

Utah Transit Authority's Connection Protection System: Perceptions of Riders and Operators

Chris Cluett and Jeffrey H. Jenq, Battelle
Mitsuru Saito, Brigham Young University

Abstract

The effectiveness of the Utah Transit Authority's (UTA) Connection Protection (CP) system was evaluated from the perspective of riders and operators. The CP system was installed to improve the reliability of transfers from higher frequency light rail TRAX trains to lower frequency bus services. The evaluation determined that overall satisfaction among riders with their connection experience was generally high, but operator opinion on the value of CP was mixed. The level of reported rider satisfaction was only weakly related to whether the bus trip was CP protected, and bus operators reported receiving a high number of unnecessary CP messages. Several factors were considered to have affected the results of the evaluation, including CP malfunction during the survey, low operator compliance for "hold until" messages, and the existence of inaccurate "hold until" messages. The qualitative evaluation findings gave rise to a number of suggestions for how the CP system could be improved.

Introduction

The Utah Transit Authority (UTA) implemented a Connection Protection (CP) system to improve the reliability of transfers from the higher frequency light rail TRAX trains to the lower frequency bus services. The CP system examines the status of TRAX trains and issues a “hold at (*station name*) until (*time*)” message to buses waiting at the connecting rail stations via the buses’ onboard Mobile Data Terminal (MDT), if the lateness of the train is within a predetermined threshold (e.g., three minutes). The system was completed in January 2002 prior to the Winter Olympic Games in Salt Lake City. Figure 1 presents a high level CP system configuration diagram.

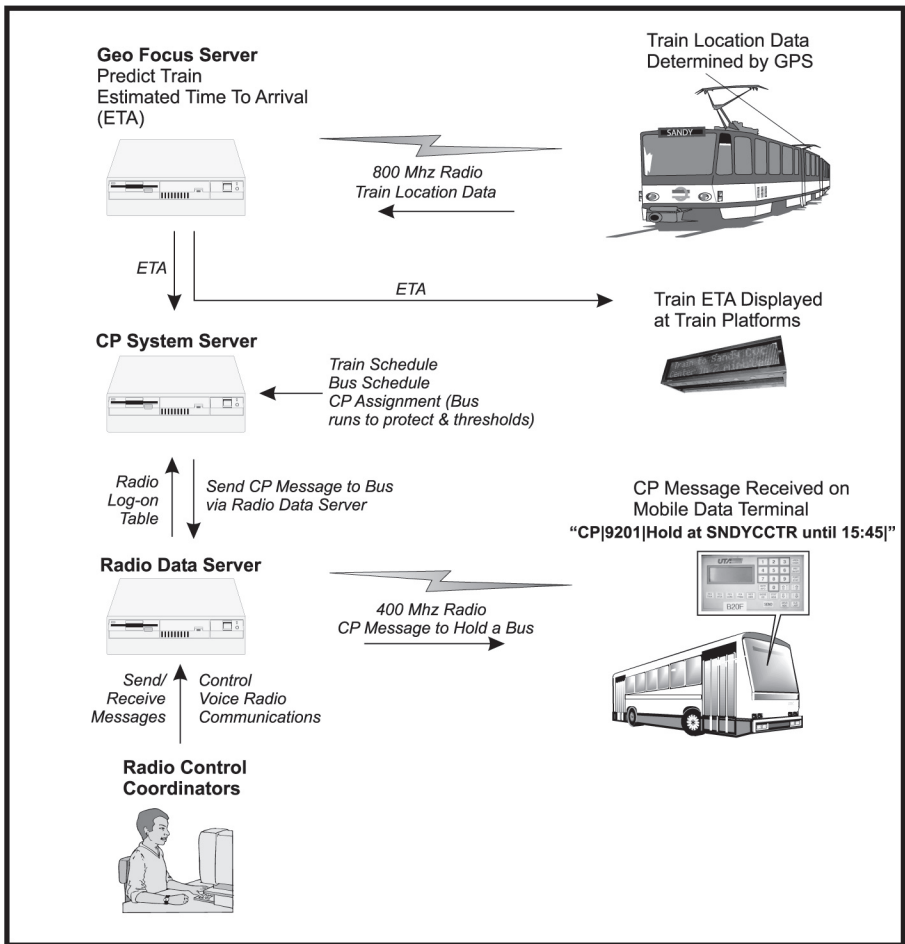
The Federal Transit Administration (FTA) and the U.S. Department of Transportation (USDOT) Intelligent Transportation System (ITS) Joint Program Office (JPO) selected UTA’s CP system for a national evaluation. The objectives of the evaluation were to assess and document the performance of the CP system and share the experience and lessons learned with UTA and other agencies that may be considering a similar system.

Battelle was selected in September 2002 to conduct the evaluation. Brigham Young University (BYU) in Provo, Utah, provided field data collection support. The evaluation consisted of qualitative and quantitative components. This article presents the results of the qualitative assessment and offers suggestions to improve the effectiveness of the CP system. A quantitative assessment of the CP system performance is documented in a separate report (Jenq, Pierce, and Pate 2005). The approach and detailed methods can be found in Battelle 2003a, 2003b, 2004.

The Problem

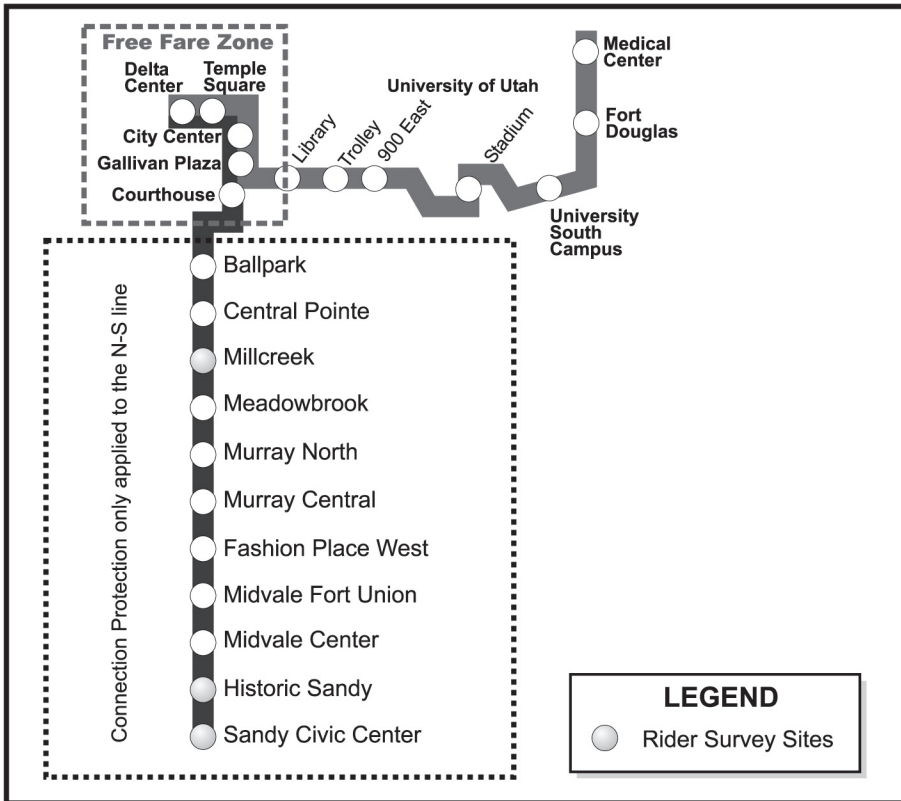
TRAX consists of two routes: a north-south route that connects downtown Salt Lake City and the city of Sandy about 13 miles south of downtown and an east-west route connecting downtown Salt Lake City and the University of Utah. Figure 2 presents an annotated TRAX system map indicating the study locations where rider surveys were conducted. TRAX trains run on a regular schedule typically at 15-minute intervals and connect with many different UTA buses at various stations throughout the day along the light rail route. The UTA buses are on different headways that vary typically in increments of 15 minutes. TRAX trains can be delayed by traffic congestion or other causes in downtown Salt Lake City at the beginning of their trip, or elsewhere along their route due to time needed by dis-

Figure 1. High Level CP System Configuration



embarking and embarking passengers. When this happens, late train arrivals can propagate down the line, depending on the ability of the train to make up some or all of its lost time. A relatively small number of TRAX trains are late overall (about 2% of all train trips experience late train events), but, when a train does arrive late at its station, passengers on the TRAX wishing to transfer to a particular bus may miss their scheduled connection. UTA instituted an automated CP program and made it operational in January 2002, nine months prior to this evaluation, to instruct the operators of the connecting buses to hold until after the late TRAX train had arrived to ensure successful connections. CP was developed as a low-cost

Figure 2. UTA TRAX System and Survey Sites



tool to target the relatively rare late train impacts on missed bus connections as a kind of insurance policy for riders. This evaluation was designed to assess the responses of riders to their connection experiences and of operators to the CP program. It is important to note that the rail-to-bus transferring riders were unaware of when and where the CP system was operational; they only knew whether or not they were able to make a successful connection.

Evaluation Approach

Three TRAX stations (Millcreek, Historic Sandy, and Sandy Civic Center) that receive most of the CP messages were selected as sites for the rider surveys (see Figure 2). These TRAX stations comprise a large number of protected bus trips

and late train events. The objective of this qualitative evaluation was to assess the perception of users, including bus riders, bus operators, UTA supervisors, and radio control coordinators. The assessment was conducted through surveys and in-person interviews. The surveys assessed rider experiences over the prior month taking account of all their transfer experiences, not just those associated with late train events. This evaluation, therefore, covers the full range of potential connections, with and without CP operating, and for all combinations of train and bus schedules.

Student interviewers from Brigham Young University (BYU) were assigned to three TRAX stations to survey a mix of CP-protected and unprotected bus trips over a three-day period in October 2003. One survey was conducted for riders who were transferring to bus from a TRAX train and another for riders who were on the bus but had not transferred at the TRAX station where the survey was conducted. Interviewers boarded the selected buses at these TRAX stations and distributed paper questionnaires to rail-to-bus transfer riders and a different questionnaire to on-board passengers. The evaluation resulted in 522 completed questionnaires, including 433 riders transferring from rail to bus and 89 on-board passengers. Among the completed survey forms, 53 percent were on bus trips designated for CP protection, though the CP system was not always functioning properly during the evaluation period, and therefore it is likely that some of the respondents were exposed to bus trips for which CP protection was designated but not functional. Tables 1 and 2 show the distribution of respondents by TRAX station, rider types, and protection status.

Table 1. Distribution of Survey Respondents by TRAX Station and Rider Type

<i>TRAX Station</i>	<i>Train-to-Bus Riders</i>		<i>On-Board Passengers</i>	
	<i>Number</i>	<i>Percent</i>	<i>Number</i>	<i>Percent</i>
Millcreek	176	41%	57	64%
Historic Sandy	74	17%	12	14%
Sandy Civic Center	183	42%	20	22%
Totals	433	100%	89	100%

Table 2. Number and Percent of Protected Trips by TRAX Station and Rider Type

<i>TRAX Station</i>	<i>Train-to-Bus Riders</i>		<i>On-Board Passengers</i>	
	<i>Protected</i>	<i>Unprotected</i>	<i>Protected</i>	<i>Unprotected</i>
Millcreek	55 (31%)	121 (69%)	6 (10%)	51 (90%)
Historic Sandy	48 (65%)	26 (35%)	6 (50%)	6 (50%)
Sandy Civic Center	153 (84%)	30 (16%)	10 (50%)	10 (50%)
Totals	256 (59%)	177 (41%)	22 (25%)	67 (75%)

A bus operator survey was distributed to all UTA bus operators (i.e., drivers) in November 2003. The survey could be filled out by hand and returned to the office or completed on-line over the Internet. An incentive was offered to the respondents, and 251 completed surveys were returned, for an overall estimated response rate of 28 percent. This low response rate, coupled with a disproportionate number of extra board operators in the sample, is likely to introduce biases into the analysis of operator responses and makes it difficult to generalize findings to all operators. Nevertheless, the results yielded useful insights and practical suggestions for UTA’s consideration as it seeks to improve the CP system. This survey sought to understand bus operators’ experiences with CP, their responses to late train events either with or without CP “hold until” messages being issued, and their perceptions of the CP program and suggestions for improvement. See Table 3 for the distribution of responses among regular drivers and temporary (“extra board”) drivers.

Table 3. Responses to the Operator Survey

<i>Operators</i>	<i>All UTA Operators (Est.)</i>		<i>Survey Respondents</i>		<i>Response Rate (Est.)</i>
	<i>Number</i>	<i>Percent</i>	<i>Number*</i>	<i>Percent</i>	
Regular	790	88%	183	73%	23%
Extra Board	110	12%	66	27%	60%
Totals	900	100%	249	100%	28%

Members of the evaluation team conducted interviews in November 2003 with UTA radio controllers who are in constant contact with UTA bus operators, operations supervisors and work dispatchers, bus operators who were available in their dispatch waiting room, and other UTA staff responsible for the CP program and management of customer complaints.

Evaluation Hypotheses

Hypotheses were framed early in the evaluation process, and some additional hypotheses were developed later in the evaluation that were based on a more detailed understanding of the operations, to take advantage of refinements in the test plans, and to support more focused evaluation components.

Table 4 provides a list of the evaluation hypotheses, framed to help assess potential improvements in transit service with regard to rail-to-bus transfers. Some of the user perception hypotheses identified in the evaluation plan are not shown in Table 4 because they could not be addressed due to the lack of adequate or appropriate data. The hypotheses were tested for the rider survey data using Chi-square tests for statistical significance at the 95 percent confidence level. In Table 4, the term “supported” indicates either that a hypothesis tested was significant, or in the case of qualitative interview data that the anecdotal results supported the hypothesis. “Partially supported” indicates either a nonsignificant or weak outcome in the expected direction. Data from several questions in both the surveys and qualitative interviews were examined where they were relevant for judging the degree of support offered for selected hypotheses.

Qualitative Evaluation Findings

Overall, riders transferring from train to bus and on-board passengers at the TRAX stations report a high level of satisfaction with their connection experience. For the transferring passengers on all trips (both protected and unprotected), 46 percent said they were “very” satisfied and 40 percent said they were “somewhat” satisfied (total 86% satisfied). On the other hand, transferring riders who report missing one or more connections in the past month are three times more likely to say they are dissatisfied (22%) compared with those who have not missed any connections (6%), a statistically significant difference. However, riders who were surveyed on trips that were CP protected were only slightly more likely to report being “somewhat” or “very” satisfied (87%) compared with those who were not

Table 4. User Perception Hypotheses Addressed by the Evaluation

<i>Objectives</i>	<i>Hypotheses</i>
Increase satisfaction of transit users	TRAX rail riders perceive that bus connections are reliable, and more reliable than they used to be. [PARTIALLY SUPPORTED]
	Bus riders transferring from TRAX are satisfied with their ability to make their connection successfully from rail to bus. [SUPPORTED]
	Rail-to-bus riders on CP-protected routes report they are more likely to make their connections than those on nonprotected routes. [PARTIALLY SUPPORTED]
	On-board passengers with down-line transfers are at greater risk of missing those connections on CP-protected trips. [PARTIALLY SUPPORTED]
Increase satisfaction of bus operators, dispatchers, and transit system managers	Bus operators are more satisfied with connection performance. [PARTIALLY SUPPORTED BUT NOT FULLY TESTABLE]
	System operators/dispatchers/managers are satisfied with rail/bus system performance. [SUPPORTED]
	Interviewees (operators, dispatchers, managers) perceive a beneficial effect of CP on connection success and bus schedule performance/adherence. [PARTIALLY SUPPORTED]
	Bus operators are more likely to wait for a late train with a CP "hold until" message than without a CP message. [PARTIALLY SUPPORTED]
	Regular operators are more likely to wait for late trains than extra board operators, regardless of CP "hold until" messages. [PARTIALLY SUPPORTED]
	Overall, bus operators report that most of the CP messages they have received are helpful and needed. [NOT SUPPORTED]
	Bus operators regularly communicate with their passengers about waiting for TRAX trains beyond scheduled departure, and are more likely to do that on CP-protected trips than on trips not protected by CP (i.e., when the wait is discretionary). [NOT SUPPORTED]
	Bus operators who report tight schedules are less likely to wait for passengers or to wait shorter periods of time than operators whose schedules have more slack. [SUPPORTED]
	The more experience an operator has with CP and as a bus operator with UTA, the more supportive they will be of the CP program. [NOT SUPPORTED]

on CP-protected trips (85%), a difference that is not statistically significant. The likelihood that riders who are not connecting to a CP-protected bus trip will report a high number of missed connections at their TRAX station (4 or more in past 30 days) is twice as great as riders on CP-protected trips. Overall, 41 percent of transferring riders report missing one or more connections on bus trips under CP versus 47 percent for trips without CP. While these effects suggest a small but positive effect of CP as measured by rider reports of trip satisfaction and connection success, the differences are not statistically significant.

Many experienced transfer riders reported taking an earlier train to avoid missing their bus connection. Sixty-three percent of the train-to-bus transfer riders report that they at least sometimes take an earlier TRAX train to be sure they make their connection, and one-quarter of them (26%) do this for most or all of their trips. There is no difference in the proportion of riders who do this whether their bus trip is CP protected or not. The potential benefit of CP to riders is reduced to the extent that more than half of all transferring riders felt a need to travel 15 minutes earlier than normal to be assured of making their intended connection.

The lack of a significant difference in both reported connection success and satisfaction with connection experience for both CP-protected and nonprotected trips is likely in part related to the fact that bus operators say they are very likely to wait for connecting passengers regardless of whether they receive a CP “hold until” message. Only 8 percent of operators say they will “never” wait without a CP message, and 47 percent say they “always” wait. Even though there is a difference in perspective between the operators and transferring passengers regarding reported wait behavior, it appears that most bus operators will wait most of the time for two or more minutes for connecting rail passengers. This willingness to wait is a positive endorsement of UTA management’s customer orientation that they frequently communicate to all their bus operators as an “expected” way to behave toward passengers. Scheduling constraints appear to be the main factor limiting willingness to wait. Bus operators expressed concern that the advantages to transferring passengers of waiting for late trains is offset by the disadvantages to on-board passengers who are put at risk of missing their later connections or on-time arrival.

An important factor that influences the willingness of operators to wait for late trains is the tightness of their bus schedule. Regular operators who agreed that their routes were so tightly scheduled that it was difficult for them to wait are about half as likely to say they always waited compared with operators who did not report tightly scheduled routes (38% vs. 69%). That is, 7 out of 10 regular operators said they always waited if their schedules were not too tight; otherwise, only 4 in 10 would wait if they perceived their schedules to be tight. Open-ended comments and suggestions from the operators included many related to their perception of a need for more reasonable schedules.

Compliance with CP “hold until” messages by bus operators was relatively low. Only 51 percent of bus operators who received a CP message (i.e., “hold until”) departed after the suggested departure time. However, if 100 percent of the opera-

tors had followed the suggestions of CP, then the percentage of successful connections could potentially have been *increased* by 28 percent over observed levels.

Overall, about half (49%) of the bus operators agreed with the idea that CP should be used on more routes than it is now. Fewer than one in five operators disagreed with that idea, and the rest were neutral. If endorsement that CP should be extended to additional routes can be interpreted as operators' support for the CP program, then these results are decidedly mixed, with the operators evenly split on the matter.

About half of the operators (49%) agreed that tight scheduling often caused them to arrive late at the TRAX stations. More than half of the bus riders (53%) reported that they have been on a bus when it arrived late at the TRAX station one or more times in the past month. To the extent that many buses are arriving late at the station, this is expected to account for many of the successful connections that otherwise would have been at risk of being missed if the bus had arrived and departed on schedule, assuming no CP message was issued. In such situations when a CP message is issued, it is likely to be perceived by the bus operator as unnecessary when the bus is late enough to pick up late-arriving TRAX passengers anyway. In fact, bus operators reported that 64 percent of all the CP messages they received were unnecessary, either because the train had made up time and arrived close enough to schedule, or presumably because the bus was late enough in arriving that the connection was successful without needing any additional wait time, or perhaps because no passengers actually transferred from the train when it did arrive.

While CP offers benefits to TRAX passengers trying to make connections to buses, passengers arriving at the TRAX station or boarding from the station's park-and-ride facility depend on the bus leaving on time and adhering to its schedule along the way. When CP causes the bus to wait, later bus-to-bus connections are jeopardized down the line for the riders. Waiting past the scheduled departure at the TRAX station is associated with missing other transfer connections and with arriving late at their final destination, and riders who have these experiences are less likely to say they are satisfied with their transit experience compared with those who do not. There is some evidence suggesting that CP may make it more likely that a bus rider will experience one or more late arrivals at their final destination, so this needs to be factored into an overall assessment of the impact or benefit of CP. In fact, bus operators reported their perception of the inequity of a CP message that requires them to wait for an uncertain number of connecting passengers

knowing that the passengers already on their bus will potentially be negatively affected by the wait time.

In summary, the rider and operator surveys and interviews suggested that CP is a useful tool that can help operators better meet the needs of their customers, but operator judgment is a key ingredient in determining when and how long to wait with or without a CP message, and in balancing the effects of bus schedule constraints, current on-time status of their bus, observed TRAX train status, and the needs of their on-board riders versus the needs of their likely TRAX-transfer riders. CP is perceived to make a difference in only some of the CP-protected trips, for a number of reasons:

1. TRAX can often make up lost time after a CP message is issued.
2. Most operators are conditioned to waiting where possible, such that more than half the time they consider CP messages that have been issued to be unnecessary, and they wait most of the time even when no CP message was issued.
3. Many riders elect to take an earlier TRAX train specifically to avoid the risk of missing their connection.
4. Due to tight scheduling, buses often arrive behind schedule at TRAX stations, making it easy to pick up late-arriving TRAX passengers without additional wait time.

Even though the effectiveness of CP was limited in this early application of the system, CP is a relatively low-cost service compared to many other transit ITS systems. Moderate capital cost is achieved by utilizing the existing system data (e.g., train status and schedules) and the delivery mechanism (e.g., Mobile Data Terminal, radio data server, bus and train radio systems) already deployed for other ITS functions. Operating and maintenance costs also are moderate because the CP operation is fully automated without the need for human intervention.

Conclusions and Suggestions

CP aims to improve the reliability of rail-to-bus connections. It serves as a relatively low-cost “insurance policy” to help increase connection success. CP targets relatively rare late train events to improve the probability of successful connections. This rationale was affirmed by the evaluation data that there were only 4,641 (2%) recorded late train events (out of more than 187,000 arrivals) that subsequently

triggered 1,508 “hold until” messages during the three months of data collection. Despite its marginal benefits compared to other transit ITS functions (e.g., train control systems, computer-aided dispatch), CP fills an important niche in a multi-modal light rail and bus transit operation.

The findings of the qualitative evaluation of UTA’s CP system suggested that CP could improve the probability of successful train-to-bus connections. Overall satisfaction among riders with connection experience was generally high, but operator opinion on the value of CP was mixed. The level of reported rider satisfaction was only weakly related to whether the bus trip is CP protected, and bus operators reported a high number of unnecessary CP messages received. Hence, CP effectiveness was found to be less than it could be at the time of this evaluation. It is likely that the following factors contributed to this outcome:

- There were periods when CP was not functional during the data collection.
- Operator compliance with CP “hold until” messages was low.
- Issuance of CP “hold until” messages was sometimes inaccurate.
- A few bus operators fail to log on to their MDT, thereby disabling text messaging.
- Many experienced transfer riders have learned to take an earlier train to avoid missing their bus connection.
- Most bus operators wait most of the time to pick up train passengers, regardless of whether they receive a CP “hold until” message.

The evaluation findings gave rise to a number of suggestions for how CP systems might be improved further. These are expected to offer useful guidance both for UTA and for other transit agencies that may be considering implementing a similar CP program in their area. Although the effectiveness of the CP system in this evaluation study turned out to be less than it could be, the system has a potential to become an asset to further improve services to passengers once the following suggestions are implemented, the CP operation perfected, and the cooperation of bus operators increased. Suggestions include:

- *Increase compliance through training and education.* Findings from the operator survey and interviews suggest that compliance can be improved by increasing the reliability of the CP messages (increase trust), adjusting schedules to better accommodate required waits (more equitable treatment

of transfer riders and on-board riders; less pressure on operators from tight schedules), and further clarifying agency policy regarding wait decisions versus schedule adherence, considering the consequences for both transferring and on-board passengers.

- *Adjust bus schedules with respect to their effects on connection success.* Provide more schedule slack to accommodate comfortable waits at TRAX stations, or at least the capacity to make up lost time at critical points in the bus trips. Assess why many bus trips are reported by riders to be behind schedule and seek solutions where problems are found.
- *Obtain and integrate information about bus location with train location in fine-tuning the CP algorithm.* When buses are running late, a CP message may not be needed. When a train makes up lost time, a CP message may not be needed. When a later bus on a given trip can more efficiently pick up passengers from a late train, a CP message may not be needed. When real-time bus location information is not available, the CP algorithm cannot consider the bus status in the computation. As UTA considers the Automatic Vehicle Location (AVL) system for its bus fleet in the future, it is highly desirable to incorporate bus status as part of the CP parameters.
- *Improve the predictive accuracy of CP messages.* Inaccurate messages may cause bus operators to say that many of the CP messages they receive are not needed. A major reason for this is assumed to be the ability of the train to make up time between stations. Options for addressing this problem may include reducing the forecasting horizon to less than three TRAX stations in advance of the anticipated connection, or sending out a follow-up message to rescind the “hold until” message when it is determined that the train no longer meets the lateness threshold.
- *Examine management integration of CP.* This could include an assessment of the need to better coordinate the complex interdependencies between ITS systems. Examples include separate database components in different parts of the organization, and the multiple positions in the organization with responsibility for the CP assignment data. Also, seek to be sure there is a common understanding throughout the agency regarding recommended wait times among the radio control coordinators, management, and bus operators, consistent with the CP algorithm-based instructions.
- *Promote rider awareness of agency efforts to increase connection success.* Both riders and operators expressed concerns that bus and rail schedules

were not adequately coordinated, that buses were often late, and that the CP program was “one sided” in its focus on rail-to-bus transfers and not bus-to-bus or bus-to-rail. These kinds of concerns could be mitigated by providing more information and rationale about the CP program.

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About the Authors

CHRIS CLUETT (cluett@battelle.org) is a research leader in the transportation sector of Battelle in Seattle, Washington. He received a Ph.D. in sociology from the University of Washington in 1977. He has 27 years of experience with Battelle in behavioral science research and project management and has been manager of numerous ITS research and evaluation projects over the past decade. Dr. Cluett's areas of research include evaluation, institutional and societal analysis, public outreach and involvement, focus groups and survey implementation. He is an active member of the Intelligent Transportation Society of America, Transportation Research Board, and American Sociological Association. He is currently on the board of ITS Washington and is co-chair of the University of Washington's Department of Sociology Advisory Board.

JEFFREY H. JENQ (jenqj@battelle.org) is a senior research scientist in the transportation sector of Battelle's Phoenix, Arizona, office. He received his Ph.D. in transportation engineering from Northwestern University in Evanston, Illinois, in 1999. The early part of Dr. Jenq's career involved the development and integration of ITS in the areas of traveler information and traffic and transit management. In 1996, he served as a task manager and successfully deployed three of the five state-of-the-art Advanced Traveler Information Systems (ATIS) in USDOT's Traveler Information Showcase demonstration in Atlanta during the Summer Olympics. Dr. Jenq's research has since focused on the evaluation and assessment of leading-edge ITS technology deployment, including transit, traffic, CVO, traveler information, and more recently transportation security.

MITSURU SAITO (msaito@byu.edu) is a tenured full professor of transportation engineering in the Department of Civil and Environmental Engineering of Brigham Young University, Provo, Utah. From 1988 to 1997 he taught at the City College of New York of the City University of New York. Dr. Saito received his Ph.D. in transportation engineering from Purdue University in West Lafayette, Indiana, in 1988. He has published more than 40 technical papers (31 in peer-reviewed publications) in the field of traffic engineering, transportation planning, and infrastructure management. His research interests are in transportation engineering, operation, planning, infrastructure management, and public transit. Dr. Saito is an active member of the American Society of Civil Engineers (ASCE), Transportation Research Board, and Institute of Transportation Engineers and has been involved in the organization of a number of professional conferences in the area of transportation engineering. He is a former chair of the Infrastructure Systems Committee and currently the secretary of the Transportation Operations Committee of ASCE.