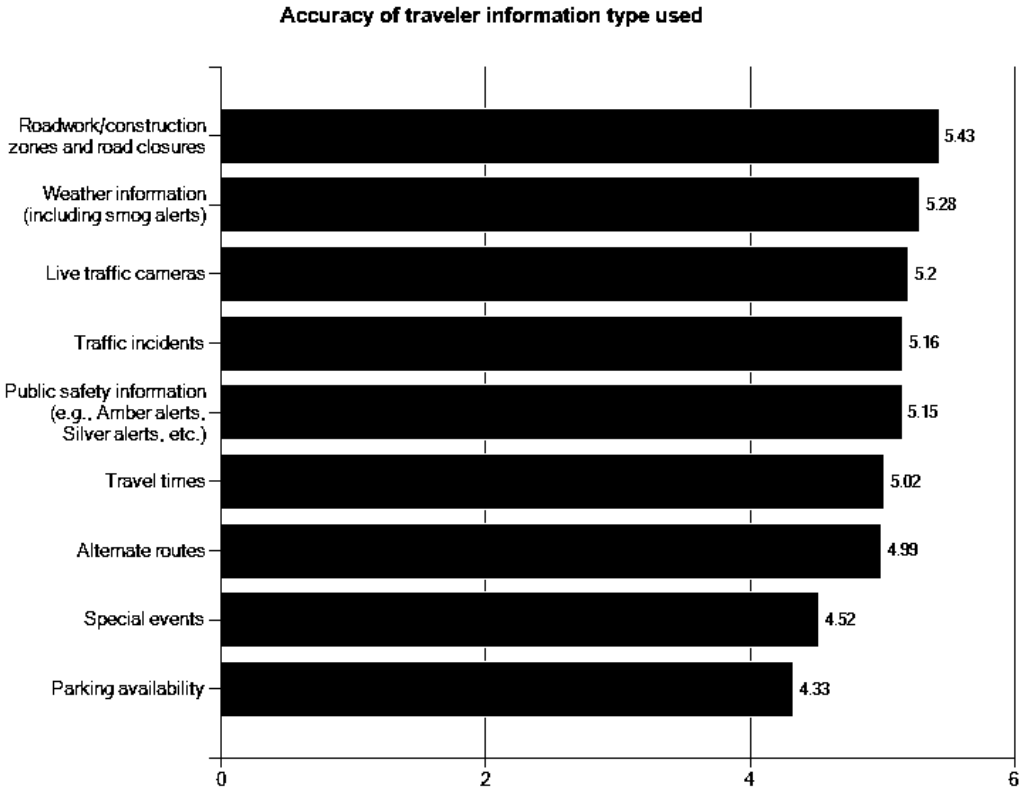

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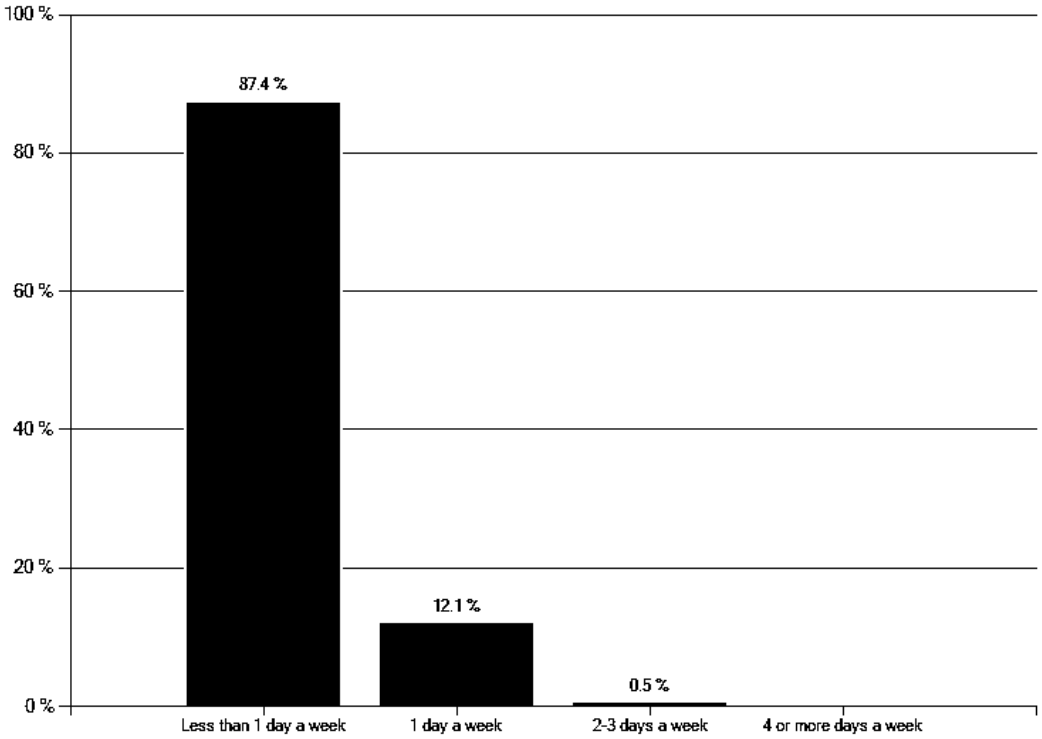
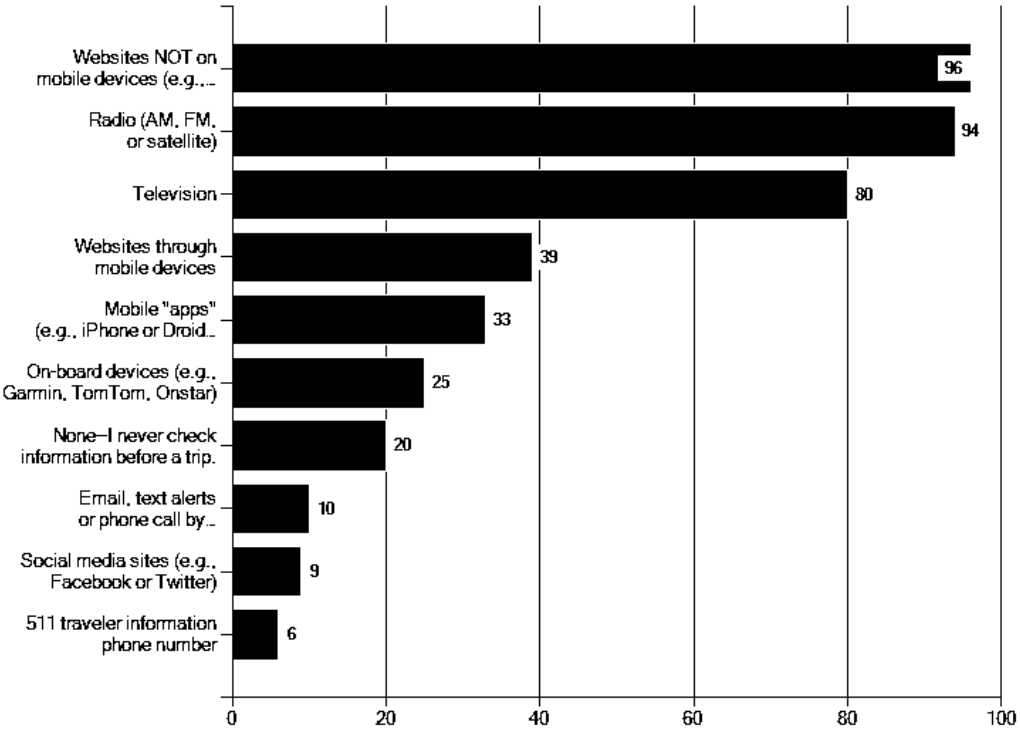
Frequency of making a decision to change a trip prior to trip start



Traveler information source used to make trip change decision prior to trip start



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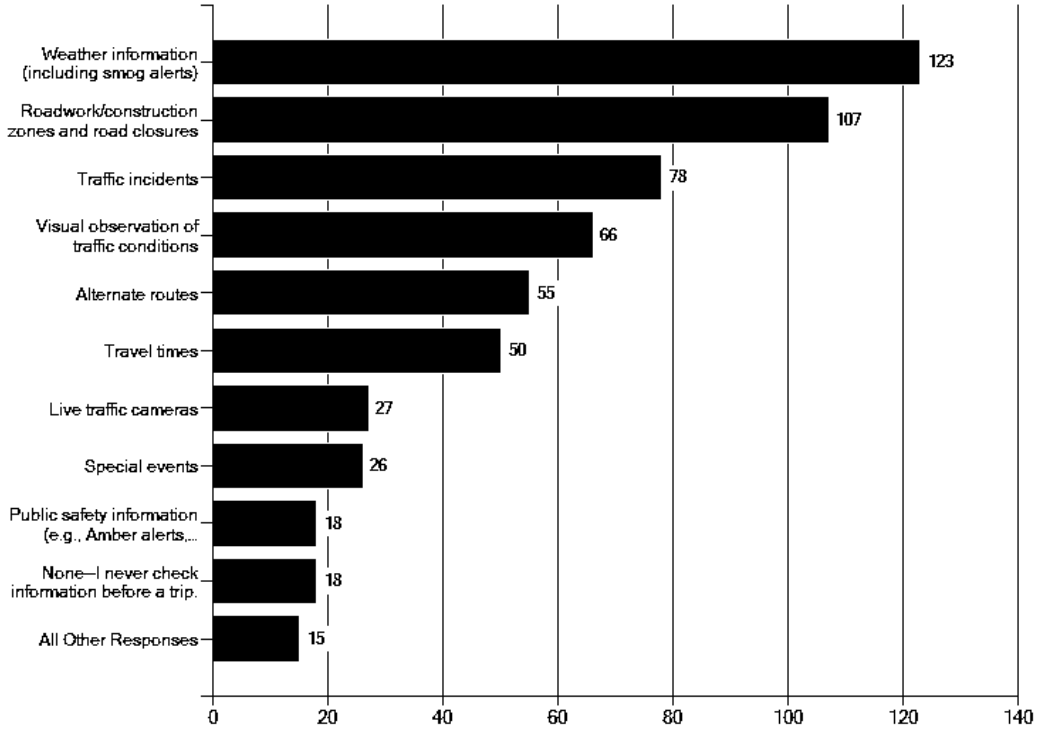
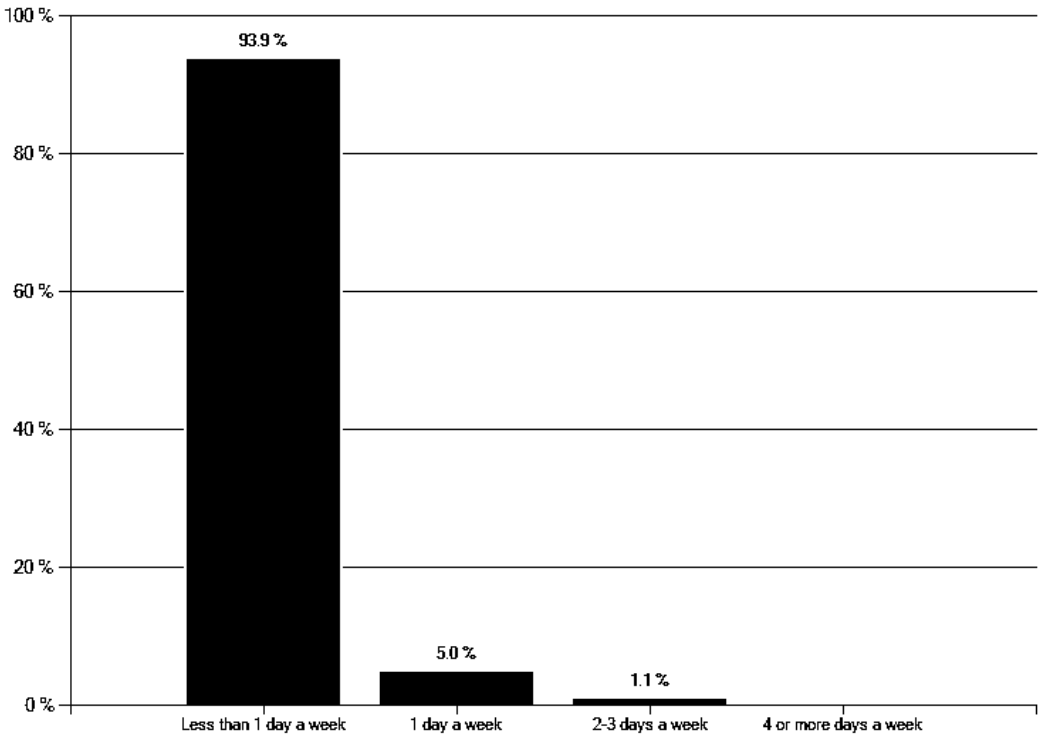
Traveler information type used to make a trip change decision prior to trip start



Frequency of making a decision to change a trip while in transit



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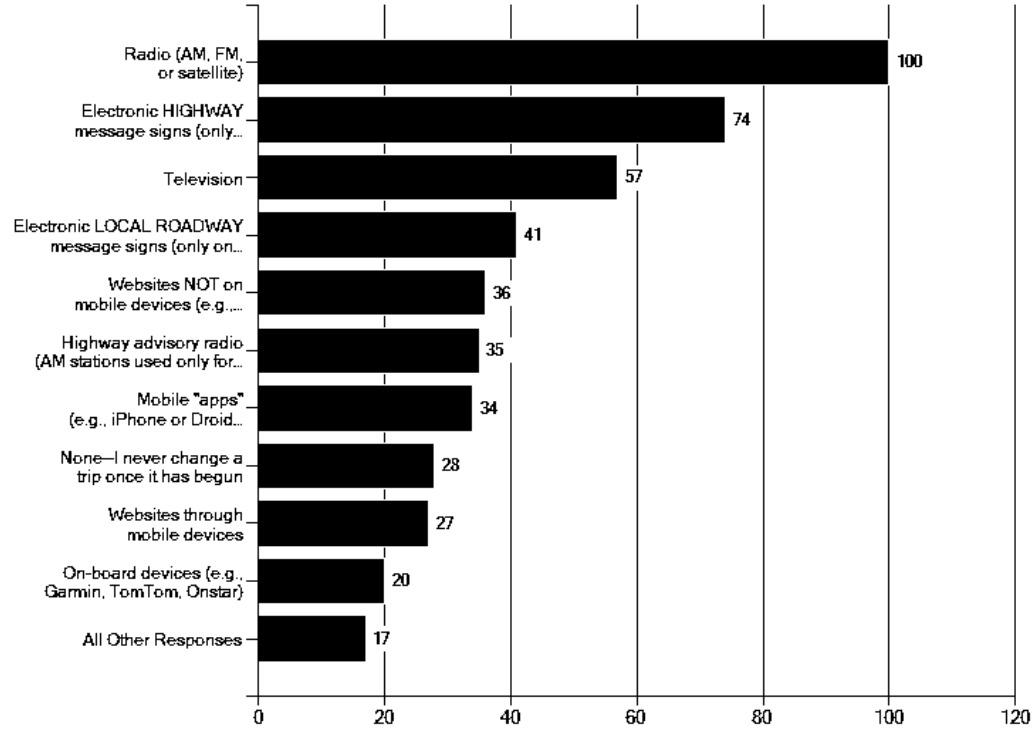
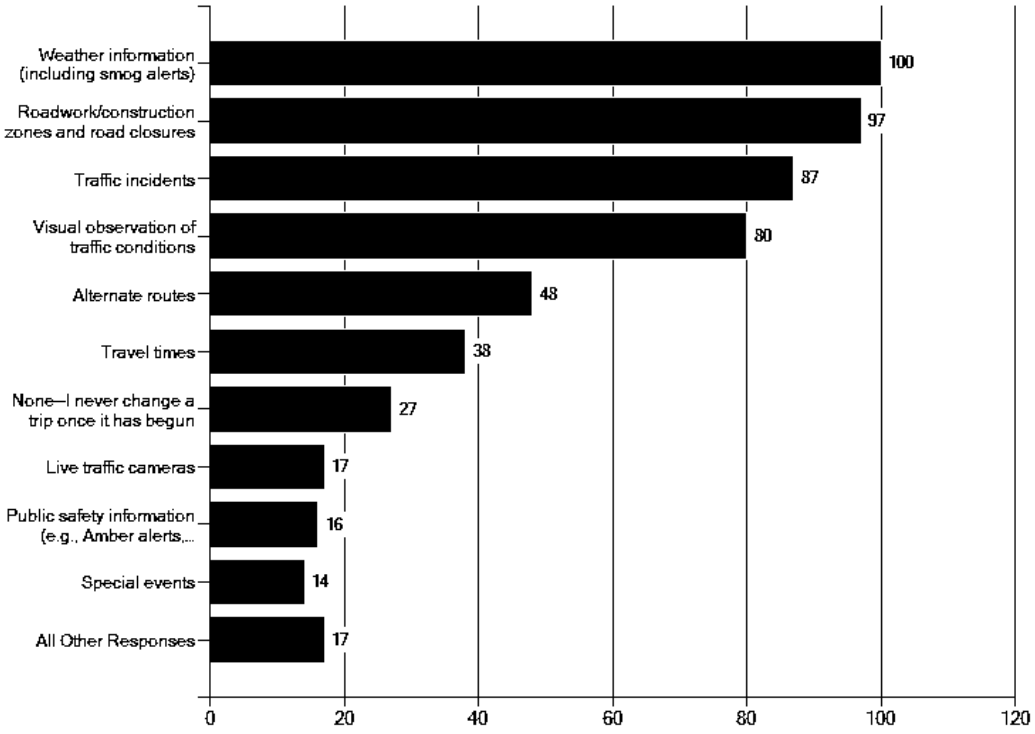
Traveler information source used to make trip change decision while in transit



Traveler information type used to make trip change decision while in transit



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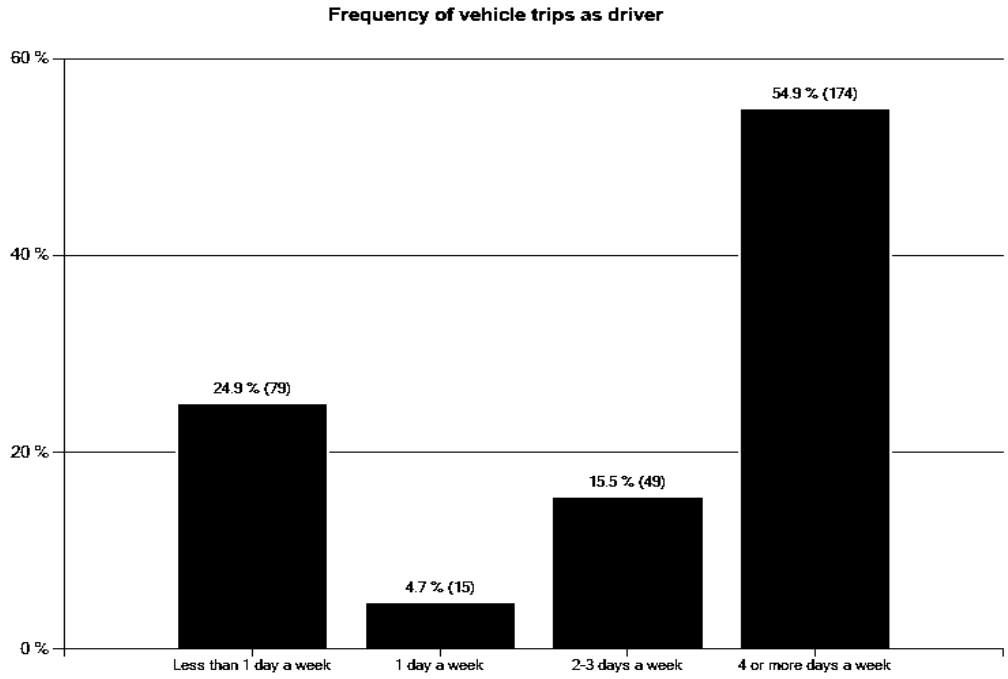
APPENDIX M

Results (combined): NYC (Teaneak,NJ)/Orlando/San Francisco/Washington, DC (Rockville, MD) Metro Areas



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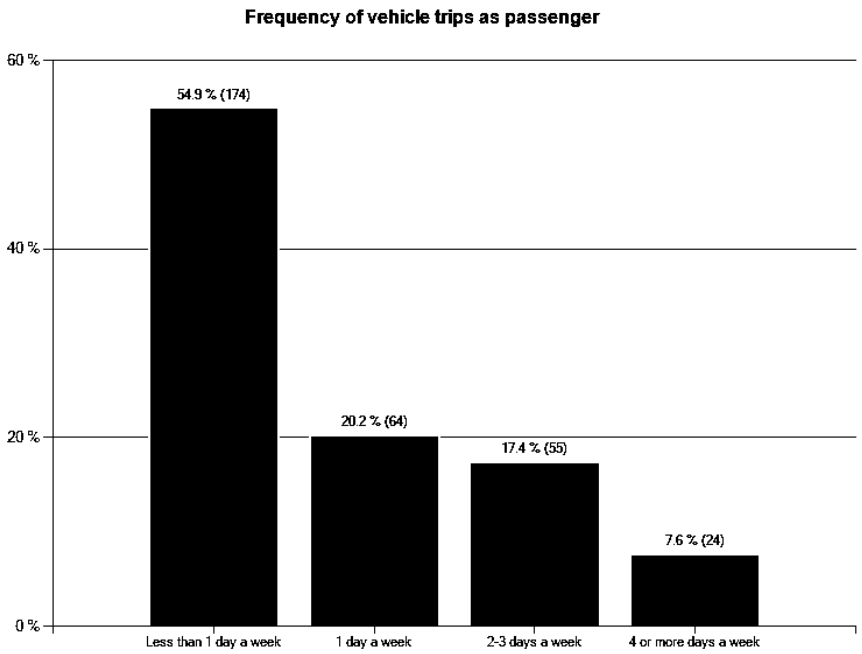

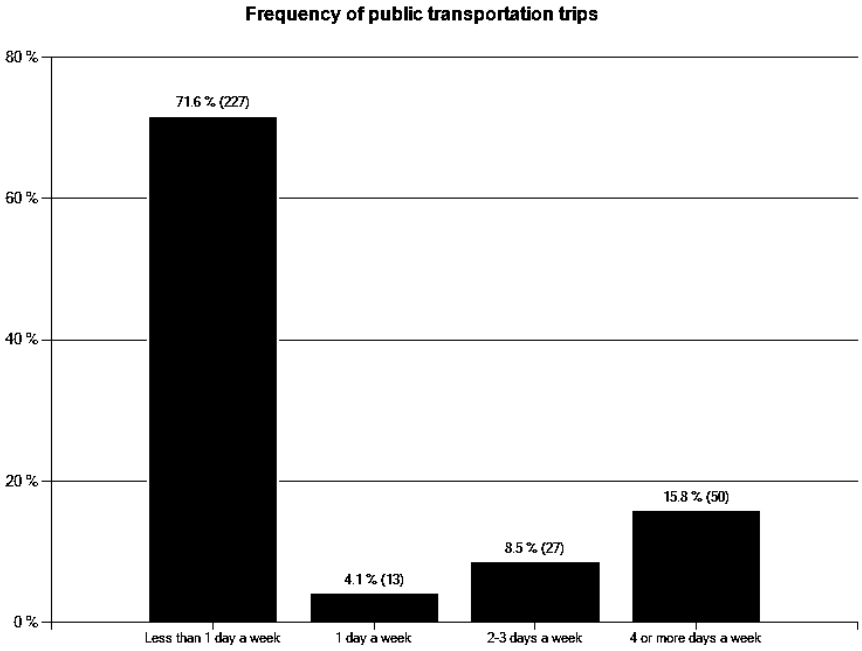

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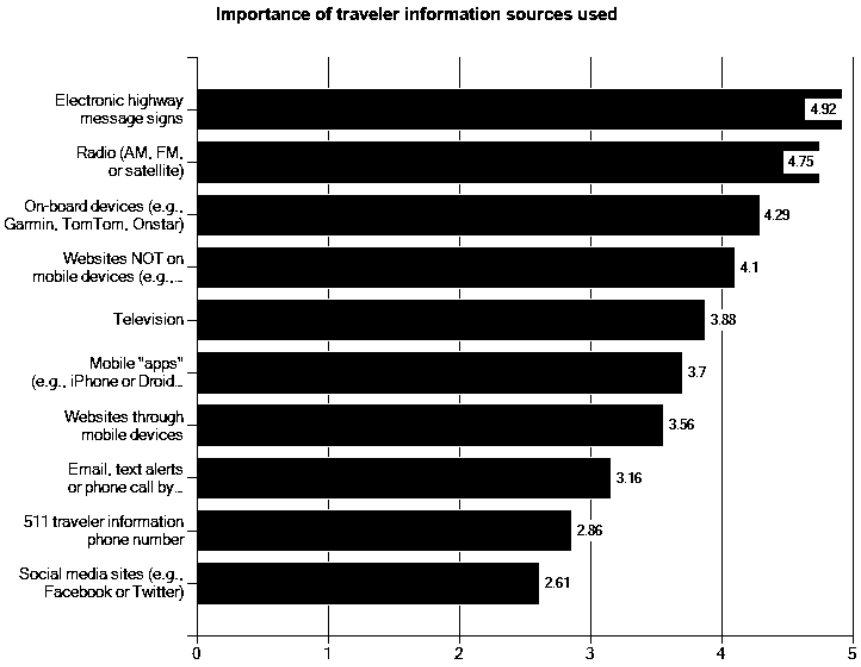

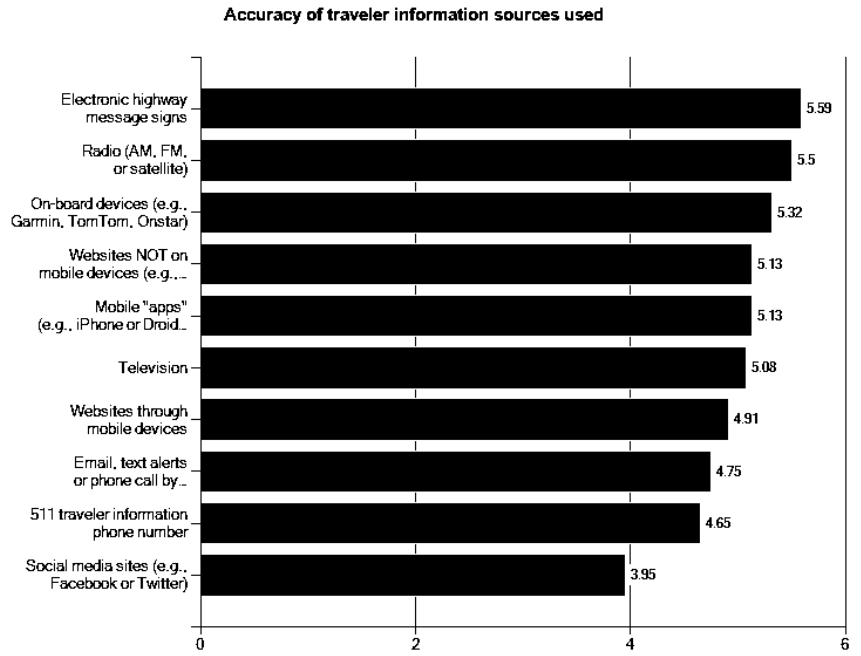

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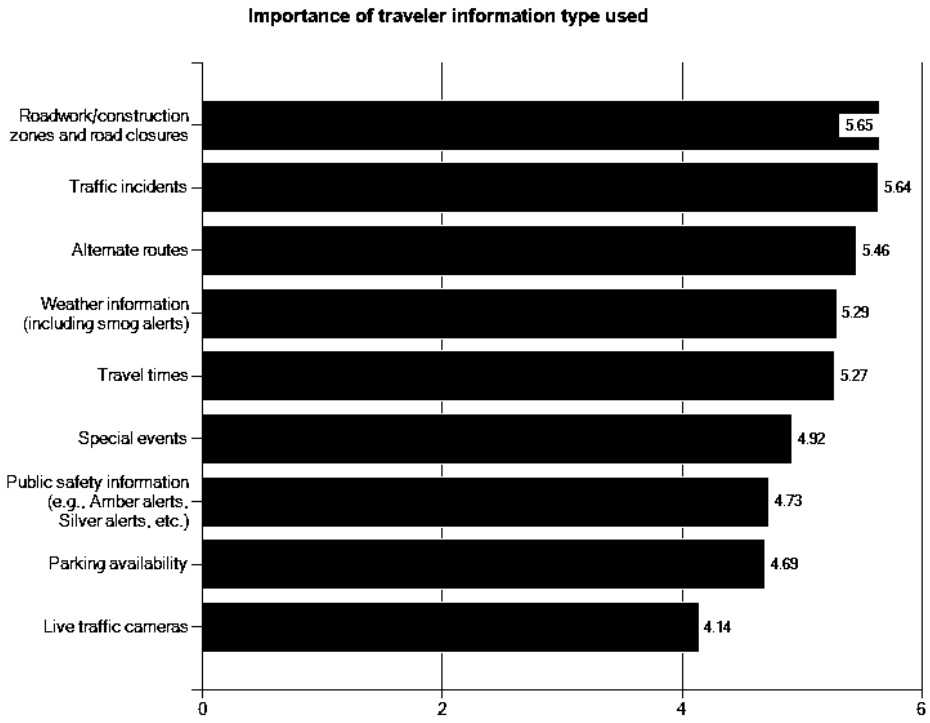

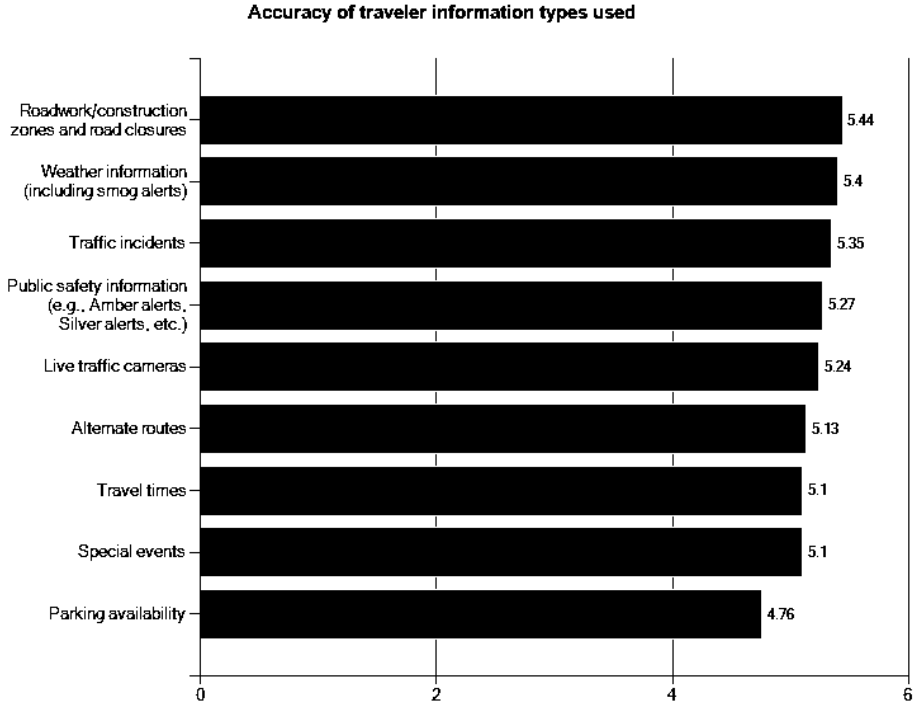

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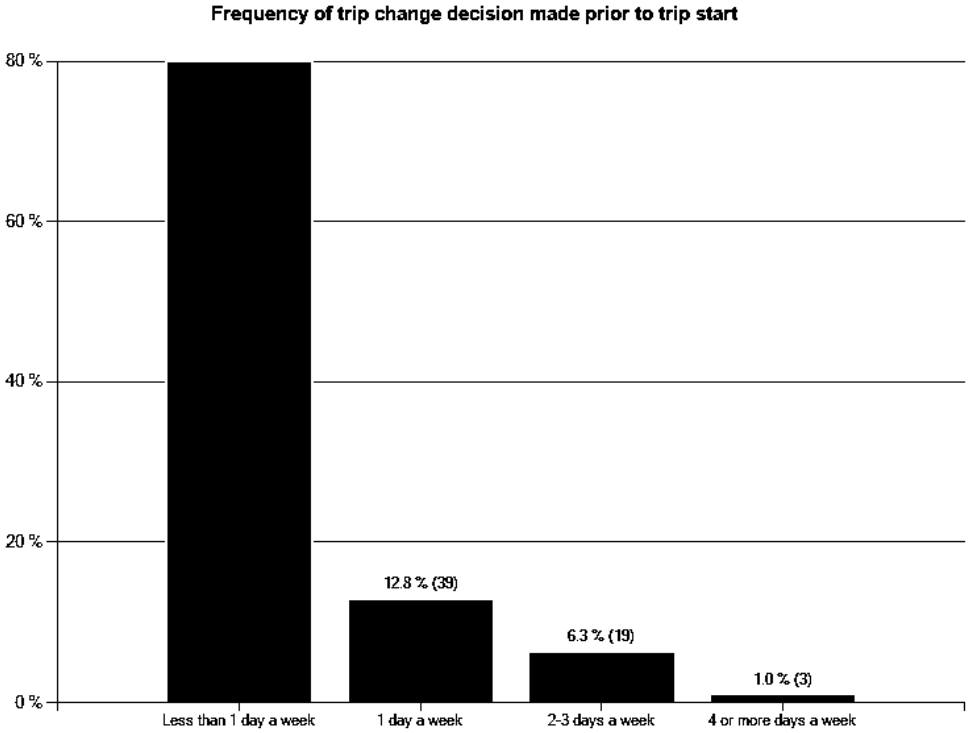

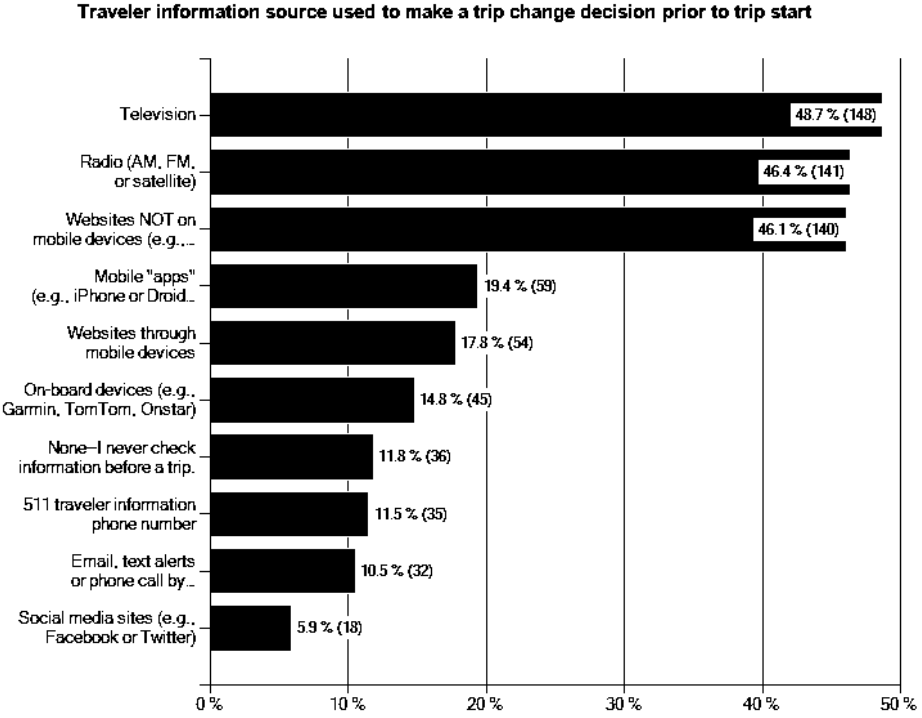

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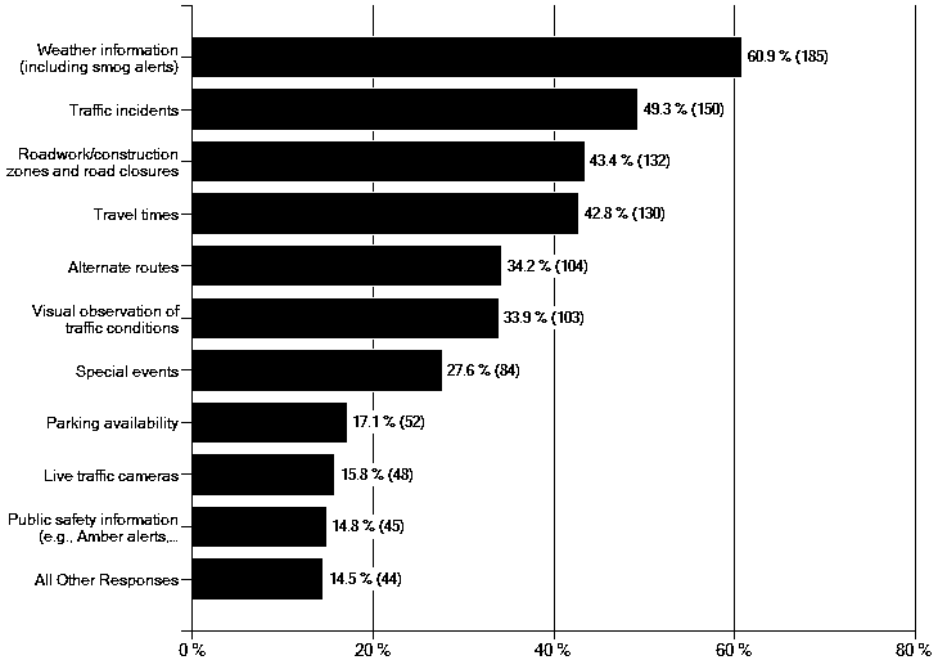
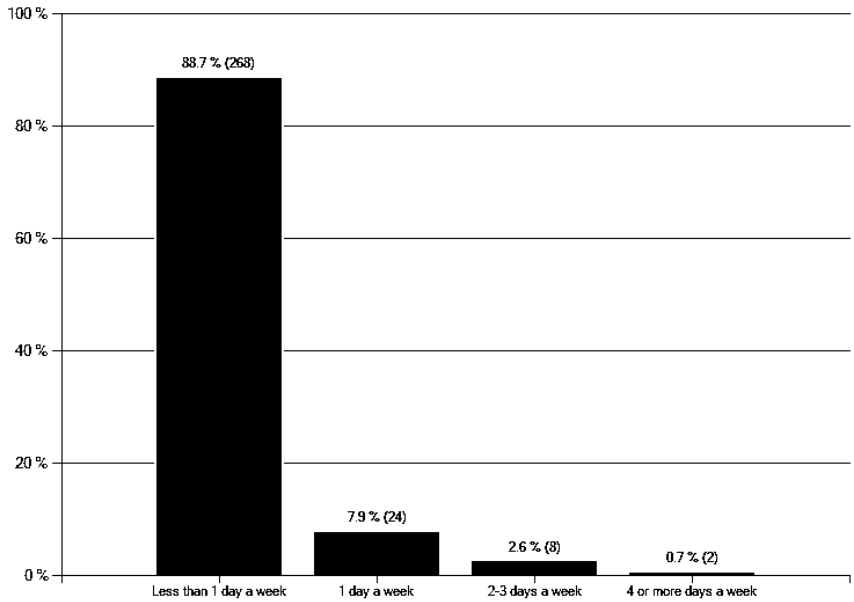
Traveler information type used to make a trip change decision prior to trip start



Frequency of trip change decision made while in transit



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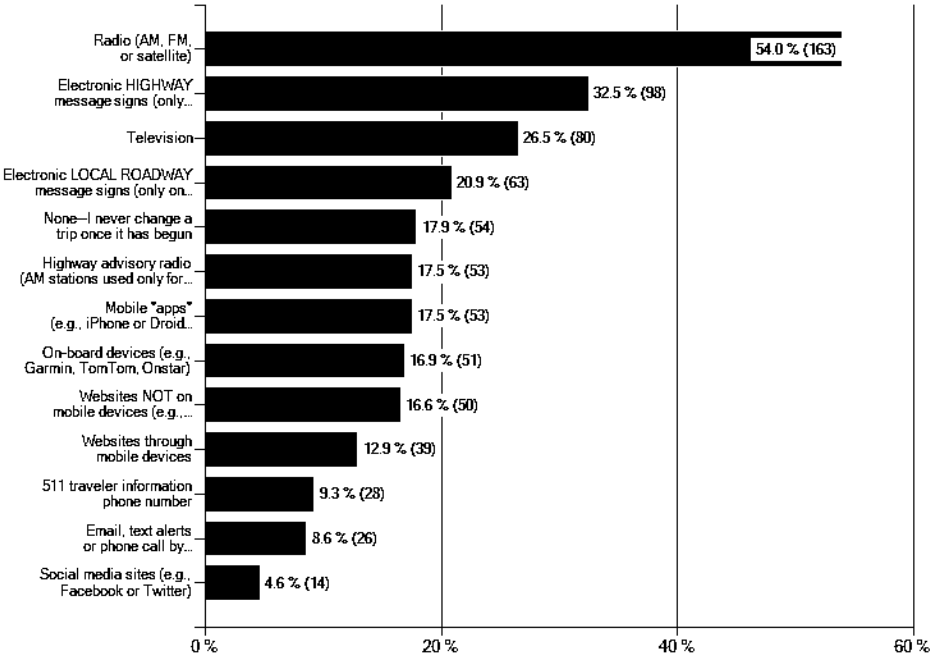
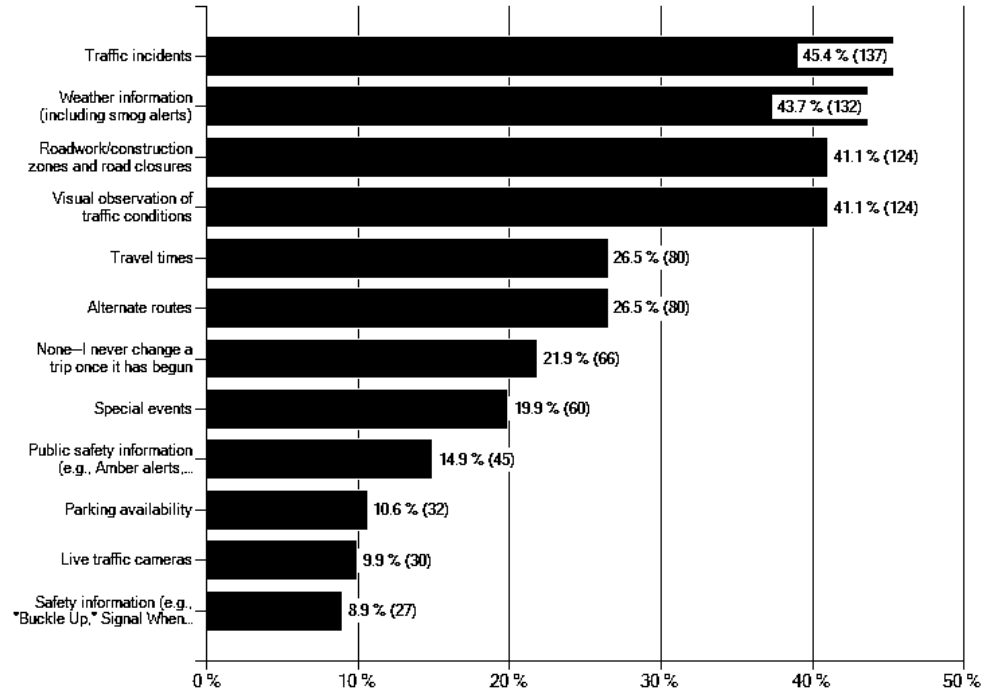
Information source used to make a trip change decision while in transit



Information type used to make decision to change trip while in transit



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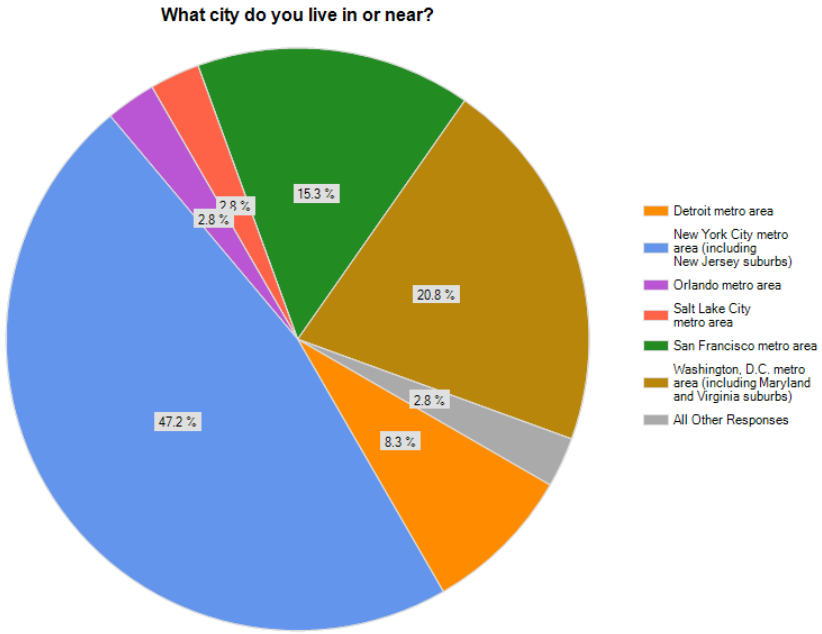
APPENDIX N

Supplemental Survey Results (6 Cities Combined)

Supplemental survey (6 cities)

72 respondents who have changed a trip in the last 3 days.



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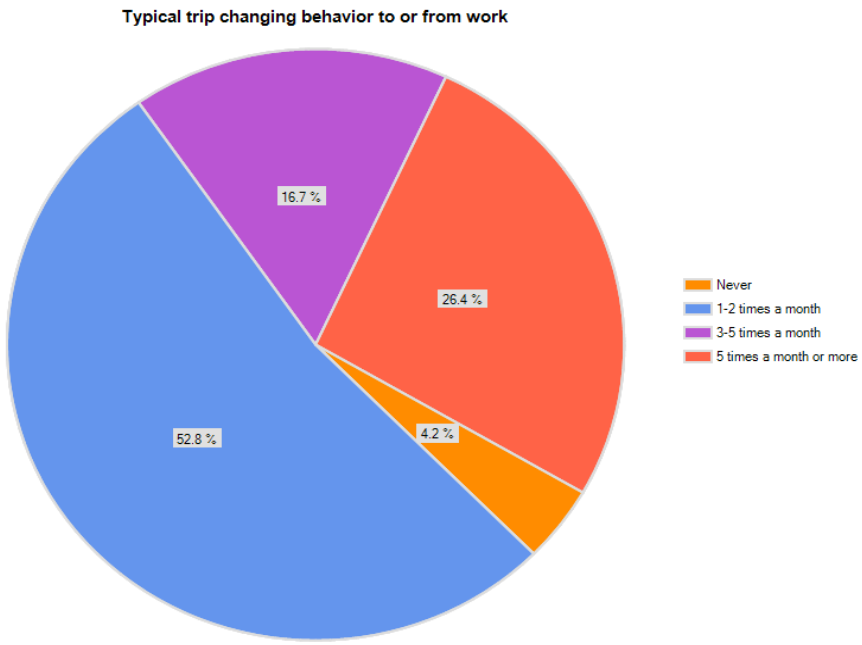

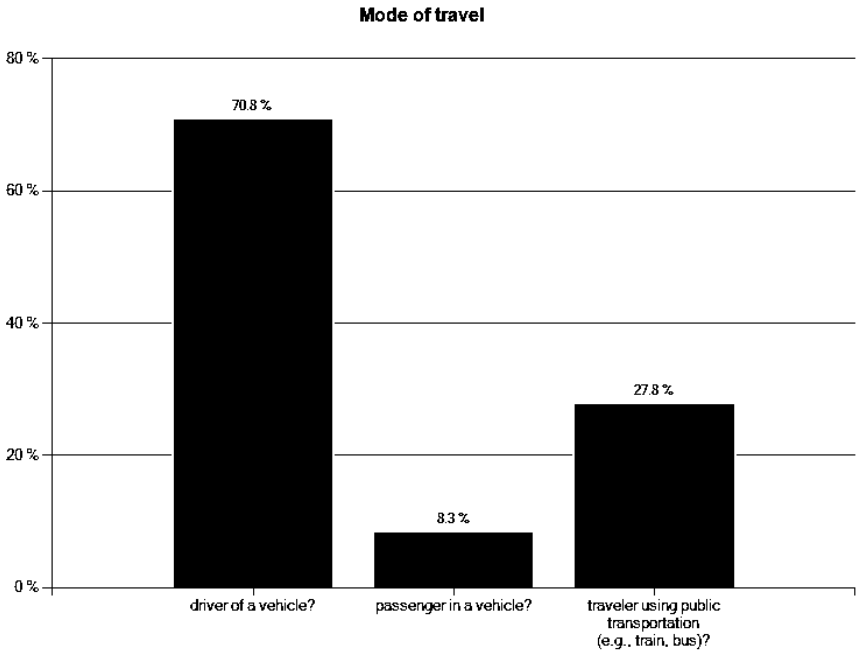

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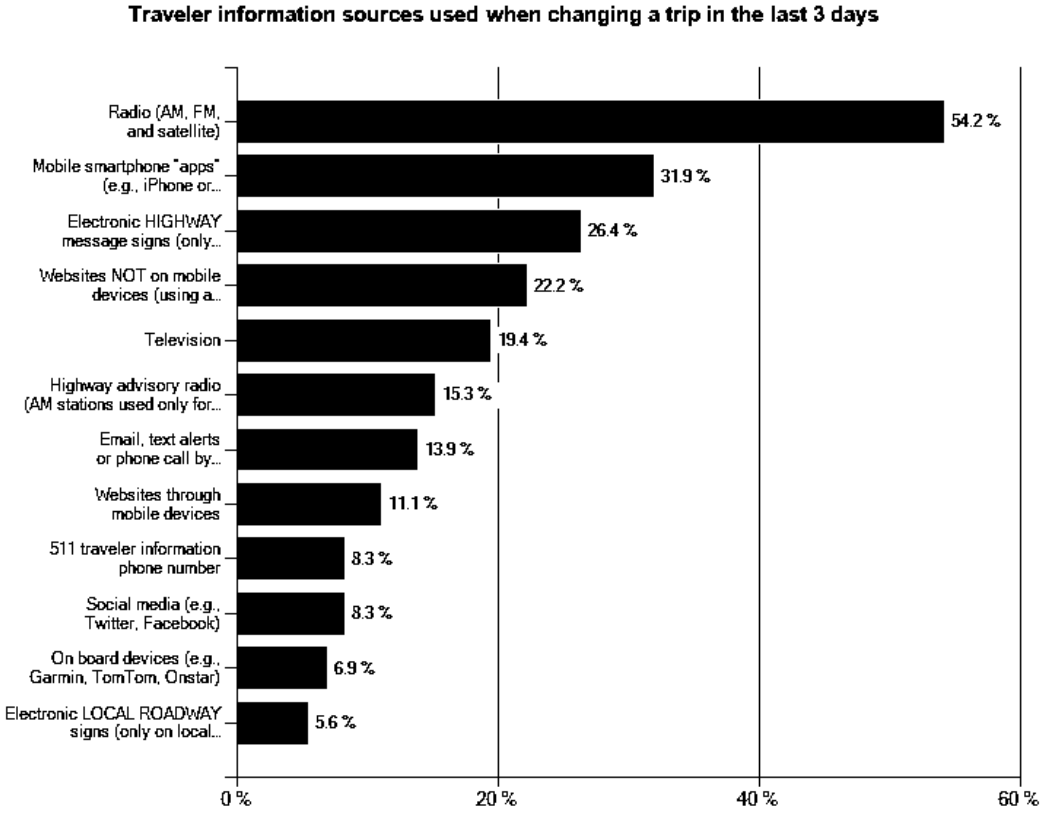

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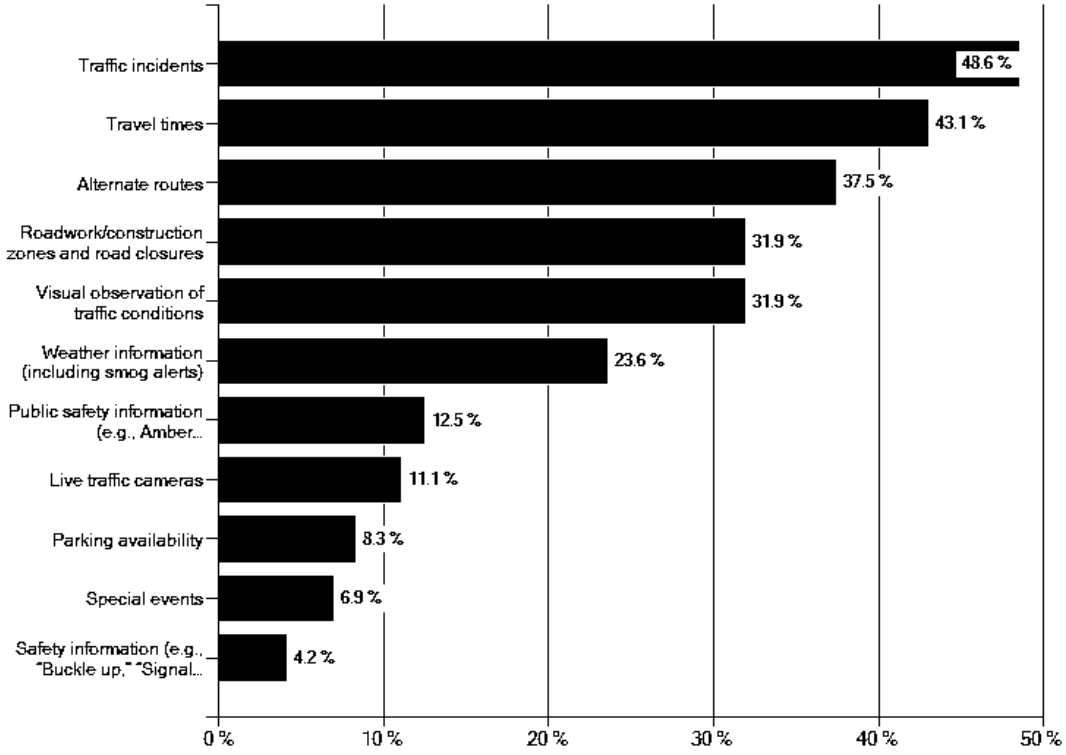
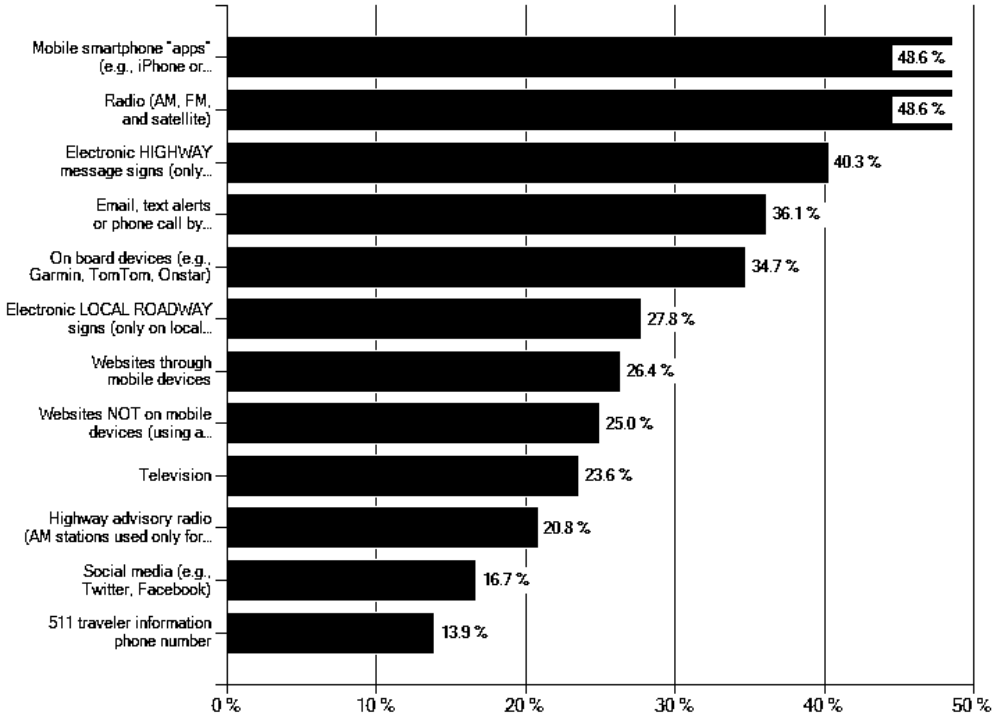
Traveler Information types used when changing a trip in the last 3 days



Desired traveler information sources



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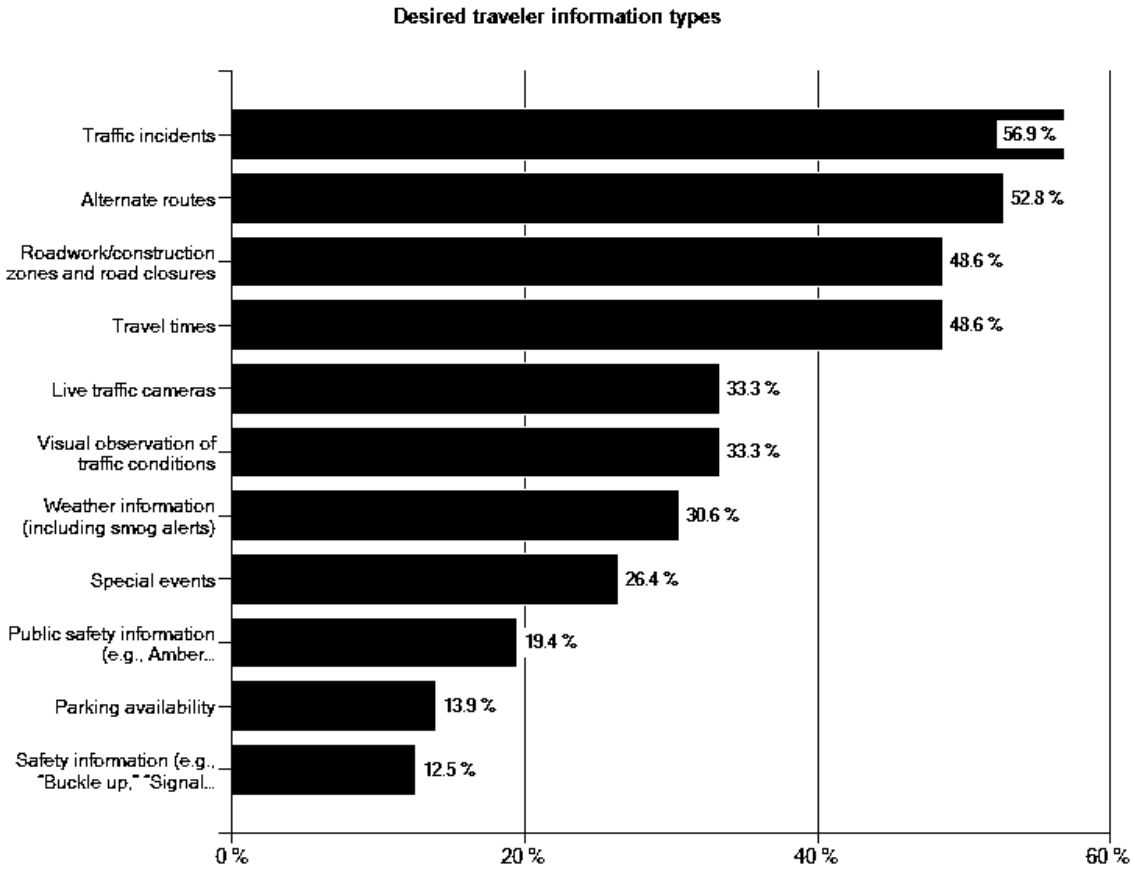

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APPENDIX O:

Features, Guidance, and Future Facilitation of an Effective TI Program

(1) Features of effective TI Program

- Emphasis on providing *information* that allows traveling public to *make better travel decisions*
- Real-time information is provided concerning transportation system status including non-recurrent events (e.g., incidents and roadwork) and planned events (e.g., roadwork and special events)
  - Roadwork/Construction Zones
  - Weather Information
  - Special Events
  - Parking Availability
  - Travel times
  - *Travel reliability*
  - Traffic incidents
  - Roadway CCTV video
  - Roadway condition status
- A wide array of information dissemination methods are used
  - Dynamic message signs
  - *Highway Advisory Radio (if implemented correctly)*
  - 511 System
  - Desktop/laptop/mobile websites
  - *Social media*
  - Mobile apps
  - *Onboard devices (OEM & other)*
  - Commercial media (radio and TV)
- TI programs incorporate ongoing evaluation techniques
  - Traveler surveys

(2) Guidance on assessing TI effect on trip behavior

- Assessing the use and impact of a TI system goes beyond call volumes and web page hits. It is necessary to gather qualitative information tailored to an area.
  - A combination of low-cost methods is necessary and optimal for understanding the complex nature of responses to TI systems.
    - "Toolbox" approach (in order):
      - Focus groups targeting certain travelers; tested and developed on populations of interest; moderator's guide; recording
      - Traveler logs—pilot testing, focus on travel behavior; look for shifts in planned route, pre-trip and en-route behavior, outcomes, and perceived benefits
      - Targeted surveys (including web-based)—deployed with off-the-shelf software; cognitive interviewing and item development; target relevant census tracts and corridors; recruitment from mail-outs and survey panels
      - Interviews—question path piloted and constructed based on survey and focus group questions
      - Use available data where

(3) How agencies can facilitate TI in future

Readily Attainable

- Make agency data accessible to developers, media outlets, universities, and others without severe bureaucratic navigation
  - Design agency databases/systems such that data is accessible
- Actively support provision of agency data/information to private sector to support additional dissemination mechanisms (e.g., in-vehicle devices)
- Consider use of new data sources (e.g., third party probe data) to supplement agency data sources for supporting TI as well as other operations and planning functions
- Program funding to support ongoing TI evaluation work
- Conduct and sponsor research to develop effective techniques to quantify operational impacts of TI programs
- Support a wide range of distribution mechanisms/opportunities
- Incorporate into TI Program a focus on the customers experience/use of TI – actively manage and evaluate TI content from traveler use perspective
- Stay abreast and make continued use of social network and new technologies to make TI consumable for travelers
- Improve the reliability, timeliness, and quality of existing agency disseminations resources (e.g., highway advisory radio, DMS, etc.)
- Partner with neighboring agencies to fuse data from multiple sources to provide the best, most complete information to the traveler.

Looking Farther into the Future

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(1) Features of effective TI Program	(2) Guidance on assessing TI effect on trip behavior	(3) How agencies can facilitate TI in future
○ Web statistics ○ 511 Call statistics ○ E-mail/web forms ○ Traveler Focus Groups, Interviews, and Logs • TI content is evaluated for effectiveness including: ○ Information timeliness, accuracy, availability, and accessibility ○ Decision-making ▪ Departure time ▪ Destination choice ▪ Mode choice ▪ Pre-trip and en-route route choice • TI is assessed for its impact on transportation system performance using a variety of measures: ○ Vehicle-hours of delay ○ Person-hours of delay ○ Travel time ○ Speed ○ Throughput ○ Travel time index ○ Planning time index ○ Buffer index ○ Duration of congestion ○ Cost benefit or ROI • TI should align with demands of the public: ○ Targeted, local, relevant to the consumer ○ Easy to access and use ○ Source/medium should be accessible while on the road, and match the prevailing laws ○ Clear, concise, trustworthy information that is accurate and reliable ○ Special event or emergency information that can drastically affect routes is vital ○ Use of technologies that are widely available to everyone and easily implemented (e.g., radio)	possible—traffic and congestion data, usage data already being collected • In order to develop a profile of TI effects on trip behavior and TI usage in an area, the following should be collected (via combination of methods): ○ Traveler type (e.g., commuters, elderly, frequency of TI use, technology use) ○ Information type (e.g., travel time, congestion levels, incident information, weather) ○ Information source or media used (e.g., mobile apps, websites, radio, TV, highway signs) ○ Temporal information need (e.g., pre-trip, near trip, en-route) ○ Traveler perception of quality, accuracy, reliability, availability ○ Information comprehension ○ Effect on travel behavior ○ Likeability/satisfaction ○ Frequency of use ○ Traveler perception of risk (e.g., distraction of mobile devices)	• Integrated multisource and multimodal data on a regional level • Intuitive, location and mode option specific information • Anticipation of traveler's specific information needs based on location, time of day, typical individual historical travel patterns • Improved agency operations with robust and comprehensive • Real-time user updates • Develop information to be disseminated through an in-vehicle device or docked smartphone that incorporates a wide variety of real-time traveler information

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