

Public Transport Service Optimization and System Integration

Samuel Zimmerman and Ke Fang

The World Bank, Washington, USA

Public transport has the most customer appeal and is most efficient when it is planned and operated as a seamless, integrated system. This is particularly important in urban environments in fast growing economies such as China and India, where public transport must increasingly compete with private vehicles which offer door-to-door, "one seat" travel irrespective of time of day or day of the week.

International experience suggests that public transport planners must recognize two integration dimensions: (a) integration among all modes and routes comprising the multi-modal public transport network, (b) integration of the physical and operational elements of each respective mode and service, e.g., metro or bus. Successful integration in both dimensions will provide a more customer-friendly experience and make public transport more efficient and cost-effective. This will help maximize public transport ridership and revenue, increase customer satisfaction, reduce costs and subsidies and generate environmental, social and economic benefits for the investment.

The note below outlines the issues associated with the first dimension, modal integration both intra and intermodal, and how they should be addressed. The note closes with illustrations of good practice.

Introduction

Improved public transport integration can bring benefits to both public transport users and public transport providers. First, it can provide passengers with a better travel experience by making it easier and more convenient to use, especially in competition with private modes such as motorbikes, cars and taxis. Second, effective public transport system integration can enhance public transport's financial sustainability by decreasing overall costs through reduced overlap and redundancy and increasing revenue by attracting more customers.

Public transport integration has a number of dimensions: (a) integration among all modes and routes comprising the multi-modal public transport network, (b) integration of the physical and operational elements of each respective mode and service, e.g., metro or bus. Because the latter is more engineering- oriented, this note, with a service planning focus, will focus on integration among all routes and modes, including metro, light rail, bus rapid transit (BRT),

local and long-distance buses and passenger rail within a multi-modal public transport network.

Key Service Planning and Design Issues

From a public transport passenger's perspective, a trip normally involves a number of discrete time segments, beginning at the actual origin of the trip and ending at the ultimate destination. Each time segment is perceived in different ways that need to be considered during public transport planning and design.

1) Walking

No matter which type of public transport is used, public transport trips include time spent walking, to the initial boarding stop/station either from the actual trip origin or from a car or bus parking space, from the last alighting stop/station and, if a transfer is needed, walking after alighting from the service initially boarded to the boarding place of the next service.

Travel research throughout the world has consistently shown that travellers view walking time as significantly more difficult than time spent riding. Depending on the situation, walking time can be considered up to twice as onerous as riding time in travel decision making.

Exhibit I: Elasticity of Walking Time Relative to Riding Time

Mode	Work	Leisure	Other
Car	1.37	1.74	1.55
Bus	1.67	1.66	2.02
Rail, Metro	1.99	1.97	1.37

*Source: *The Demand for Public Transit, a Practical Guide*, Transport Research Laboratory, TRL, UK, 2004

The values shown in Exhibit I compare public transport demand elasticity (the ratio of the percentage change in public transport demand per percentage change in time) for walk time compared to the elasticities for time actually riding on a public transport vehicle. They are illustrative of the importance of all aspects of walking as a factor in public transport demand. The fact that the ratios are significantly greater than 1 for all trip purposes and modes indicates the importance public transport riders (and other travellers) place on walking in making travel decisions, e.g., mode choice. The concerns this reflects are:

- the perceived effort it takes to walk, especially for travelers carrying packages and where level changes via stairs or ramps are required;
- the importance of the perceived safety and security of the walking environment, especially for women;
- the frequent absence of continuous side walks in good condition, free of impediments like hawkers, parked cars, mud filled pot-holes, etc.

2) Waiting

Waiting time is also perceived by travelers to be much more onerous than riding time for travelers, as shown in Exhibit II.

The reason that waiting time is viewed so much more negatively than riding time reflects:

- Uncertainty and nervousness as to when the next bus or train will actually arrive;
- The fact that when waiting, no progress is being made in moving to the ultimate destination;
- Perceived safety and security while waiting, especially at night and/or for women and other vulnerable groups;
- The need to stand in a potentially hostile environment that may be hot or cold and/or without light, weather protection;
- Poor passenger information about routes, schedules, way-finding.

Exhibit II: Elasticity of Waiting Time Relative to Riding Time

Mode	All Purposes
Car	2.1
Bus	1.6
Metro	1.2
All	1.8

*Source: Same as the Exhibit I.

3) Transferring

The potential need to transfer between public transport services is an important consideration in travel decision making. Travel research also finds that if one or more transfers are needed this is in itself a negative factor, in addition to the measurable impact of walking from one service alighting point to the next service's boarding point, potentially paying an additional fare and waiting.

Exhibit III: Perception of the Effect of a Transfer In Terms Of Min. Of Riding Time

Modes	Equivalent to in-vehicle time
bus	20
rail transit	17

*Source: Same as the Exhibit I.

Exhibit III is an illustration of the dislike travelers have for transferring. Stated another way, travelers using public transport in places reflected in the table prefer riding on a single service for up to 20 minutes longer to avoid one

transfer, all else being equal. The value for a second transfer is, no doubt, higher which is a reason that so few are typically made, even within a high frequency and quality urban rail network.

Documented in a paper published by the U.S. Transportation Research Board in 2004, "Assessment of the Transfer Penalty for Transit Trips: A GIS-based Disaggregate Modeling Approach," two MIT researchers analyzed the impact of the transfer environment for trips using the urban rail system (metro, LRT) to access the CBD in Boston Mass. They modeled the choice between travelers walking to their ultimate destination in the CBD after arriving by rail versus transferring to another rail line with a station closer to their ultimate destination. This was done for different station pairs with different transfer environments within the respective stations and underground in between, and the respective walking environments for the alternative, all outdoor pedestrian paths.

Table 1 was taken from the paper and the values it contains are consistent with the TRL synthesis. In addition to confirming other research (e.g.,

TRL's, Op.Cit.), the authors found that the negative perception of an "assisted" (escalator) level change in Boston's urban rail system was equivalent to about 4 minutes of walking time, irrespective of how long it actually took. They also found a significantly higher range of values for transfer penalties in the off peak (e.g., at night) than in peak periods. This implies that transfers requiring walks in underground, poorly lighted and potentially insecure passages were more negatively perceived when few other travelers were around than in the peak periods.

In summary, the negative perception of transfer requirements is a reflection of traveler concerns regarding:

- the potential unreliability of the service transferred to
- the possible need to leave a seat on one service to stand on another
- the quality of the transferring environment in terms of lighting, weather protection, safety/security
- the need for level changes
- poor way-finding information guiding new users to the second service

Table 1: The Range of the Transfer Penalty and the Goodness-of-Fit of Models

Model Number	Underlying Variables	Adjusted p^2	The Range of the Penalty (Equivalent Value of)
A	Transfer constant	0.309	9.5 minutes of walking time
B	Government Center (GOVT) Downtown Crossing(DTXG) State (STAT)	0.369	4.8-9.7 minutes of walking time
C	Transfer constant Transfer walking time Transfer waiting time Assisted Level Change	0.385	4.3-15.2 minutes of walking time
D	Transfer constant Transfer walking time Transfer waiting time Assisted Level Change GOVT	0.414 (Peak) 0.357 (Off-peak)	4.4-19.4 minutes of walking time (Peak) 2.3-21.4 minutes of walking time (Off-peak)

Source: N. Wilson & Z. Guo, 2004

Network Integration

The discussion above makes clear that integration of urban public transport networks, irrespective of mode, is extremely important in determining whether travelers select public transport as their travel choice, and if so, their satisfaction with their choice. Key dimensions of network integration include the route structure, stops and transfer stations, schedules, fares and passenger information. These will be discussed individually below.

1) Network structure, individual route terminals/alignment/stops/stations, levels of service

This integration dimension involves making sure that the entire public transport network supports travel among the entire array of origins and destinations in a minimum of travel time and cost, accounting for the traveler preferences with regard to walking, waiting and transferring noted above. Public transport networks should be planned, implemented and operated to support door-to-door travel irrespective of the mode or modes, route or routes used. The starting points for integrated public transport network planning are current and expected future travel market needs. Given travel patterns, networks are modified and/or expanded to minimize duplication, indirection of travel, walking and transfer requirements and make it easier for the traveler to understand and use.

In the simplest cases, the types of changes that might be contemplated include:

- individual route alignments and terminals
- stop locations
- stops added or eliminated
- frequencies increased or reduced

These changes can be made to minimize total travel times for the largest number of passengers, reduce operating and maintenance costs for operators, minimize transfers or even

make them more attractive by bringing routes where transfers are being made (or might) closer together to a common stop. New routes can be proposed and/or some may actually be eliminated as cities grow and markets change.

An entire network can be restructured along “functional” lines, each type of service oriented to a different market type, all day central business district circulation versus long-distance, peak period commuting versus all day, all week local bus or rapid transit. Irrespective of types and magnitude of changes being considered, it is usually not obvious what should be done. Most public transport network planning efforts will involve the iterative analysis of successively better service options, keeping in mind financing, roadway and sidewalk capacity and other constraints.

The levels of service provided by the different routes comprising a network can also be important in system integration. Transfers from one route or mode to another can only be adequately accommodated if sufficient capacity is available on the route transferred to leaving the transfer point. This is an issue with many rapid transit systems at within rapid transit transfer points and it is a problem where rapid transit interfaces with lower order, lower capacity parts of the public transport network (e.g., “feeder bus routes”). Consideration should be given to the relationship of the levels of service/capacities of the various routes meeting at transfer points, the respective route demands through the stop and transfers volumes.

2) Schedule integration/coordination

Schedule integration has two implications. The first is to ensure that all routes serving a particular stop or terminal are in operation during the same hours (known as “span of service”) so that no one is left “stranded.” For example, bus routes serving a terminal rapid transit station should have a span of service such that the last BRT vehicle or train of the day is either met by a departing local or “feeder” bus,

or the bus departs from the station after the rapid transit vehicle arrives.

The second is to coordinate schedules, especially in network with low frequencies so that the different routes serving an important transfer station are scheduled to arrive and depart at the same time and “held” for enough time between or among them so that all applicable transfers can be made.

3) Transfer Stops/Stations/Terminals

As a general rule, public transport service planners work to avoid transfers because of the negative traveler perception of the time and difficulty involved in making them. That having been said, it is often more attractive to a traveler to have an alternative available which involves a transfer but is always available, requires a minimum of travel time and travel difficulty, including cost, than a direct travel alternative without a transfer that is long, circuitous, slow and only available in the peak periods.

Assuming that service planners have developed an efficient, attractive network route structure that for market, geography and other reasons results in significant transfer volumes at certain locations, it is imperative that the transfers be made as seamless as possible, with the minimum of time and difficulty.

This means:

- minimum walking distances and level changes between stopping locations
- safe, secure level change equipment and facilities which enable travel by all citizens including the physically challenged (e.g., seniors)
- enhanced lighting and weather protection (sun, rain, wind) in walking and waiting areas
- platforms and passages large enough to accommodate expected flows and numbers of waiting/boarding passengers

- well lighted and traffic signal (or more) protected street crossings where required for transfers
- off-street drop off/pick up facilities for bus transfers at rapid transit stations and at large bus transfer locations
- amenities for passengers so that the trip involving public transport through these locations can be made more pleasant and productive, thus presenting a more competitive alternative to private vehicles use.

Perhaps the most important planning and design issues for intermodal and intra modal transfer terminals are both the reality and the perception of safety and security.

Passages between stops and stations and level change devices (steps, escalators and elevators) are places where significant numbers of accidents and crimes can take place. These issues are particularly important for women and senior citizens, and should be among the primary planning and design concerns both to attract and facilitate more people using public transport.

Fire and disaster evacuation is also a critical issue not only in case of real emergencies but also in the way travellers perceive the “quality” and attractiveness of public transport.

How the above issues are addressed is subject to the volumes of passengers transferring, the number of distinct services (and modes) involved and subject to physical, operational and financial constraints.

4) Fare integration

Public transport users (and those who desire to be) are not only sensitive to the absolute level of fares, but also to the number of times that fare must be paid and how fare media are purchased. This is obviously most important for travelers that must transfer but also has implications or those who don't. The objective in fare setting

and payment should be to maximize convenience and minimize the perceived cost to the user of public transport. Having to pay for public transport one trip at a time or take a public transport fare card, ticket, pass or cash (the worst) out of a secure pocket or purse multiple times for a trip involving multiple services is very inconvenient. It also increases the negative perception of public transport use compared to driving where the user costs of a single trip are not perceived at all unless tolls are paid or parking is charged for.

From the perspective of operators, increased numbers of discrete fare media (IC and magnetic cards, tickets, token, etc.) purchases and fare payments increases station/terminal dwell times and thus operating costs and also increase the possibility of revenue shrinkage through fare-non payment and theft.

To overcome these difficulties, many public transport companies are moving to integrated fares paid electronically with IC cards. These provide the mechanism to charge by distance or time irrespective of the number of transfers made. They also provide an equitable way of dividing revenue among different public transport operators where there is more than one serving the same market or markets. Payment of a fare for a certain amount of elapsed time from the initial boarding means that travelers can get off a vehicle mid-trip, do an errand and get back on the next one without having to pay twice, as long as it is within the parameters set by policy. It also reduces the perception of a financial transfer penalty.

5) Passenger Information

In surveys done in both developing and developed cities, the lack of easily available and understandable traveler information on public transport route alignments, stops, terminals, schedules and fares are cited as a problem. This makes it difficult for new riders to begin using public transport and for existing riders to make new kind of trips, for new purpose, at new times

of the day or week and/or to new destinations. Potential travelers who may need or want to use the system irregularly often perceive that the effort to learn how is insurmountable. In the case of generally easier to understand mass rail transit system, infrequent users can account for up to 40% of total travel volumes.

The provision of comprehensive, easy to understand and easy to access information is important for pre-trip planning and en routes. The goals of the information are to make use of the system as easy as possible both before and during the trip and to reduce anxiety about where to get off once on board. Integrated information should be presented to facilitate travel from actual origin to actual destination irrespective of how many different routes or modes may be used.

The information should be available at home, at work or school, on board and at stops, stations, terminals and interchange points. The type of information will include:

- Schedules and next service arrival times at the first boarding stop
- Way finding information directing travelers between major public transport stops, stations and terminals and major activity centers
- Way finding information within transfer facilities
- Schedules and next service arrival times at transfer points

The key objective is to provide the needed information in one easy to use and understand format for all services and access/egress and transfer points, irrespective of route and mode to facilitate total trips from origin to destination.

Summary

Public transport networks are perfect examples of economic systems where the integrated whole produces far more benefits than the un-integrated sum of its parts. When satisfaction

surveys are conducted for existing public transport customers, the problems usually cited as significant most often deal with poor integration, both at the network level and within a specific mode or service. Problem areas at the network level include:

- the need to take multiple routes, uncoordinated with respect to schedules, availability of service, alignments and passenger information
- the need to inconveniently pay multiple, often additive fares
- the need to walk far and change levels numerous times between different services with little or now way-finding guidance between them.

Non-customers frequently cite the same problems as reason for not taking public transport at all or not more frequently.

Institutional Arrangements and Public Transport Integration

These integration issues not only adversely impact the number and satisfaction of people using public transport, but also impact fare revenue and operating costs and thus the financial viability of public transport.

Public transport integration issues in most developing cities are difficult to resolve not necessarily because practitioners do not recognize them or do not know how to address them. Service and physical planning issues are relatively straight forward to deal with technically.

The reason is invariably related to the way public transport is organized, and how the institutions and the people that work for them relate to one another. In an ideal world, all public transport, irrespective of mode would be planned, implemented and managed under the aegis of a single authority with a mandate covering an entire metropolitan area. The specifics of how this might be accomplished could vary from

place to place according to history, the governmental system, etc., but the key characteristics of the needed institution are:

- multi-modal scope
- metropolitan area-wide jurisdiction
- strong role in capital investment project selection and priority setting
- strong role in operating subsidy policy making and allocation

Unfortunately, most developing cities have a number of unique, parallel public transport entities whose mandates do not extend beyond the individual system or municipal jurisdiction boundary. If there is no body with a serious coordinating role connected to project approval and funding in these cases, it is unlikely that all services and network components will work together as the synergistic, integrated whole described above. Far too often, public transport companies or agencies believe that their mission and functions begin and end once a customer arrives at their respective access points and ends once the customer leaves their part of the system. It is clear that this should not be and the challenge is how to change institutional arrangements for urban transport to effect the needed integration.

Samuel L. Zimmerman is an Urban Transport Consultant to the Department of Sustainable Development, East Asia and Pacific Region in the Washington Office of the World Bank and was formerly a Senior Urban Transport Specialist there.

Ke Fang is a Lead Urban Transport Specialist in South Asia Region of the World Bank, based in the World Bank New Delhi Office.

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For comments, please contact Mr. Ke Fang (kfang@Worldbank.org) or Gerald Ollivier (gollivier@worldbank.org) from the Beijing Office of the World Bank.

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