

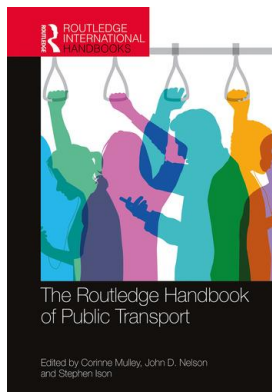
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Corinne Mulley, John D. Nelson, Stephen Ison

### Intermodal connections

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Bianca Eiben, Jianqiang Cui

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# 7

## INTERMODAL CONNECTIONS

*Bianca Eiben and Jianqiang Cui*

### **Introduction**

Around the globe, major cities are faced with the challenge of increasing mobility while simultaneously reducing car dependency, congestion and pollution (Hernandez & Monzon, 2016). With rapid population growth contributing to urban sprawl, distances travelled and travel times have increased (Hernandez & Monzon, 2016; Zito & Salvo, 2009). Longer travel times and distances have pushed many public transport users to combine multiple modes of transport to complete their journeys (Hernandez & Monzon, 2016; Zito & Salvo, 2009). This, however, has decreased the attractiveness of public transport for users as a result of additional wait periods and transfers needed to complete a trip (Hernandez & Monzon, 2016; Iseki & Taylor, 2009). The added inconvenience compared to private modes results in a decrease in user satisfaction due to inefficiency and discourages use of public transport (Daudén et al., 2014; Hernandez & Monzon, 2016). To reduce the impacts of intermodal transfers and increase the attractiveness of public transport, intermodal connections need to adopt the principle of intermodality, which is a planning approach that aims to deliver a seamless journey for passengers using different modes of transport in a combined trip chain (Daudén et al., 2014).

Integrating multiple modes of transport is becoming more and more complex, with growing populations placing pressure on transport services to balance supply and demand for public transport users. In order for public transport to remain a viable and competitive option in comparison to private modes, providing seamless connectivity is essential for encouraging public transport use (Hernandez et al., 2016). While determining the factors that discourage use is significant, identifying and applying new policy to resolve issues is also important. A Park and Ride scheme is one such example which has become a favourable option to combat some of the common issues surrounding interchange for intermodal connections. Park and Ride schemes have been implemented globally to encourage public transport use, combat congestion in inner-city areas and provide a convenient interchange between public and private modes (Aros-Vera et al., 2013; Lam et al., 2001; Rosli et al., 2012).

This chapter explores the issues surrounding intermodal connections for both public and private transport users, examining the role of interchange and Park and Ride schemes in public transport networks. It begins with a review of the relevant literature detailing the key areas of importance for intermodal connections, including key issues for public transport users as well as

identifying the role of Park and Ride. A case study of the Gold Coast Light Rail Park and Ride in Australia is then presented, followed by a discussion of key issues and implications for public transport users. This chapter concludes with a summary of key points.

## **Literature review**

### ***Intermodal connections***

Intermodal connections are the connections between different modes of transport, that is, between active, public and private modes or, for example, the connections between buses and rail (Pitsiava-Latinopoulou & Iordanopoulos, 2012). For most public transport users, intermodal connections are a necessary part of a journey, with long distances travelled requiring transfers between modes (Cheng & Tseng, 2016). However, with these additional transfers and sometimes insufficient services which decrease satisfaction, users are shifting behaviour away from public transport. While most intermodal connections adopt the planning principle of intermodality to provide better services, it is often challenging to provide positive experiences for all users and encourage public transport use (Beirão & Cabral, 2007). Intermodality can be defined most simply as combining different modes of transport to create a seamless travel experience. As such, reducing wait periods and transfers to deliver seamless connectivity were highlighted as important goals in many policies (Liu et al., 1997). But it is often hard to define what seamless connectivity entails.

A seamless journey can be defined as having a fully integrated intermodal approach between all transport services, and needs to be the best option for all individuals to get to their destination as quickly and comfortably as possible (Chowdhury & Ceder, 2016). According to the OECD 2016 policy paper, providing a seamless transport system is a process of adapting infrastructure, operations, fare structures and payment systems while also providing the essential information that delivers a convenient travel experience. Therefore, to achieve seamless connectivity, transport networks need to consider the planning and design of terminals to better accommodate passenger needs and the operational management between modes, as well as understanding the travel behaviour of users and non-users to identify gaps and areas for improvement (Beirão & Cabral, 2007; Hernandez & Monzon, 2016; Pitsiava-Latinopoulou & Iordanopoulos, 2012).

### ***Travel behaviour***

Throughout the research conducted on travel behaviour, it has been highlighted that user experiences play a significant role in modal choice. This is because creating a reoccurring behaviour requires a satisfactory experience to first take place to provide feedback that reinforces the association with a particular goal (Aarts et al., 1998; Ajzen, 1985). Better experiences therefore link to stronger associations and increase the likelihood of repeating a certain behaviour, or in this instance encouraging public transport use. Keeping this in mind, an unsatisfactory experience produces the opposite and may cause a shift in behaviours (Bolles, 1972; Hull, 1943). Identifying the motives for selecting a specific mode is also important to consider when understanding travel behaviour, as they can help identify issues in providing seamless connectivity in transport systems and user experiences.

The literature confirms that factors such as cost, convenience and design are emphasised as key issues affecting modal choice (Aros-Vera et al., 2013; Keijer & Rietveld, 1999; Loutzenheiser, 1997; O'Sullivan & Morrall, 1996; Van Acker et al., 2010). Aspects such as an individual's

socioeconomic demographic, the cost of parking, public transport fares and fuel prices were all identified as attributes considered in mode selection regarding costs of travel (Rosli et al., 2012; Rye & Koglin, 2014; Seik, 1997; Song et al., 2017; Ying & Xiang, 2009; Zhu et al., 2013). How convenient a mode was perceived as being was also identified as having a substantial influence. Convenience is defined by aspects such as speed, reliability, travel time, distance, purpose of travel, accessibility and transfers needed, and can be used to compare the same attributes on different modes (Olaru et al., 2014; Parkhurst, 2000; Rosli et al., 2012). The design of the facilities being used also has influences on mode choice and includes factors such as location, lighting, weather protection, safety and security, ease of wayfinding during transfer and seating availability (Cheng & Tseng, 2016). Whilst considering design for intermodal connections, it is notable that differences in terminal design may affect user experiences and are a crucial aspect to consider when trying to achieve seamless connectivity.

### ***Planning and design of intermodal terminals***

In planning and designing intermodal terminals, there are a number of issues highlighted in the literature. These include terminal design, choice of location and surrounding land uses (Pitsiava-Latinopoulou & Iordanopoulos, 2012). These are important issues to address, as they significantly impact achieving seamless connectivity as well as influencing the travel behaviour of public transport users. Whilst considering terminal design, Pitsiava-Latinopoulou and Iordanopoulos (2012) distinguished five specific types of intermodal terminals: intercity terminals, commuter transit centres,<sup>1</sup> interchanges, Park and Ride and on-street facilities. This chapter focuses on interchange and Park and Ride. Each terminal type has specific design standards that should be met, as poor planning, incorrect location choice and inadequate operational management may cause disruptions to transport systems, as well as discouraging use (Pitsiava-Latinopoulou & Iordanopoulos, 2012). Although there are different types of terminals, each terminal should have six essential functions: providing reliable service, adequate facilities, low-cost travel, accessibility for all users, competitive travel time compared to trips without transfer and direct access to different modes serviced at the same terminal (Pitsiava-Latinopoulou & Iordanopoulos, 2012). Providing these six functions during the design of intermodal connections improves facilities and the potential for positive experiences, and aids in creating seamless connectivity between modes.

The location of intermodal terminals, whilst dependent on the type, holds significance in planning for facilities. Incorrect planning for the location and type of terminal may affect the capture of new users and impact current passengers (Pitsiava-Latinopoulou & Iordanopoulos, 2012). Keeping this in mind, the location must consider surrounding land uses to optimise connectivity. Land use planning has become a significant aspect in the planning of transport networks and achieving sustainable development, as there are many benefits to well-planned neighbourhoods, such as reduced travel times, enhanced non-motorised modes and greater accessibility and efficiency of public transport (Geerlings & Stead, 2003; Lah, 2019). For many transport systems, implementing policies such as Transit Oriented Development (TOD) optimises user catchments given the co-ordination between surrounding land uses and transport. TOD has seen success in encouraging public transport use through implementing mixed-use development of residential, business and leisure activities (Carlton, 2009). Intermodal connections between active modes such as walking and public transport have seen beneficial outcomes in developing positive user experiences through more convenient accessibility by adopting land-use planning approaches such as TOD; thus, it is important to consider surrounding land uses whilst planning for and designing intermodal terminals (Carlton, 2009).

### ***Operational management***

The operational management of intermodal connections has also been identified as a key aspect of interest for intermodality. The literature outlines that key issues in operational management include the need to overcome poor co-ordination between stakeholders, information provision to passengers and poor governance (Chowdhury & Ceder, 2016; Hernandez et al., 2016). A lack of co-ordinated planning processes between land uses, transport systems and environmental considerations results from poor co-ordination between key stakeholders, and may lead to a segmented approach to policy making and prevent the development and implementation of integrated plans, which in turn impacts achieving seamless connectivity (Geerlings & Stead, 2003). Furthermore, a lack of co-ordination in urban travel and land use policy between the various stakeholders can lead to organisational problems and inefficiencies (Geerlings & Stead, 2003). This can significantly impact the operational management of intermodal connections and may cause issues in timetabling, information provision and providing transport services (Cheng & Tseng, 2016; Geerlings & Stead, 2003).

### ***Interchange***

As mentioned by Pitsiava-Latinopoulou and Iordanopoulos (2012), an interchange is one example of an intermodal terminal (see also Chapter 6). An interchange can be defined as either an intermodal facility found at connection points of different modes of a transport network or a connection point between different routes for the same mode (Pitsiava-Latinopoulou & Iordanopoulos, 2012). They are normally established in central districts or commercial areas where most public transport routes pass and are easily accessible by active modes such as walking or cycling (Pitsiava-Latinopoulou & Iordanopoulos, 2012). Interchanges should be designed to meet the needs of frequent users and reduce transfer time (Pitsiava-Latinopoulou & Iordanopoulos, 2012). By doing so, the attractiveness of public transport can be increased through reduced walking and waiting periods (Hernandez & Monzon, 2016).

When designing interchanges, usability principles (including accessibility, ease of navigation, comfort and amenities, information, safety, local area integration and community ownership and activity) were developed and considered by the Station User Panel in 2011 for the Victorian government railway system to improve user experiences (Hernandez & Monzon, 2016). These principles have been identified in various studies as key areas of interest for interchange (e.g. Lois et al., 2018; Lucietti et al., 2016; Monzon et al., 2017), with the most relevant issues being seen as information provision (see also Chapter 25), transfer conditions, accessibility and safety (Hernandez & Monzon, 2016). Whilst considering the issues for interchanges, it is acknowledged that there are two types of issues for users, functional and psychological. The two main functional issues hindering interchange were indicated to be information provision and accessibility, while psychological aspects included safety, security and comfort (Hernandez & Monzon, 2016). Other issues identified in the literature included the layout of the interchange, internal connections, the ease of movement, waiting areas, open spaces, ventilation, lighting, functional and aesthetic integration with the surrounding urban area and additional services (Hernandez & Monzon, 2016; Lucietti et al., 2016).

Of the two functional issues, accessibility has been well researched throughout the literature and is highlighted as a key factor impacting intermodality. Functional issues regarding accessibility predominantly revolve around connectivity between modes, transfer times and the overall ease of movement. Numerous articles have discussed ways of reducing the inconvenience of transfers through interchange design (Cheng & Tseng, 2016; Geerlings & Stead,

2003; Pitsiava-Latinopoulou & Iordanopoulos, 2012). For interchanges which involve significant transfer distances such as changing between terminals not within the immediate vicinity, improving pedestrian access via zebra-striped crossings, traffic lights activated by pedestrians, pedestrian islands for crossing large roads and adding traffic calming measures not only reduced transfer time but also increased safety, thus, ensuring a likely positive experience for users (Zito & Salvo, 2009). Information provision at stations is also highlighted as a key area of interest for interchange design. Providing users with more information regarding services, delays and amenities available significantly increased user experiences (Hernandez & Monzon, 2016; Zito & Salvo, 2009). For example, providing well-signed pedestrian routes in terminal areas reduced time spent on transferring. Another area of interest is ticketing. In some instances, users are required to purchase multiple tickets to transfer between modes, which again adds additional time for transfers. In a number of cases, lack of kiosks further delayed transfer due to the need for queuing. Terminals should be designed with sufficient ticketing machines available or alternative options such as e-tickets, smart cards, the sale of on-board tickets and monthly or yearly passes should be considered (Dorbritz et al., 2009).

### ***Park and Ride***

The development of Park and Ride since the 1930s has gained significant interest in transport-planning policies for its potential in alleviating congestion, reducing the need for parking in inner city areas and, in some circumstances, preventing private vehicle intrusion into historic cities (Aros-Vera et al., 2013; Lam et al., 2001; Parkhurst, 1995; Rosli et al., 2012). It works on the principle that commuters combine public and private modes of travel, driving part of their journey to a Park and Ride facility that is usually situated on a urban fringe and then taking public transport (either bus, train or tram) to a central location (Aros-Vera et al., 2013; Olaru et al., 2014). This method allows commuters to save on a higher cost of parking and fuel and avoid congestion during peak hours (Aros-Vera et al., 2013). Used in conjunction with limiting available parking, implementing time restrictions and high-cost paid parking in central locations, Park and Ride has shown promise in relieving congested arterial roads as well as encouraging public transport use (Rye & Koglin, 2014; Seik, 1997; Song et al., 2017; Zhu et al., 2013).

The location of Park and Ride should take into account the surrounding land uses to the Park and Ride location, including the proximity to residential housing, additional services nearby, accessibility to other modes of transport and distance to Park and Ride and final destination (Maat et al., 2005). According to the literature reviewed (e.g. Meek et al., 2008; Mingardo, 2013; Parkhurst, 2000), there are three general areas in which Park and Ride facilities are normally situated. These are:

- 1 In remote areas, with the purpose of collecting drivers at the beginning of their journey. These are usually located in suburban residential areas;
- 2 On the urban fringe, with the purpose of intercepting drivers just before their final destination and;
- 3 Local Park and Ride, normally situated in non-residential suburban areas along main transport corridors. These have the purpose of intercepting drivers somewhere along their trip between the origin and the destination (Mingardo, 2013).

Of these three locations, remote Park and Ride locations are preferred and should be considered to maximise the reduction in car use, as not only would the unintended effects be lower,

but there would be an overall reduction in car use due to the early intercept of motorists. This method should be favoured to increase public transport use and reduce congestion (Meek et al., 2008; Mingardo, 2013; Parkhurst, 2000).

The design of Park and Ride facilities plays a significant role in the perceptions and attitudes towards Park and Ride use. This takes into account the location and Park and Ride attributes, as well as policy implementation. Of the issues for the design of Park and Ride, poorly planned locations were one of the most considered factors found to influence use. This is because when selecting a mode of transport, commuters consider the shortest path and speed needed to arrive at a destination and often select the mode which is most convenient (Mingardo, 2013). Therefore, poor planning of Park and Ride locations that increased the distance to a transfer location reduced the probability to use public transport (Keijer & Rietveld, 1999; Loutzenheiser, 1997; O'Sullivan & Morrall, 1996; White, 2016). The potential time savings was found to be highly valued by users and in some cases more valued than cost savings (Dickins, 1991; Pas, 1998). Therefore, poorly locating a Park and Ride facility can significantly impact the use and hinder the desired outcomes.

It must be acknowledged that while the introduction of Park and Ride may bring many benefits to a transport network, several articles reviewed reported an overall increase in private vehicle use because of the introduction of Park and Ride. It appears that public transport users who previously relied on services became aware of the convenience of travelling partway by private vehicle and therefore adjusted their travel behaviour (Wiseman et al., 2012, p. 39). Traffic redistribution, trip generation and abstraction of users from public transport occurred due to the introduction of these facilities (Dickins, 1991; Hamer, 2010; Meek et al., 2008; Parkhurst, 1995). As this literature review has discussed, this highlights the need for careful consideration towards implementing the usability principles and land use integration when designing intermodal connections. The development of Park and Ride for the Gold Coast Light Rail, discussed as a case study in the next section, is one example of how travel behaviours may change when introducing new intermodal connections into a transport network.

### **A case study of the Gold Coast Light Rail Park and Ride**

The following case study of the Gold Coast Light Rail (GCLR) Park and Ride provides an example of how Park and Ride can be used in intermodal connections as well as demonstrating how design can be used to address some of the issues of interchange, as discussed previously.

On the Gold Coast, rapid population growth and a lack of competitive public transport options has led to high car dependency and congestion (Aurecon, 2015; Yigitcanlar et al., 2008). With increasing population and limited scope for the continued expansion of road networks; considerable development is required for public transport infrastructure on the Gold Coast to provide viable alternatives to cars (Aurecon, 2015; Goodwin, 1999). In a bid to shift the travel behaviours of commuters and encourage the use of public transport, the introduction of new services was proposed to increase connectivity. The light rail was implemented and has since gained popularity with commuters, evidenced by the reported reprieve in congestion, with a reduction in vehicle traffic by 13.9% for the Gold Coast Highway, as well as an overall increase in public transport use of 27% since it began operation in 2014 (City of Gold Coast, 2017). A stage two extension has been initiated which incorporated Park and Ride facilities and linked stage one of the light rail to a major existing interchange which serves heavy rail and bus.

Park and Ride facilities were proposed at two locations (Helensvale and Parkwood) and were designed to increase intermodality and provide convenient services for existing and potential

users (Department of Transport and Main Roads, 2015). Through upgrading existing facilities at the Helensvale interchange, users were provided with greater modal choice at the terminal and better connectivity to inner-city areas as a result of reduced travel times and fewer transfers compared to bus. This increased seamless connectivity and the attractiveness of public transport. Moreover, constructing new Park and Ride facilities further along the stage two alignment adjacent to the Smith Street Motorway and the Pacific Motorway as part of a local Park and Ride design enabled the potential for capturing more passengers (Department of Transport and Main Roads, 2015). In addition to implementing new transport services on the Gold Coast, changes were also made to policies regarding high-cost paid parking in inner-city areas and time restrictions around public transport facilities and high-traffic areas. These changes aimed at producing negative associations with the use of private transportation by increasing the cost of travel and inconveniencing private transport users with the idea of financial penalty if they exceed parking time limits, thus, increasing the attractiveness of public transport.

Improvements to the Gold Coast transport network also aimed at increasing usability across all modes of public transport through a number of means such as optimising information provision both online and at terminals, providing users with sufficient ticketing machines and various options for paying fares and making public transport cost effective. Providing users with apps such as Journey Planner, which enables users to plan their journeys beforehand by time and mode, as well as detailing service numbers, schedules and information about potential delays, better accommodates user convenience. In addition to this, all light rail terminals are fitted with electronic scheduling boards which provide the time until the next departure.

Terminals and transport systems on the Gold Coast were also designed to provide users with a range of options for purchasing tickets, which provides better services for users. Tickets include a range of paper tickets, on-board ticketing for buses and smart cards (Go Cards), as well as discounted tickets for concession, students and children. For commuters using multiple modes of transport, Go Cards are most convenient, as they can be used across all modes of public transport, are easily purchased at any self-service kiosk and can be linked to either a credit card or debit card, reducing the need to queue for top ups. Alternatively, Go Cards can also be topped up at self-service kiosks or other convenience stores. To further encourage the use of public transport, users who own a Go Card are provided additional discounts to fares. Using a Go Card is at least 30% cheaper than a single paper ticket, and travel within off-peak hours is an additional 20% cheaper, therefore providing a cost-effective alternative to private modes (TransLink, n.d.). Further, Park and Ride facilities are free to use for those travelling on public transport and offer 24/7 closed-circuit television (CCTV) surveillance to provide users with additional security.

## Discussion

As evidenced in many transport studies, understanding the travel behaviour of users and non-users is an essential part in developing successful public transport systems. Determining what factors are valued by users, as well as understanding the attitudes and perceptions of a particular mode, are necessary areas to comprehend when planning for and designing transport infrastructure. Failure to identify and provide for the needs of commuters can negatively impact travel behaviour and the prospects for achieving intermodality. Taking into consideration the GCLR Park and Ride example, it is evident that transport planners aimed to fill the gap in available, reliable and efficient public transport provision through the introduction of new services while also addressing the key issue of congestion and high car dependency. By introducing new modes of transport for commuters on the Gold Coast network, transport planners were able



to incorporate usability principles by increasing functionality on the network which in turn improves intermodality. The implementation of the GCLR can be suggested as a good example of how to implement intermodal connections in a growing transport system. As identified in the literature review, several aspects needed to be considered to increase intermodality, which included the travel behaviour of users, terminal design and the operational management of the transport system.

Whilst considering how transport planners were able to shift behaviours towards public transport for the GCLR Park and Ride study, the travel behaviour of commuters needs to be examined. As identified in the literature review, factors such as cost, convenience and design are highlighted as key influencers in mode selection. For the GCLR study, transport policies targeted cost, convenience and accessibility as key aspects to improve for intermodal connections, as they are identified as highly valued factors in modal selection. Policies took into account that most commuters want to use a mode of transport that is convenient, cost effective, reliable, comfortable and accessible. Acknowledging that one of the main issues with transport systems on the Gold Coast was a lack of public transport options, the introduction of new services instantly became appealing for commuters just by being available for use. Acknowledging (from the review) that the two key issues for users of interchange are functional and psychological, improving these factors in existing facilities and applying previous learning in similar modes can prove beneficial in achieving intermodality across a network.

When planning for and designing intermodal connections, policies must also consider the factors surrounding the cost of travel, as this is a significant aspect considered by commuters in modal selection. Rising fuel prices and increasing cost of vehicle maintenance and registration, as well as additional parking expenses in central areas for those using private modes, further influence modal selection and travel behaviours, with commuters seeking cheaper options. Ensuring that Park and Ride facilities are free to use without time constraints and that public transport fares are affordable for all users increases the appeal of public transport, as seen in the GCLR Park and Ride example. Through providing users with the option of further cost savings via the use of the Go Card, which can be used across all transport modes, users gained additional incentive to use public transport. Notably, to further encourage and promote public transport on the Gold Coast, during major events such as New Year's Eve or sporting events, public transport is free to use. This allows commuters to not only test the convenience and reliability of the service without having to sacrifice financially but also aims to provide users with the opportunity to receive positive feedback that may increase the likelihood of continued use.

The design of new terminals for the GCLR was also considered in order to optimise convenience for commuters and expand the catchment for existing and potential passengers. As highlighted in the literature review choice of location, terminal design and surrounding land uses all impact providing users with seamless connectivity. For the GCLR Park and Ride, this was mediated by selecting locations on the urban fringe that would capture users commuting through areas of high congestion for the Parkwood station and by selecting locations with accessibility to other modes of transport and additional services at Helensvale. Furthermore, terminals were designed with consideration to disability access and ease of movement between the Park and Ride and the light rail stations, as well as to other amenities at Helensvale, with signalled crossing to shops and access to other modes within the same terminal, which reduces transfer penalties. This highlights the need for careful consideration with surrounding land use integration when planning for intermodal terminals to optimise user catchments and the need to consider the operational management within existing transport networks.

The literature review also identified that the operational management of intermodal connections needs to address poor co-ordination between stakeholders, information provision to passengers and poor governance. The GCLR Park and Ride example demonstrates how integrating planning networks can successfully provide satisfactory services for users. This is achieved by co-ordinating public transport networks through one main agency (in this case the Queensland Department of Transport and Main Roads), which contracts work to private stakeholders, and using universal ticketing across all modes, as well as developing a system of information provision across all light rail networks both online and at terminals via electronic notice boards. This demonstrates a good example of how to provide users convenient and up-to-date information on delays and scheduled services to increase connectivity and provide users with a seamless journey.

## Conclusion

This chapter has discussed how interchange and Park and Ride schemes are used in intermodal connections and examined the GCLR Park and Ride model that was recently introduced. The chapter outlined key areas of interest in intermodal connections and discussed the importance of intermodality and what measures can be taken to achieve seamless connectivity for public transport users. Key takeaways from this chapter include the need for transport policies to understand the travel behaviour of users in order to optimise user experiences and encourage public transport use through cost-effective, reliable, accessible and convenient services. When designing intermodal connections, public transport systems need to thoroughly consider terminal design, location and surrounding land uses to encourage the use of public transport. In order for public transport networks to remain a competitive and viable alternative to private modes, it is evident that the introduction of new policies that hinder the use of private transportation is necessary in conjunction with improving existing and new public transport facilities. This chapter highlights several key areas for further research, including investigating better strategies for mitigating increasing private vehicle use when introducing new modes, researching strategies to optimise terminal design suitable for the population densities they serve and investigating best practice for community engagement prior to planning for new infrastructure to improve the delivery of intermodality on transport networks.

## Note

- 1 Commuter transit centres mainly serve travel to and from urban centres, are located in central areas of the cities and give high-frequency hourly services with access to numerous modes – so basically a multimodal hub (Pitsiava-Latinopoulou & Iordanopoulos, 2012).

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