User Evaluations of Intermodal Travel to Work: Exploratory Studies

MTI Report WP 10-03

MINETA TRANSPORTATION INSTITUTE
MTI

MINETA TRANSPORTATION INSTITUTE

The Norman Y. Mineta International Institute for Surface Transportation Policy Studies was established by Congress in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The Institute's Board of Trustees revised the name to Mineta Transportation Institute (MTI) in 1996. Reauthorized in 1998, MTI was selected by the U.S. Department of Transportation through a competitive process in 2002 as a national "Center of Excellence." The Institute is funded by Congress through the United States Department of Transportation's Research and Innovative Technology Administration, the California Legislature through the Department of Transportation (Caltrans), and by private grants and donations.

The Institute receives oversight from an internationally respected Board of Trustees whose members represent all major surface transportation modes. MTI's focus on policy and management resulted from a Board assessment of the industry's unmet needs and led directly to the choice of the San José State University College of Business as the Institute's home. The Board provides policy direction, assists with needs assessment, and connects the Institute and its programs with the international transportation community.

MTI's transportation policy work is centered on three primary responsibilities:

Research

MTI works to provide policy-oriented research for all levels of government and the private sector to foster the development of optimum surface transportation systems. Research areas include: transportation security; planning and policy development; interrelationships among transportation, land use, and the environment; transportation finance; and collaborative labor-management relations. Certified Research Associates conduct the research. Certification requires an advanced degree, gener-ally a PhD, a record of academic publications, and profession-al references. Research projects culminate in a peer-reviewed publication, available both in hardcopy and on TransWeb, the MTI website (http://transweb.sjsu.edu).

Education

The educational goal of the Institute is to provide graduate-level education to students seeking a career in the development and operation of surface transportation programs. MTI, through San José State University, offers an AACSB-accredited Master of Science in Transportation Management and a graduate Certificate in Transportation Management that serve to prepare the nation's transportation managers for the 21st century. The master's degree is the highest conferred by the California State University system. With the active assistance of the California Department of Transportation, MTI delivers its classes over a state-of-the-art videoconference network throughout the state of California and via webcasting beyond, allowing working transportation professionals to pursue an advanced degree regardless of their location. To meet the needs of employers seeking a diverse workforce, MTI's education program promotes enrollment to under-represented groups.

Information and Technology Transfer

MTI promotes the availability of completed research to professional organizations and journals and works to integrate the research findings into the graduate education program. In addition to publishing the studies, the Institute also sponsors symposia to disseminate research results to transportation professionals and encourages Research Associates to present their findings at conferences. The World in Motion, MTI's quarterly newsletter, covers innovation in the Institute's research and education programs. MTI's extensive collection of transportation-related publications is integrated into San José State University's world-class Martin Luther King, Jr. Library.

MTI REPORT WP 10-03

USER EVALUATIONS OF INTERMODAL TRAVEL TO WORK: EXPLORATORY STUDIES

Steven Silver, PhD

June 2011

A publication of
Mineta Transportation Institute
Created by Congress in 1991

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. CA-MTI-11-1025	**2. Government Acession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle User Evaluations of Intermodal Travel to Work: Exploratory Studies		**5. Report Date** June 2011 **6. Performing Organization Code**
7. Authors Steven Silver, PhD		**8. Performing Organization Report** MTI Report WP 10-03
9. Performing Organization Name and Address Mineta Transportation Institute College of Business San José State University San José, CA 95192-0219		**10. Work Unit No.** **11. Contract or Grant No.** DTRT07-G-0054
12. Sponsoring Agency Name and Address California Department of Transportation Sacramento, CA 94273-0001 U.S. Department of Transportation Research and Innovative Technology Administration (RITA) Office of University Programs 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** **14. Sponsoring Agency Code**
15. Supplemental Notes		

16. Abstract

The general importance of intermodal travel (i.e., travel in which there is a combination of modes to a destination, for example, train or light rail and a bus connection) has been emphasized in extensive congressional hearings and in state and regional sponsored transportation studies. Available empirical studies of the use of intermodal travel have predominantly been in cases where travel is across cities or regions. These studies have most often related use of intermodal travel options to distance, time of day and user demographics and user-identified factors and ratings that evaluate these factors. The principal objective of this exploratory study is to identify candidate factors that users relate to the public transit options when work travel is within a local corridor.

Two focus groups were conducted in each of two travel corridors in Northern California's Bay Area. Results identify four factors that are reported to be major considerations in user evaluation of intermodal travel to work. The importance of these factors is indicated by their independent identification in each group and the amount of discussion of the factors. The cost of uncertainty in waiting time between connections and the imputed lack of coordination between modes in service offerings were among the predominant factors in the discussions of all groups.

17. Key Words Intermodal transportation; Mode choice; Travel by mode; Work trips	**18. Distribution Statement** No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 40	**22. Price** $15.00

Form DOT F 1700.7 (8-72)

Library of Congress Catalog Card Number:
2011925905

To order this publication, please contact:

Mineta Transportation Institute
College of Business
San José State University
San José, CA 95192-0219

Tel: (408) 924-7560
Fax: (408) 924-7565
Email: mineta-institute@sjsu.edu
www.transweb.sjsu.edu

062911

ACKNOWLEDGMENTS

The author thanks Manoj Kashyap Chavali and Karthik Indukuri for their competent research assistance. He is grateful to MTI Research Director Karen Philbrick, PhD for her interest and facilitation of the research and Research Support Manager Meg Fitts for her directions on project management.

The authors also thank MTI staff, including Director of Communications and Special Projects Donna Maurillo; Student Publications Assistant Sahil Rahimi; Student Research Support Assistant Joey Mercado; Student Graphic Artist JP Flores; and Webmaster Frances Cherman. Additional editorial and publication support was provided by Editorial Associate Cathy Frazier and Frances Cherman.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The general importance of intermodal travel (i.e., travel in which there is a combination of modes to a destination, for example, train or light rail and a bus connection) has been emphasized in extensive congressional hearings and in state and regional sponsored transportation studies. As has been noted in those hearings and studies, single-passenger, own-vehicle travel in short range trips that include travel to work have well-recognized economic and environmental costs. Available empirical studies of the use of intermodal travel have predominantly been in cases where travel is across cities or regions. These studies have most often related use of intermodal travel options to distance, time of day and user identified factors and evaluations of these factors. This exploratory study had the principal objective of identifying candidate factors that users consider to be related to use of the public transportation options when work travel is within a local corridor. Results for two focus groups in each of two travel corridors in Northern California's Bay Area identified multiple factors in user evaluation of intermodal travel to work. The importance of these factors was indicated by their independent identification in each group and the amount of discussion of the factors. The cost of uncertainty in waiting time between connections and the imputed lack of coordination between modes in service offerings were among the factors that were identified in the discussions of all groups.

I. INTRODUCTION

A frequently referenced public policy goal is to reduce or limit the growth of single-passenger private vehicle use for routine trips (Siggerud 2006). This policy goal continues to have limited success in the densely-populated travel corridors of California. The most common routinized local traveling is clearly in travel to work. While work travel is about 20% of total travel in the U.S., it remains important because of its absolute size and the regularity in its timing. This suggests the possible efficiency that coordinated planning can offer. In many parts of the country, the public transit option is necessarily intermodal. Available intermodal transportation can involve a number of modes that include long distance bicycling; this study emphasizes the combination of bus and train transports that are the predominant modes in urban California corridors.

For many, if not most, households in the corridors studied, a principal difficulty in using public transportation for travel to their workplaces is that it does require intermodal connections. Employees in major urban areas of California do not have access to a single transportation mode in traveling to work. Reasons for this can be understood from historical backgrounds of location decisions. Although there is an extensive background on integrating land use and transportation modes, including Abraham and Hunt (1999), Bennett (1999), and Metropolitan Transportation Commission (2003), decisions of private companies regarding location have most often heavily weighted cost and industry factors. In contrast, decisions on residence location have most heavily weighted the price of a residence size, neighborhood quality and amenities such as the quality of schooling and location of cultural and ethnic facilities (Manaugh, Miranda-Moreno and El-Geneidy 2010).

In background studies of the use of intermodal public transportation for the work trip in urban corridors, Bovy and Hoogendoorn-Lanser (2005) and Benjamins, Lindveld and Van Nes (2002) have assessed preferences revealed from mode use in networks for intercity travel in the Netherlands. Their results suggest the importance of some previously unreported factors such as whether the trip is to an activity or a home-end trip (i.e., travel to a destination vs. travel from a destination). Since their studies are limited to revealed preferences, factors that are not manifested in actual behavior cannot be addressed. Additionally, these authors study intercity rail facilities. Data gathered in this study addresses travel to work within U.S. local corridors.

A series of focus groups were convened to identify predominant factors in decisions to use intermodal travel. These factors are typically entered as stated preferences in analysis of mode choice (Tayyaran and Khan 2007). The focus groups were engaged in direct discussion of what transit users considered to be predominant factors in their own intermodal travel decisions, the relative importance of these factors, and alternatives in mode designs that are within design capabilities of planners. Simply stated, the general questions this study investigates are: (1) What do travelers see as the primary factors in evaluations of their current use of more than one transportation mode in a work trip? and (2) How would they feasibly modify present intermodal offerings to better serve users? This study and subsequent report was generated in two parts. The first part of the report is an exploratory study with the objective of identifying factors that are important to those who use intermodal travel to work. The second part of the report is a pilot study that indicates the factors

identified in focus group can be reliably scaled in questionnaire investigations of mode choice.

II. RESEARCH OBJECTIVES

This exploratory study queried participants who travel to work by intermodal public transport. Study resources did not permit comparison groups of work travelers who have an intermodal public transport option but use their own vehicle. The pilot study was able to include own vehicle users regarding rated importance of factors identified by the study's author. Given the well-defined results on choice of transportation mode when the alternatives are in single travel modes, one would expect that identified factors and their weightings in the intermodal case can be assessed and used to inform on the design of integrated intermodal transportation systems.

The study's longer-term objective is to increase the understanding of factors in decisions on local travel to work and the heuristic rules that travelers use in choice of mode for travel to work when the public alternative is intermodal. The intention is to use results from studies of intermodal work travelers and input from policy makers to more clearly indicate the design of alternatives that ensure high usage rates by travelers and cost-effectiveness.

III. USER FOCUS GROUPS

METHODOLOGY

Design

Two four-person focus groups in each of two travel corridors were convened. This design allows for replications of identified factors within and across travel corridors.

Format

The focus group format style was facilitator-guided open discussion. The discussion was organized into topics of what is “most burdensome” and ”least burdensome” in using intermodal public transport for work travel and recommendations for improvements in service offerings that would contribute most to continued use of intermodal work travel. Discussion of each of the organizing topics was allowed to continue until all participants indicated that they had no additional comments.

Participants

Focus group participants were employees who work for high-tech firms in travel corridors in Northern California’s Santa Clara and Alameda counties. The screening criteria for participants were that they live more than 10 miles and less than 60 miles from work, and use an intermodal connection in travel to work. In Santa Clara County, travel was from locations within five square miles of San José State University’s campus to high technology firms in the city of Santa Clara. In Alameda County, travel was from within five square miles of the University of California, Berkeley campus to industry or government offices in downtown Oakland or San Francisco. These travel corridors are common to professional groups that are employed in high-tech occupations in the counties studied.

All participants had completed at least four years of higher education and were in professional occupations. Their ages were between 24 and 36 years. Two of the participants had school-age children but had outside arrangements for their transportation and care. Each participant was paid $20 for an approximately one-hour session discussing the designated topics in intermodal travel.

County Demographics

Both Alameda and Santa Clara counties have higher than the statewide averages for education, income, and population density but report about equivalent mean travel times to work as in the entire state. County demographics are summarized in table 1.

Table 1. County Demographics (2009)

Descriptor	Santa Clara County	Alameda County	State of California
Percent of residents with bachelor's degree or higher	40.5	34.9	26.6
Median household income	$88,525	$70,217	$61,017
Mean travel time to work (minutes)	26.1	30.8	27.7
Persons per square mile	1,303	1,956	217

Source: U.S. Census Bureau 2010 (http://www.census.gov/)

RESULTS

Transcripts of the focus group sessions were analyzed with software for coding and categorizing qualitative data (Atlas t_i ;Muhr and Friese 2004). The analysis used number of words in discussions of a factor and the position of the factor in the discussion flows to hierarchically decompose an exhaustive list of the factors in the transcripts. Within each of the discussion topics of "most burdensome," "least burdensome," and "recommend/use more," a list of factors were identified and further categorized into the tree organization of sub-factors shown in figures 1, 3, and 5. For each focus group, the study's author examined both line and word counts in the transcripts of discussions as measures of the amount of discussion on designated grouping factors. The counts are conservative in that only on-topic discussion directly related to discussion questions was included. Numbers of words and observations of the organization in discussion flows are used to define the hierarchies shown in the figures.

Figures 2, 4, and 6 show the number of words as a measure of discussion time on sub-factors of the main grouping factors. Across all groups, most of the discussion was in the categories of most burdensome and recommend/use more. Exemplary statements in each of the main grouping factors are reported in Appendix B. Sub-factors within each main grouping factor are discussed in the next section.

Most Burdensome

Within this main grouping factor, first order sub-factors were on connections between modes and attributes of modes. Issues that related to connections between modes clearly predominated in the discussion on most burdensome and recommend/use more. Within discussions of connections between modes, the second order sub-factors related to wait time and to distance between modes. The second order grouping factor of wait time was further divided into length of time for a connection and uncertainty. Uncertainty in wait time was clearly discussed as distinct from how long the wait time was in their experience.

Uncertainty was predominantly linked to bus travel and was seen as increasing trip time for most of the participants, since arriving late to work is not an option. In contrast, arriving early was seen as having a small benefit but generally made necessary because of the large variance in connection wait times. In discussing uncertainty in trip time, the lack

of continuously shared information on scheduling and managerial flexibility in vehicle dispatching were discussed separately as factors that underlie high uncertainty in wait time.

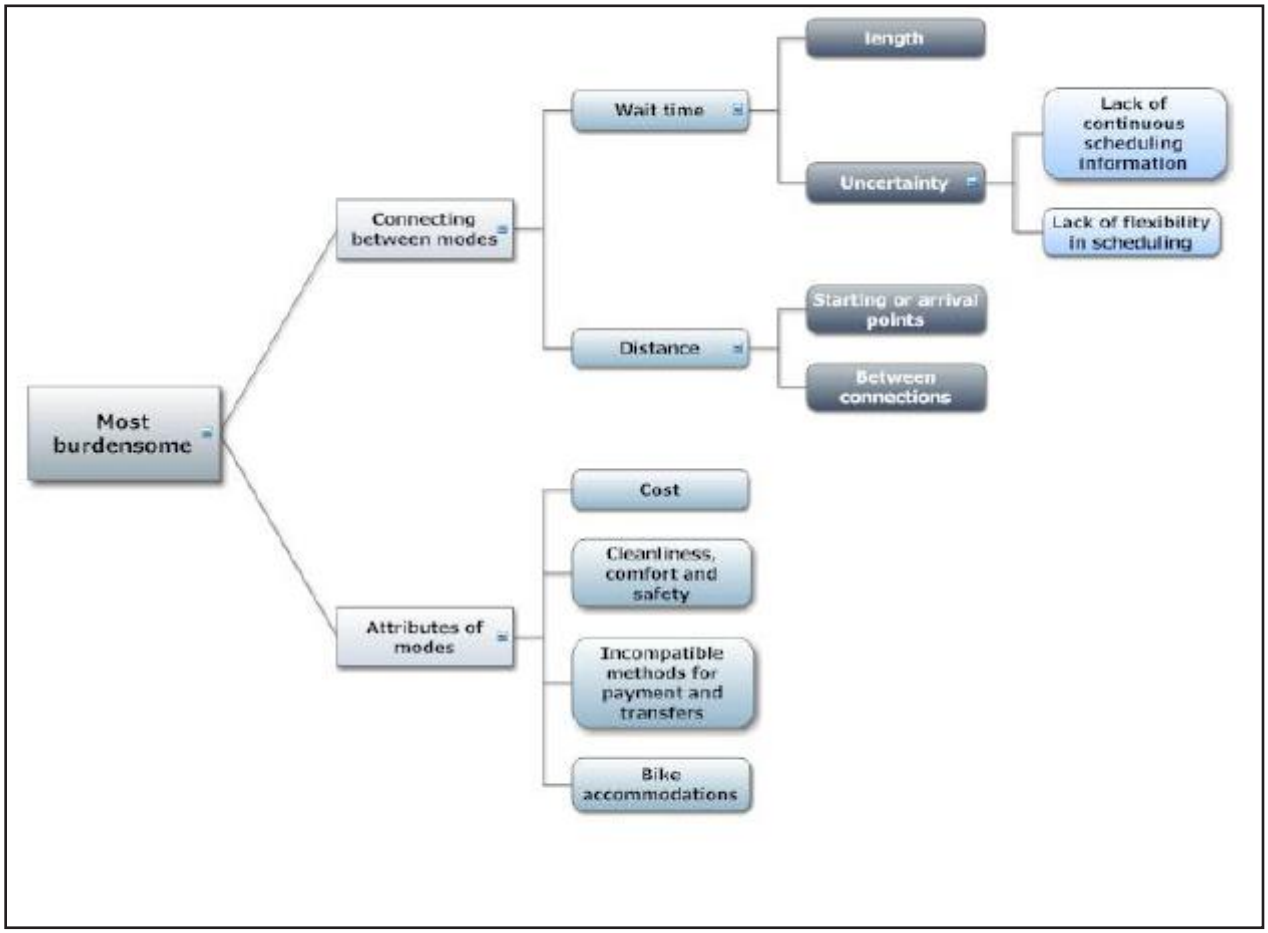

Figure 1. Organizational Schematic of Focus Group Discussions: Most Burdensome

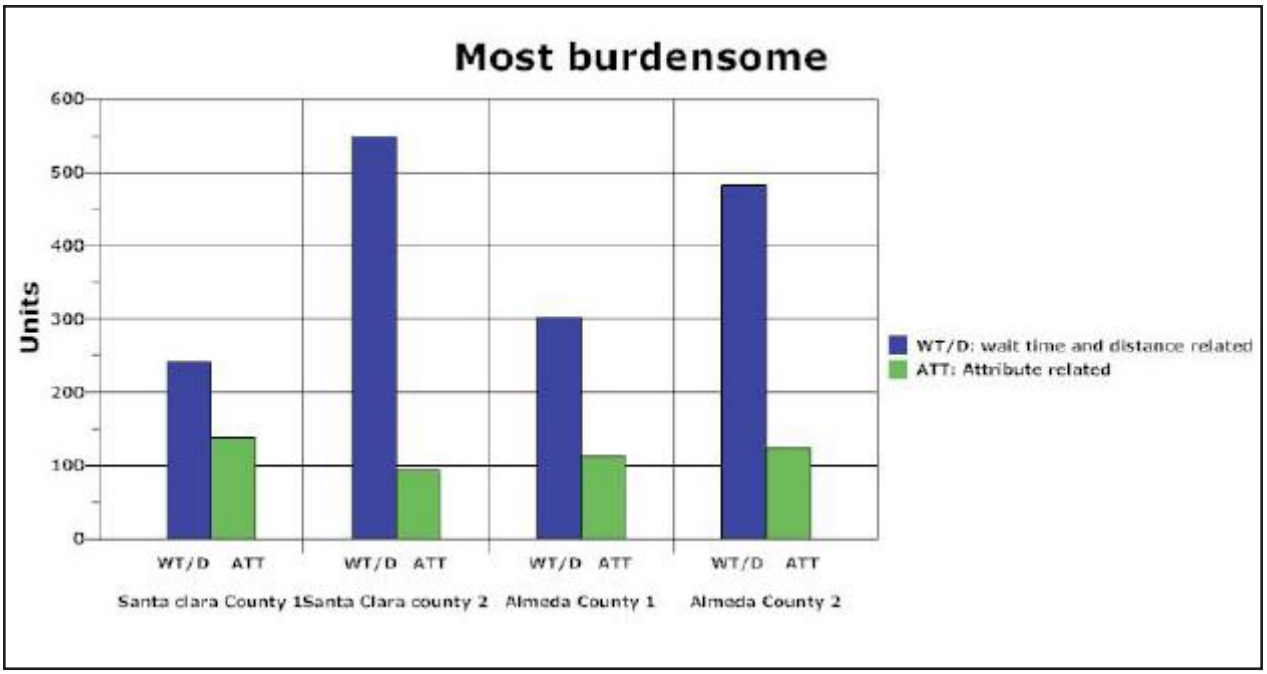

Figure 2. Number of Words by Grouping Factors Within Most Burdensome

Least Burdensome

The principal sub-grouping factors for discussion in least burdensome were the rail experience in general, consequences of not driving, opportunity to work in transit and experiential benefits (i.e., social and personal travel experience). Within discussions of the rail experience, general comfort and efficiency of rail modes were sub-factors. Efficiency was seen as a result from better coordination and varied frequency with work time. Not driving was discussed in terms of less travel time, not negotiating traffic and reduced cost. Under experiential, the personal benefits of "going mindless" for a while, opportunities for social contacts, and in some cases scenic views were discussed.

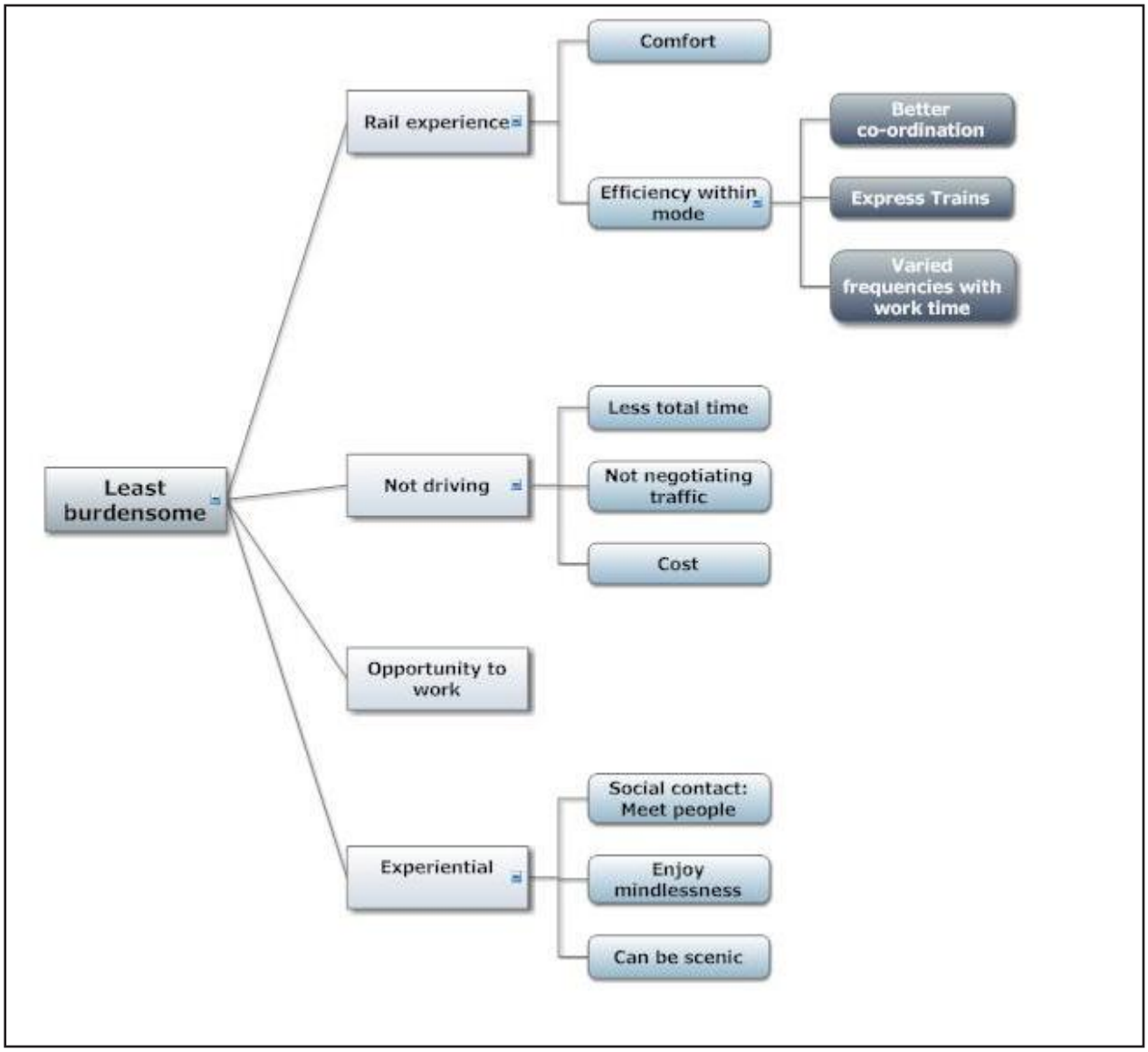

Figure 3. Organizational Schematic of Focus Group Discussions: Least Burdensome

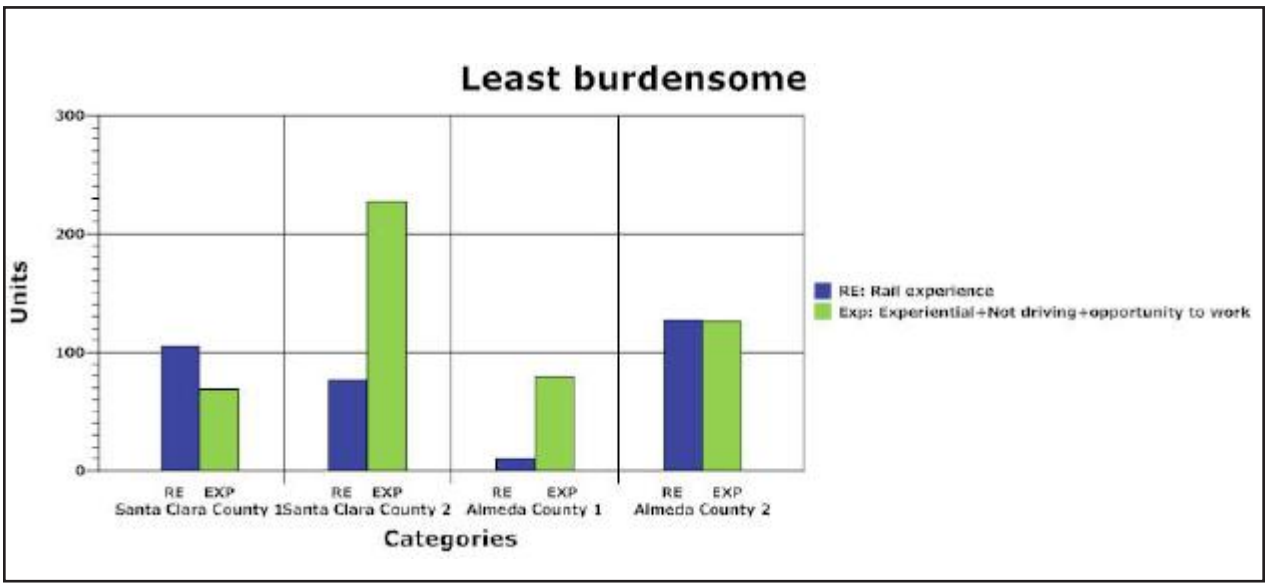

Figure 4. Number of Words by Grouping Factors Within Least Burdensome

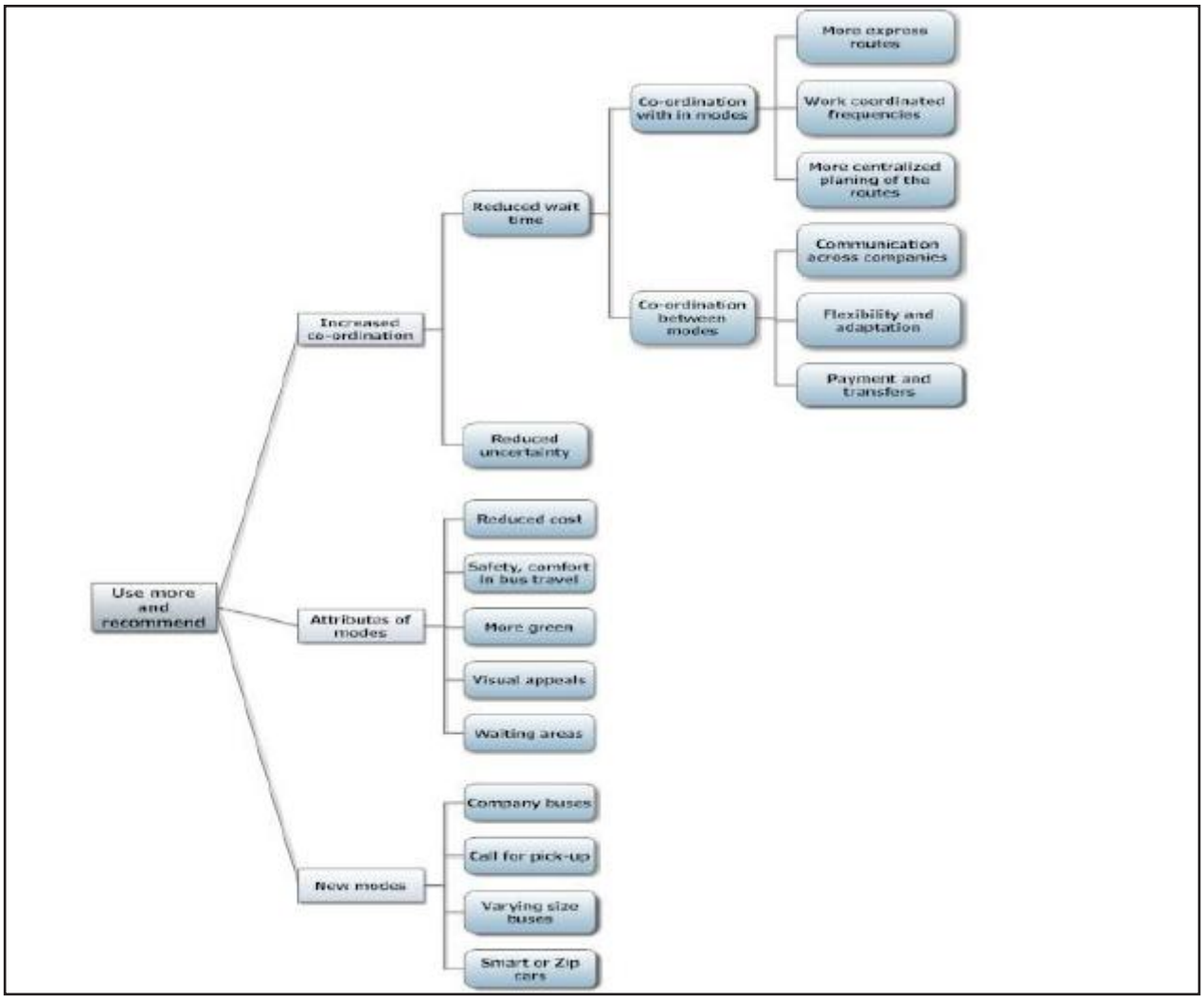

Figure 5. Organizational Schematic of Focus Group Discussions: Use More and Recommend

Use More/Recommend

In the discussion of factors that would increase the use of intermodal options by work travelers and general recommendations to facilitate this goal, the first order grouping factors were increased coordination, attributes of modes, and new modes. Participants indicated that they expected that increased coordination would decrease wait time and uncertainty in wait time. Discussion on wait time was further divided into factors of coordination within modes, and coordination between modes. These sub-factors received particular emphasis by each of the focus groups. It was suggested that coordination within modes would increase coordination between arrivals and departures for most commonly used connections. More express routes and better overall route planning was discussed as reducing wait time. Finally, increased communication between companies and simpler payment and transfer options were suggested as ways to increase flexibility and adaptation.

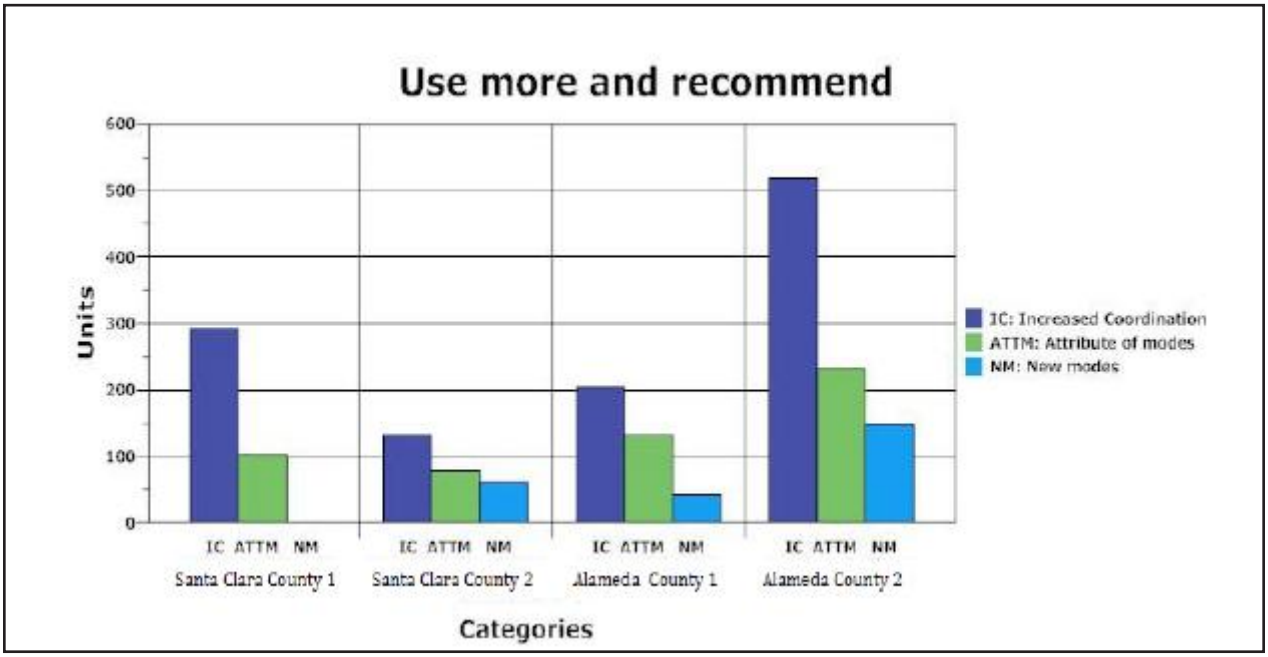

Figure 6. Number of Words by Grouping Factors Within Use More and Recommend

The factors and sub-factors defined from transcripts of the focus group discussions are summarized in table 2.

Table 2. Summary of Identified Factors in Organizational Schematics

Most burdensome

- Interface between modes
    - Wait time
        - Length of time
        - Uncertainty in length of time
        - Lack of continuously updated information
        - Lack of flexibility in scheduling
- Distance between modes in the interface
- Attributes of modes
    - Cost
    - Comfort
    - Cleanliness
    - Safety
    - Bike accommodations
    - Payment compatibility across modes

Least burdensome

- Rail experience
    - Comfort
    - Efficiency
- Not driving
    - Reduction in total travel time
    - Not having to negotiate traffic
    - Cost reduction
- Opportunity to work
- Experiential
    - Social contacts
    - Opportunity to be “mindless”
    - Can be scenic

Use more/recommend

- Increased coordination
    - Reduced wait time
    - Reduced uncertainty
- Attributes of mode
    - Reduced cost
    - Increased comfort and safety in bus travel
    - More green
    - Visual appeals
    - Improve waiting areas
- New modes
    - Company buses
    - Call for pick-up
    - Varying size buses
    - Smart cars/zip cars

IV. PILOT STUDY OF THE IMPORTANCE OF FACTORS IN MODE CHOICE

This chapter includes the results of a pilot study of ratings of the importance of factors in mode choice for travel to work by high-frequency users. The objective of the pilot study is to establish that factors identified by focus groups can be reliably scaled in closed-end questionnaires and that differences in rated importance by users and non-users of public transportation are interpretible. For these factors, one might expect cost and environment to be more important to public transit users and total travel time and uncertainty in travel time to be more important to own vehicle users.

METHODOLOGY

Participants

This study used a convenience sample of respondents. The questionnaire was distributed to full-time employees of high-tech companies located in one of the study's travel corridors. Most employees used their own vehicle to travel to work. A total of 68 completed questionnaires were obtained in a two-week period.

Design

The introductory statement of the three-page questionnaire indicated the general importance of the transportation modes individuals use to get to work. A first section elicited information on the regularity of travel to work, distance from residence to work location and the frequencies of the modes they used in the past month. A second section requested ratings of the importance of factors in the choice of mode. The rated factors included those identified in the focus group studies. The third section requested background demographic information.

RESULTS

Analyses were limited to completed questionnaires in which respondents traveled to work at least 20 times in the past month. Public transit users were defined as those who used public modes in at least ten of their trips in the past month. Only five of those who used a public transit regularly reported using a single mode and these were not included in the analysis. The reported comparisons compare those who were defined as intermodal work travelers by study criterion and a sample of own vehicle users. (Public Transit Users: monthly travel to work ≥ 20, intermodal travel ≥ 10 [n=26]. Own Vehicle Users: monthly travel to work ≥ 20; intermodal travel = 0 [n=42]). Means and standard deviations for the seven factors rated by respondents by traveler groups are reported in table 3.

Table 3. Rated Importance of Factors in Mode Choice

	Public transport users		Own vehicle users	
Factor*	M	SD	M	SD
Cost†	7.720	1.969	6.522	2.979
Distance	7.921	1.847	7.848	2.944
Clean	7.04	2.517	7.065	2.816
Environment†	7.241	2.420	6.283	3.038
Wait time	8.540	2.159	8.326	2.733
Travel time	8.462	1.702	8.739	2.294
Uncertainty†	7.808	1.573	8.565	2.296

* "Cost" is trip cost, "Distance" is distance between residence and work location, "Clean" is cleanliness of mode, "Environment" is consequence of mode choice for environment, "Wait time" is average time between mode connections, "Travel time" is total travel time, and "Uncertainty" is the variance in total travel time.

† Indicates rated importance is significantly different ($p<.05$) between user groups.

Differences in within group ratings of factor importance for public transit users, wait time and travel time were significantly greater ($p<.05$) than for other factors. All other differences in ratings of factor importance were not statistically significant for this group. For own vehicle users, wait time, travel time and uncertainty were significantly greater than other factors in terms of importance. Other differences in means were not statistically significant.

In comparisons of rated factor importance across public transit and own vehicle users, cost, environment and uncertainty were significantly different in rated importance ($p<.05$). Cost and environment were rated as significantly greater in importance by public transit users. Uncertainty in travel time was rated as significantly greater in importance by own vehicle users. Other differences in means were not statistically significant.

The main objectives of the pilot study were to demonstrate that factors could be reliably scaled and differences in means between public transit users and own vehicle users were in predicted directions.

Coefficients of variation for each factor were in ranges that indicated reliable measurement. While the small sample size in a pilot study limited the differences between public transits and own vehicle users that were statistically significant, the differences in means between user groups that were significant are in predicted directions.

The study's author does note that although the sample size for own vehicle users was greater than for public transit users, standard deviations are consistently larger in ratings by own vehicle users. This may be indicating that there is more heterogeneity (i.e., multiple segments) among own vehicle users. Segments with different factor importance within this user

group can, in turn, be responsive to different incentives to using public transit in their travel to work. This observation could be explored further in closed-end questionnaire studies.

V. SUMMARY AND CONCLUSIONS

Focus groups discussions were organized by topics of “most” and “least” burdensome in usage and recommendations to increase usage of public transit options. The discussions were then hierarchically decomposed and summarized, and ultimately factors were identified in diagrams for the organizing topics. The factors identified were replicated across groups in both of the travel corridors studied. The results of the focus group studies were then used to investigate the rated importance of the main factors in a pilot study.

Results of the pilot study showed reliable measurements of these factors and differences between intermodal public transit users and own vehicle users that were in predicted directions. The importance of cost and environment were rated as significantly more important to mode choice by public transit users than to choice by own vehicle users. In contrast, uncertainty in total travel time was rated as significantly more important by own vehicle users than by public transit users. While total travel and wait time were expected to be among predominant factors, uncertainty in travel time was rated more important and given more discussion time in the focus group than anticipated.

Results of other investigators have suggested its subjective importance to travelers (Abkowitz 1981; Bhat and Sardesai 2006; Connors and Sumalee 2009; Lam 2000) and in other consumer applications (Rajamma, Paswan and Hossain 2009). Laboratory results reported by Avineri and Prashker (2006) support this suggestion. However these studies have not distinguished between single mode and multi-mode travel. The latter may markedly increase the importance of uncertainty and further emphasize a policy direction to increase the use of intermodal travel to work. Results of this exploratory study do suggest that given its importance to the users studied, uncertainty in total travel time be more directly investigated in subsequent studies in both its factual accuracy and in its perception when users are intermodal work travelers. It benefits planners to understand the extent to which the noxiousness of the experience is biasing the judgments and whether the actual variances in wait and total travel time when travel is intermodal are as large as those suggested by these participants.

The summary of empirical results is supplemented with qualitative observations gleaned from the focus groups. Results of focus group discussions, word counts for main grouping factors and our observations from multiple viewing of the sessions indicate that the participants placed greater emphasis on what they considered to be most burdensome in using the public transport option than they did on what they considered to be least burdensome. That is, groups were more vocal and displayed more affect in discussing what they considered to be limitations they face as intermodal travelers than they were in discussing benefits. Among the modes they used, much more of the discussion of most burdensome was directed to travel that was through multiple buses or travel that involved a bus connection. Rail, in general, and particularly light rail, appeared to be regarded far more favorably.

Additionally, while they noted the benefits of public transit use in travel to work, it appeared that in many cases, their usage was seen as more a necessity in their personal cases than an active choice among alternatives. This distinction is important since an objective is to maintain usage of public transit options when personal constraints no longer require it. It

may, for example, be that some work travelers remain users of public transit because of their income and schedules. Designer objectives would then be to maintain their usage when income and flexibilty in schedule offer more feasible alternatives. This researcher's view is that the emphasis on most burdensome is regrettable since, as catalogued in discussions of least burdensome, there are bases for more positive experience and evaluation. These inferences from observations of group discussions merit being investigated and elaborated upon in closed-end questionnaire results.

Finally, additional directions are noted for subsequent study. To efficiently identify and group issues in an exploratory study, the participants in focus groups were regular intermodal travelers. Resources did not permit a comparison study of focus groups with commuters who have the option of using public intermodal transport to work but elect to use own vehicle transportation. While there may be considerable similarity in the factors that are identified, it is also possible that own vehicle users would introduce additional factors.

The focus group discussions also suggest that participants take note of the use of public transit for intermodal travel by their peers. This, in turn, suggests that studies of mode choice would benefit from directly studying peer groups of travelers as in professional cohorts in multiple organizations. This would allow analysis of travel mode decisions in interacting peer networks.

In subsequent study, researchers' attention could be directed to examining factors that have the greatest discrepencies between public transit users and own vehicle users. This study's results reveal uncertainity in wait time and total travel time, and the importance of environmental factors. As also noted, the generally larger variances of judgments by own vehicle users may suggest that there are multiple segments in this group. Larger samples with more background measures of individual differences could better identify differences between these segments in profiles of importance ratings and affective judgments.

One could also expect that capturing the factors and combining rules in decisions on intermodal travel in routinized work trips will require more than an extension of single mode choice models. Advances in modeling, notably in mixed and nested logit models (Silberhorn, Boztug and Hildebrandt 2008; Train 1999; Wen and Koppelman 2001), contribute to capabilities in representing mode choice. However investigators, including Hensher and Layton (2010), and Kamakura, Kim and Lee (1996), at least suggest that travelers do not closely follow standard compensatory rules in combining their judgments on factors in their decisions. For example, it may be that the judgments on factors in mode choice enter decisions hierarchically. That is, a mode is not evaluated on a second criterion until a minimum standard in a first criterion is at least met. The fit of alternative models of combination rules to data from larger more representative samples can allow direct inference on the underlying combination rules and be useful to planners.

Finally, in considering directions for subsequent study, it merits being noted that this study's sample group has an educational level and occupations that are not representative of the general population. These differences may be biasing judgments of factors such as the importance of total travel time and uncertainty. This can be addressed in subsequent stud-

ies of intermodal travelers that have resources to draw from frames that are representative of the total population.

From this study's perspective, discussions on use more/recommend are encouraging to transit designers. As well as indicating alternatives that can be guidelines for design, these discussions suggests that participants recognize positive directions for public transportation that is intermodal, and are able to articulate what would lead to more favorable judgments of the intermodal experience. While many of these alternatives would require additional funding and are operationally difficult to put in place, others provide guides to using technology and managerial skills in what are presently feasible modifications. These include increased communication and coordination across transit mode providers, increased coordination of mode arrivals and varying bus sizes to manage costs. Considering what is at stake in both the direct and unmeasured (e.g., environmental) costs of the extensive use of single passenger, own vehicle travel to work in the major travel corridors in California and other states, there are strong incentives to identify and modify factors in the design of intermodal public transit at this time.

Looking forward, mode choice in travel to work can be expected to remain important to the economy and environment. Telecommuting and "virtual" alternatives to physical presence are likely to increase and have a continuing effect on residence location (Tayyaran, Khan and Anderson 2003). There are also analyses that suggest that there are more optimizing alternatives to traditional configurations of firm locations and residence locations (Lucas and Rossi-Hansberg, 2002). However, physical presence can be expected to continue to dominate in most work designs for skilled labor and a range of other occupations. It remains a priority for those who conceptualize travel decision making and those who implement policy to identify and address factors that underlie satisfaction and use. To date, many of the most advanced studies of user experience and evaluation of intermodal travel have been in European countries and Australia where conditions and personal factors are likely to differ from the American case. United States-based investigators have the methodological capabilities to complement these studies in domestic settings.

APPENDIX A: FOCUS GROUP SCRIPT

At this meeting, we will be discussing the intermodal transportation that you routinely use in traveling to work. Examples of this are travel in which at least one connection between train or light rail and bus or multiple buses is required. As I expect you can appreciate, even if it is not a major decision for you, how you travel to work is of great significance to those who do planning for transportation of all those who travel to work in a community. There are, for example, environmental costs and maintenance costs that individuals do not generally include in their personal costs.

Hearing about what you think is extremely helpful to the service we can provide in the public interest. The most basic rule of our discussion is just to be as thoughtful as possible on the issues we discuss and to speak freely when you have information or an opinion. There is obviously no right or wrong answers to the questions that come up and to the issues raised by other members of our group.

Can we begin by asking each member of the group to describe the intermodal connection that is or would be required in using public transportation to get to work? *(Let each group member respond)*

Next can you tell us what is most burdensome in using the intermodal connection to travel to work? *(Let each group member respond)*

Can you also tell us what is least burdensome in using the intermodal connection to travel to work? *(Let each group member respond)*

Can you please describe the ways in which you see intermodal travel as different from traveling when there is a single mode? *(Let each group member respond)*

How important is the transportation that others in your work group or among your colleagues use to get to work to your decision on your use of public transportation to get to work? *(Let each group member respond)*

Could you please describe what improvements would contribute most to you regularly using a public transportation option to get to work when an intermodal connection is required? Please also describe improvements that would most increase your personal satisfaction. *(Let each group member respond)*

Brainstorm: Finally, our discussion has highlighted the importance of using intermodal public transportation to work and the problems that people like you face when an intermodal connection is required. Can you think a moment about how you would personally approach solutions to the problem from the point of view of a planner? *(Let each group member respond)*

Is there anything else you would like to add to our discussion? *(Let each group member respond).*

Thank you for participating. We take seriously what we hear in these meetings.

APPENDIX B: EXEMPLARY TEXT IN IDENTIFYING GROUPING FACTORS

Most Burdensome 1

P 1: Santa Clara Group 1.doc – 1:1

Codes: [F1 P1 most burdensome co-ordination between modes in frequency of off-time arrivals]

P 1: Yes when I get out at the light rail station I have to wait around an hour and its cumbersome. The bus I take is not so frequent, it is only frequent in the morning time and I have to go in the evening (and) probably in the midday at around 3:00 clock.

Most Burdensome 2

P 1: Alameda Group 1.doc

Codes: [F1 P3 most burdensome not enough co-ordination between independent companies]

P 3: Totally agree. I travel to work using three different services, I mean one is run by VTA, and one is by BART and third one is by AC transit. For these the common problem is that if I miss a bus I have to wait. The second problem is that like the fare—I mean the charging—is different for each service, for example we can just get a monthly pass for VTA transit and for AC transit we can get a monthly pass but for BART it is on a different system and there are still some services which use common fare which can be used for three services, but I like to use a common service which can be used to charge for all the three, because sometimes I had to carry three different kinds of passes.

Least Burdensome 1

P 1: Alameda Group 1.doc – 1:8

Codes: [F1 P3 least burdensome using BART and light rail, increased frequency when compared to using VTA and AC]

P 3: Using BART. Like the maximum time difference between each trip here is like 20 min even in peak hrs and in the morning hrs. They are also having frequent service like for 5 or 7 minutes. Here for VTA and AC transit the time difference is at least 20–30 min each. BART has comforts I like.

Least Burdensome 2

P 1: Santa Clara Group 2.doc – 1:9

Codes: [F1 P4 least burdensome meeting new people]

P 4: The only thing I like is that every day I meet new people and recently I made a couple of friends

Least Burdensome 3

P 1: Santa Clara Group 1.doc – 1:10

Codes: [F1 P5 least burdensome can do own work]

P 5: I have a lot of work to do with systems. The best thing is I can open my laptop and keep working in light rail I know that‘s not safe every time but sometimes I feel like its okay you can do that.

Use More 1

P 1: Santa Clara Group 1.doc – 1:16

Codes: [F1 P5 more wireless to do own work]

P 5: Almost 30-40% of the people I travel with are employees who work for software companies and being in the Silicon Valley, they prefer the bus to provide some wireless connection for people use laptops. I know it’s pretty expensive for them, but many people have shifted their journeys into light rail or bus just because they don’t have that in their cars.

Use More 2

P 1: Alameda Group 2.doc – 1:18

Codes: [F1 P2 better co-ordination, better display of expected times at bus stations]

P 2: What I would suggest might be impractical but maybe buses could have displays like when it is approaching the nearby light rail station. It should tell the like what time the particular light rail is arriving so that they won’t be having to access the internet for that. So if possible that could be a good option.

Use More 3

P 1: Santa Clara Group 2.doc

Codes: [F1 P3 increased frequency at peak travel times]

P 3: I want to suggest that they increase the frequency of the buses on the busiest routes, like Fremont. Daily you can find more people during from 8:00 till 11:00 o’clock and from evening 4:00–6:00 o’clock.

Most Burdensome 3

P 2: Alameda Group 2.doc

Codes: [F4 P1 most burdensome payment across modes exact change]

I don't use Muni enough to get a Muni pass. When I am coming from BART I have to go and change coins, change my dollar bill into a dollar coin as you can only put coins in the turns tile. Perhaps that's more burdensome than the timing, that thing makes it very annoying. Sometimes I go ahead and pay $2 but even then I have to get them in coins, perhaps this new flipper thing would make it somewhat easier.

Most Burdensome 4

P 2: Alameda Group 2.doc

Codes: [F4 P2 most burdensome co-ordination between modes]

BART will hold trains if there is a slow connection or something particularly these south bay expresses. There are may be two or three that run at distinct times—they would hold them if (other) trains were running late. For buses, if one is late then you have to wait for the next 30 or 40 minutes. Awkward part is the waiting and the fact that the transits don't talk to each other where they could hold something for the late trains or buses.

Most Burdensome 5

P 2: Alameda Group 2.doc

Codes: [F4 P4 most burdensome frequency of the buses coordination]

P 4: It's just the frequency of the buses; they don't come when they are scheduled to come and if they do there are sometimes there are the same buses in a row. That gets really frustrating when you have been waiting really long and you are trying to get somewhere fast. I guess (they should be) more schedule strict that the same number buses wouldn't come one after the other.

Least Burdensome 4

P 2: Alameda Group 2.doc

Codes: [F4 P2 least burdensome good co-ordination in BART and other companies]

I would agree with that. BART is very good when it comes to lining things up. If one of the trains that is suppose[d] to connect is running a few minutes late, they will hold the other train. If in the evening where you can only get directly to the east to Berkeley, there will be one waiting for you which they will hold if they are running late. So they talk to each other and make sure the connections are there.

Most Burdensome 6

P 2: Alameda Group 2.doc

Codes: [F4 P24 most burdensome complaint about transfers]

Something that's frustrating for the AC transit at least, the transfers are only good for an hour and half, but the San Francisco Muni lines are good for three hours are something like that. Before I got my bus pass, I would go somewhere on a bus and I wouldn't necessarily be done an hour and half to hop on to another bus so I had to pay another $2.

Most Burdensome 7

P 2: Alameda Group 2.doc

Codes: [F4 P1 increased concern about co-ordination between modes]

P 1: Well I think I have already said sometimes the way of paying is different (across modes) and I think we have all talked about the fact they are not that coordinated. Basically you have to just to be prepared to do two different modes that are not connected really. One thing that is helpful nowadays is that the trip planning websites that can actually help you to some extent.

Most Burdensome 8

P 2: Alameda Group 2.doc

Codes: [F4 P2 modes are independently distributed and face different problems]

P 2: Well delay it's the worst part of intermodal, I want to minimize the amount of intermodal because two different systems are likely to be independently distributed in what causes their lateness and you are just going to have greater delays.

Most Burdensome 9

P 2: Alameda Group 2.doc

Codes: [F4 P3 increased importance of bike accommodations]

P 3: I have to say if I am traveling with a bike and say I am in a BART and then get on a bus, sometimes on the trans bay [train] they allow only about two bikes and so you may have to wait another hour or so, (and its) not often the best place to hang out and you may need to get somewhere.

Most Burdensome 10

P 2: Alameda Group 2.doc

Codes: [F4 P4 covered bus stops with heat lamps]

P 4: For me I have no choice but to take two buses, I mean there is no other way for me to travel. I totally agree with the suggestion of covered bus stops, sometimes it gets really cold waiting for buses at night especially for buses that run like half-hour in between.

Most Burdensome 11

P 2: Alameda Group 2.doc

Codes: [F4 P1 co-ordination between agencies]

P 1: Well yes, starting with the concurrent situation I would get those different agencies together and better coordinate. They also probably (could) find out more what the public transportation needs are—like where people could go or would go. There are certainly people who would rather drive. I don't know what to do about that.

Use More 4

P 2: Alameda Group 2.doc

Codes: [F4 P2 low prices]

The only thing I would think that would get lot of people out of cars and into public transportation is drastic cuts in prices. Remember in Portland Oregon (this is 20, 30 years ago), they made buses free, my brother was living up there at that time; that's the reason I am aware of it.

Use More 5

P 2: Alameda Group 2.doc

Codes: [F4 P4 visual appeals as in color]

P 4: Kind of farfetched I guess but it's more like visual things make it more appealing. Like change of the colors. Like how Virgin and Pacific [airlines] change their airlines to make it more appealing to the young generation. If they made it more like club dance color it would entice the younger crowd. They could play music or something and maybe change up the uniforms of the people. I mean I am not even joking about it because you know if they look nice people would probably be nicer to them and want to be on the same bus.

Use More 6

P 3: Alameda Group 1.doc

Codes: [F2 P1 frequency in mode less cost]

P 1: In general what it would take for me is increased frequency and feasible costs.

Most Burdensome 11

P 4: Santa Clara Group 2.doc – 4:3

Codes: [F3 P2 most burdensome lack of continuous information on schedule and wait time]

No memos

P 3: With me also the same problem. The schedule, I think we have only one bus from 7th Street to Cupertino. And the thing is that as I said it often comes earlier or a bit late. So it takes 45 minutes but I need to get up so early, or else if I miss the bus and need to wait for half an hour. I suggest that if there would be a rapid bus for 522 and 23, then it would be much better. Because we have many companies close by, that would be a good option.

Most Burdensome 12

P 4: Santa Clara Group 2.doc

Codes: [F3 P2 most burdensome stops too far apart]

P 2: To add one point for (name of other participant) and me. In taking 72 for an extension of 2.5 miles, I need to again pay for the bus and the light rail. You can just get in at this stop and get off at the next stop and pay $2.

Least Burdensome 5

P 4: Santa Clara Group 2.doc – 4:11 (67:67) (Super)

Codes: [F3 P2 least burdensome rail travel is efficient]

No memos

P 2: For me light rail is very good option. It goes very early when compared to like [the] other busses. So if you take the bus it will be 10 to 15 minutes more. Light rail is like pretty fast and it'll have its own clearance, so I would take light rail rather than busses.

Use More 6

P 4: Santa Clara Group 2.doc

Codes: [F3 P2 shorter overall time]

P 2: For me only distance and time matters. If I am going to my office and it is late it doesn't matter any more that I would like to go by public transportation.

Use More 7

P 4: Santa Clara Group 2.doc

Codes: [F3 P1 better co-ordination between companies so wait time is less]

P 1: If in intermodal transportation we could have a communication system where after this bus comes in then that bus is supposed to be so that because if they have a network of that kind, they would actually keep up with the timing better.

Use More 8

P 4: Santa Clara Group 2.doc

Codes: [F3 P2 more variable frequency at certain times]

P 2: I would say that it's (about) trying to get to the logistics. Looking at the where the real companies are located and where the people are really going to. In that way if they can just increase the frequency of the public transportation in the morning from 8–10 and evening from 5–7 or 4–6 it's a peak time and all will be going to their office and coming back from their office to their home. So if they can really increase the efficiency and lower transportation cost. Lots of people would want to do that.

BIBLIOGRAPHY

Abkowitz, M. 1981. “Understanding the effect of transit service reliability on work-travel behavior.” *Transportation Research Board* 794: 33-41.

Abraham, J. and Hunt, J. 1999. “Policy analysis using the Sacramento meplan land use-transportation interaction model.” *Transportation Research Record* 1685: 199-208.

Avineri, E. and Prashker, J. 2006. “The impact of travel time information on travelers’ learning under uncertainty.” *Transportation* 33: 393-408.

Benjamins,M., Lindveld, Ch.D.R. and van Nes, R. 2002. “Multimodal travel choice modeling using a supernetwork approach.” *Proceedings 81st TRB Annual Meeting*, Washington DC # 02-2948.

Bennett, C. 1999. “Metro-North’s Cortlandt Station: Regional Intermodal Success Story.” *Transportation Research Record* 1677: 3–9.

Bhat, C. and Sardesai, R. 2006. “The impact of stop-making and travel time reliability on commute mode choice.” *Transportation Research Part B,* 40: 709–730.

Bovy, P. and Hoogendoorn-Lanser, S. 2008. “Modeling route choice behaviour in multi modal transport networks.” *Transportation* 32: 341–368.

Connors, R. and Sumalee, A. 2009. “A network equilibrium model with travelers’ perception of stochastic travel times.” *Transportation Research Part B* 43:614–624.

Hensher, D. and Layton, D. 2010. “Parameter transfer of common-metric attributes in choice analysis: implications for willingness to pay.” *Transportation* 37: 473–490.

Kamakura, W., Kim, B. and Lee, J. 1996. “Modeling Preference and Structural Heterogeneity in Consumer Choice.” *Marketing Science* 15(2): 152–172.

Lam, T. (2000) “Route and scheduling choice under travel time uncertainty”. *Transportation Research Record*, 71–78.

Lucas, R. and Rossi-Hansberg, E. 2002. “On the internal structure of cities.” *Econometrica* 4: 1445–1476.

Manaugh, K., Miranda-Moreno, L. and El-Geneidy, A. 2010. “The effect of neighbourhood characteristics, accessibility, home–work location, and demographics on commuting distances.” *Transportation* 37:627–646

Metropolitan Transportation Commission. 2003. “A Smart Growth Friendly Transportation System.” Presentation at Local Government Commission Conference.

Michiel, B., Lindveld, C. and van Nes, R. 2002. “Multi-modal Travel Choice modeling: A Supernetwork Approach.” In *Preprints TRB Annual Meeting* CD-ROM.

Muhr, T. and Friese, S. 2004. “Atlas.ti 5.0.” Second edition. Berlin: Scientific Software.

Rajamma, R., Paswan, A. and Hossain, M. 2009. “Why do shoppers abandon shopping cart? Perceived waiting time, risk, and transaction inconvenience.” *Journal of Product and Brand Management,* 188–197.

Siggerud, K. 2006. “Intermodal Transportation: Challenges to and Potential Strategies for Developing Improved Intermodal Capabilities.” Testimony Before the Subcommittee on Highways, Transit and Pipelines, Committee on Transportation and Infrastructure, U.S. House of Representatives Thursday, June 15, Washington D.C.

Silberhorn, N., Boztug, Y. and Hildebrandt, L. 2008. “Estimation with the Nested Logit Model: Specifications and Software Particularities.” *OR Spectrum* 30: 635–653.

Tayyaran, M., Khan, A. and Anderson, D. 2003. “Impact of telecommuting and intelligent transportation systems on residential location choice.” *Transportation, Planning and Technology* 26: 171–193.

Tayyaran, M. and Khan, A. 2007. “Telecommuting and residential location decisions: Combined stated and revealed preferences model.” *Canadian Journal of Civil Engineering* 34: 1324–1333.

Train, K. 1999. “Mixed logit models for recreational demand.” In Joseph A. Herriges and Catherine L. Kling (eds). *Valuing Recreation and the Environment*. Northhampton, MA: Edward Elgar.

Wen, C. and Koppelman, F. 2001. “The Generalized Nested Logit Model.” *Transportation Research Part B* 35(7): 627–641.

ABOUT THE AUTHOR

STEVEN SILVER, PhD

Steven Silver is a professor in the Lucas Graduate School of Business and College of Business at San José State University. He has earned an MA and MBA from the University of Chicago, a PhD from the Haas School of Business, University of California, Berkeley and has been a visiting scholar and post-doctoral fellow at the London School of Econom-ics and at Stanford University. Dr. Silver has authored numerous reports and publications in consumer behavior, urban economics and measurement methodology. He has also served on advisory groups and panels for management of the arts and the design of trans-portation-related programs.

PEER REVIEW

San José State University, of the California State University system, and the MTI Board of Trustees have agreed upon a peer review process required for all research published by MTI. The purpose of the review process is to ensure that the results presented are based upon a professionally acceptable research protocol.

Research projects begin with the approval of a scope of work by the sponsoring entities, with in-process reviews by the MTI Research Director and the Research Associated Policy Oversight Committee (RAPOC). Review of the draft research product is conducted by the Research Committee of the Board of Trustees and may include invited critiques from other professionals in the subject field. The review is based on the professional propriety of the research methodology.

MTI FOUNDER

Hon. Norman Y. Mineta

MTI BOARD OF TRUSTEES

Honorary Chairman
John L. Mica (Ex-Officio)
Chair
House Transportation and Infrastructure Committee
House of Representatives

Honorary Co-Chair, Honorable Nick Rahall (Ex-Officio)
Vice Chairman
House Transportation and Infrastructure Committee
House of Representatives

Chair, Mortimer Downey (TE 2013)
Senior Advisor
PB Consult Inc.

Vice Chair, Steve Heminger (TE 2013)
Executive Director
Metropolitan Transportation Commission

Executive Director
Rod Diridon* (TE 2011)
Mineta Transportation Institute

Barron, Thomas E. (TE 2013)
President
Parsons Transportation Group

Barron de Angoiti, Ignacio (Ex-Officio)
Director Passenger and High Speed Department
International Union of Railways (UIC)

Boardman, Joseph (Ex-Officio)
Chief Executive Officer
Amtrak

Camph, Donald H. (TE 2012)
President
California Institute for Technology Exchange

Canby, Anne P. (TE 2011)
President
Surface Transportation Policy Project

Cunningham, Julie (TE 2013)
Executive Director/CEO
Conference of Minority Transportation Officials

Dorey, William (TE 2012)
President/CEO
Granite Construction Inc.

Dougherty, Malcolm (Ex-Officio)
Acting Director
California Department of Transportation

Fernandez, Nuria I. (TE 2013)
Senior Vice President
Major Programs Group CHRMHill

Guilbault, Rose (TE 2012)
Vice President
American Automobile Association

Hamberger, Ed (Ex-Officio)
President/CEO
Association of American Railroads

Horsley, John (Ex-Officio)*
Executive Director
American Association of State Highway and Transportation Officials (AASHTO)

Kempton, Will (TE 2012)
CEO
Orange County Transportation Authority

Millar, William* (Ex-Officio)
President
American Public Transportation Association (APTA)

Mineta, Norman Y. (Ex-Officio)
Vice Chairman
Hill & Knowlton
Secretary of Transportation (ret.)

Pinson, Stephanie L. (TE 2013)
President/COO
Gilbert Tweed Associates, Inc.

Steele, David (Ex-Officio)
Dean, College of Business
San José State University

Toliver, Paul* (TE 2013)
President
New Age Industries

Townes, Michael S. (TE 2011)
President/CEO (ret.)
Transportation District Commision of Hampton Roads

Turney, David L.* (TE 2012)
Chairman, President & CEO
Digital Recorders, Inc.

Wytkind, Edward (Ex-Officio)
President
Transportation Trades Department, AFL-CIO

** Honorary
* Chair
^ Vice Chair
# Past Chair

Directors

Hon. Rod Diridon, Sr.
Executive Director

Karen E. Philbrick, PhD
Research Director

Peter Haas, PhD
Education Director

Donna Maurillo
Communications Director

Brian Michael Jenkins
National Transportation Security Center

Asha Weinstein Agrawal, PhD
National Transportation Finance Center

Research Associates Policy Oversight Committee

Asha Weinstein Agrawal, PhD
Urban and Regional Planning
San José State University

Jan Botha, PhD
Civil & Environmental Engineering
San José State University

Katherine Kao Cushing, PhD
Enviromental Science
San José State University

Dave Czerwinski, PhD
Marketing and Decision Science
San José State University

Frances Edwards, PhD
Political Science
San José State University

Taeho Park, PhD
Organization and Management
San José State University

Diana Wu
Martin Luther King, Jr. Library
San José State University

MINETA
TRANSPORTATION INSTITUTE
MTI

SAN JOSÉ STATE
UNIVERSITY

Funded by U.S. Department of
Transportation and California
Department of Transportation