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Developing a Method for Assessing National Demand-Response Transit Level of Service

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Abstract

Demand-response transit service is a major source of mobility for older adults and people with disabilities in both urban and rural areas in United States. Federal Transit Administration (FTA) grant programs under sections 5307, 5310, and 5311 all have components designed to increase the availability of paratransit or demand-response transit service. However, there is little information in the National Transit Database (NTD) or elsewhere about the extent of demand-response transit service coverage across the country. The lack of data makes it a challenge to identify gaps in service and unmet needs. The primary objective of this study was to fill the data gaps to the available NTD database to effectively determine the demand-response transit level of service. This study also developed a priority ranking procedure to identify where the greatest needs for service improvements exist in a state.

Keywords: Demand-response transit level of service, DRT, LOS, public transportation, demand-response transportation coverage

Introduction

Demand-response transit (DRT) service is a major source of mobility for older adults and persons with low-income or disabilities in urban and rural areas. DRT also is known by terms such as dial-a-ride, demand-activated transportation, shared-ride paratransit, and flexible-route service. Americans with Disabilities Act (ADA) paratransit is a type of DRT provided for people with disabilities who cannot use a fixed-route service. In general, DRT may serve the general public or certain rider groups such as older adults, persons with a disability, transportation-disadvantaged persons, etc. (KFH 2008).

Federal Transit Administration (FTA) grant programs under sections 5307, 5310, and 5311 have components designed to increase the availability of paratransit or DRT service. In many rural areas, DRT is the only form of transit available, whereas urban areas rely on DRT to complement fixed-route services. Although DRT is a critical
component of a community’s transit system, the data needed to assess the level of service being provided are lacking.

The general transit feed specification (GTFS) has proven to be very useful for allowing public transit agencies to share service information such as locations of stops and routes, schedules, stop times, headways, etc., making it easier to identify and evaluate the level of service being provided. However, the information in GTFS is specific to fixed-route service, and a different method needs to be developed to allow for transit agencies nationwide to share key information about their DRT level of service.

The National Transit Database (NTD) is a standard reporting system for urban and rural transit providers and can be used to assess transit system performance. However, there is little information in the NTD or elsewhere about the extent of DRT coverage across the U.S., which creates challenges in identifying gaps in service coverage and understanding unmet needs. Transit agencies, metropolitan planning organizations (MPOs), and state departments of transportation (DOTs) planning for DRT service often lack data on where the greatest needs for additional service coverage exist. Therefore, there is a great need to fill the data gaps to the available NTD database to effectively assess DRT level of service. The different types of DRT services that were considered in this study include general public DRT, limited eligibility DRT, ADA paratransit, and human service transportation.

The general objective of this study was to develop a method for assessing national DRT level of service. Specific objectives were to determine data needs, design a survey tool for collecting the necessary data, design a framework for identifying DRT service coverage and level of service, test the survey method and framework in selected test states, provide recommendations for deploying a nationwide survey tool, and develop a method for identifying unmet needs and prioritizing service investments.

Framework of the Study

The framework for evaluating level of service (LOS) for DRT was adapted from the second and third editions of the Transit Capacity and Quality of Service Manual (TCQSM) (Kittelson & Associates, Inc. 2003, 2013). This framework was then tested in two pilot states—North Dakota and Florida—chosen because they provide a mix of geographic types. North Dakota is largely rural with some small urban areas; Florida has large urban and suburban areas, along with smaller urban and rural areas. Testing the framework in areas with a mix of geographic types could ensure that the effort would be successful if applied nationwide.

The TCQSM defines the level of service for DRT service based on various parameters such as response time, service span, reliability, on-time performance, trips not served, and travel time of demand-response transit (Kittelson & Associates, Inc. 2003). Service span measures the days per week and hours per day that service is available in a particular area and is a key measure of service availability and quality of service. This study uses service span as a key part of the method for identifying DRT LOS, adopting the framework shown in Table 1.
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The framework shown in Table 1 was adapted from the second edition of the TCQSM with minor modification for the lowest level for hours of service per day, which was implemented from the third edition. Although the third edition no longer combines days and hours of service, this procedure was found to be useful for quantifying service span with a single measure. Based on the number of days and number of hours per each day the DRT service is provided, Table 1 can be used to determine the LOS of the DRT service in that geographic location. A lower number indicates a higher level of service, with LOS 1 being the highest level of service. Further, the method calls for service span data to be integrated with service location to better understand the DRT service coverage. The DRT LOS data then can be mapped to show areas with higher or lower levels of service. Mapping the DRT LOS for each transit agency in a state can provide valuable information regarding service area and LOS throughout the state, and these maps could be used to better understand where service improvements are necessary.

Data Availability and Data Needs

Although there have been many studies and reports documenting various measures to determine the performance of a DRT service (KFH Group et al. 2008, GAO 2012, Kittelson & Associates et al. 2003, Ellis 2009, Godavarthy et al. 2014), few studies are available to determine the extent of demand-response service coverage in United States due to the lack of primary data needed for its calculations in the NTD. Key variables for identifying the level of DRT service across the U.S. include geographic coverage, days of service per week, hours of service per day, advance reservation requirements, and service eligibility, data that largely are missing from the NTD. Service span and geographic coverage are two variables that are especially important but have limited data availability. Although the NTD has data for service days and hours for some transit agencies, service span data for DRT service are not available for any agency in the rural NTD.

With regard to geographic coverage data, very general service area (city, or counties served) information is available for some transit agencies in the NTD, but the data available are not specific or precise and, therefore, are inadequate for the study methodology. In the rural NTD, agencies are asked to identify the county or counties in which they provide service. Some of the multi-county providers do not list all of their

<table>
<thead>
<tr>
<th>Hours per Day</th>
<th>Days per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5**</td>
<td>LOS 6</td>
</tr>
<tr>
<td>5.0–8.9</td>
<td>LOS 6</td>
</tr>
<tr>
<td>9.0–11.9</td>
<td>LOS 5</td>
</tr>
<tr>
<td>12.0–15.9</td>
<td>LOS 5</td>
</tr>
<tr>
<td>≥16.0</td>
<td>LOS 1</td>
</tr>
</tbody>
</table>

*Service twice per month.

** The second edition of the TCQSM uses “< 4 hours” as the lowest level for hours of service, but this was revised to “< 5 hours” in the third edition, which is what is used in this study. The third edition of the TCQSM no longer combines days and hours of service into a single level of service measure.

Source: TCQSM, 2nd Edition; TCQSM, 3rd Edition
counties, so the data are incomplete. The data also are imprecise because an agency might not provide service within some areas of the county, or the level of service provided may differ within the county. Some areas might receive daily service, and others have service twice per week. Geographic coverage and level of service information at a level finer than county would be helpful. This level of information is not available through the NTD. More detail regarding ADA paratransit service areas also would be useful. ADA paratransit providers may offer service within three quarters of a mile of fixed-route service, as required, or they may provide service to a larger geographic area.

Further, the availability of additional service data for DRT agencies such as minimum advance reservation time, eligibility for using demand-response service and/or ADA paratransit service, and type of DRT service provided (curb-to-curb, door-to-door, etc.) would be helpful for identifying the type and level of service being provided. These data also are not available from the NTD. A significant limitation of the NTD is that it does not distinguish ADA paratransit from general public DRT and other forms of demand-response services.

**Developing a Survey Tool for Gathering Data Needed for Determining DRT LOS**

Based on the study framework and the analysis of NTD data, there is need for additional service details from transit agencies providing DRT service in the United States. As the long-term vision from this project likely would be to expand and understand the level of service coverage of DRT service nationwide, uniform, complete, and accurate data would be needed from the NTD or another data source. To collect the necessary data, a new survey tool needed to be developed that could be administered nationwide. To that end, this study developed two versions of a survey tool and tested them with transit agencies in North Dakota and Florida.

**North Dakota Study**

An online survey tool was prepared by the research team and distributed in August 2014 to all transit agencies providing DRT service in North Dakota. The intent of the survey was to gather information on service eligibility, service span, service area, service type, minimum advance reservation time, and trips turned down. A map tool was developed and used in the survey to collect information regarding service area and span of service. The reason for using a map tool was that it may be easier and quicker for transit agencies to identify and select their service areas on a map than to provide this information in some other way. Census tracts were used as clickable areas to provide service span and other details.

The survey was distributed to 33 transit agencies in North Dakota identified by the North Dakota Department of Transportation (NDDOT). Responses were received from 27 agencies, yielding a response rate of 82%. The high response rate was due to the fact that NDDOT requested transit agencies to complete the survey. The DRT service details for the transit agencies that did not respond to the survey were obtained from the agency’s website, and the results were summarized to be used for calculating the level of service values.
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Most transit agencies in North Dakota (23 out of 27) provide DRT service for the general public, one provides limited-eligibility DRT service for older adults, and the remainder provide ADA paratransit. Transit agencies operating DRT services commonly require reservations to be made 24 hours in advance or during the previous service day, but more than half allow reservations to be made the same day as the trip, including nine agencies that provide trips within 30 minutes of making the reservation. More details about the survey questions, detailed survey responses, and other data can be found in the final report of the study (Godavarthy et al. 2015).

Using the number of days DRT service was provided and number of hours of service per day, the level of service in the census tract areas was calculated using the methodology described in Table 1. Based on this framework, the LOS for all types of DRT services was calculated and mapped across the state (Figure 1). Results show that DRT LOS was highest in the urban areas of Fargo, Bismarck, and Grand Forks and indicate that the lowest levels were in the north central parts of the state and some eastern counties.

Most respondents did not have a problem using the map and selecting the regions with DRT service. However, an issue identified was that sometimes small census tracts were missed (not selected in the map tool) by the survey respondents—some towns have their own census tract, with the rest of the county divided into one or more larger tracts, and the respondents did not see the smaller tract. For this reasons, the research team decided to use a different approach for the Florida survey.
Florida Study
An online survey tool was prepared by the research team using Qualtrics software and was distributed in February 2015 to all transit agencies providing DRT service in Florida. Similar to the survey conducted in North Dakota, this Florida survey gathered details about service eligibility, service span, service area, service type, and minimum advance reservation time. However, the approach for determining the geographic location of the service provided was different from that used in the North Dakota survey.

Instead of using a map to identify service areas, respondents were asked to identify counties and cities in which their agency provides service and the days and hours of service in each. Respondents were first asked to identify counties in which their agency provides DRT service; then, for the individual county or counties selected, they were asked if the agency provides the same days and hours of service throughout the county, or different levels of service, or does not serve some areas. If service was the same throughout the county, agencies were asked to identify the number of days and hours of service provided. If service differed, respondents were asked to identify the number of days and hours of service for each from a list of cities in the county, and. Rural areas of a county not belonging to any city also were included and referred to as “other rural areas.”

The survey was distributed to Florida DRT agencies via Florida Community Transportation Coordinators (CTCs), the Florida RTAP listserv, and contacts from the Florida Public Transportation Association. Transit agencies identified in the NTD were contacted by email individually if they did not respond. From 56 transit agencies identified in Florida according to the NTD, responses were received from 48 agencies (86%) providing some kind of DRT service—38 from the NTD list, 7 whose service details were gathered from their website or via phone conversation, and 3 that were not on the NTD list. Since this study aimed toward gathering service details for all counties in the state, a response closer to 100% would have been more useful.

More than 50% of the responding transit agencies in Florida provide traditional-fixed route transit service. DRT service for the general public was provided by 22 responding agencies, and ADA complementary paratransit service was provided by 27 agencies. Most agencies (25) operating DRT services required reservations to be made 24 hours in advance or during the previous service day; a few providers (9) required reservations 48 hours in advance.

Since the Florida survey was not conducted using a map, mapping the resulting service data required a few extra steps. Using census tracts for mapping is desirable because of the availability of tract-level population and demographic data from the American Community Survey (ACS). Census tracts also provide greater detail than simple county-level data. To map the Florida level of service data, census tracts were assigned either to a city or, if the tract was completely outside a city, to the “other rural areas” for its county. Using ArcGIS, census tracts were dissolved together to create 450 geographic areas for the state, representing individual cities and one rural area for each county. These 450 geographic areas matched the areas included in the survey.
Using the number of days of DRT service and hours of service per day, the level of DRT service for the areas in Florida was calculated using the methodology described in Table 1. Figure 2 shows the LOS for all types of DRT services in Florida, except for a few counties for which data were not available.

Similarly, Figure 3 shows the level of DRT service available to the general public in Florida. Because Florida has a number of fixed-route transit systems, many DRT services consist of ADA paratransit, which is not available to the general public. This differs from North Dakota, where most DRT service is available to the general public.
Most Florida agencies found the survey “very easy” or “easy” to complete and without a significant time commitment. Only two agencies responded that the survey was “somewhat difficult” to complete, and none indicated that it was “difficult” or “very difficult.” Most agencies completed the survey within 5–15 minutes, and many completed it within 10 minutes.

By replacing the map tool used in the North Dakota survey with a set of simple questions, it was easier for the transit agencies to provide the necessary information. Furthermore, the data collected from the Florida survey were more detailed, as they included specific information for every city in the state and were of a higher quality. The method used in the Florida survey left fewer possibilities for data collection error. The only drawback from the survey was that mapping the survey data and comparing those results to ACS population data required a few additional steps, as discussed above.
Priority Ranking for DRT Service Improvements
The LOS values and service coverage data derived above provided valuable information about the extent of DRT service, but these measures did not completely identify if the mobility needs of transit-dependent populations were being met, nor did they identify the areas with the greatest needs for service improvements. There should be a sound procedure to understand the populations that are dependent on DRT service and if enough service is being provided. Also, there is a need for understanding which locations have greater needs for new or improved service. Such assessments can be made by comparing LOS data with population and demographic data. The study focused on analyzing the transit needs of target markets who would be using some type of a DRT service (including ADA paratransit) and who are transit-dependent.

Previous research by Mielke et al. (2005) and Mattson and Hough (2015) developed a mobility needs index to identify counties in North Dakota with the greatest need for mobility services. This study used the previously-developed model and applied it to areas in North Dakota and Florida. The factors deemed important for determining mobility needs were populations age 65 or older, populations with a disability, and populations below the poverty line—categories of people who would most likely use some type of DRT service.

The index was calculated using the following procedure. First, population densities were calculated for each of these three factors. Census tract level data from the ACS 2009–2013 five-year estimates were used for total populations age 65 or older, total populations with a disability (including all age groups), and total populations with income at 100% or below poverty. Second, the geographic areas were ranked from highest to lowest population densities and grouped into five equally-sized classes, using quintile values, for each of the three factors. Geographic areas in the lowest 20% were given a value equal to 1, the next 20% were given a value equal to 2, and so on, and the highest 20% were given a value of 5. In the last step, the three values were averaged for each geographic area to produce its mobility needs index. The process thus ranked all regions on a scale of 1 to 5, with higher values identifying areas with greater mobility needs. Although the procedure did not directly measure need, the measure could be used as a proxy for need.

The resulting mobility needs indices for North Dakota and Florida are mapped in Figures 4 and 5. As noted by Mielke et al. (2005), this methodology is only an attempt to measure needs associated with identifiable demographic groups; the measurement does not suggest that all needs are unmet. To the contrary, some cities may have systems and services in place that satisfy many residents’ mobility needs.
FIGURE 4. Mobility needs index for North Dakota

FIGURE 5. Mobility needs index for Florida
Identifying Priorities for Service Improvements

Comparing the mobility needs index with the existing LOS provides information about where the greatest needs exist for service improvements. This study developed a method of combining these two sources of information to rank areas in terms of needed improvements. This information can help transit agencies, MPOs, and state DOTs in making investment decisions by planning or improving DRT service.

The priority rank incorporates two factors: the mobility needs index and the existing LOS, as calculated in previous sections. Combining these two data sources, a matrix was created to prioritize needed service improvements, as shown in Table 2. To determine the priority rank for an area, the level of DRT service available was first determined. Then, from the LOS columns in Table 2, the mobility needs index for the area was determined to find the priority rank. A scale of 1–10 was used, with 1 indicating the greatest need for service improvements and 10 indicating the least need.

### TABLE 2.
Priority Ranking Measure for DRT Service Improvements

<table>
<thead>
<tr>
<th>Mobility Needs Index</th>
<th>LOS 8</th>
<th>LOS 7</th>
<th>LOS 6</th>
<th>LOS 5</th>
<th>LOS 4</th>
<th>LOS 3</th>
<th>LOS 2</th>
<th>LOS 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>5–4.34</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>4.33–3.34</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>3.33–2.34</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>2.33–1.34</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>1.33–1.00</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Areas with a high population density (and, therefore, a high mobility needs index) and a low level of service have the highest priority for service improvements; those with a low population density (and low mobility needs index) and a high level of service have little or no need for service improvements. As the table shows, areas with a higher mobility needs index or lower level of service have greater priority for improvements. However, identifying priorities is subjective; the table provides one possible method for prioritizing needs, but different transit planners and decision-makers may have their own preferred priority rankings. The point of this exercise was to demonstrate how the LOS data collected in this study could be combined with ACS data to identify areas with the greatest needs for DRT service improvements.

Using the mobility needs index values and LOS values of DRT service for all the geographic regions and following the procedure from Table 2, the priority rankings for all geographic areas in Florida and North Dakota were estimated and mapped (Figures 6 and 7). The Florida priority rankings were calculated based on all DRT services currently available. Areas with higher priority rankings, those ranked 1–5 (shown as red or orange the figures), are the locations where the mobility needs are not being met as well with DRT service and where there should be greater priority for DRT investments. There is a greater variation of priority rankings in North Dakota than in Florida due to a greater variation in current service levels.
FIGURE 6. Priority ranking for DRT service improvements in North Dakota

FIGURE 7. Priority ranking for DRT service improvements in Florida
This is one method for prioritizing investment needs that should be considered in conjunction with other sources such as existing NTD data and public input. Other data collected in the survey, such as service type, service eligibility, and minimum advance reservation time, also should be considered when analyzing current services.

Conclusions and Recommendations

This study attempted to determine the level of service of DRT transit service in North Dakota and Florida. Based on the framework adapted in this study to determine the national DRT level of service, DRT service details such as service span and service area are critical for determining the coverage of DRT service. Therefore, having such data available in the NTD or elsewhere for all U.S. transit agencies operating any type of DRT, including ADA paratransit, would be helpful for understanding the current level of service being provided and identifying areas that should be prioritized for service improvements.

Availability of additional DRT service details such as type of service eligibility, service provided (door-to-door, curb-to-curb, etc.), and minimum advance reservation time would be helpful to better understand DRT quality of service and thereby address transit needs in an effective way. Distinguishing between ADA paratransit, general public DRT, and other forms of DRT also would provide valuable information. Gathering these details from transit agencies would help to better identify the service levels being provided to target markets. This study developed a survey tool to collect these service details from DRT agencies, overcoming current data limitations.

As evidenced by responses from the survey of Florida agencies, the reporting burden for transit agencies to provide this information is minimal. Therefore, this study recommends using the survey instrument for the Florida survey for other states or nationwide. Surveys conducted with transit agencies in North Dakota and Florida did not have a 100% response rate, but the North Dakota survey had a very high response rate because of assistance from the state DOT. Making responding to the survey mandatory through the NTD or some other data collection method would be needed to achieve 100% response.

A mobility needs index was developed based on population densities of older adults, people with disabilities, and those living in poverty to identify areas that likely have greater needs for DRT services. This study also developed a priority ranking procedure to understand where the greatest needs for service improvements exist by comparing the mobility needs index values with existing levels of service. This procedure allows transit planners to more easily identify areas with the greatest needs for service improvements. Although this procedure ranked all areas 1–10, the ranking is subjective and could be modified according to priorities in any state.

There are some limitations to the study and areas for future research. Although the survey tool provides a significant improvement in service coverage data, it may not capture all details in service levels. For example, service levels may differ within the same city or within the rural areas of a county, and service boundaries might not follow census tract boundaries. Future research could use a different approach for calculating
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population densities. This study based population density on total area, but basing it on total inhabited land could provide better results. Future research also could consider remote populations as a population of need, because long travel distances also could be a contributing factor to transit needs.

Acknowledgments

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Perceived vs. Actual Distance to Transit in Santiago, Chile

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Abstract
To plan public transport supply and to increase transit patronage, it is indispensable to be aware of people’s perception of the actual supply, that is, how extensive and accurate people's knowledge is regarding the concrete features of transport supply, such as the locations of transit stops, timetables, and fare structures. This paper addresses the gap between the perceived and real distances to transit stops. The comparison between the real and perceived supply shows a considerably accurate perception. Nevertheless, a pattern is apparent. Metro supply has a higher overestimation rate than buses, i.e., walking distances are perceived as significantly shorter than they actually are. These results suggest that the transport mode is correlated with perception. This mode has the best reputation in the studied city, in contradistinction to buses, whose reputation was heavily damaged by the public transit reform occurring at the time of the research.

Keywords: Travel behavior, perceived distances, public transport, Latin America

Introduction
Public transit is a key public policy measure to tackle contemporary urban challenges to sustainability, such as mobility needs (especially for the urban poor), congestion, and pollution, among others. Despite the important role of public transport for achieving sustainable urban development in social, economic, and environmental terms, people often underuse this mode and consider it hardly adequate to meet people’s mobility requirements. In some countries, it is commonplace to consider public transport as a transport mode made “for the poor.” Sometimes, this affirmation derives from a relatively objective assessment of transit provision quality, which in some cities could be actually labeled “disastrous.” However, it also can respond to subjective perceptions of service quality that may not be accurate. In other words, a lack of acceptance
may respond to actual quality and functioning problems, but it also could be the consequence of bad reputation and misperception by the population.

For supply planning, the design of an adequate network and efficient exploitation is crucial. Nevertheless, to guarantee and enhance patronage, an understanding of people’s travel behavior and mode choice decisions also is needed. One of the dimensions of this understanding has to do with peoples’ perception of the actual supply, that is, how extensive and accurate their knowledge is regarding the concrete features of the transport supply, such as the locations of transit stops, timetables, and fare structures.

This could be the case of perceived distances to public transport stations, which the literature mentions as one of the major factors to explain mode choice (Commins and Nolan 2011; Escobar, Tudela, and González 2009; Paulley et al. 2006). Knowing how people estimate distance will matter in planning transport supply and adopting measures for increasing transit patronage. Distance estimation traditionally has been in the spatial cognition domain (Golledge and Stimson 1997) and has evolved within the psychological area. Among other objectives, it has been used to understand shopping behavior and ways of learning and building cognitive maps. It is important to note that these literature results are not categorical regarding the identification of strong predictors of distance estimation abilities. With a few exceptions (McCormack et al. 2008), specific studies that approach distance perception as a component of the evaluation of transit service quality often are not found.

The objective of this paper is to describe the gap between perceived and real distance to stations in Santiago de Chile city. This description will account for divergent patterns among modes that could be viewed as an effect of transport-specific variables. After a descriptive analysis of the information is provided, the implications for transport planning are discussed.

The remainder of the paper consists of five basic parts. The next section exposes some theoretical findings on travel behavior and mode choice decisions as well as the role of variables such as personal habits and experiences. Then, the methodological approach is explained, and the case study area of Santiago is briefly introduced. Empirical findings and results are presented, and the paper concludes by noting the need for further research and proposing some derivatives for appropriate public transport planning and policy making.

**Theoretical Framework**

Rietveld (2010) argues that the gap between the actual and perceived supply of public transport refers to a wide array of aspects, such as frequencies and headway regularity, travel comfort, waiting times outside of vehicles, access and egress times to and from stops, reliability and punctuality of services, vehicle occupation, and the availability of seats. In the same vein, Munizaga et al. (2008) note that waiting time outside of the vehicle and spent on mode transfers is perceived as double the actual travel time in the vehicle. Nevertheless, conventional transport demand models often neglect this fact, which affects the overestimation of actual demand and ignorance of user
dissatisfaction. Related to this, many transport demand models are based on average door-to-door travel times, neglecting possible delays. Delays become particularly problematic for the users, if trips include missed mode transfers in a system without a regular interval timetable (Kaufmann et al. 2009; Rietveld 2010).

The importance of previous experiences of transport users in the context of actual perception and satisfaction has been the subject of many studies (Flamm, Jemelin, and Kaufmann 2008; Flamm and Kaufmann 2006; Van Acker, Van Wee, and Witlox 2010). Thus, we can distinguish between reasoned influences on travelers’ behavior and mode choices, such as rational, time-related restrictions and individual preferences and attitudes, and unreasoned aspects, dealing with hardly reflected influences, such as long-lasting habits and impulsiiveness (Van Acker, Van Wee, and Witlox 2010).

A comprehensive explanatory approach to this issue is provided by van Acker et al. (2010), who explain travel behavior as the result of a hierarchical decision structure (Salomon and Ben-Akiva 1983), in which short-term decisions related to traveling and daily activities are based on longer-term decisions, such as residential location and lifestyle choices. On the other hand, the temporal hierarchy of these individual decisions is embedded in a specific social and societal environment, which is again conditioned by the spatial and built environment. However, different temporal and contextual levels or domains form a very complex construct of influence factors in which the resultant individual decisions on activities and traveling form the core of interest.

The importance of these two items in the transport domain have been recognized in many other studies and has produced theoretical concepts such as the motility concept by Kaufmann (2002). Kaufmann notes the individual prerequisites of competences and skills in addition to temporal and spatial access to become spatially—or socially—mobile. Moreover, a third dimension is included, which is defined as “appropriation” or simply as the transport project itself, as a result of the person’s interpretation of access and skills in the context of a specific travel end. Again, the appropriation domain is mainly shaped by individual aspirations and plans and originates from the person’s values, perceptions, and habits. Kaufmann (2006) underpins the high significance of habits in travel behavior according to the theoretical approach by van Acker. As an example, they mention the “rejection by principle” of specific modes such as public transport and suggest the continuing influence of a person’s experiences (or lack of experiences and effective use) with these modes during childhood. This is a key variable according to our approach because mode perception could be part of the past experience necessary to estimate distances to bus or metro stations. Thus, if a transport service is evaluated as slow, inconsistent, unsafe, or imposing time costly transfers, the distance to the station also may be overestimated. In accordance with the aforementioned motility framework, when a mode has a social prejudice, this also could feed the previous experience of the traveler and may influence distance perception.

Regarding “mode reputation,” note that misperception does not necessarily refer to a worse perception of an actually good supply. It might equally refer to the ignorance of effective deficiencies of transportation features due to people’s good image and previous experiences with this transport system.
In that sense, Alshalalfah and Shalaby (2007) explore the relationship between walk access distance to transit and various characteristics of the transit service and transit users in the city of Toronto, Canada. They consider quality of service to be one of the most important variables regarding willingness to walk. Indeed, they find that people in Toronto are willing to walk farther to get to routes whose frequencies are higher. The higher the frequency of the transit service, the longer people are willing to walk to access transit. It is plausible that if riders are willing to walk farther to access these routes, they also would tend to perceive the distance to a stop for one of these services as more walkable. The authors’ evidence also reflects the same situation for metro services regarding bus and streetcars. People tend to walk, on average, 100 additional meters to get to the stations, even when almost 8 of 10 dwellers have transit services within approximately 500 meters. Our argument is consistent with this evidence. If people are willing to walk farther to metro stations than to buses or streetcars, they will conceive metro stops as being closer than they really are, either because they are willing to “spend” a physical energy surplus to use a better quality service or because the overall quality spreads to other attributes, such as walking distance to the network.

Methodology
The research question addressed in this paper is about the gap between actual and perceived distance to public transport stations. The empirical evidence describes how well people who live in the studied districts perceive the actual provision of public transport network. This description considers two basic modes: buses and metro.

The empirical evidence was gathered through a 2009 mobility survey conducted in a home-based way in 2000 households in five (of 37) districts of Santiago de Chile. These districts include the most significant centrality in the city—including the city’s central business district (CBD)—and representative samples of periphery low-income communes and affluent households sectors. By the same token, the selected territories present a wide array of scenarios regarding public transport supply, either metro or bus services. In each commune, approximately 400 people were surveyed. Respondents were selected according to a semi-random method (random selection of residences; selections of persons surveyed in each residence according to quotas established for age, gender, and income). The number of 400 respondents per commune provides a representative sample size per commune, with a 95% confidence level and a 0.05 confidence interval. Table 1 presents the minimum threshold to guarantee a representative sample for each district under the mentioned parameters.

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1 This survey was originally designed and collected for the purpose of the research work published in Witter (2012).
Perceived vs. Actual Distance to Transit in Santiago, Chile

The final sample population observed differed only slightly from the sample selection required, with a slight under-representation of women and low-income households and a slight over-representation of older adults. Unweighted data were used for several reasons. First, the criteria used for quotas are not necessarily the (only important) explanatory factors, and other quotas may have been equally pertinent. Second, the sensitivity analysis conducted showed that the results of the analysis using weighted and unweighted data differed only slightly and the conclusions of both analyses were the same. After all, the data were rather reliable, but some bias cannot be excluded due to a probable fatigue effect of respondents, as the survey that took 25–30 minutes in total to complete.

For all data analyses, we focused on some descriptive statistics, combined with a simple spatial analysis conducted in a geographical information system. To build the “dependent” variable, it was necessary to overlap two measures of distance: the perceived distance and the actual distance. The former—perceived walking distance to metro and bus stops—was revealed through a question about each mode’s station availability within approximately 400 meters (or “within 4 or 5 minutes walking”). The answers referring to the perceived supply were superposed with the real supply measured using GIS (aerial distance to metro stations and bus routes). Then, a new variable was built with three categories: “correct estimation,” considerable “overestimation,” and “underestimation” of walking distances.²

The Case of Santiago de Chile

The metropolitan area of Santiago de Chile comprises 37 boroughs or municipalities with approximately 5.5 million inhabitants (2002 Census), spread over a surface of 76,000 hectares. Morphologically, the city is characterized by a rather mono-centric-radial structure with the traditional CBD in the central (homonymous) municipality of Santiago-Centro and radial transport axes, connected by a privately-run ring road highway. In addition, in the last decade, a second economical center has emerged in the affluent cone of wealth in the eastern part of the city, which has gained increasing economic dominance over the traditional CBD (Witter and Hernández 2012).

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² A 100-meter misperception was accepted. Thus, if a person answered that he/she does not have a bus stop within 400 meters, to be classified as “underestimating” supply, the stop should be within a 300-meter area of influence. Conversely, to “overestimate,” a person should declare the availability of buses but must be at least 500 meters from the closest route.
FIGURE 1. Surveyed households and location of Santiago’s districts

Figure 2 shows the public transport network, which encompasses a vast bus network with trunk services composed of high-capacity articulated buses that serve routes along the city and feeder services that extend to local areas. It also includes subway services (5 lines), which operate under a tariff union scheme with buses. The bus system went through a serious crisis after the implementation of a new reregulated system known as Transantiago, an ambitious failed project aimed at providing high-quality, cost-effective services that, after an abrupt start, immediately provoked actual chaos in the city (for information on the Transantiago project, see Witter and Hernández 2012; Figueroa and Orellana 2008; Muñoz and Gschwender 2008a; Muñoz and Gschwender 2008b; Witter 2012). This is a reason why bus systems are very unpopular with the population. In contrast, the metro enjoys a very positive reputation. The tariff union brought many new users—one of the most positive effects of the Transantiago project—that generated very high metro occupancy, which caused it to become much more crowded than usual, especially during peak hours. However, this mode is still evaluated as providing fast and reliable service.
Results: Perceived and Actual Distances

To begin the empirical analysis, the actual and perceived distances to the network from households in the survey sample are described. First, in Table 2, the actual distances to trunk bus routes and metro stations are depicted. In the case of trunk routes, the network extension and density is extremely high. As a result, in four of the five studied districts, at least 92% of the interviewee households have a trunk route within approximately 400 meters. Puente Alto commune constitutes an exception, with only one-third of the households in the sample being located within the service area.
As with the service area, the average distance to a trunk route also reflects that the network is very dense with high coverage. In three districts, the average distance is between approximately 160 and 200 meters. At the highest endpoint, Puente Alto has more than 600 meters of average distance, whereas Santiago has the denser network supply, with the average distance being approximately 56 meters from each household in the sample. Note that Santiago is still the most important urban centrality in which governmental, economic, and political resources locate. Moreover, a relevant portion of urban routes—especially trunk routes—pass through this district or have their destination there.

Regarding the metro network supply, it is almost the opposite situation of the bus network. Indeed, it is clear that the metro network has a lower density and is not spread through the city as in other urban agglomerations. Two districts did not have any households within 400 meters when the data were collected. In Puente Alto and Las Condes, only approximately 3% of households are within a 400-meter buffer of any metro station. Santiago is the only district in which a fairly dense metro network exists. Similar to the bus network density, its central role in urban life explains this fact. Nevertheless, the percentage of households is still low (20%).

Given these data, the first limitation arises because some scenarios will have to be discarded. For logical reasons, underestimation of metro services is not found in Lo Espejo and Maipú, and it will be difficult to find in Las Condes and Puente Alto as well. For the same reasons, it is unlikely that overestimation of bus supply will be found for any districts except Puente Alto. Having said that, in the following tables and charts, both supply measures—actual and perceived—are depicted.

Figure 3 shows the overall percentage of correct estimation, overestimation and underestimation of metro station and trunk bus routes. It must be noted that these figures include the five districts, which, as shown before, are very different regarding each mode’s actual supply. Despite these differences, the relevant fact to note is that at least 8 of 10 persons “correctly” answer the question about bus and metro supply in his neighborhood. The data indicate that people are aware of the existence or absence of such services.

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1 The extension of one of the metro routes currently reaches the district of Maipú.
of public transportation supply and are able to estimate distance regarding a given distance threshold. As expected, the percentage of metro overestimation is higher than that for buses because the former network extension is smaller than the latter. This fosters the potential for overestimation when answering the question.

To some extent, this indicates that people are responsive to actual supply. Accordingly, it could be argued that they will be responsive to changes in quality of the service—at least they will be responsive in terms of awareness of these changes, regardless of changes in their behavior that it could cause.

Table 3 analyzes the gap between actual and perceived supply for each commune. By doing so, it is possible to control for the different actual supply mentioned above. For the three districts in which some type of metro supply exists, the availability of metro services is very often overestimated, which means that distances to the metro network are underestimated.
For all of the districts, the underestimation of metro supply is very low. As previously mentioned, it is senseless to pay attention to the underestimation figures of the metro in communes in which only 3% of the interviewees live within 400-meter walking distance of a station. Nonetheless, the underestimation is also marginal in the case of Santiago district, in which the actual service is relatively extended.

Regarding bus services, once again it is pointless to consider overestimation in those districts with almost full availability within a 400-meter walking distance. In the case of Puente Alto (with only 31% availability), however, overestimation is registered. Indeed, more than 19% of people from this neighborhood affirm that they have access to the bus supply closer than they really do. Moreover, the underestimation figure is the second lowest of the five districts.

Do the figures in this table mean that the overestimation of metro or bus service is just an artifact of the actual supply? In other words, do people overestimate (when the network is not as extensive as the metro) or underestimate (when the network is as extensive as the bus network) as an automatic reflection? It is mathematically impossible to collect overestimations if 100% of people live within a given walking distance under the adopted distance threshold. Nevertheless, we posit that the overestimation is different between metro and bus services. In fact, the former seems to be more frequently overestimated than the latter.

To illustrate this point, in the remainder of the paper, the focus is on the two districts for which a comparison seems reasonable. The case of Puente Alto and Santiago are adequate because both have metro services (minimal in the case of Puente Alto) and low coverage of buses, thus providing the potential for comparison between modes. Unfortunately, the built environments in these communes are rather different. Santiago is a typical urban “walkable” setting with high dwelling density and mixed land use. On the contrary, Puente Alto has less density and mixed land use.

Table 4 synthesizes the amount of overestimation regarding actual supply for the cases in which it exists: bus and metro in Puente Alto and metro in Santiago. The upper side of the table presents the data on actual and perceived distances to both networks. The overestimation as a percentage of the actual supply is higher in the case of metro service, regardless of the district. In Puente Alto, the “total” metro supply is more than five times the actual one. This means that despite the very limited service within a 400-meter walking distance, 14% of the population perceives that they can reach the metro service within that distance. In the case of Santiago, even when the percentage of actual metro service is 20%, the overestimation still almost double, reaching a “total supply” of almost three times the actual service.

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4 To be classified as underestimating the service, the person should have answered “no availability” regarding having a station or route within 300 meters of his dwelling. This decision was made to be more categorical about the misperception. Nevertheless, the difference between this measure and the one taken to determine the precise distance of 400 meters is minimal.
TABLE 4.
Actual and Total Supply including Perception Correction, Metro and Trunk Bus Service, Santiago and Puente Alto

<table>
<thead>
<tr>
<th></th>
<th>Puente Alto Metro</th>
<th>Santiago Metro</th>
<th>Puente Alto Trunk Buses</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Actual supply</td>
<td>3</td>
<td>20</td>
<td>31</td>
</tr>
<tr>
<td>(b) Overestimation</td>
<td>14</td>
<td>39</td>
<td>19</td>
</tr>
<tr>
<td>(c) Underestimation</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>“Total” supply (a + b – c)</td>
<td>16</td>
<td>57</td>
<td>46</td>
</tr>
</tbody>
</table>

Meanwhile, for the case of bus overestimation (Table 5), the figures are much lower than those for the metro. The “total supply” in this case is approximately 1.5 times the original one. Thus, it is possible to speculate that the metro as a mode tends to maximize supply overestimation.

TABLE 5.
Actual Average Distances for People who Overestimate Transportation Supply, Metro and Trunk Bus Service, Santiago and Puente Alto

<table>
<thead>
<tr>
<th></th>
<th>Puente Alto Metro (m)</th>
<th>Santiago Metro (m)</th>
<th>Puente Alto Trunk Buses (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1,076</td>
<td>1,103</td>
<td>776</td>
</tr>
<tr>
<td>Quartile 1</td>
<td>669</td>
<td>765</td>
<td>603</td>
</tr>
<tr>
<td>Median</td>
<td>878</td>
<td>1,091</td>
<td>778</td>
</tr>
<tr>
<td>Quartile 3</td>
<td>1,325</td>
<td>1,368</td>
<td>922</td>
</tr>
</tbody>
</table>

The data in the Table 5 refer to the actual distances to the metro and bus services from the residence of people who overestimate each mode supply. In short, people from Puente Alto who answered yes to the question “Is there a metro station within 400 meters” even though no station exists within a 500-meter area is, on average, actually 1076 meters from the closest metro station. To some extent, this distance sets a threshold of “willingness to walk” to a metro station because they perceive it as a very short one.

It is interesting that metro “overestimators” are, on average, approximately 1,100 meters away from the closest station because the overestimations of buses in Puente Alto are notably lower, at 780 meters. One of the reasons is that trunk routes in Puente Alto are, on average, closer than metro stations. Nevertheless, the relevant question is if trunk routes had longer distances, would people who overestimate increase that threshold? By the same token, it is plausible that people would not underestimate walking distance to the metro after 700 meters, but they did so. Those questions will remain unanswered, but evidence suggests that the metro’s willingness-to-walk threshold (i.e., perceive as longer than a 400-meter walking distance) is higher than the buses’ threshold.

Concluding Remarks
People have a relatively accurate perception of the transport supply around their residence location. In general terms, when perceived supply does not match the actual supply, the bias is towards an overestimation of the actual supply by underestimating walking distance to the metro station or the bus stop.
In particular, distances to metro stops are perceived to be shorter than they are in reality. A generally very good image of this transportation mode, particularly in comparison with less efficient bus services, may have an important influence on people’s underestimation of distances and overestimation of actual supply quality. With very limited network coverage, metro services have a greater effect on perceived supply. Even when this does not necessarily mean that people will switch from private to public transit, one plausible explanation is that when a good image exists, people will be prone to walk farther to use this service because they perceive the distance as “walkable.”

A substantial discussion can take place. First, in contradistinction to some pieces of literature, in this case, people do not tend to systematically overestimate distances. On the contrary, regardless of the mode, when the actual supply was limited (such as the metro for all of the districts or buses for Puente Alto), a portion of people overestimated actual supply, assuming that the network was within 400 meters in cases in which it was much farther than that. In the case of the metro, the threshold for what people consider walkable distance was higher than for buses.

This evidence could support Lee’s (1970) “decreasing factor” of overestimation because for very long distances, the proportional overestimation factor decreases. The metro service location was systematically farther than bus routes. That could be a reason why people keep declaring the existence of supply within 400 meters even when the closest station is more than 900 meters away.

Finally, even when data do not help to confirm it, the quality of the service as a factor that fosters overestimation of supply remains a plausible hypothesis. Empirical evidence of this paper is in line with Alshalalfah and Shalaby’s (2007) findings, which show that people’s willingness to walk is higher for buses with more frequent schedules. There are two possible mechanisms that drive “quality effect” on supply perception. The first is Flamm and Kaufmann’s (2006) “rejection by principle” (or “compliance by principle,” we would add) of specific modes such as buses. The second is a more rational argument that could be part of the reasoned influences on traveler behavior and mode choices (Van Acker, Van Wee, and Witlox 2010). Considering that the metro is a faster public service (and more reliable, in the case of Santiago de Chile), people might make a trade-off between time in the vehicle and time walking to the station. In this case, the individual should conceive of the trip as a unit.

The results of this paper are a description based on data with several limitations. The gap is calculated using fixed thresholds (400 m) and without considering the stations actually used by the respondents. Nevertheless, the empirical evidence is robust enough to suggest that mode is a key variable to understanding distance estimation to the stations. It is clear that there are several mode characteristics other than distance that influence how far or close people perceive a given mode station to be. In that sense, the paper provides strong motivation to go further in the field of distance estimation in the context of transport studies.
References


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En-Route Planning of Multi-Destination Public-Transport Trips Using Smartphones

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Abstract

Public transport travelers require well-integrated, real-time information systems to use a network. The objective of this study was twofold: (1) to develop a model to determine the effect of personalized information provision through smartphones on user ability to plan multi-destination trips, and (2) to understand user perception of riding public transport aided by real-time, multi-destination trip-planning smartphone applications. Auckland Pioneer was developed for multi-destination trip planning and integrates real-time public transport services with search functions for places of interest. A test trial was conducted in Auckland, New Zealand, and the findings show the effects of the application on multi-destination trip planning in comparison to traditional information sources such as Google Transit. This research contributes to existing literature by demonstrating the importance of personalized information en-route for user multi-destination trip planning. With information to assist trip planning and provide step-by-step guidance en-route, users tend to feel more confident to ride public transport.

Keywords: Public transport, mobile applications, mobile devices

Introduction and Research Objectives

The Intergovernmental Panel on Climate Change has identified improving public transport (PT) systems as a strategy for mitigating issues related to global warming. Commuters’ low mode share of PT is a global issue (Buehler and Pucher 2012). For example, in New Zealand, from 2010–2013, only 4.3% of trips were undertaken using PT (Ministry of Transport 2014). PT also plays a critical role in the attractiveness of a city for tourists; cities with effective and extensive PT networks are potentially more attractive for tourists (Le-Klahn and Hall 2015). To improve PT services globally, transport agencies are upgrading their networks to be more integrated (Chowdhury and Ceder 2013). A key integration element is information integration. An integrated information system is essential to facilitate urban trip planning (Zografos et al. 2008). With many advanced
PT information systems available, real-time information can be made accessible directly to users en-route (Zhang et al. 2011). One such provision is the use of smartphones to deliver real-time information to travelers en-route.

The aim of this study was to develop a model that demonstrates the impact of planning on multi-destination trips. The effects of a mobile application, Auckland Pioneer, for PT users with smartphones was assessed and, thereby, their perception to ride PT. This application was designed to assist in multi-destination trip planning for travelers with smartphones, both commuters and tourists, by providing the capability to search places of interest. Traditionally, travelers can use online services such as Google Transit or timetables to correlate their places of interest with appropriate PT services. In most cases, such services will provide information in a static scheduled data format and cater only to single-destination trips. If a user wishes to incorporate a journey with multiple destinations and various arbitrary times to spend at each of the intermediate destinations, then the planning becomes more cognitively challenging. The importance of real-time data for planning is clear. Factors such as traffic conditions will render a pre-planned schedule not optimized or, in some cases, invalidated. Auckland Pioneer aims to improve the usability of the PT network by reducing the time spent planning trips and, thereby, overall journey time. An important design feature of Pioneer is that it caters to users undertaking multiple ad-hoc stops en-route to their final destination and allows them to explore unfamiliar areas through a searchable interface integrated with the PT services. The application has been released for Android smartphones in Google Play and integrates sources such as Google Maps for PT route selection and real-time operational data from government agencies such as Auckland Transport. Travelers are able to find places of interest using keywords and are guided step-by-step by the application to reach their destinations. A test trial of the developed application was conducted in Auckland, New Zealand, and a model was developed showing the impact of planning on multi-destination trips.

This paper includes a review of literature, discusses the methodology undertaken to determine the research objectives, provides the results of the simulation and the user survey, offers discussion, and provides a conclusion.

**Literature Review**

**Need for Real-Time Information**

Although some studies (Zografos et al. 2008, Molin and Chorus 2009) have investigated the need for PT information, relatively less attention has been given to pre-trip information use for planning (Farag and Lyons 2012). The study by Farag and Lyons (2012) found that travelers consult pre-trip PT information more often when making a business trip than a leisure trip. Cebon and Samson (2011) explained that in many cities, services run only somewhat close to printed schedules and, as such, real-time information is required for travelers to make informed decisions. Providing real-time information can assist travelers with trip planning and also can reduce the frequency of operation for service providers (De Borger and Fosgerau 2012). Cherry et al. (2006) discussed that the mapping features of GIS can be used to provide travelers with user-specific routes. Watkins et al. (2010) discussed the importance of web GIS-based trip
planners and developed the Explore Attraction Search Tool, which searches online databases for places of interest specified by the traveler using keywords; the traveler specifies a starting point along with other trip characteristics and an attraction type such as doctor, bar, park etc., to integrate PT services with attractions. Nelson and Mulley (2013) stated that the use of Intelligent Transport Systems (ITS) for PT information in Australian cities is poor in comparison to European cities. A focus area for the National ITS Strategy for Australia is “traveler information systems,” and personalized messaging system through smartphones was identified as a provision.

**Examples of Mobile Applications for Navigation**

The use of smartphones has influenced how we spend our personal time and the norms governing human interactions (Berry and Hamilton 2010). A number of recent studies have been conducted to determine the applicability of smartphones for route selection. Navigation systems using smartphones are beneficial for users, as they allow a new market for travelers and providers to attain a large amount of data conveniently.

Gkiotsalitis and Stathopoulos (2014) developed an application that complies with a traveler’s preferences and proposes intermodal routes, with the objective to reduce total travel time. The application includes both autos and PT, supports a combination of different means of transport modes, and reduces auto use.

Salcedo and Battistuti (2014) proposed a PT navigation system to find the fastest route in Mexico City’s chaotic and uncertain network. The algorithm assessed trip attributes such as transfer time, waiting time, speed of each mode, and time and date of trip to determine the optimal route.

Hung et al. (2012) emphasized the importance of customized navigation systems and developed an application that takes into account traveler preferences to produce the shortest PT route.

Other studies developed navigation systems for travelers with visual disabilities. Huang and Liu (2004) proposed an application that provides contextual information by making use of voice cues of known buildings and landmarks along with directional information. The location of the user is tracked at regular intervals, and the application announces a feature nearest the user’s position based on current coordinates.

Korbel et al. (2013) developed a mobile application that retrieves information dependent on user location from PT passenger information systems; the trip planner optimizes travel time and walking distance to the destination.

Many PT operators are implementing smartphone applications globally. In Portugal, the MOVE-ME mobile application can be used by users to navigate the network. Auckland has the AT Public Transport application to assist its commuters. Common applications used in Australia include TransitTime, NextThere, and TripGo. TubeMap in London and RATP in Paris assist travelers with their metro networks. In the U.S., many applications have been developed by PT operators, including DC Metro Rails (Washington, DC), MARTA (Atlanta), TransitGenie (Chicago), Tiramisu (Pittsburgh), and Subway Time (New York) (Global Mass Transit Report 2014).
Holistic Multi-Destination Planning

The work presented in this paper differentiates from previous studies by focusing on information integration that supports a holistic approach to planning for multi-destination trips. The overarching philosophy is to recognize the complexity of multi-destination planning, particularly when travelers require information from multiple sources.

Auckland Pioneer

Auckland Pioneer was developed by students at the University of Auckland and integrates information from many sources such as Google Transit, Google Directions, Google Search, and real-time information from Auckland Transport (the local PT service provider). Although the application currently uses the local PT service provider for real-time information, the integration of Google Directions web service equips Pioneer with the flexibility to automatically be usable in any city in which information is provided by Google Directions. Using the smartphone’s GPS coordinates, the application integrates navigation guidance services (route generation and walking directions) with search functionality to assist users in finding their places of interest by using keywords.

To use Pioneer, it is important to determine a trip’s purpose, as this dictates the information requirements. Pioneer acknowledges this by first asking users for the main purpose of the trip, as shown in Figure 1(a). By knowing the purpose for using PT for either a single-destination “planner” or a multi-destination “explorer,” the application can immediately hide unnecessary features and simplify its usage in the route planning stage. Whenever available, Pioneer communicates with live data from Auckland Transport for the real-time arrival information of services. Notifications are sent to users throughout their trip, especially when real-time data change.
The feature of Pioneer that distinguishes it from other applications is its exploration functionality. Once users have a preliminary route in place (at least a start and an end), the search function can be used to help plan intermediate stops, targeting users who are exploring (unfamiliar with the location of destinations) while still allowing them to enter addresses of known destinations. A search query is in the form of:

"keyword(s)" within [500m, 1km, 2km, 5km, 10km, 50km] of [Start, End, Tap on Screen]

The predefined radius options represent levels of walking distance (500m and 1km for easy walking, or 2km and 5km for active walkers), as well as more distant ranges (10km and 50km). These distances are centered at predefined points, namely “Start,” “End,” or “Tap on screen,” for flexibility. Figure 1(b) shows an example in which a user is searching for an art gallery within easy walking distance of his/her start location. When the user completes adding intermediate stops, he/she is presented with a high-level overview of the journey, as shown in Figure 1(e). Each entry represents the intermediate trips, where tapping on one will expand the view with more detailed information. GPS tracking helps the user follow the directions on the map.

Model Development

The main focus of this research was on promoting efficient planning for trips that involve multiple destinations. Although an important aspect is reducing the overall time required in trip planning, another aspect is improving traveler overall in-vehicle experience. For example, by providing a tool that improves the efficiency of pre-trip planning, travelers who are prone to motion sickness can relax in-vehicle while maintaining a reasonable overall travel time.

This section presents a simple model that represents traveler planning. The model recognizes that travelers not only are going to multiple destinations but require time at
each of them (e.g., a tourist sightseeing or a traveler running errands). The notations and their definitions are given as follows:

\[ n = \text{number of destinations in a multi-destination trip (excludes start)} \]
\[ D_i = i^{th} \text{destination in a multi-destination trip, where } D_0 \text{ represents the start and } D_n \text{ represents the final destination} \]
\[ p_i = \text{planning time incurred at } D_i \text{ in determining how to travel to } D_{i+1} \]
\[ w_i = \text{waiting time incurred at } D_i \text{ waiting for the vehicle to transport } D_{i+1} \]
\[ v_i = \text{exemplar in-vehicle travel time to travel from } D_i \text{ to } D_{i+1} \text{ using public transport} \]
\[ r_i = \text{traveler’s minimum required time at destination } D_i \text{ (e.g., for errands/appointments)} \]
\[ T = \text{total time to get from } D_0 \text{ to } D_n \]
\[ P_{\text{overlap}} = \text{total planning time that is overlapped with waiting and/or in-vehicle times} \]
\[ Q = \text{measure of quality for passenger’s in-vehicle time not overlapped with planning} \]

Figure 2 shows the model in its simplest form, which assumes that the traveler plans each intermediate destination “one step at a time.” Equation 1 gives the total time without any planning overlap.

**FIGURE 2.**
Example of all time components—travel time \((v_i)\), trip planning \((p_i)\), waiting time \((w_i)\), duration of stay \((r_i)\)—at each destination in a multi-destination journey

\[
T_{\text{zero overlap}} = \sum_{i=0}^{n-1} v_i + \sum_{i=1}^{n-1} r_i + \sum_{i=0}^{n-1} p_i + \sum_{i=0}^{n-1} w_i
\]  

However, it is more likely that travelers making multi-destination trips would opt to overlap the planning with other trip components to reduce overall trip time. For example, when a passenger at the “Start” has finished planning his/her route to \(D_1\) (planning time represented by \(p_0\)), he/she may start to plan \((p_1)\) while waiting \((w_0)\) for a vehicle to \(D_1\). The traveler can decide to continue this pre-trip planning for successive destinations. This planning overlap may occur at any of the \(w_i\) or \(v_i\) components, but never at the \(r_i\) times of each intermediate destination. Two models represent the overall travel time, depending on when the traveler undertakes the planning:
• Partial overlap – traveler is either prone to motion sickness or wishes to relax in-vehicle; only planning is overlapped during waiting times (never in-vehicle).

• Maximum overlap – traveler is not prone to motion sickness and decides to plan in-vehicle while in motion.

Further details of the two models is as follows.

**Partial Overlap Model**

In the partial overlap model, the amount of time a traveler can save (the overlap amount) is capped depending on the proportion of planning versus waiting time:

- If the waiting time exceeds the planning time, then the passenger saves $\sum_{i=1}^{n-1} p_i$ (which corresponds to the planning times of traveling from $D_1$ to $D_{n-1}$).

- If the planning time exceeds the waiting time, then the passenger saves $\sum_{i=0}^{n-1} w_i$ (which corresponds to the waiting times at $D_0$ and $D_{n-1}$, inclusively).

Equation 2 provides the partial overlap model, which subtracts this overlap of planning time and waiting time:

$$T_{\text{partial overlap}} = T_{\text{zero overlap}} - P_{\text{overlapped with waiting time}}$$  \hspace{1cm} (2)

$$= T_{\text{zero overlap}} - \min(\sum_{i=1}^{n-1} p_i, \sum_{i=0}^{n-1} w_i)$$

**Maximum Overlap Model**

In the maximum overlap model, the amount of time a passenger can save is capped depending on the following:

- If both the waiting and in-vehicle times exceed the planning time, then the passenger saves $\sum_{i=1}^{n-1} p_i$ (all planning was undertaken during the waiting and in-vehicle travel times).

- If the planning time exceeds both the waiting and in-vehicle times, then the passenger saves $\sum_{i=0}^{n-1} w_i + \sum_{i=0}^{n-2} v_i$ (entire waiting and in-vehicle times were fully saturated with planning).

Consequently, Equation 3 shows the maximum overlap model, which subtracts this overlap of planning time and waiting time:

$$T_{\text{partial overlap}} = T_{\text{zero overlap}} - P_{\text{overlapped with waiting time}}$$  \hspace{1cm} (3)

$$= T_{\text{zero overlap}} - \min(\sum_{i=1}^{n-1} p_i, \sum_{i=0}^{n-1} w_i + \sum_{i=0}^{n-2} v_i)$$

**Pioneer: Holistic Multi-Destination Planning Model**

The primary motivator for this research was to provide travelers with a more holistic approach to multi-destination planning. Searching for arbitrary places of interest, retrieving real-time vehicle information, and map visualization of multiple destinations should all be integrated within the same application. If passengers are equipped with such technology, it is likely they will accomplish the same amount of planning in less time. This model is given in Equation 4, with a factor applied on the planning
components, as determined from the case study of a participant trial of the application; its impact is evaluated in the model simulation.

\[ T_{\text{Pioneer}} = \sum_{i=0}^{n-1} v_i + \sum_{i=1}^{n-1} r_i + \text{factor} \cdot \left( \sum_{i=0}^{n-1} p_i \right) + \sum_{i=0}^{n-1} w_i \]  

(4)

**In-Vehicle Quality Model**

Whereas passengers following the maximum overlap model will decrease their overall travel time, the model acknowledges that planning is an overhead that is preferred to be avoided and is likely to contribute to passenger discomfort. In-vehicle quality time is defined as the proportion of in-vehicle time that is not used for pre-trip planning time, given in Equation 5:

\[ Q = \frac{\sum_{i=0}^{n-1} v_i - P_{\text{overtopped with in-vehicle travel}}}{\sum_{i=0}^{n-1} v_i} \]

\[ = \frac{\sum_{i=0}^{n-1} v_i - \max(0, \sum_{i=0}^{n-1} p_i - \sum_{i=0}^{n-1} w_i)}{\sum_{i=0}^{n-1} v_i} \]  

(5)

The amount of planning time that is overlapped in-vehicle is the total planning time less the planning time accomplished while waiting. The model captures the possibilities that the planning was sufficiently undertaken while waiting. It also allows for a negative quality, which is when a large amount of planning could not be accomplished while waiting and in-vehicle. This corresponds to the total journey time being delayed while planning needs to be continued out of vehicle.

**Trial and User-Preference Survey**

A trial of Pioneer was conducted at the University of Auckland with Engineering students to determine the effectiveness of the application for multi-destination trip planning and user perception of PT use. An invitation was sent to undergraduate and postgraduate students to participant in a two-day trial. For the trial, 21 students participated, 62% male and 38% female and 67% international and 33% domestic. All participants were given four routes, two in each set, and a self-administered survey to complete at the end of the trial. Participants were instructed to use Pioneer for one set and to use “conventional” methods of their choice, such as Google Maps, Google Search, printed timetables, or any other application for the other set. Each route had three different intermediate stops. In Route 1 of Set 1, pre-determined intermediate stops with specific addresses were provided. In Route 2 of Set 1, the intermediate destinations were open-ended and determined using keywords and distances (e.g., “Find a pizza place within 500m of …”). The aim of the design of Route 1 was to mimic a scenario of a local user who used the PT network regularly and made errands along the journey from an origin (e.g., home) to a destination (e.g., University of Auckland). Route 2 was designed for explorers (e.g., tourists) and, as such, the intermediate stops included attractions that were searched using keywords. Routes 3 and 4 in Set 2 had different destinations and stops to Routes 1 and 2, but they were characteristically equivalent.
Participants were given a form for each route to record their start time, waiting time, vehicle boarding time, arrival time, and planning time for each intermediate destination.

The questionnaire was composed of 16 items, of which 2 were related to participant socio-economic characteristics. The remainder of the questions focused on the usability of Pioneer, participant intentions for future use, and if the application succeeded in reducing their anxiety when exploring unfamiliar areas. Table 1 provides the items and the response scale.

**TABLE 1. Questionnaire Components**

<table>
<thead>
<tr>
<th>Items in Questionnaire</th>
<th>Response Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male/Female</td>
</tr>
<tr>
<td>Student type</td>
<td>International/Domestic</td>
</tr>
<tr>
<td>Who do you think Auckland Pioneer will be useful for?</td>
<td>Tourists/Locals/Both</td>
</tr>
<tr>
<td>Do you feel the ideas and principles behind Auckland Pioneer are advantageous over other current travel planning options?</td>
<td>Yes/No; reason for response</td>
</tr>
<tr>
<td>Personalized information about my journey helped me use the public transport network more easily.</td>
<td>5-point Likert Scale (Strongly Disagree to Strongly Agree)</td>
</tr>
<tr>
<td>If you were to plan (in the future) a single-destination trip using public transport, would you use Auckland Pioneer?</td>
<td>Yes/No/Maybe; reason for response</td>
</tr>
<tr>
<td>If you were to plan (in the future) a multi-destination trip using public transport, would you use Auckland Pioneer if (a) the exact addresses of all intermediate destination points were known? (b) a majority of intermediate destinations were unknown and had to be searched for?</td>
<td>Yes/No/Maybe; reason for response</td>
</tr>
<tr>
<td>Did Auckland Pioneer help reduce the amount of time required for planning your routes?</td>
<td>Yes/No/Maybe; reason for response</td>
</tr>
<tr>
<td>I found the bus/train/trip arrival times reported by Auckland Pioneer to be accurate.</td>
<td>5-point Likert Scale (Strongly Disagree to Strongly Agree)</td>
</tr>
<tr>
<td>Do you think the instructions given for walking are clear?</td>
<td>Very Clear/Average/Not Clear/Not Applicable</td>
</tr>
<tr>
<td>Did you use the “recalculate from current position” feature? When would you use it?</td>
<td>Often/Sometimes/Not Applicable; reason for response</td>
</tr>
<tr>
<td>Please rank the following features in Auckland Pioneer that you found most useful (1 being most useful, 5 being least useful)</td>
<td>6 features of Auckland Pioneer</td>
</tr>
<tr>
<td>Auckland Pioneer made me feel more confident about using the public transport network in unfamiliar areas.</td>
<td>5-point Likert Scale (Strongly Disagree to Strongly Agree)</td>
</tr>
<tr>
<td>Auckland Pioneer helped reduce my anxiety (about how to get there, which bus/train to catch, how long I have to walk, etc.) when travelling in an unfamiliar area.</td>
<td>5-point Likert Scale (Strongly Disagree to Strongly Agree)</td>
</tr>
<tr>
<td>What difficulties did you meet while using Auckland Pioneer?</td>
<td>Open-ended question</td>
</tr>
<tr>
<td>What additional features or improvements do you feel would make Auckland Pioneer more helpful?</td>
<td>Open-ended question</td>
</tr>
</tbody>
</table>
Results

Simulation

A parametric study of the model discussed previously was implemented to simulate the effects of multi-destination trip planning. Figure 3 shows the overall travel times for a passenger constructing a multi-destination trip consisting of five destinations and compares the models of passengers using a non-integrated approach (e.g., using multiple and separate applications such as Google Maps, Google Search, and timetables) with Pioneer. The parameters used closely represent the test trial discussed previously, namely a multi-destination consisting of 5 destinations approximately 20 minutes apart with an average 10-minute wait for the next vehicle. The figure shows how the total trip time increases as the passenger requires more planning time per destination. Based on the 21 participants in the test trial, it was noted that passengers required 35% less planning time when using Pioneer over the combination of multiple non-integrated applications. A factor of 0.65 was used in the simulation for Pioneer. In addition to the planning application used (Google vs. Pioneer), the two types of users (prone to motion sickness or not) was also distinguished. For users who are not prone to motion sickness, the quality of in-vehicle time reduces as they are consumed by planning in-vehicle. Figure 3 shows that at Point A, passengers using non-integrated applications are limited to 12.5 minutes of planning per destination. If they require more planning per destination, then they will need to either continue their planning in-vehicle (thereby reducing in-vehicle quality) or do the planning out-of-vehicle (thereby increasing overall trip time). With a factor of 0.65, it can be seen that using Pioneer allows passengers to achieve the equivalent of 20 minutes (an extra 8.5 minutes) of planning per destination.

FIGURE 3.
Total travel time for multi-destination journey with varying planning time
Figures 4(a) and (b) show how the in-vehicle time becomes consumed by planning for passengers willing to plan during this time. The vertical scale on the right represents the in-vehicle time quality, with 100% representing “good quality” due to no planning in-vehicle and 0% representing “poor quality” for planning during the entire duration in-vehicle. As more planning is performed in-vehicle, it reduces the passenger’s in-vehicle time quality, particularly with lower waiting times (i.e., more frequent PT services). For destinations 20 minutes apart, this occurs when more than 25 minutes of planning is desired but the waiting time is less than 4 minutes. This corresponds to the entire trip (i.e., both waiting and in-vehicle times) being fully consumed with planning and requiring more time while planning is undertaken. This scenario could correspond to a tourist who thoroughly plans in a large city with frequent PT services.

**FIGURE 4.**
Simulation of quality of in-vehicle time for Google (a) and Pioneer (b)
**User-Preference Survey**

Results showed that the participants found Pioneer to be advantageous over other trip planning provisions for its capability to plan multi-destination trips, and most intended to use the application to plan their future journey with PT. Approximately 80% intended to use the application given known address of their destinations, and approximately 67% intended to use Pioneer if the search function is required. Further analysis of the data showed that of the 21 participants, only 1 (a domestic student) denoted that he would not consider using Pioneer when planning a multi-destination trip requiring the entry of known addresses due to the inconvenience resulting from “bugs” when using Pioneer. This is not necessarily a negative statement towards Pioneer, but merely an implementation shortcoming in the current prototype. When it came to performing trip planning with multiple destinations requiring the search function, all participants denoted they would consider using Pioneer.

Three items were used to assess participants’ perceived ease of using the PT network given a personalized information system such as Pioneer. Response was measured by a 5-point Likert scale, with 1 being “strongly disagree” and 5 is “strongly agree.” Results indicate that Pioneer lowered apprehension and improved the ease of navigating Auckland’s PT system. Approximately 67% of participants selected “agree” or “strongly agree” in response to “Personalized information helped me use the network more easily,” and 67% selected “agree” or “strongly agree” that they felt more confident when traveling in unfamiliar areas; 58% stated that it reduced anxiety and stress during their journeys. This finding emphasizes the need for personalized information to increase travelers’ willingness to use PT, particularly for more intricate multi-destination trips. It supports the findings by Chowdhury and Ceder (2013), which states that high-quality information improves users’ control beliefs, leading to a stronger intention-behavior relationship.

Participants were asked to rate the features of Pioneer from most to least useful. The features included real time, multi-destination planning, duration time, search function, walking direction, and route recalculation. In total, 80% of the participants ranked multi-destination planning as the most useful feature, with another 10% specifying it as the second most useful. A total of 10% of the participants specified the feature allowing participants to incorporate duration times within their trip plan as the most useful, with another 45% specifying it as the second most useful feature. Another notable feature was the integration of the search function as a useful feature (despite the shortcoming with Pioneer’s stability), and features such as walking directions and real-time capability were considered less useful in comparison. This helped identify the importance of assisting users in planning complicated multi-destination trips.

**Discussion**

Overall, the results of the study demonstrated the importance of personalized information for PT users’ multi-destination trip planning. In terms of the cognitive effect of Pioneer on PT use, 80% of the 21 participants commented that the application reduced the effort required for multi-destination trip planning and assisted with journeys in unfamiliar areas of the city. Features such as specifying durations at each
intermediate stop and adding multiple destinations throughout the journey eased the creation of user-specific routes for the 21 participants. As for the operation of Pioneer, the application was capable of saving the time taken to plan trips and reduce total travel time. This capability of the application can especially be appreciated by tourists who desire to optimize their limited time in an unfamiliar city; Pioneer allows them to see the “whole picture” in developing their trip plan.

This research contributes to existing literature by demonstrating that real-time, en-route information through smartphone applications that allows exploration features can assist PT users in making multi-destination trips. The main limitation of the study is the small number of participants in the trial. Therefore, the results are indicative and require future research. The proposed approach has been implemented in the form of a free-to-use Android application that has been released as an open source software project and allows developers to freely adapt and expand the application for the needs of their city. It also provides researchers with a platform in which they can continue future research on smartphone applications for trip planning.

Conclusion
Public transport (PT) users require well-integrated information systems to use a network efficiently. Auckland Pioneer was developed for multi-destination trip planning for both commuters and tourists by providing the capability to search places of interest integrated with real-time PT route information. A test trial consisting of 21 participants was conducted at Auckland. A total of 80% of the 21 participants commented that the application reduced the effort required for multi-destination trip planning and assisted with journeys in unfamiliar areas of the city.

This paper presents two contributions to existing literature. First, the impact of planning is modeled and simulated to emphasize the importance of holistic planning approaches for multi-destination PT trips. Second, the proposed approach has been implemented in the form of a free-to-use Android application and released as an open source software project to allow developers to freely adapt and expand the application for the needs of their city. It also provides researchers with a platform in which they can conduct further research on smartphone applications that provide explorative search features. Overall, results of the study have demonstrated the importance of personalized information en-route for PT user multi-destination trip planning.

References


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Analyzing and Assessing the Experience of Traveling by Public Transport

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Abstract

The experience of traveling (as an aggregate of sensory impressions in relation to social and psychological needs) has so far rarely been considered as a factor influencing travel and modal choice. This paper proposes a practical way to disaggregate the “travel experience” into its separate components and suggests a procedure to assess the “experiential qualities” of (mainly public) transport services. This assessment allows planners to compare different user groups’ expectations as well as the provider’s strategic objectives. The procedure then is discussed in relation to several recent strands of transport/mobility research that are approaching the travel experience from different points of view. The discussion concludes that much of this recent work has analytical objectives, whereas the present procedure is oriented towards the practical, service planning, and development context. However, the various concepts should be seen as complementary rather than competing, and there is much potential for mutual learning in further developments.

Travel Experience and Transport Planning – Two Different Worlds?

Since the activity of traveling is an integral part of transport (in the sense of moving people or goods), one would expect that transport science has taken some interest in the various ways in which travel can be performed and the different effects these forms have on people and their mobility. However, this has, by and large, not been the case so far. The demand or desire for travel is often considered as a “derived” phenomenon, shaped and explained by time, costs, and spatial factors. From this perspective, studying the journey itself appears to be of secondary importance (for a more detailed critique of this perspective, see Schiefelbusch 2010).

Fortunately, the situation is changing: For some years, the research community has started to broaden its view, and to some extent this can be said about the non-academic professional world as well. Several strands of activity can now be identified which approach what will be called the “travel experience” from different perspectives, although the object of interest is not necessarily referred to as such (see the next section).
This paper presents one of these new approaches—it discusses the experiential dimension of travel and explores possibilities for handling it in transport planning, in particular in the design of public transport services. The “travel experience” is considered as a complement to the existing views, with the overall aim of getting a deeper, more comprehensive understanding of travel behavior and to develop more suitable policy responses.

The ideas presented here are based on research that had two main objectives: first, to identify ways of capturing and structuring the travel experience as such, and second, to establish the way this dimension was handled in planning and implementing public transport services. Due to limited space, this paper focuses on the issue of establishing and assessing the “experiential qualities” of a transport service. It sets out the assessment procedure developed as part of that research together with the terminology used, but leaves aside most of the theoretical framework and empirical results. Readers interested in those aspects are referred to Schiefelbusch (2008, 2010) for further information.

The research and concepts discussed here were developed in the (Western) European context, which is reflected in the material collected (Schiefelbusch 2012), but probably also in an implicit understanding of the role of public transport for society that may be European rather than American or “global.” However, the way in which public transport is organized (as an industry under strong public sector influence) and the ways in which it is produced (as predominantly fixed-route, fixed-timetable bus, light and heavy rail services) does not differ that much. Some specificities are discussed further below. The topic of this paper and its basic idea should therefore be of interest for American as well as for European readers.

The paper proceeds with a synthesis of the research strands that have over the last about 10 years started to address the “travel experience” before the assessment procedure is presented. This is done in four stages: setting out the aim and scope of the process, providing the main definitions used, describing the various stages of the assessment process, and discussing the findings, further development needs, and the potential policy implications.

The Travel Experience as an Evolving Research Topic

A growing interest in the experiential dimension of travel can, without doubt, be observed in the recent past. This applies both to transport research as such and to its neighboring disciplines such as social science mobility research, psychological mobility research, cultural studies of mobility, and marketing. A greater interest in customer orientation, commercial thinking, and efficiency in the public transport sector also plays a role (Schiefelbusch 2010). Technological developments, in particular the rapidly-growing diffusion of ICT devices, offer new possibilities to use travel time for other activities. As a result, the perception of travel time has changed significantly over just a few years (Lyons, Jain, Susilo 2011; Gripsrud, Hjorthol 2012).

Table 1 provides a very brief overview of the main strands of recent research. Such a synthesis inevitably includes generalizations and imprecision. In particular, it should be
noted that interrelations between the different approaches can exist. Furthermore, the allocation of the studies shown to just one of these approaches cannot always do them justice in terms of the issues and methods they deal with.

### TABLE 1. Synthesis of Research Strands

<table>
<thead>
<tr>
<th>Type of Approach</th>
<th>Studies (Examples)</th>
<th>Relation to Travel Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Travel time use</td>
<td>Flaig, Kill (2004), Lyons, Jain (2007), Jain, Lyons (2008), Tillema, Schwanen (2009), Berry, Hamilton (2010), Lyons, Jain, Susilo (2011), Gripsrud, Hjorthol (2012)</td>
<td>Travel time (in public transport) is conceptualized as a potential occasion for other activities, which can be both work and leisure-related. In addition to activities, it may also be useful as “transition time.” This challenges the traditional classification of travel time as unproductive or useless.</td>
</tr>
<tr>
<td>(2) Travel as activity in its own right</td>
<td>Heinze (1979), Mokhtarian, Salomon (2001), Mokhtarian (2005), Ory, Mokhtarian (2005), Diana (2008)</td>
<td>The notion of mobility as purely derived from external demands is modified by acknowledging that it can to some extent/in some circumstances have an appeal in its own right (see Figure 1).</td>
</tr>
<tr>
<td>(3) Sensory dimension of physical mobility</td>
<td>Schulz et al. (2000), Steg (2005), Gardner, Abraham (2007), Dick (2009), Lois, Lopez-Saez (2009), Basmajian (2010)</td>
<td>Physical/corporeal mobility is perceived as exposing the traveler to sensory and cognitive experiences (acceleration, lateral forces, driving skills, etc.), with much variation according to situation and mode. These experiences can be seen positively or negatively.</td>
</tr>
<tr>
<td>(4) Mobility and lifestyle</td>
<td>Götz et al. (1998), Zahl; Götz (2001), Hunecke (2009), van Acker et al. (2010)</td>
<td>Mobility is embedded in the way of life and as such influenced by personal values, priorities and attitudes, including importance given to mobility (see Figure 1).</td>
</tr>
<tr>
<td>(5) Mobility as practice of everyday life</td>
<td>Schwanen, Dijst (2002), Lyons, Chatterjee (2008), Poppitz (2009)</td>
<td>As before, the focus may be seen more on the practical requirements of organizing everyday life by means of mobility.</td>
</tr>
<tr>
<td>(6) (Perceived) quality of service of (public) transport</td>
<td>Werner (2001), Susnie, Jurkauskas (2001), Hensher et al. (2003), Kittelson &amp; Associates (2003), Hensher, Mulley et al. (2010), Friman (2010), Rietveld (2005)</td>
<td>Following from the general definition of quality as fulfillment of predefined criteria, the quality perceived by the users of a transport service is related to the experience during the trip and influenced by both measurable and subjectively perceived parameters.</td>
</tr>
<tr>
<td>(7) Transport and well-being</td>
<td>Ettema et al. (2010), Olsson, Gärling et al. (2011), Jakobsson Bergstad, Gamble (2011), de Vos et al. (2013)</td>
<td>Based on the concept of well-being as an overarching objective, the potential contribution of mobility is examined.</td>
</tr>
<tr>
<td>(8) Comfort and convenience in transport</td>
<td>Crockett, Hounsell (2005), Cantwell et al. (2009), Buys, Miller (2011), Blainey et al. (2012)</td>
<td>Convenience or comfort quite often emerges as an important parameter of mobility in several surveys, which has a clear link to the experiential dimension. A major challenge lies in the operationalization of these concepts.</td>
</tr>
<tr>
<td>(9) Policy impact assessment</td>
<td>Kottenhoff (1999), Bamberg (2011)</td>
<td>Evaluation and impact analysis studies of policy measures that take into account their psychological effects.</td>
</tr>
<tr>
<td>(10) Design of vehicles, services, etc.</td>
<td>Kottenhoff (1999), Bates (2004), Dziekan (2008)</td>
<td>The travel experience is shaped by the design of the travel environment, whose perception by the users is captured through surveys, experiments, observations, etc.</td>
</tr>
<tr>
<td>(11) Customer experience research (in general)</td>
<td>Kagelmann (1999), Oriade (2008), Carrera et al. (2013)</td>
<td>Assessment of the perception of a service, based on a holistic, customer-focused view (for example, in tourism and leisure studies)</td>
</tr>
<tr>
<td>(12) Travel experience as a result of service features and psycho-social needs</td>
<td>Schönhammer (1998), Klühspies (1999), Perone et al. (2005), Guiver (2007), Stradling, Carreno et al. (2007), Urry (2007), Lois, Lopez-Saez (2009), Carrera et al. (2013)</td>
<td>Experiential needs can be linked to psycho-social requirements. Different ways of being mobile are characterized by psycho-social parameters (in addition to others).</td>
</tr>
</tbody>
</table>
One conclusion from this highly-condensed review is that the travel experience can be approached with a range of methods and from a wide range of perspectives. They range from studies that discuss mobility on a very general level to works that seek to evaluate different transport services. Some (in particular, the first two entries) can be seen as evolutions of travel behavior studies that seek to provide data and models on mobility patterns. In most other cases, a social or psychological interest is more dominant.

Very few of the studies listed above discuss the practical consequences of taking such a broader view of travel behavior. An analytical and modeling interest is, by far, the dominant approach. This is not surprising (and legitimate) given the relative novelty of the field and the broad range of research interests behind the above list. However, this means that it is difficult to derive conclusions for transport planners, designers, and managers on how to consider the travel experience as part of their respective roles and tasks. This is the more true the more concrete issues related to the shape of a specific service are considered. In this situation, an awareness of the complex and multi-faceted nature of the travel experience is only of limited value—it is necessary to “break down” this awareness into parameters, procedures, and possible measures that can be understood and applied in this environment.

The procedure presented in this paper seeks to respond to this situation. In the conceptual work, priority was, therefore, given to making the travel experience as a whole accessible for the language and philosophy of transport research and planning. While it has taken inspiration from the different perspectives developed in neighboring disciplines (Schiefelbusch 2008, 2010), the conceptual work itself was undertaken in parallel with most of the works mentioned in Table 1. A comprehensive coverage of the subject with its many dimensions was favored over a high level of differentiation and precision in specialized sub-areas.

Of the research strands listed in Table 1, only those considering the design of vehicles (#10) and, less so, to the quality of service (#6) and the last one can be said to combine an interest the travel experience with a look at the circumstances of different travel environments. In studies analyzing design features, it is to some extent common to compare user reactions to different solutions for seat layouts and the like. However, by focusing on the material dimension, many other influences shaping the travel experience are left out. Quality-of-service research has gained importance in recent years following the growing interest in measuring and assessing the performance of transport providers together with performance-based payment. While the quality perceived captured through surveys is influenced by the travel experience, these measurement methods usually capture aggregates of user impressions, and the range of items included is often not detailed enough to go into more detail.

The approach chosen is most closely related to the last group of studies listed in Table 1, by comparing requirements with product features. The difference lies in the level of analysis and detail—the process was developed with an applied rather than academic focus to allow planners to compare different user groups’ expectations regarding the travel experience and evaluate service concepts in the light of different strategic objectives of the provider.
Aims and Scope of the Present Work

A Wider Perspective on Mobility

The discussion of the travel experience’s different aspects has to start with the question of why somebody is making a journey. There is no doubt that the need to get from A to B is the main driver for mobility, and it is this instrumental perspective which has by far dominated the thinking and doing of transport research so far (Schiefelbusch 2010). But to determine the “travel experience” both in analytical and practical ways, it is necessary to go beyond this understanding of mobility by acknowledging that traveling can also be an activity in its own right, performed for its own (“intrinsic”) sake; the embeddedness of mobility into people’s personal life—not only as a geographical, but also as a mental link between activities (Meier-Dallach 2004; Jain and Lyons 2008), and the possibility (function) of travel to serve other needs such as a desire for social status, distraction or liberty.

Figure 1 aims to illustrate this by defining three perspectives on mobility—from left to right, “mobility as an activity” focuses on the act of traveling as such, whereas “mobility as a means to an end” is another way of phrasing the traditional, instrumental view of transport planning. Finally, “mobility as a part of life” refers to the fact that traveling has to be seen as part of a wider setting of activities, cultural practices, but also norms and values.

The travel experience, as defined in this paper evidently is linked to the activity of traveling, but can also be influenced by factors not directly related to a specific journey. Moving from left to right in Figure 1, the focus of interest shifts from specific to general, and it becomes more and more difficult to link, for example, the results of lifestyle-related studies, back to concrete manifestations of travel behavior.

Conceptual Issues for Assessing the “Travel Experience”

Comparison, assessment, and selection of alternative solutions to a problem or task are key elements of any planning process. A large number of procedures has been developed to ensure a balanced and comprehensive evaluation of the available options and to arrive at the best possible choice.

Regarding the “travel experience,” the question arises how this can be defined and how this “soft” dimension can be linked to the planning sphere with its traditional focus on “hard” issues such as time, cost, reliability, and capacity. This requires criteria for the description and comparative assessment to be developed, the presence or absence of which can be used as an indicator for the “experiential quality” of the service.
To do so, a compromise has to be found between the multi-faceted nature of the “travel experience” and of the large variety of possible instruments and the need for structuring, standardizing and quantifying the characteristics of all planning processes. It is, thus, necessary to reduce the complexity of the travel experience to a practicable number of elements and to develop a list of criteria and an assessment scale that allows meaningful comparisons in spite of the often limited quality of the input data. Furthermore, the assessment procedure should take account of, and be practicable for, different objects and contexts such as various kinds of interventions and customer groups.

This paper outlines such a procedure for the assessment of the “experiential qualities” of public transport services as well as and of “travel experience instruments.” The following elements need to be part of such an assessment:

1. A comprehensive description of the scheme (transport project, service etc.) under consideration—in particular, regarding its sensory appearance and usability from the users’ point of view.

2. An assessment of the scheme’s impact on the “emotional requirements”—which of these are positively influenced, which ones are compromised?

3. A review of the scheme’s user groups (if possible including their market share) and their expectation—features should be weighted according to the importance given to them.

4. Consideration of the potential users’ reactions to the scheme—both direct and indirect ones.

In this way, the “emotional” strengths and weaknesses of different options become apparent. Combined with data about the resources (costs) required by the schemes, the most viable option can then be chosen. Caution should be used, however, in conducting an economic appraisal (in the strict sense of the word) due to the qualitative nature of many criteria and frequent time lags before the effects can be seen.

Defining and Structuring the “Travel Experience”

Definitions

Travel experience—A commonly-agreed definition of the “travel experience” has not been developed so far. It may be associated with “comfort,” a criterion at least familiar from vehicle design, capacity planning, and also occasionally included in transport models. Yet, a closer look shows that not all aspects that shape the travelers’ perception are related to “comfort.” Aspects such as en-route activities or the outside view can for example hardly be put in the category of “comfort,” but certainly influence the way the journey is perceived. Moreover, these examples (also) show that the “travel experience” is a multi-faceted phenomenon which can mean many different things to the travelers. We define, therefore, the “travel experience” as “the aggregate of sensory impressions a driver or passenger experiences during the course of his or her journey.”
This description includes a variety of impressions—that can be of different origin and can be experienced through all senses, a variety of elements causing these impressions—both “hard” and “soft,” both main roles of traveling—the “active” driver and the more “passive” passenger,” the journey in all its parts, including access/egress, change of modes and breaks or stopovers, and, importantly, the notion of the experience by the mobile person himself; hence, the subjective perception.

Some clarifications may be necessary regarding the scope of “travel” and “experience.” The former may be associated with “traveling” long distance, as in case of going on holiday, and thus linked to relatively rare journeys. However, a focus on such trips is not intended here—the journeys which have to be analyzed can be of any length. Likewise, an “experience” might be understood as a “spectacular,” unusual event that creates a lasting impression. Again, the concept of the “travel experience” must not be considered as limited to such occurrences. The general concept can also be applied to different modes of travel as well, despite of the focus on public transport in the present paper.

**Travel experience instruments**—Based on the “travel experience” as a user-focused phenomenon, we now turn to the “input” activities that are capable of shaping this experience. In public transport, the facts that people who do not necessarily know each other travel together in one vehicle, services are shaped (in terms of service patterns and vehicle design) and operated according to a pre-established plan, and services are provided by an operator rather than the travelers themselves, providing an important, and challenging, framework condition for the development of the overall “travel experience.” We will refer to these activities as “travel experience instruments” or “schemes,” defined as “elements of a transport service that are provided during the journey (including access/egress and waiting times) in order to create emotional impressions, entertainment, or experiences, and, presuming that these elements are usually provided with positive intentions, with the aim of a more attractive and successful product.”

This definition implies a link to a specific journey; hence, general marketing/publicity activities conducted by transport providers—for instance, through advertising—would not be included. These instruments can be conducted by or on behalf of the service provider, but, of course, the travel experience can also be shaped by the passengers and their fellow travelers themselves.

A large variety of interventions can be used here, ranging from small-scale customer service features to vehicle and infrastructure design. Possible solutions also differ in their duration, the number and kind of users targeted, and the service provider’s intentions. The range of options is described in other works by the author (Schiefelbusch 2008, 2012).

**Emotional attractiveness**—The third important term used in this paper is the so-called “emotional attractiveness.” This is part of the assessment process proposed here and described in more detail later in the paper. Based on the considerations provided so far, the “emotional attractiveness” can be defined as “the aggregate of the sensory qualities provided by a transport service or a travel experience instrument, based on a comparison of the service’s or instrument’s characteristics with the range
of psychological, physiological and social expectations the service users may have.”
This definition requires two main inputs: first, a comprehensive description of the
instrument under examination, and second, a set of criteria that can serve as a frame of
reference for the assessment.

The Travelers’ Needs
The discussion of the travel experience’s different aspects has to start with the travelers’
expectations. To determine the “travel experience,” it is useful to look at social science
mobility research, and psychology in particular. In focusing on the individual and,
thus, the transport users’ view, this provides a further set of criteria that can be used
to describe the potential user needs. The following list summarizes the items used by
the author, based on a review of relevant studies from these disciplines. It combines
items that also have a “practical” dimension (the first five items), as well as less tangible
criteria, which are be referred to as “psycho-social needs” in the following.¹

- The transport function refers to the usability of the available services for a
  concrete transport need, as defined by origin, destination, time of travel, and the
  passengers’ needs for a direct journey, as well as assistance in boarding due to a
disability, etc. Good or poor fulfillment of these features has obvious implications
  on the propensity to choose the service and on the users’ satisfaction. It would
  be wrong, therefore, to exclude them from the elements influencing the “travel
  experience.”

- Physiological comfort may be understood as comprising all issues related to the
  passengers’ physical accommodation during the journey, such as the design of
  seats, temperature and ventilation, or luggage storage arrangements.

- Psychological comfort and relaxation refers to the ability of using the service
  without the need to perform driving duties, with confidence and free from
  interferences that create stress (for instance, in cases of crowding, dominant
  behavior of other passengers or feeling disoriented). The freedom from driving
  duties (but not necessarily from other potentially stressful tasks such as finding
  one’s way through the transport system) is a distinguishing feature of public
  transport and a prerequisite to perform other activities (e.g., reading, working,
  listening to music).

- Entertainment and stimulation refers to the already-mentioned fact that travel
  can generate sensory impressions and experiences that may be perceived as
  valuable in their own right. Entertainment may be provided by the travelers
  themselves or by the operator—for example, through performances during the
  journey or on-board video equipment.

- Travel time may be used for other activities and, thus, serve other needs. An
  obvious example is the possibility to eat or to work on the train.

¹ The sequence of presentation does not indicate relative importance or priority. The definition of the
criteria has been slightly modified since the original work of the author.
• **Communication and contact opportunities**—possibilities for contact with others as a basis for the fulfillment of other needs such as inspiration, mental and corporal vicinity, or appreciation. A simple example is a conversation between passengers sharing a compartment.

• **Image and prestige**—the individual transport user’s possibilities to “produce” his/her image and influence the others’ view of oneself by the way mobility is performed. This may be influenced through image-building for the service in general or branded services for certain groups, like “premium services” (Rideout 2009; a recent example being the “Leap” service in San Francisco, Weinberger 2015).

• **Substitution for a friend or a partner**—possibility to build up a “relationship” with the vehicle, which offers the feeling of being understood and to compensate other communicative deficits.

• **Physiological stimulation** refers to the sensory effects caused by the movement itself (acceleration/deceleration, vibrations, lateral forces). Trips on historic vehicles, open cars, or the like (e.g., the San Francisco Cable Car) provide such experiences.

• **Feeling of freedom and thrill** goes beyond this. It describes the stimulation obtained by a self-controlled exposure to “exciting” influences. In the regulated public transport environment, such experiences are evidently difficult. A now-historic example is the well-known London Routemaster bus with its open rear platform onto which passengers could jump on and off with the vehicle moving.

• **Regulation of aggression and social fears**—possibilities to “let loose” one’s emotions, to let emotions run free, in particular to compensate previous negative experiences elsewhere, in order to re-obtain the personal psychological balance. A passenger playing a simple video game on his/her computer after a stressing day of work may serve as an example.

• **Finding identity and meaning**, contribution to a meaningful and satisfactory life. Mobility can contribute to this as an activity, but also indirectly as an objective to which one devotes time and resources (such as volunteering for a transport heritage scheme or saving money for a long holiday).

• **Regulation of privacy** sums up possibilities to delineate a personal territory and to obtain a “personal space” that can be designed and controlled independently. Public transport can respond to this—e.g., by differentiated seating arrangements.

When using these criteria, some limitations of the present list must be kept in mind. First, it aims to be comprehensive but does not exclude overlaps between the individual criteria. Second, the items should not be understood as the “final word” in terms of their terminology and delineation. They are open to refinements and modification in detail in subsequent research. However, the basic layout of the procedure presented below should be considered independently from such modifications. Third, there are obvious incompatibilities between some of the criteria (for example “relaxation” can
hardly be reconciled with “thrill”), so it is unlikely that any service will ever be able to fulfill all requirements at the same time.

The Service Providers’ Views
Whereas the previous section has dealt with the possibilities to shape the “travel experience” as a service provider, the “content” of such activities is, of course, not the only issue to consider. Travel experience instruments can be of large or small scale, permanent or temporary, and can be used on a variety of services.

Furthermore, the provider’s interests have to be considered as well. Although operators can, of course, introduce such offers in response to customers’ needs, they will most likely consider the costs and possible profits from such activities in addition to the mere satisfaction of their clients. Other interests and expectations—for example, the image of the company and longer-term objectives—also may come into play. The provider’s assessment therefore will be based on different criteria. Table 2 presents a set of items to describe “travel experience instruments” from this perspective. As discussed below, these criteria do not have the same relevance on each occasion.

| TABLE 2. Provider’s Criteria for Selection and Development of “Travel Experience Instruments” |
|---------------------------------|---------------------------------|---------------------------------|
| **Criterion**                   | **Definition**                  | **Unit of Measurement**         |
| Resources for development       | Resources required for conceptual work and practical preparation, e.g., investment, planning and preparation costs, time spent by own staff | Monetary units, time (per instrument) |
| Operating costs                 | Costs for providing the service (own and external staff, material, licenses, etc.) | Monetary units (per period or occasion of use) |
| Possibility for standardization | Possible duration of use, ease of repetition in different places and/or at a different time | Time span, qualitative assessment |
| Transferability of an idea      | Independence of the content to concrete locations/occasions | Qualitative assessment |
| Practical flexibility           | Independence of the concept of other features of the service, e.g., requirements of vehicle space or equipment | Qualitative assessment |
| Potential for differentiation   | Possibility to provide the service on a smaller scale, such as only in parts of the vehicle or on a personal level | |
| Compatibility                   | Impacts of instrument on operations and other services | Qualitative assessment, possible measurements in monetary units |
| Willingness to pay              | Possibilities to implement and market the instrument in a way that additional revenue can be obtained (either for a separate premium service or as a part of a general service upgrading) | Qualitative assessment, possibly estimate based on experiences |
| Publicity                       | Attractiveness for media reports due to novelty value or other characteristics, suitability for use in other public relations work | |

The potential for differentiation and the (users’) willingness to pay also are not necessarily connected. The same is true for the decision on the introduction of the instrument and on special charges for it—the provider may, for example, renounce to generating extra revenue for practical reasons. In addition, there are goal conflicts between some criteria as well—for example, between “publicity” and “potential for differentiation.”
Those interested in creating “experiences” also need to be aware of the practical issues and criteria to choose the right elements for their concrete application. The issues to be considered relate, for example, to the type of transport service, customers of the service and possible target groups for experience elements, the necessary resources and the time required for preparation, implementation and—on the users’ side—actual consumption of the experience instrument (such as time needed to watch a film, etc.).

**Assessment Procedure**

**Basic Layout and Case Study**

Having defined the assessment criteria as the “ingredients” of the procedure, this section describes the assessment process itself. It is disaggregated into several stages.

For this presentation, the stages are numbered from 1 to 6, but as Figure 2 shows, they do not necessarily have to be undertaken in this sequence. Each of these stages covers one segment of the overall evaluation and can be used as a separate procedure as well. This also has the advantage of reflecting the various criteria relevant for users and providers (see above) and of making the process more transparent. Different interests can be integrated as well. Figure 2 illustrates the process, which is described more fully in the following sections of this paper.

**FIGURE 2.**

Stages of the Assessment Procedure

Travel experience instruments usually are introduced in an environment of existing public transport services—for example, as a feature of a new series of vehicles or as a service operated for specific occasions or customer groups. Looking at the public transport system as a whole, persons who benefit from these instruments will therefore be found alongside people who do not. In practice, it will not always be possible to distinguish clearly between these two groups. From this, and for the sake of simplicity, the following procedures refer only to those customer groups that have access to the new “travel experience” elements and to those service characteristics the “travel experience instrument” brought into play.

The procedure is demonstrated in the following section using the “Sparrows’ tram” (Spatzenbahn) as an example, a rebuilt light rail vehicle featuring different games for children in a specially-designed interior (Schiefelbusch 2008).
FIGURE 3.
The Sparrows’ tram vehicle was rebuilt from a standard tram car type KT4D, originally to provide a special service and to link the city of Gera with the children’s film festival held there (which has the sparrow as its symbol). It was equipped with several games and simple entertainment features for children of pre-school age to allow them to play during their journey. The seat layout was changed to provide facing seats with tables in between, and an original tram drivers’ dashboard was installed for playful use. Local kindergarten staff advised the transport company on the modifications required.

The tram was in regular service from 2003 to 2013 and was used both for private group hire and in regular service on several days per week. For private hire, a commercial rate was charged whereas during scheduled operation normal fares apply. In regular service, the tram operates coupled to a normal vehicle which provides room for other passengers.

The application of the procedure is presented for this case study in its implemented form, but its greatest value arguably lies in the possibility to compare different instruments in different settings in an easy and transparent way.

The present case study may appear as an unusual example as it refers to a “niche” service targeting a specific customer group and offered only on a single occasion. This observation is correct to some extent, but it is also a reflection of the actual use of travel experience instruments at the time the research was conducted. As discussed in detail elsewhere (Schiefelbusch 2012), initiatives undertaken so far are considered mainly in terms of their publicity value rather than their contribution to service development.

As mentioned earlier, the empirical material for the present work was collected in Europe, specifically in Germany, Austria and Switzerland. The possibilities for developing ideas for the travel experience are perhaps better in this environment than in other parts of the world, because there is a relatively comprehensive public transport offer, based on a political consensus that such an offer is necessary for various reasons. In other words, public transport is neither limited to the most essential commuter
and school services nor stigmatized as a “poor persons’ means of travel” not worth further development efforts, nor are services so heavily used that experience-related interventions are impractical for reasons of capacity.

In this respect, there are certainly differences between countries—in particular, if the situation in North America is considered. However, the situation is quite varied. There are places where public transport has a good reputation and position on the transport market, either traditionally or as result of recent policy changes. Two popular types of “travel experience measure” that are found also in North American are the use of heritage vehicles (either original or re-constructed after historic designs) on light rail systems (Harris 1997; Hobe 2001) and the use of art in the public spaces of metro or train stations (Harnack 2010; Iseki and Taylor 2010).

The Procedure in Detail

Stage 1: “Emotional Attractiveness” from the Users’ Group View

What is considered “attractive” depends on personal preferences and needs. An assessment process suitable for general use cannot be built on one specific set of such preferences. Rather, it must be valid for a variety of such sets that covers all cases relevant in practice.

The passengers’ possible needs regarding the “experiential qualities” of a transport service have been disaggregated into 13 elements. These items are used as criteria for the “emotional attractiveness” in the assessment process. The features of the “travel experience instrument” are analyzed to establish whether they influence any of the criteria described. Points are given for the fulfillment of each criterion. As information on the relevance of the individual criteria is not always available, the scale used is limited to one point for a clear impact and a half point for a limited impact on a criterion. Negative point values also are possible. As mentioned above, conflicts between some criteria do exist as well. Tables 3 and 4 show a model assessment. A total point score is the final result of this stage, defined as the net value of points given for all 13 criteria.
Analyzing and Assessing the Experience of Traveling by Public Transport

Stage 2: Weighting According to User Group Preferences

In the first stage, an inventory of the overall emotional attractiveness has been made. This is now adjusted to the interests of different customer groups. These interests are to be derived from market research or other suitable sources and need to show the respective group’s attitude to the criteria used in the previous stage of assessment. Depending on the quality of these descriptions, weighting factors can be applied to the criteria.

The example shown in the two right-hand columns of Table 4 includes two such “profiles” of customer groups—one interested in experience and entertainment, the other preferring a high level of comfort and personalized service. Target group definitions of this type can be found in the literature; however, their appearance here should be seen as exemplary and does not preclude others. The “weighting” used in this example consists in the elimination of all criteria that can be considered of little or no relevance for these

<table>
<thead>
<tr>
<th>TABLE 3. Assessment of Experiential Criteria—Sparrows’ Tram Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A transport function is given because the service can be used for normal “A to B” journeys (not just round trips).</td>
</tr>
<tr>
<td>• Physiological comfort—neutral as the instrument involved no changes in this respect.</td>
</tr>
<tr>
<td>• Psychological comfort and relaxation—the journey may be passed in a more relaxed way due to the enhanced possibilities for other activities, but stressful situations may also be experienced, such as in the case of arguments over the use of the facilities.</td>
</tr>
<tr>
<td>• Entertainment and stimulation is provided by possibilities to play and re-enact tram driving at the second drivers’ desk.</td>
</tr>
<tr>
<td>• Other uses of travel time are facilitated by the games provided, but as these can also hinder other activities, the effect is only considered to be of limited effect. The fact that children probably prefer to use the Sparrows’ Tram may contribute to a more quiet atmosphere in the other part of the train, facilitating other activities there as well.</td>
</tr>
<tr>
<td>• Communication and contact opportunities—positive impacts because the modified interior design with facing seats and games supports interaction between passengers. Limited positive impacts, because the games used are not specifically aimed at groups.</td>
</tr>
<tr>
<td>• Image and prestige—potential positive impacts can be assumed because the service is targeted at a specific group (children/parents).</td>
</tr>
<tr>
<td>• Substitution for a friend or a partner—limited positive impacts because of the finite possibilities to play, which can lead to new acquaintances or distract from feelings of loneliness.</td>
</tr>
<tr>
<td>• Physiological stimulation—neutral as the instrument involved no changes were made in this respect.</td>
</tr>
<tr>
<td>• Feeling of freedom and thrill—neutral as the features of the instrument can be assumed to have only a marginal impact in this respect.</td>
</tr>
<tr>
<td>• Regulation of aggression—positive effects due to the possibilities for playing.</td>
</tr>
<tr>
<td>• Finding identity and meaning—limited positive impacts assumed because a figure with relevance for the city’s identity (the sparrow) features in the design of the service and its presentation to the public.</td>
</tr>
<tr>
<td>• Regulation of privacy is supported because the seating arrangements structure the vehicle into pseudo “compartments”; furthermore, playing offers further possibilities to designate a “personal” space.</td>
</tr>
</tbody>
</table>

Criteria for which no impact was established (neutral) are not mentioned here.
Analyzing and Assessing the Experience of Traveling by Public Transport

TABLE 4.
Establishment of “Emotional Attractiveness” – Results of Stages 1 and 2

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Example Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage 1 General</td>
</tr>
<tr>
<td>Transport function</td>
<td>+ 1</td>
</tr>
<tr>
<td>Physiological comfort</td>
<td>0</td>
</tr>
<tr>
<td>Psychological comfort and relaxation</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Entertainment/stimulation</td>
<td>+ 1</td>
</tr>
<tr>
<td>Other use of travel time</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Communication and contact</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Image and prestige</td>
<td>+ 1</td>
</tr>
<tr>
<td>Substitute for a friend/partner</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Physiological stimulation</td>
<td>0</td>
</tr>
<tr>
<td>Freedom and thrill</td>
<td>0</td>
</tr>
<tr>
<td>Regulation of aggression</td>
<td>+ 1</td>
</tr>
<tr>
<td>Identity and meaning</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Regulation of privacy</td>
<td>+ 1</td>
</tr>
</tbody>
</table>

**Results – Stage 1**

- Maximum/minimum possible score: +/- 13
- Points obtained (example): + 7.5
- Points obtained as percentage of total: 57

**Results – Stage 2**

- Group-specific maximum/minimum score: +/- 9
- Points obtained (example): + 5.0
- Points obtained as percentage of total: 55

xx = criterion not considered for this target group
n/a = not applicable

**Stage 3: Characteristics of the Instrument from Provider’s View**

To consider the “travel experience instrument” from the provider’s point of view, the items shown in Table 2 were used as assessment criteria. The value under review has to be analyzed regarding its impact on each criterion.

As a general rule, solutions that offer the best possible “benefit” with lowest possible costs are evidently the most attractive ones from an economic perspective. However, what counts towards both benefits and costs is not necessarily clear-cut; neither is it easily possible to quantify or monetarize all possible items, in particular when the limitations of data availability that often exist in practice are considered. Furthermore, the “size” of possible solutions varies greatly, ranging from short-term small-scale interventions to long-term investment decisions. Hence, costs and benefits also have to be seen in proportion to the level of resource inputs.
The scale used, therefore, is again kept intentionally simple, allowing the assessment to be made based on qualitative evaluations. The value of the travel experience instrument’s contribution to each criterion is expressed as “low,” “medium,” or “high.” A value of 1, 2, or 3 points, respectively, can be allocated per criterion, as shown in the second column of Table 5. Intermediate results have been permitted as well. If the solution can be developed in different ways, the results have to be distinguished according to the circumstances. In the example, this applies to the different degrees of willingness to pay for the instrument if it is offered as a part of normal operations on the one hand or as a separate activity (private hire of the complete vehicle for a group) on the other. As in Stage 1, a total point score for the proposed instrument can thus be established.

### Table 5. Service Characteristics from the Provider’s Strategy Point of View

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Example Value</th>
<th>Stage 3</th>
<th>“Public Attention Strategy”</th>
<th>Stage 4</th>
<th>“Comfort Strategy”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>General Assessment of Importance (c)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Resources for development</td>
<td>2</td>
<td>high</td>
<td>4.0</td>
<td>medium-high</td>
<td>3.0</td>
</tr>
<tr>
<td>(2) Operation costs</td>
<td>3</td>
<td>medium-high</td>
<td>4.5</td>
<td>high</td>
<td>6.0</td>
</tr>
<tr>
<td>(3) Possibility of standardization</td>
<td>3</td>
<td>low-medium</td>
<td>1.5</td>
<td>medium-high</td>
<td>4.5</td>
</tr>
<tr>
<td>(4) Transferability of an idea</td>
<td>3</td>
<td>low-medium</td>
<td>1.5</td>
<td>high</td>
<td>6.0</td>
</tr>
<tr>
<td>(5) Practical flexibility</td>
<td>3</td>
<td>medium</td>
<td>3</td>
<td>medium-high</td>
<td>4.5</td>
</tr>
<tr>
<td>(6) Potential for differentiation</td>
<td>2.5</td>
<td>low</td>
<td>0.625</td>
<td>high</td>
<td>5.0</td>
</tr>
<tr>
<td>(7) Compatibility</td>
<td>3</td>
<td>low</td>
<td>0.75</td>
<td>medium-high</td>
<td>4.5</td>
</tr>
<tr>
<td>(8) Willingness to pay</td>
<td>(a) in scheduled service:</td>
<td>low</td>
<td>(a) 0.25</td>
<td>(a) 2.0</td>
<td>(b) 0.75</td>
</tr>
<tr>
<td></td>
<td>(b) for private hire:</td>
<td>3</td>
<td>(b) 0.75</td>
<td>high</td>
<td>(b) 6.0</td>
</tr>
<tr>
<td>(9) Publicity</td>
<td>2</td>
<td>high</td>
<td>4.0</td>
<td>low</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Results Stage 3

- **Maximum possible score**: 27
- **Points obtained**
  - (a) 22.5
  - (b) 24.5
- **As percentage of total**
  - (a) 83%
  - (b) 91%

### Results Stage 4

- **Interest-specific maximum score**: 24.75
  - (a) 20.125
  - (b) 20.625
- **Points obtained**
  - (a) 10.125
  - (b) 10.625
- **As percentage of specific total**
  - (a) 81%
  - (b) 83%
  - (a) 84%
  - (b) 94%

(a) In scheduled service.
(b) For private hire.
(c) Values shown are the numerical equivalents of the assessment of importance: 3 = high, 2.5 = medium-high, 2 = medium, 1.5 = medium-low, 1 = low. Note that for the two cost-related criteria (1) + (2), a “low” estimate is desirable; hence, given the value of 3, for the others, a “high” value.
The assessment of the “Sparrows’ Tram” case study from the provider’s point of view shown in Table 5 is based on the following considerations:

- **Resources for development**—moderate requirements, because the vehicle was rebuilt in the company’s own workshops using mainly existing spare parts and some donations.
- **Operation costs**—low; the converted unit replaced a normal one, so no extra staff or energy costs were caused.
- **Possibility of standardization**—good; the various parts were robust, required very little maintenance, and the vehicle could be used without modification for a long time.
- **Transferability of idea**—although the vehicle was rebuilt for the occasion of the local children’s film festival, the basic idea of a special “playground” vehicle appears transferable to other locations.
- **Practical flexibility**—high, because the vehicle could be used on the whole network without restrictions as before.
- **Potential for differentiation**—rather good, because the use of the Sparrows’ Tram in a two-vehicle train unit allowed to separate the targeted user group from other passengers. But as adults were not prevented from boarding the tram either, this separation was not guaranteed.
- **Compatibility**—the vehicle could be used alongside others in everyday service and did not require changes to schedules or other procedures.
- **Willingness to pay**—during the tram’s use in regular service, some additional trips may have been made because of its special features, but this effect is likely to be marginal. The implementation of the concept does not lend itself to a special fare (honor system, no permanent staff available for checking). However, extra revenue was generated for private hire use of the vehicle.
- **Publicity**—the start of the instrument provided a good occasion for positive publicity, but only very limited chances to repeat this during the later use of the vehicle.

**Stage 4: Weighting According to Provider’s Strategy**

As in case of different user groups, transport providers are likely to have different expectations and objectives guiding their decisions. This will impact on their attitudes towards any action taken. The assessment process would have to reflect these differences adequately.

The empirical work done by the author (Schiefelbusch 2012) identified two main reasons why public transport operators implement features to enhance the “travel experience”:

- **public visibility and attention**—such a service is seen as an opportunity for positive media coverage and to position the company as forward-looking, modern, customer-focused and linked to the community it serves.
• **customer service and comfort**—“travel experience instruments” are seen as an essential part of providing a high-quality, comprehensive service either in general or for specific markets.

These two strategies imply that the assessment criteria described in Table 2 are of different importance. This is operationalized by applying weighting factors for each criterion, as shown in the right part of Table 5. Again, this differentiated view leads to a different theoretical maximum score per strategy and different degrees of fulfillment for the same instrument according to the strategy chosen as reference.

**Stage 5: Comparison of User Group and Providers’ View (Interest-Specific)**

The previous stages have assessed the features of a “travel experience instrument” from different perspectives. All of these views produce a result that is meaningful in its own right. However, decisions on how to proceed with different planning options (in this case, concepts for “travel experience instruments”) also will require an aggregate view that sums up the different stages of assessment.

A comparison of the users’ and providers’ views is useful to see if they rate the same concept similarly. Stage 5, therefore, consists of a comparison of the perceived worth shown in the user group-specific (Table 4) and provider strategy-specific (Table 5) assessment. The different point scales used in previous stages 2 and 4 can be standardized by expressing the points obtained as percentages of the relevant theoretical maximum score (bottom lines of Tables 4 and 5). These can be compared either manually or by calculating an average of the results for each assessment. Similarities and diverging assessments become apparent. Service developers can then decide how to proceed, using also other background information like the specific costs of the different instruments or their potential customer base.

This assessment at first can be done for specific user groups and provider strategies. The rationale behind this is that each operator has (or should have) an idea of its strategy and objectives regarding the experience quality provided for its customers. From these follow the market segments the operator will focus on. For example, an operator that follows the “comfort strategy” will aim to develop its services accordingly and he will target “comfort oriented” customers in particular. However, in practice it is of course not always possible to “match” user and provider perspectives in this way.

**Stage 6: Summary of Interest-Specific Assessments**

Stage 5 has produced a result for a specific user group-strategy combination. This setting, however, is not always given in reality. Many public transport providers indeed cater for a wide range of user groups which mix on all services they offer, without (much) the opportunity for creating targeted services.

In a situation in which different user groups are mixed, their preferences should be considered in a comprehensive way by comparing each group’s preferences with the features of the proposed service, followed by a weighting according to their market share and summing up of all group-specific results. This would give an “average experiential attractiveness” indicator. In mathematical terms:
Total experiential = \sum \text{group-specific attractiveness} \times \text{Group's share of attractiveness rating all customers (a)}

(a) = expressed as fraction (0. . . ) of total

This assessment evidently requires some information about the customers’ attitudes towards the “experiential qualities” of their transport service—the more specific, the better. As discussed below, such information is only rarely available to determine the value of specific “travel experience instruments,” but some conclusions may be derived from more general travel behavior surveys, provided they include questions on attitudes towards travel and different modes of transport and/or travel time use. In the absence of such information, some issues could be assessed based on small-scale qualitative surveys or focus group discussions or (as a last resort) by trained service developers making practical assumptions based on common sense.

On the provider’s side, the absence of a specific strategy directed at certain user groups may be compensated for by defining one general set of operator priorities and weighting factors for the parameters shown in Table 5. Both sides’ views can be compared following the same principles as outlined in stage 5.

**Synthesis**

Across its different stages, the procedure outlined here produces a range of results. These will be more or less useful depending on the specific interest of the user. The indicators described above are probably the more useful, the more they can be put into a wider perspective by comparing different instruments or looking at the expectations of different customer groups. Such comparisons cannot be made here in full detail due to space limitations, but some interpretation of the assessment results from above can nevertheless be provided:

- **General “emotional attractiveness”—**the total value of 7.5 points or 57% of the theoretical maximum does not appear particularly good at first sight. However, the wider experience with the procedure shows that this rating is at the top end of what is achieved in practice. Reasons for this lie in the inevitable conflicts between some requirements and in the fact that some of these are hard to address in the public transport environment in general.

- **Suitability for different interest groups**—the instrument appears slightly more suitable for “comfort-oriented” than for “entertainment-oriented” customers, which is somewhat surprising given the first impression of the instrument. Two observations can be offered to explain this: first, the instrument addresses some criteria deemed important for “entertainment-oriented” customers not sufficiently (values 0 or + 0.5 in Table 4), and second, a comparison with other instruments shows that more “intensive” entertainment features can be offered to target such an audience. Furthermore, it should be borne in mind that other target groups may be defined as well— in this case for example “parents with small children.”

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2 For more details, in particular on the characteristics of other schemes, see Schiefelbusch 2012.
• Providers’ strategies—Table 5 shows that the concept is rated positively in most respects, which is reflected in both the general and the strategy-specific results. The main “weakness” lies in the concept’s limited publicity value, contributing significantly to the lower overall rating from a “public attention strategy.” This impression is also confirmed if the Sparrows’ Tram is compared with other concepts.

• Match between customer and provider perspectives—the above indicates that the Sparrows’ Tram concept performs quite well in all assessments undertaken so far. Such a synthesis of results must be interpreted with two questions in mind. First, which overall values are achieved; hence, how does the concept “perform” in relation to the requirements and in comparison with alternative solutions? Second, are there conflicts between the various assessments that may result in problems once the instrument is applied and which have to be addressed—for example, if different customer groups have contrasting views about the concept, is it feasible to separate them?

Discussion

Possibilities and Needs for Further Development

As discussed earlier, the travel experience has in recent years become a matter of interest in different strands of mobility-related research. Compared to these, the present concept proposes a somewhat different view. Rather than mutually exclusive, the different ideas have to be seen as complementary. The procedure outlined earlier should be seen as a starting point that needs refinement, which in pursuing this can benefit significantly from other research. At least three possibilities for doing so come to mind:

• Analytical research into travel time use, the sensory perception of travel, and the like can provide information on the perception of different service elements in a much more detailed way. Condensed into suitable indicators, such information can inspire the assessment of concrete planning and policy options, for example, specifying the parameters used here (stages 1 and 2). From a practical perspective, it is not realistic to presume that such values can be established empirically for each single case.

• Furthermore, the longer-term effects of service instruments require attention. Following the choice of focusing the present procedure on the transport service itself, these inevitably are not adequately reflected.

• The present procedure focuses deliberately on the experiential dimension. But in reality, this dimension must be seen alongside with other expectations and transport system characteristics like speed, reliability, or capacity. It may be reasonably straightforward to integrate experience-related questions in surveys for analytical purposes, but the joint use of such information in subsequent planning procedures has yet to be worked out.
The procedure is also an attempt to strike a balance between the structured, often quantitative ways of thinking with which the transport industry is well familiar, and the multi-faceted, subjective nature of this phenomenon.

Another reason for the lack of more detail in the above-mentioned procedures is the scarcity of reliable information. At the time the research was conducted (early 2000s), “travel experience instruments” used in public transport were rarely evaluated comprehensively, sometimes not at all, and often limited to an assessment of their publicity impact (Schiefelbusch 2012). Very little is known at present about the perception of different service elements and their effects on the travelers’ needs discussed above. Growing research in this field hopefully will contribute to changing this situation in the future.

In this respect, it is interesting to note that the current list of transport-related topics in the EU’s main research and innovation program “Horizon 2020” proposes a reassessment of paradigms in transport planning and decision making with explicit reference to the changing role of travel time. Although travel time savings were “often the principal benefit[s] of a transportation project ... as technology evolves ... people can use their time during travel for business or leisure thus reducing the cost of travel in economic terms and allowing other considerations ... to affect their travel time preferences” (anon. 2015, topic MG-8.5-2017). This resonates with some of the recent research strands described in Table 1 (in particular, the first one) and should give rise to a reassessment of other aspects of the travel experience as well.

**Policy Interest**

A better understanding of the factors influencing the “travel experience” can help to explain why mobility choices are made the way they are and open new “soft” options to change travel behavior. In times where lifestyle and status-driven considerations can affect decisions more than practical requirements, the importance of this field has risen (van Acker et al. 2010; Choo and Mokhtarian 2004).

For products with clear emotional characteristics, a positive image can be developed more easily. This will be of use for marketing these products to the end users, but also improve their in the political arena; policy options that do not have enough political appeal are more easily overlooked when resources are allocated.

The rationale for addressing these issues lies not only at an analytical level. Transport research has from time to time acknowledged the emotional dimension of mobility, in particular the appeal of the private car (e.g., Czerwenka 1998; Marsh, Collett 1991; Redshaw 2007; Verron 2004) but failed to consider it in its actual analytical and planning work. Given the widely- and long-known problems caused by current levels of car traffic, it is timely to address this deficit—in particular, times in which lifestyle and status-driven considerations often affect consumer decisions more than practical requirements (Holt 1997; Zahl and Götz 2001; Ory and Mokhtarian 2005).

But the situation in transport is also characterized by a modal imbalance. Unlike transport planning, the car manufacturing industry has known and used the “emotional appeal” of their products since their invention (Vaillant 1995; Schönhammer 2000;
Langzaam Verkeer 2002; Lois and Lopez-Saez 2009). Over time, car design and marketing has made ever greater use of the emotional dimension of travel, with great success in the transport market. For public transport, the opposite development can be observed—its character as a “collective” service already leads to a different emotional profile and limits its possibilities to compete with the car (Klühspies 1999). But regulation, lack of political interest, and the focus on technical issues and operational efficiency have equally led to a neglect of these issues. It may seem a novel idea, but concepts for “emotionally attractive” public transport (and also walking and cycling possibilities) are a necessary step to secure its role in the future.

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References


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Perceptions of Crime Prevention Through Environmental Design (CPTED) at Australian Railway Stations

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Abstract

Personal safety and security are essential criteria for measuring the quality of public transport, and research has consistently demonstrated that crime and fear of crime affect levels of patronage. Although authorities throughout the world are implementing Crime Prevention Through Environmental Design (CPTED), research and practice commonly focus on the elements of surveillance, territoriality, and controlling access. Few studies have investigated the CPTED concepts of “image management” or “geographical juxtaposition” (the surrounding environment). This research compares and contrasts the perceptions of rail users and security experts in relation to two railway stations in Perth, Western Australia. One station was designed in accordance with CPTED principles, and one was not. Interestingly, the findings indicate that the rail users perceived the station that was not designed using CPTED to be marginally safer and to exhibit slightly higher levels of CPTED qualities. This exploratory investigation suggests that the effectiveness of CPTED is mediated by the local environment surrounding each station and its associated image.

Introduction

One of the essential criteria for measuring the quality of public transport is safety and security (Dragu, Roman, and Roman 2013). Although “crime on public transport is relatively rare” (Batley et al. 2014, 33), research has demonstrated consistently that crime and fear of crime can affect levels of patronage (Crime Concern 1997, 2002, 2004; Cozens et al. 2004; Delbosc and Currie 2012). Patronage levels could be more than 10% higher if people felt more secure when traveling and waiting at railway stations (Crime Concern 2002, 2004).
Crime Prevention Through Environmental Design (CPTED) has been increasingly used to reduce crime on public transport and, in particular, in and around railway stations (Carr and Spring 1993; Loukaitou-Sideris and Banerjee 1994; Department of Transport and the Regions 1998a; Cozens 2003a, 2003b, 2004). However, most research and applications of CPTED have concentrated on Newman’s (1973) concepts promoting surveillance and territoriality (e.g., La Vigne 1996, 1997; Department of Transport and the Regions 1998b; Cozens 2002, 2003a, 2003b, 2004) and in managing graffiti and vandalism (Sloan-Hewitt and Kelling 1997; Thompson et al. 2012).

This study explores the relatively under-researched CPTED elements of image and stigma and geographical juxtaposition in relation to two railway stations in Perth, Western Australia (WA). Furthermore, since the research indicates there are reported differences in the perceptions of “experts” and the general public (Groat 1982; Devlin 1990; Downing 1992; Purcell and Nasar 1992; Stamps and Nasar 1997), this research compares rail users’ and security “experts” perceptions of crime, image management, geographical juxtaposition, and CPTED at two railway stations in WA. One of these stations was designed using CPTED and the other was not.

Crime Prevention Through Environmental Design (CPTED)

Perceptions of safety are influenced by many factors, including the built environment and the design of railway stations (Gilling 1997; Smith and Clarke 2000; Schmucki 2002; Cozens et al. 2002, 2003a, 2003b, 2004; Smith 2008; Sorensen, Hayes, and Atlas 2008; Vilalta 2011; Delbosc and Currie 2012). Thus, it follows that good environmental design may decrease crime and fear of crime. CPTED is now a relatively common approach used to reduce crime and the fear of crime in and around railway stations (La Vigne, 1996; 1997; Department of Transport and the Regions 1998b; Cozens 2002, 2003a, 2003b, 2004; Batley et al. 2012).

A recent review of the UKs Secured Station Scheme (SSS) reveals that reductions in crime (e.g., theft from the person, criminal damage, and vehicle crimes), higher levels of personal safety, and increases in patronage were associated with stations which were awarded SSS accreditation (Batley et al. 2014). This scheme was launched in 1998, and more than 1,250 stations have received accreditation (Batley et al. 2014) based on three criteria: (1) stations must achieve a specific ratio of crimes per passengers, (2) stations must achieve a high CPTED audit score, and (3) stations must demonstrate adequate management processes and low levels of passenger perceptions of crime (DETR 1998a, 1998b). Crucially, accreditation is for a two-year period, after which re-accreditation is necessary.

CPTED focuses on seven key concepts—territoriality, surveillance, image management, activity support, access control, target hardening, and geographical juxtaposition (see Figure 1). These ideas have been presented at length elsewhere (e.g., see Cozens et al. 2005; Ekblom 2011; Cozens 2014; Cozens and Love 2015) and are discussed briefly below.
Territoriality refers to designing spaces in a way that provides a sense of ownership and proprietary concern by residents/users so that they potentially are more likely to act as guardians. This might involve intervening in some way if they witness a crime (e.g., call the police) and includes the use of signage, fences, and barriers to define public and private spaces. Territoriality may alert offenders that certain behaviors are unacceptable and that criminality is more likely to be observed and reported (Sorensen, Hayes, and Atlas 2008).

Surveillance is about how design can enhance visibility, since most offenders do not want to be noticed. It can be promoted or hindered by environmental design and can influence crime and the perceptions of safety of those using such spaces (Newman 1973; Nasar and Fisher 1993; Schmucki 2002; Cozens et al. 2004; Moore 2010). The use of closed circuit television (CCTV) and security guards is another means of promoting the opportunities for surveillance, which can also help to reduce crime and the fear of crime (Ziegler 2007).

Access control is related to territoriality in that it helps define private and public space and controls who enters a specific site, building, or room and can include card entry systems, bollards, fencing, and walls (Cozens, Saville, and Hillier 2005; Sorensen, Hayes, and Atlas 2008).

Target hardening is a form of access control and focuses on making criminal activity more difficult by limiting opportunities for crime at the scale of the building (Ziegler 2007). It includes using stronger doors and windows and more efficient locks and alarms and seeks to harden targets by increasing the effort required to commit a crime (Gilling 1997; Sorensen, Hayes, and Atlas 2008).
Image management is about creating an environment that looks like it is cared for and supervised. A clean and well-kept environment provides a sense of orderliness and control, which can nurture perceptions of safety as well as deter criminals (Wilson and Kelling 1982). Examples include the rapid removal of graffiti and the prompt repair of vandalism (Smith and Clarke 2000; Vilalta 2011).

Activity support involves attracting safe and legitimate activities into areas that are perceived as unsafe. This is achieved through the thoughtful design of urban spaces and the use of local events, functions, and other land uses to attract legitimate users. It is argued that with higher levels of “eyes on the street,” criminals potentially are less likely to offend since they may have increased risks of being seen and potentially apprehended (Sorensen, Hayes, and Atlas 2008). Pedestrians also potentially may feel safer as a result.

Geographical juxtaposition refers to the influence that nearby land uses and activities may have on the safety and security of a particular site (Newman 1973). This particularly relates to land uses that have the tendency to generate crime, such as prisons, pubs, bottle shops (off-licenses), pharmacies, seedy hotels, vacant lots/buildings, and cash converters/pawn shops (Newton 2014). This also has been observed in relation to public transport with regard to bus stops (Loukaitou-Sideris 1999; Loukaitou-Sideris et al. 2001). However, it has been asserted that reference to the wider environment and geographical juxtaposition is lacking in the CPTED literature and, consequently, is rarely considered in the design of urban spaces (Cozens 2014). Therefore, it is likely that in addition to the CPTED principles outlined above, the wider environment plays a significant role in shaping perceptions of safety at railway stations (Cozens 2011, 2014). This also is supported by research in the field of environmental criminology, defined as “...the study of crime, criminality, and victimisation as they relate first, to particular places, and second, to the way that individuals and organisations shape their activities by place-based or spatial factors” (Bottoms and Wiles 1997, 305).

In Crime and Everyday Life, Felson and Boba (2010) highlight how different types of settings generate large amounts of crime. The riskiest settings include public routes (especially footpaths, parking facilities, and unsupervised transit areas), recreational settings (especially bars and some parks), public transport (especially stations and their vicinities), retail stores (especially for shoplifting), educational settings (especially at their edges), offices (especially when entered for theft), human support services (especially hospitals with 24-hour activities), and industrial locations (especially warehouses with “attractive” goods). Some of these types of land uses act as crime generators, crime attractors, or crime detractors (Brantingham and Brantingham 1993b, 1995, 1998, 2008). Crime generators are specific areas that attract large numbers of people for reasons unrelated to crime but provide criminal opportunities to offenders who may notice them. These include, for example, shopping centers and entertainment areas. Crime attractors are activity nodes that entice motivated offenders due to their known criminal opportunities for specific types of crime. Examples include entertainment districts, prostitution areas, and drug markets. Crime detractors are locations lacking attractive activities that discourage use by legitimate citizens (Brantingham and
Brantingham 1995). Although such locations resonate with Newman’s (1973) Defensible Space concept of geographical juxtaposition, it has been argued that the surrounding environment has not been subject to much research in the field of CPTED (Cozens 2014).

Indeed, Brantingham and Brantingham (1998, 53) argued “most planning proceeds with little knowledge of crime patterns, crime attractors, crime generators … or the site-specific solutions that facilitate or even encourage crime.”

The concepts of image management and geographical juxtaposition are referred to by Newman (1973) in his book *Defensible Space: People and Design in the Violent City*. It is commonly recognized that modern CPTED is based on these ideas. The four elements of defensible space act together to help create and maintain a safer urban environment and include:

1. Capacity of the physical environment to create perceived zones of territorial influence.
2. Capacity of physical design to provide surveillance opportunities for residents and their agents.
3. Capacity of design to influence the perception of a project’s uniqueness, isolation, and stigma.

Although “image management” emerged from Newman’s third principle, and the rapid repair of vandalism and graffiti removal is a well-accepted CPTED strategy, research on image management also has been largely absent from the CPTED literature (Cozens 2014). This is particularly the case in relation to the research on railway stations, which has tended to concentrate on surveillance and territoriality/access control.

**Railway Station Study in Perth**

The Perth rail network is controlled by the Public Transport Authority (PTA), a government agency responsible for providing the train, bus, and ferry networks in WA. The Transperth division of the PTA is responsible for delivering these services within the Perth Metropolitan Region. Currently, there are five train lines, all of which converge at the Perth train station (see Figure 2)—Armadale, Midland, Fremantle, Mandurah, and Clarkson. In total, these lines service approximately 63 million passengers per year (Public Transport Authority 2014).
In 2014, WA was named Australia’s best rail network and was rated the safest in the country during daylight hours (Wahlquist 2014). Overall, crime is relatively low, with 40 incidents per million passengers recorded in 2013 (Wahlquist 2014). The Armadale line serviced around 9 million passengers in 2013/2014 (Public Transport Authority 2014) but is consistently associated with increased levels of crime (ABC News 2013). Indeed, a survey of 247 rail users on the Armadale line identified Oats Street as being the worst of five crime hotspots (Irons 2015). Interestingly, Gosnells station was not one of the five crime hotspots (Irons 2015).

Train stations along the Armadale train line were chosen due to an awareness of the negative reputation of this train line (Robertson 2012a, 2012b; Hickey 2013; Waters 2014a, 2014b). In terms of crime statistics and perceptions of crime, the Armadale line can be considered a “hot route” (Newton 2008; Thompson et al. 2009).
The Gosnells and Oats Street train stations (see Figure 2) were selected for investigation due to their contrasting design characteristics and their similar reputations in the media, their relative proximal location to each other on the Armadale “hot route,” and the fact that one was designed using the principles of CPTED and the other was not.

Importantly, Gosnells was designed as part of the Safe City Urban Design Strategy (City of Gosnells 2001). This strategy reportedly applied CPTED principles to the town center’s urban structure and its local streets and surrounding land uses/residential areas. It was described by then WA Commissioner of Police Bob Falconer as “the best community safety strategy in Australia” (City of Gosnells 2001, 5).

The key characteristics of the Gosnells and Oats Street stations are shown in Table 1. A photograph of Gosnells station is shown in Figure 3 and an aerial image of its surrounding environment is shown in Figure 4. Oats Street station is illustrated in Figure 5, and a location map of its surrounding environment is illustrated in Figure 6.
FIGURE 4.
Aerial photograph of Gosnells train station

FIGURE 5.
Oats Street train station

Source: Google Maps 2014

FIGURE 6.
Aerial photograph of Oats Street train station showing surrounding land uses
According to the literature, perceptions of safety and the presence of CPTED features at Gosnells station should be perceived to be higher than that of Oats Street station. This research investigates this hypothesis. It also probes the CPTED/Defensible Space concepts of “image management” and “geographical juxtaposition.”

Research Methodology
This study adopted three methodologies, all conducted during September and October 2014. First, five public transport security experts were interviewed about crime and the CPTED strategies used (or not) at each station.

Second, 100 intercept survey questionnaires were conducted (50 each at Gosnells and Oats Street stations). Quota sampling ensured that responses maintained a gender balance and representation across all age groups. Drawing on the literature, the questionnaires probed three key areas. Two questions were directed at eliciting data on perceptions of safety while at the station and when entering/exiting the station. Four questions investigated respondents’ perceptions of the presence or absence of CPTED qualities, including visibility at the station, surveillance from passers-by and surrounding land uses, CCTV, and security guards and exit points. Finally, two questions probed respondents’ perceptions of the image and reputation of the stations and whether this would deter them from using the station. Binary yes/no responses to these questions were scored and are discussed below. This approach has been used elsewhere (e.g., see Cozens et al. 2003a, 2003b, 2004). The authors recognize that there are limitations to this exploratory research in that caution should be applied in drawing any conclusions from a relatively low sample size of 100 respondents.

The third methodology involved conducting a basic audit of the land-uses surrounding the Gosnells and Oat Street stations. This was to provide some insights in the local context and the influence of “geographical juxtaposition” on perceived safety, “image management,” and the CPTED qualities at the two stations.

According to CPTED theory, Gosnells station should produce higher levels of perceived safety and CPTED qualities since it was reportedly designed using CPTED principles. The station user questionnaires adopted a simple quantitative method, and the interviews used a qualitative method, facilitating a more comprehensive meaning and comparison of the results (Sogunro 2002). These also could be contrasted with the land use survey to further explore the potential influence of the “geographical juxtaposition.”

Research Findings
Interviews with “Expert” Security Staff
Five security staff were interviewed to investigate their “expert” opinions on crime and safety at the two train stations. When asked if they thought CPTED principles were applied to the Gosnells and Oats Street stations, all PTA interviewees confirmed that Gosnells station had been designed with CPTED principles and that Oats Street was not (n=5). Respondents believed that Gosnells station was well-designed (n=3) and that lighting and vegetation were particularly considered to be of a high standard at Gosnells station.
Perceptions of Crime Prevention Through Environmental Design (CPTED) at Australian Railway Stations

However, it was also noted that despite the use of CPTED principles at Gosnells station, surrounding land uses did not produce a lot of activity to provide passive surveillance of the station (n=2). The land uses are in private ownership and, thus, the owners need to be convinced to work together to develop the precinct as an activity node (n=2).

It was reported by one PTA officer, who had completed tertiary studies in CPTED, that all new train stations in WA must use CPTED principles and architect designs must be approved. Both Gosnells and Oats Street stations are fitted with emergency panic buttons and public address (PA) systems that have direct contact with the PTA’s control monitoring room, which is manned 24 hours per day, 7 days per week (n=2). As soon as the emergency button is pressed, the closest CCTV camera zooms in on the location, and the person is able to voice their distress to the control room.

The Armadale line has been referred to as the “crime line.” However, PTA respondents indicated that the reputation is undeserved and is linked to “out-of-context media reporting” and the socio-demographics of the surrounding suburbs (n=3). There was some awareness that issues on the trains reflect those of the broader community.

Although one PTA officer believed the design of Gosnells station was effective in increasing perceptions of safety, he suggested that construction of a new station was required at Oats Street. In terms of the existing station at Oats Street, two officers felt that it was necessary to upgrade the shelters, cut down the vegetation, eliminate the level crossing, and provide more cameras, lighting, and monitored entry points to increase perceptions of safety.

Clearly, the “expert group” of PTA security staff believed that Gosnells station was designed more effectively than Oats Street, since CPTED principles had been systematically considered and applied to its design and layout.

Rail Users’ Perceptions
As noted, the relatively small sample size of 100 survey respondents indicates that the findings are exploratory rather than definitive. Further studies or more surveys would need to be conducted to corroborate the findings discussed below. This section discusses rail users’ responses to the eight questions in the survey, as set out in Tables 2, 3, and 4. Respondents could answer “strongly disagree,” “disagree,” “no preference,” “agree” and “strongly agree.” The number of responses out of 50 was recorded and expressed as a percentage score. Interestingly, overall, Table 2 indicates that respondents felt marginally safer at Oats Street station than they did at Gosnells station.

### TABLE 2.
Perceptions of Safety at Gosnells and Oats Street Stations

<table>
<thead>
<tr>
<th>Perceptions of Safety</th>
<th>Gosnells</th>
<th>Oats Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel safe at this station.</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td>I feel safe entering and exiting the station during the day.</td>
<td>47</td>
<td>49</td>
</tr>
<tr>
<td>Total Personal Safety Score (out of 100 and as a %)</td>
<td>80</td>
<td>88</td>
</tr>
</tbody>
</table>
For Gosnells station, most of the 50 respondents (66%, n=33) agreed/strongly agreed with the statement “I feel safe at this station,” and 22% (n=11) stated that they disagreed/strongly disagreed. At Oats Street station, the majority of respondents (78%, n=39) indicated that they generally felt safe at the station. For Gosnells, the majority of rail users (94%, n=47) agreed/strongly agreed they felt safe entering and exiting the station during the day, with slightly more responding similarly for Oats Street station (98%, n=49).

Respondents also were asked four questions about the perceived CPTED qualities at each station (Table 3).

<table>
<thead>
<tr>
<th>CPTED Qualities</th>
<th>Gosnells</th>
<th>Oats Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>The station is designed to be open and visible and I feel safe.</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>The design of the station allows for surveillance from passers-by and</td>
<td>26</td>
<td>52</td>
</tr>
<tr>
<td>neighbouring land uses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is sufficient surveillance from transit staff and CCTV.</td>
<td>23</td>
<td>46</td>
</tr>
<tr>
<td>There are sufficient exits to ensure my safety.</td>
<td>37</td>
<td>74</td>
</tr>
<tr>
<td>Total CPTED score (out of 200 and as a %)</td>
<td>126</td>
<td>151</td>
</tr>
</tbody>
</table>

At Gosnells, the majority of respondents (80%, n=40) agreed/strongly agreed that the design of the station was open and visible and made them feel safe, compared to a slightly higher 90% (n=45) of respondents at Oats Street.

At Gosnells, most respondents (52%, n=26) agreed/strongly agreed that passers-by and neighboring land uses could easily see into the station, and 34% (n=17) disagreed/strongly disagreed. Most of those argued that the station was in a “dead spot” situated behind shops and other land uses and was fronted by high asbestos fences. At Oats street, the majority of respondents (70%, n=35) stated that they agreed/strongly agreed with the statement, and 20% (n=10) of respondents disagreed/strongly disagreed. Some commented that there was minimal activity around the station and that neighborhood land uses were inactive after normal business hours. When asked about the presence of transit guards and security cameras, fewer than half (46%, n=23) at Gosnells station and more than half (56%, n=28) at Oats Street agreed/strongly agreed that such surveillance was sufficient.

Although the majority of respondents (74%, n=37) agreed/strongly agreed that there were enough exits at Gosnells station to ensure their safety, many of the 22% (n=11) who disagreed/strongly disagreed noted that there is only one exit on each side from Gosnells station, providing no alternative to anyone who may feel threatened on the platform. When asked if there were enough exits to exit safely from Oats Street station, most (86%, n=43) agreed/strongly agreed.

Overall, Table 3 indicates that the respondents perceived Oats Street to exhibit marginally higher levels of CPTED qualities (with a CPTED score of 76%) than Gosnells, which received a CPTED score of 63%.
When asked about the reputation of the station, a minority (16%, n=8) of respondents at Gosnells station agreed/strongly agreed that the station had a good reputation, and a significant majority (64%, n=32) disagreed/strongly disagreed (Table 4). The questionnaire also asked respondents why they felt this way. The most common responses were that people had heard from others about criminal offenses and anti-social behavior that had occurred at the station. Some had witnessed anti-social behavior themselves, and many believed that the whole area, particularly the suburb of Gosnells, had a bad reputation. There were also concerns over the types of people at the station, including drunks, people trying to start fights, and so-called “dodgy” people hanging around.

At Oats Street, 36% (n=18) of respondents agreed/strongly agreed the station had a good reputation. However, this was more than twice the number of those who felt Gosnells station had a good reputation. The same number disagreed/strongly disagreed that the station had a good reputation (36%, n=18), which was significantly lower than for Gosnells station. Reasons for disagreeing included rumors of antisocial behavior, and some respondents had witnessed fights, assaults, and drunks at the station. Some also noted the negative media reports about Oats Street station as well as the generally poor reputation of the Armadale Train Line.

The majority of the 18 respondents who agreed/strongly agreed that Oats Street station has a good reputation stated that they had never seen or heard about any criminal or inappropriate behavior. Some stated that the station seemed safe and that there were always people around, which made them feel safer. Some who disagreed noted that they had no other method of transport and, thus, no choice about whether or not to use the station. Many who agreed with the statement stated that the reputation of the station resulted in them avoiding taking the train after dark if possible.

Respondents were asked if the reputation affected their decision to use the station. At both Gosnells (26%, n=13) and Oats Street (22%, n=11), around one-fourth indicated that the poor reputation affected their use of the station. This raises the possibility that some of the respondents were “captive riders”—those who had no other travel options available to them and, therefore, must use the railway stations to travel.

As shown in Table 4, overall, rail users surveyed felt that CPTED principles at Oats Street station were marginally more effective in making them feel safer than at Gosnells station. This is in contrast to what would be expected, since Gosnells station was allegedly designed using the principles of CPTED and Oats Street station was not. At Oats Street station, 78% (n=39) of respondents agreed/strongly agreed that they felt
Perceptions of Crime Prevention Through Environmental Design (CPTED) at Australian Railway Stations

safe. This was marginally more than the number of respondents at Gosnells, in which 66% (n=33) agreed/strongly agreed.

In summary, respondents felt safer at Oats Street station than at Gosnells. They also felt that Oats Street exhibited higher levels of CPTED qualities and has a better reputation than Gosnells station.

**Land Use Audit of Surrounding Environment**

An audit of land-uses around each railway station was conducted to provide an indication of the local context of each station and to probe the issue of “geographical juxtaposition.” All land uses were recorded within a 200-meter radius of each station and were divided into various groups, including residential, retail/commercial, open space, educational settings, car parking, vacant lots/buildings, and roads/railway lines. Table 5 shows the estimated percentage of space each type of land use represents for both railways stations.

<table>
<thead>
<tr>
<th>Land Uses within 200m Radius</th>
<th>Gosnells Station % of Total Land Use Area</th>
<th>Oats Street Station % of Total Land Use Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td>Retail/commercial</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Open space</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Educational settings</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Car parking</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Vacant lots/buildings</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Roads/railway lines</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Gosnells is located in an environment dominated by retail/commercial land uses, including a variety of restaurants (some take-away), several “big box” shopping centers, retail shops, a car repair business, and health-related stores. There is a range of local government services and psychological counseling services and several employment/life skills services, as well as two large car parks, one northwest and one southeast of the station. The audit also identified several vacant lots/buildings, and a sizeable park is located east of the station.

Gosnells station is in close proximity to several land uses likely to generate or attract criminal behavior, such as the Gosnells Hotel (a licensed public house), a Totaliser Agency Board (TAB) betting/gambling establishment, several pharmacies, cash converters (pawn shops), massage parlors, vacant buildings/ lots, and Centrelink, the unemployment office. As discussed earlier, evidence from environmental criminology suggests such land uses may act as crime attractors or crime generators. In any case, they appear to affect perceptions of crime and the perceived effectiveness of CPTED in and around the station. It is possible that the activity generated from these land uses may have negatively influenced perceived safety at Gosnells station. Users of Oats Street were more likely to be University students/staff, and those using Gosnells station were likely to derive from a more diverse population of shoppers, local workers, and people
seeking to claim unemployment benefit from the surrounding suburbs. This also may impact perceptions of personal safety.

In contrast, Oats Street station is located within a predominantly residential environment, and the eastern side of the station directly faces a residential street. The polytechnic of West Carlisle is opposite the station on the west side, which is also surrounded by residential properties. The station has a small car park, and the railway line is flanked on both sides by two roads. There also is some retail, a bookstore, a gallery, a power station, a childcare centre to the south, and a small area of open space and a car park behind the polytechnic. The land uses surrounding Oats Street station does not appear to represent crime attractors or crime generators.

Geographically-juxtaposed land uses and activities may well be as important as the other CPTED concepts of surveillance, territoriality, and image management. Although more empirical studies are required, these preliminary findings suggest the surrounding environment acts to mediate the effectiveness of CPTED. For example, it would be interesting to compare two other stations with characteristics similar to Oats Street and Gosnells stations that are not on “hot” lines.

Discussion and Conclusions
The exploratory findings from this relatively small study raise some interesting issues. In summary, the five security “experts” believed Gosnells was the safest station since it was designed using CPTED principles. The literature suggests this station should be perceived to be safer than Oats Street, which was not designed using CPTED principles. However, this was not the case. The station users perceived Oats Street to exhibit marginally higher levels of CPTED qualities and felt it was slightly safer than Gosnells. These findings could, of course, be explained partly by the relatively small sample size or the fact that Gosnells station is perceived to be located in a dangerous area compared to Oats Street station. Another possibility is that CPTED was not implemented as effectively as it could have been.

The station users also felt that the reputation of Oats Street was more positive than Gosnells, although both stations were perceived to be somewhat stigmatized. This might be linked to the idea that the Armadale line is the “crime line.” The land use survey provided some insights into the concept of “geographical juxtaposition,” highlighting that crime generators and crime attractors around the Gosnells station may affect perceptions of the personal safety and the effectiveness of CPTED at the station itself. These preliminary findings suggest that CPTED surveys need to include some kind of measurement of geographically-juxtaposed land uses around the station. This was, after all, Newman’s fourth Defensible Space principle (1973). More detailed research on land uses surrounding sites at which CPTED has been implemented may shed more light on this topic.

It is suggested that some form of CPTED survey or personal safety mapping of station users could become a more systematic and regular component of customer satisfaction surveys. This could then be used to redirect and target CPTED funding at specific
stations. This also might be used to alter the number and location of CCTV cameras and/or the number of security staff.

That Gosnells station was developed in 2001 and one of the PTA’s security experts completed tertiary studies in CPTED raises the issue of the effectiveness of CPTED at the station and the knowledge-base of the PTA security experts. Since 2001, there have been many significant developments in research in the field of CPTED, which are not necessarily formally taught within any tertiary studies (e.g., see Ekblom 2011; Cozens 2014; Cozens and Love 2015). Moreover, it has been argued that built environment and security professionals need to know much more about crime patterns and environmental criminology as a foundation for underpinning the use of CPTED (Brantingham and Brantingham 1998; Cozens 2011, 2014). Furthermore, although the station may have met the CPTED principles of the time, 14 years on, it appears that the station users in this exploratory study did not perceive there were high levels of CPTED qualities at Gosnells station. One conclusion from this preliminary study is that stations may need to be more regularly reviewed. Since CPTED is a process and not a design outcome (Crowe 2000; Cozens 2011, 2014), review arguably should take place on a more routine basis. Indeed, the UK’s Secured Station Scheme requires stations to be re-accredited every two years.

CPTED is considered to be “best practice” and represents a large investment of public/private funds. This exploratory study does not in any way suggest that CPTED does not work or is not a worthwhile investment for transportation agencies. Rather, it suggests that CPTED could be applied better by considering Newman’s fourth and often forgotten Defensible Space principle of “geographical juxtaposition.” Indeed, understanding the context and nature of the local environment may help explain the negative reputation of Gosnells station and its attempts to respond in terms of the redesign of the station using CPTED principles. It may well be the case that the CPTED design efforts simply were not enough to overcome the highly negative and stigmatized reputation of the area.

References


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