Executive Summary

On-Time Reliability Impacts of Advanced Traveler Information Services (ATIS):

Washington, DC Case Study

January 2001

Dr. Karl E. Wunderlich
Matthew H. Hardy
James J. Larkin
Vaishali P. Shah

Contract Sponsor: Federal Highway Administration
Contract No.: DTFH61-00-C-00001
Project No.: 0900610D-01
Department: Q020

MITRETEK SYSTEMS
McLean, Virginia

GENERAL DISCLAIMER

This document may have problems that one or more of the following disclaimer statements refer to:

- This document has been reproduced from the best copy furnished by the sponsoring agency. It is being released in the interest of making available as much information as possible.
- This document may contain data which exceeds the sheet parameters. It was furnished in this condition by the sponsoring agency and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

EXECUTIVE SUMMARY

Initiatives to evaluate the impact of Advanced Traveler Information Services (ATIS) over the last ten years have returned what appears to be contradictory results with respect to the time savings of ATIS users: large *perceived* time savings reported by users but marginal to no *observed* in-vehicle travel time savings when measured empirically in field operational tests. This report describes a new methodology developed by Mitretek Systems at the request of the Intelligent Transportation Systems (ITS) Joint Program Office (JPO) of the U.S. Department of Transportation (USDOT) to quantify time savings and other benefits that travelers can expect by incorporating ATIS into their daily commutes.

To this end, Mitretek has developed a process called HOWLATE (Heuristic On-line Web-Linked Arrival Time Estimator) that applies dynamic programming techniques to archived observed roadway travel times data to quantify the impact of regular ATIS utilization by urban commuters. HOWLATE entails the construction of synthetic, retrospective paired driving trials between travelers with and without ATIS, conducted across regional urban networks and over months or years of archived data. In-vehicle travel time and on-time reliability measures are tracked for each paired driving trial participant. Using results from a large-scale case study in the Washington, DC area this report shows that even though ATIS users realize only marginally reduced in-vehicle travel time, they do realize more effective time management as well as improved on-time reliability and trip predictability.

Approach

In order to quantify reliability-related benefits of incorporating ATIS use into a traveler's regular commuting pattern, the HOWLATE method developed by Mitretek Systems utilizes the concept of a *simulated yoked trial*. This new analytical technique entails the efficient reconstruction of millions of hypothetical paired driving trials using archives of roadway travel times. The regional roadway travel time archive is compiled in an automated process that polls a traveler information service provider's website every five minutes and records the estimated link travel times. These archives provide not only estimates of what roadway segment travel times were during the period studied but a record of what was known about current congestion conditions at the time any trip across the region was initiated on any particular day.

ATIS Non-User: Travel Times Based on Past Experience

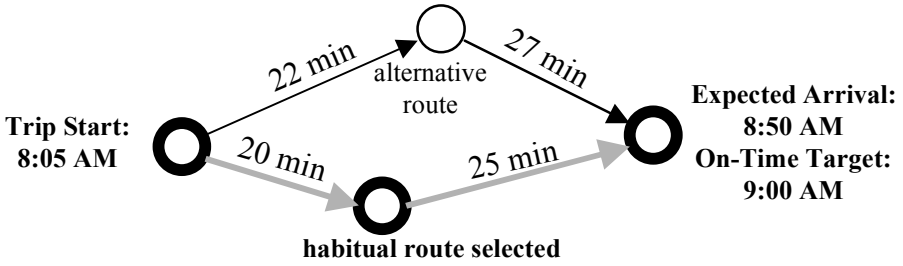

Figure ES-1. ATIS Non-User Route Choice and Trip Timing

ATIS User: Reported Travel Times at 8:00 AM

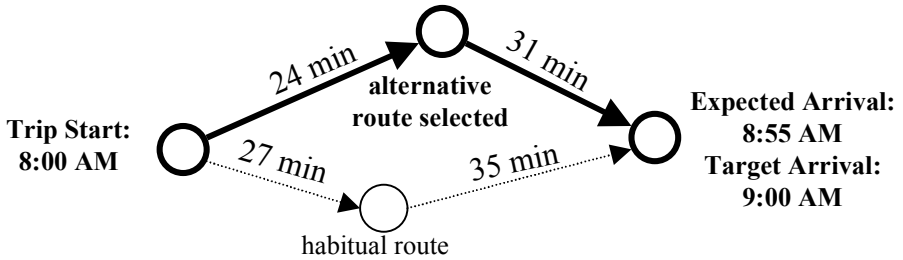

Figure ES-2. ATIS User Route Choice and Trip Timing

A simulated yoked trial consists of two steps. In the first step, traveler path and time of departure choices are established for two travelers: one who utilizes ATIS and one who does not utilize ATIS but relies on prior experience in the network. In the second step, travel times and on-time performance for each traveler are reconstructed based on the trip timing and routes chosen in the first step.

Figure ES-1 illustrates how non-user route choice and trip timing are determined. Based on experience, the non-user has estimates of average link travel times during the commute period and selects the fastest option as the habitual route. The non-user then budgets in additional time to account for expected day-to-day travel time variability to establish a habitual trip start time.

Figure ES-2 illustrates how ATIS user route choice and trip timing are determined. The ATIS user relies on the real-time estimates of travel time provided by the traveler information service provider rather than on past experience. Unlike the non-user, the ATIS users can adapt their trip timing and route choice on a daily basis. Consider a day in which higher-than-average travel times are forecast, particularly for the habitual route. The ATIS user, based on estimates provided at 8:00 AM, makes a decision to leave immediately and travel on the alternative route.

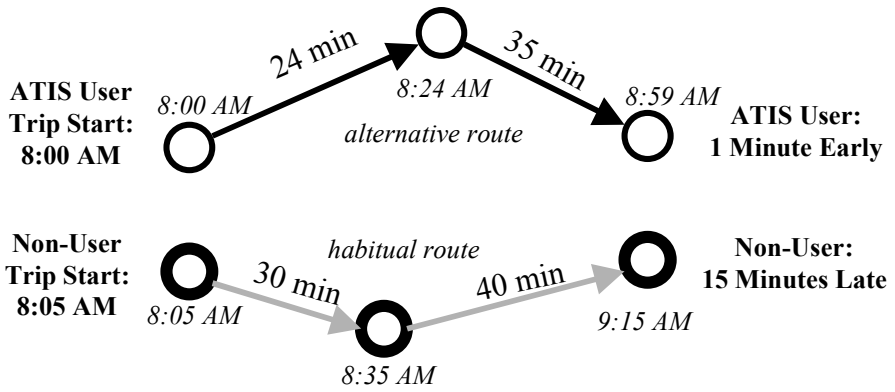

Figure ES-3. Reconstruction of ATIS User, Non-User Travel Experiences

With trip timing and route choice established for both the ATIS user and the non-user, the next step is to reconstruct what those choices implied in terms of travel time and on-time reliability for this particular slightly worse than normal day (Figure ES-3). The reconstruction is based on the travel time archive plus a random component based on the statistical accuracy of the ATIS travel link travel time estimates measured against travel times measured in field trials. In our sample day, congestion worsens over the hour between 8:00 – 9:00 AM. Based on a 8:00 AM start on the alternative route, the ATIS user is determined to have arrived at the destination at 8:59, one minute before the on-time arrival target. Note that the trip has taken four minutes longer than the ATIS user's pre-trip expectation because congestion has worsened over the course of the trip. The non-user, unaware that congestion is worse than normal, remains on the habitual route starting at 8:05 AM and arrives at the destination 15 minutes later than the target arrival time.

A critical conceptual difference between the simulated yoked study and previous ATIS field evaluations is that the paired trials are organized around the principle of *destination and target time of arrival* rather than on *simultaneous release from trip origin*. This implies that pairs of travelers (ATIS users and non-users) are yoked pairs in the sense that they both make regular trips at the same times of day with a fixed target time of arrival at the same destination. In the previous yoked driver experiments conducted as field tests, trip starts between control and experimental vehicles are essentially simultaneous. The use of target arrival times allows for *quantifiable reliability measures* to be defined and tracked along with in-vehicle travel time: on-time reliability, lateness risk, early schedule delay (time wasted by arriving too early), and late schedule delay (total accumulated lateness). Moreover, we can track traveler pre-trip expectation (e.g., knowing a late arrival is likely) versus performance, a measure of trip predictability.

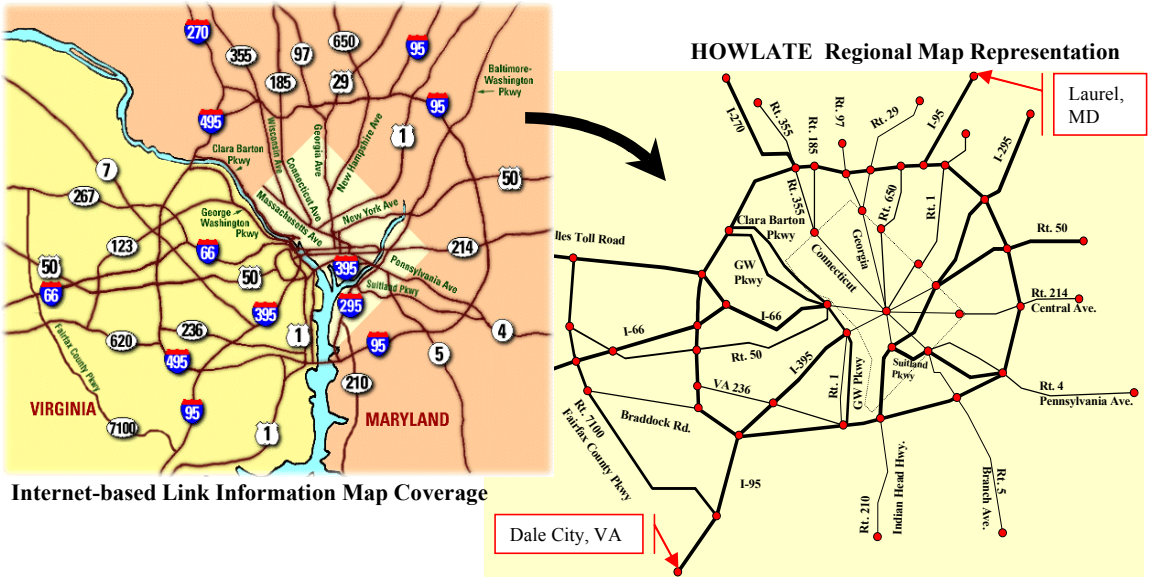

Figure ES-4. Washington DC Area Case Study Network

Washington DC Case Study

The network used for the Washington DC HOWLATE case study was based on the facilities covered by the SmarTraveler service (left half of Figure ES-4). Travel times are reported on a range of roadways throughout the region, spanning over 1200 square miles. The links covered by SmarTraveler were transformed into a more detailed representation for use in HOWLATE. The transformed network (right half of Figure ES-4) features 55 nodes, each of which represent a potential trip origin or trip destination; and 169 links, most of which correspond to freeway, expressway, and major arterial facilities within the region. Travel times were archived for 18 weekdays in August 1999 and 21 weekdays in September 1999. These daily profiles include the reported SmarTraveler travel times in the regional network at five-minute intervals from 6:30 AM to 6:30 PM. The August data was used to establish the habitual routes and trip start times of ATIS non-user, while on-time performance was evaluated using the September data.

Simulated yoked studies were conducted with ATIS users and two types of ATIS non-users, with target times of arrival at 15-minute intervals between 6:30 AM-6:30 PM. The first ATIS non-user type is considered *conservative* with respect to on-time reliability and chooses habitual time of trip start with a large additional time buffer to account for expected trip time variability. The second ATIS non-user type is more *aggressive*, and chooses a later habitual time of trip start. *Optimal* performance is also determined by finding the route and departure time (assuming perfect hindsight) that would have resulted in precise on-time arrival on the fastest possible route.

Results

Commuter	On-Time Reliability	Lateness Risk	Early Schedule Delay (ESD)		Late Schedule Delay (LSD)		In-Vehicle Travel Time	Trip Distance
			Average Monthly ESD	Maximum Observed ESD	Average Monthly LSD	Maximum Observed LSD		
Conservative Non-User	90%	10%	2.8 hours	43 min	13 min	28 min	62.1 min	80.8 km
Aggressive Non-User	78%	22%	1.4 hours	29 min	36 min	43 min	63.1 min	80.8 km
ATIS User	92%	8%	1.6 hours	32 min	7 min	19 min	62.2 min	81.2 km
Optimal Performance	100%	0%	0 min	0 min	0 min	0 min	61.3 min	80.8 km

Table ES-1. Laurel to Dale City Commute, 6:30 AM – 6:30 PM Target Arrivals

Table ES-1 presents a summary of travel performance throughout the month of September for a sample Laurel to Dale City commute. Note that the ATIS users have a better on-time performance than even the conservative non-users, while experiencing only 20% of the late schedule delay experienced by the aggressive non-users. The average monthly schedule delay figures are averaged over all target times of arrival. The maximum observed schedule delay figure is the maximum delay experienced by any one simulated yoked trial participant. These improvements in on-time reliability and predictability are achieved with marginal or no change in average travel time (or travel distance). This implies that relatively small, judicious adjustments to trip start timing combined with route choice can result in improved on-time reliability even though in-vehicle travel time may only decline marginally. The Laurel-to-Dale City trip is one of the longest in the network, with a number of alternative routes, so we may expect that the benefits of ATIS may not be indicative of all possible trips in the network. However, when the complete network is analyzed (55 origins x 54 destinations x 49 target arrival times), ATIS users experience similarly improved on-time reliability relative to both conservative and aggressive ATIS non-users, particularly in the AM and PM peak periods (Table ES-2).

Commuter	On-Time Reliability	Lateness Risk	Early Schedule Delay		Late Schedule Delay		In-Vehicle Travel Time	Trip Distance
			Average Monthly ESD	Maximum Observed ESD	Average Monthly LSD	Maximum Observed LSD		
Conservative Non-User	92%	8%	66 min	50 min	6 min	40 min	31.5 min	33.6 km
Aggressive Non-User	81%	19%	25 min	41 min	24 min	125 min	32.1 min	33.6 km
ATIS User	97%	3%	41 min	35 min	2 min	37 min	31.4 min	34.3 km
Optimal Performance	100%	0%	0 min	0 min	0 min	0 min	30.0 min	34.1 km

Table ES-2. Summary: All DC Trips,
AM Peak (6:30-9:30) and PM Peak (3:30-6:30) Target Arrivals

Key Findings

The key finding of this work is that the two pieces of evidence from survey and field research are not in fact conflicting. As survey research suggests, ATIS users do realize significant benefits in terms of time management – better on-time reliability, reduced early and late schedule delay, as well as more predictable travel. They do this, however, without significantly reducing the amount of in-vehicle travel time accumulated over a month or year of regular trip-making. Therefore, the field trials constructed to measure reduced in-vehicle travel time have likely accurately reflected the reality of regular ATIS use.

Traditional cost-benefit analysis in the transportation area is geared primarily at the monitization of in-vehicle travel time measures. Therefore, if ATIS deployments are evaluated purely on these time-savings, the benefits of ATIS will likely be grossly underestimated. ATIS users value improved travel reliability and this benefit can be quantified through simulated yoked studies. The value of improved on-time reliability is not easily nor directly monitized, but it is clear that many types of travelers can benefit from ATIS. Trucks delivering auto parts in a just-in-time manufacturing process may highly value any improvement in on-time reliability or reduction in early schedule delay. Commuters face an on-time requirement not only on the home-to-work leg of their daily trip-making, but increasingly on the work-to-home return trip in order to meet daycare pickup requirements and other commitments. Improved reliability and predictability of travel are also likely good surrogates for reduced commuter stress. From this common sense perspective, it is clear that the benefit of improved travel reliability and predictability from ATIS will outweigh whatever small return is generated from the monitization of aggregate in-vehicle travel time reductions.

Overall, ATIS use proved advantageous in efficiently managing the traveler's time. Specific quantitative examples selected from the Washington DC case study include:

- Peak-period commuters who do not use ATIS were three to six times more likely to arrive late compared to counterparts who use ATIS;
- Cases where ATIS clearly benefits the user (e.g., ATIS user on-time, non-user late) outweighed cases where ATIS clearly disadvantages the user by five to one;
- ATIS users in peak periods are more frequently on-time than conservative non-users, yet they experience only two-thirds as much early schedule delay as non-users;
- Late shock, the surprise of arriving late, is reduced by 81% through ATIS use.

Conclusions and Future Work

The HOWLATE methodology offers a new, valuable tool to the ATIS evaluator that complements the existing field study, traffic simulation and survey research techniques. It can quantify and precisely categorize benefits of time management, trip predictability, and travel reliability that other techniques cannot. Survey research can only provide qualitative assessments of ATIS user time savings or improved on-time reliability. Traffic simulation analysis cannot efficiently assess the implications of complex ATIS user behaviors. HOWLATE can be applied at a fraction of the cost of a comparable field study. This said, the benefits quantified by HOWLATE are restricted to consideration of user, not system impact. HOWLATE cannot be easily extended to assess system-level impacts of increasing ATIS market penetration nor can HOWLATE address impacts of ramp metering or other traffic control strategies. These applications are best considered using field studies or traffic simulation models. Likewise the perceived benefit of ATIS to a user cannot be measured nor quantified within HOWLATE. Field studies of ATIS are still required to examine the effect of having a "human-in-the-loop" for travel decision-making. HOWLATE adds a new dimension of potential analysis that can be conducted in conjunction with these other techniques.

Planned near-term extensions of this work include the adaptation of HOWLATE for the evaluation of en route as well as pre-trip ATIS, and the consideration of more complex traveler behavior, as well as the impact of traffic reports on commercial radio.

GENERAL DISCLAIMER

This document may have problems that one or more of the following disclaimer statements refer to:

- This document has been reproduced from the best copy furnished by the sponsoring agency. It is being released in the interest of making available as much information as possible.
- This document may contain data which exceeds the sheet parameters. It was furnished in this condition by the sponsoring agency and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.