
Summary:

How to achieve efficient public transport interchanges for travellers and for operators?

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The aim of this project was to find out how public transport interchanges can be designed to strengthen the competitiveness of public transport compared to private car. If changes between public transport modes are to be smooth, the public transport service, the switch between modes, and the design of the interchange, must be a pleasant experience. We found that high punctuality and a quick travel are the main factors that make users satisfied with their journey. We also found that operators' main wishes related to design were improvements that would also contribute to quick, secure and efficient operation through the public transport interchange.

Despite an increased focus on public transport interchanges, there have been few empirical studies aimed at users' perspectives on existing interchanges. Meanwhile, with increased demands for system efficiency, flexibility and coordination, changes between public transport modes, carriers and operators will probably be more common in the future. To contribute to the knowledge on how design of interchanges affects different users' experiences, we have sought to answer the following three questions:

- (1) Which characteristics affect travellers' perception and satisfaction with the public transport interchange?
- (2) Which characteristics contribute to quick, secure and efficient operation throughout the public transport interchange?
- (3) Which characteristics affect how travellers with disabilities perceive and are able to use the public transport interchange?

To answer these questions, we conducted literature studies, surveys on six public transport interchanges, interviews with operators and route planners, as well as interviews and go-along-studies with people with disabilities.

Which characteristics affect travellers' perception and satisfaction with the public transport interchange?

The public transport service

To reduce travel time by public transport, frequency, speed, whether one needs to switch modes or carrier, and proximity to stops, are the most important elements. These factors depend upon characteristics of the public transport network. Compared with other factors, travel time is crucial if satisfaction and competitiveness for public transport are to be increased (Reinhold 2008). Delays increase travel time and add to the uncertainty and stress travellers. This is a major drawback when travelling by public transport (Ellis and Øvrum 2014). Frequency affects total travel time, and impact on how effectively public transport operators can operate within their contracts. To achieve an overall quicker public transport service, resources can be allocated on some main lines to achieve an efficient network with high frequency

and good possibilities for switching between modes and/or carriers. In the literature, the switch between modes or carriers is in itself defined to have a disadvantage, but this disadvantage is found to vary with mode of transport, travel distance and service frequency.

We found that main factors for traveller satisfaction with public transport, were good punctuality and that public transport is a fast option compared to other modes. We found that travellers with long travels or waiting time, were not less satisfied with their journey compared to others. This suggests that the subjective expectations of how long the journey should take are of significance.

Our findings indicate that having to transfer, does not necessarily reduce travellers' satisfaction. In the regression analysis, the variable 'did switch between carriers' is not a significant explanatory factor when studying passenger satisfaction with their public transport journey. At the same time, we do find a lower share of those who 'did switch between modes/carriers' which are 'satisfied with their travel', compared to the group that 'did not switch between modes'. Many of the interchanges we studied have high frequency and switches between carriers are often carried out rather quickly. Our findings thus indicate that the characteristics of the public transport system and the interchange is of vital importance.

Transfer between modes or carriers

To make the transfer between modes or carriers easy, efficient and comfortable, the design of the stops or platforms, attractive surroundings, and safety are important. The stops and platforms should be within short walking distances of each other and should be easy to spot (Hine and Scott 2000; Ellis and Øvrum 2014). If the network and capacity allow it, few stop points are often the best solution. Universally designed (i.e. accessible) stops are important to facilitate easy access and egress for all travellers, not only for those with disabilities.

We found that the main factors for travellers finding it easy to switch modes or carriers, are that it is easy to navigate the interchange and that the transfer itself is not perceived as stressful. We found that the actual time spent at the interchange does not affect how the transfer itself is experienced. But we also found that if the travellers themselves think that the waiting time is too long, it is more likely that they will perceive the transit as problematic. It thus seems to be the subjective perception and expectation of how long one accepts to wait rather than the actual waiting time, which is of importance. In the regression analysis, the variable 'worried about catching the next departure' is not a significant explanatory factor when studying how satisfied travellers are with their transit.

Interchange design

Good and visible information is especially important for travellers who are unfamiliar with the interchange. The information must be placed so that it is visible to everyone, including people with disabilities. Signage should be consistent and standardized (Nielsen and Lange 2015). Real-time information systems make travellers perceive the travel and waiting time as shorter (Opheim et al. 2008). A coordinated ticketing system makes traveling easier for all users. The level of service should be adjusted to the interchange's functions. Large hubs should have more service functions than interchanges with mainly daily travellers. Furthermore, good lighting, well organised spaces and secure transfer can increase the physical safety of the interchange. Further, a myriad of people and features that attract different user groups can increase social security (Terzis and Last 2000; Gehl Architects 2011). Comfortable

waiting facilities with benches and weather protection can reduce the perceived waiting time (Gehls Architects 2011; Kummeneje 2014).

We found that the main factors for travellers being satisfied with the interchange itself, are protection against weather, a feeling of security, and a pleasant environment. Those waiting at the interchange for a longer time period are more unhappy with the interchange area than those with quicker transits. This is as expected, as the longer wait will make missing infrastructure and/or poor design, such as bad weather protection or unattractive environments, more evident to the traveller. Interestingly, in the regression analysis, the variables ‘seating opportunities’ and ‘overcrowding’ are not significant explanatory factors when studying how satisfied travellers are with the design of the interchange.

Table S1 displays the results of the regression analysis, showing which factors are found to be *very important* and *important* drivers of passenger satisfaction with the public transport service, the transit itself and the design of the interchange.

Table S1: Important explanatory factors for traveller's satisfaction (based on the regression analysis)

	Very important	Important
Satisfied with the travel <i>The public transport service</i>	Seldom delays Public transport a quick option	Many departures Not overcrowded Not too many transfers between modes/carriers Not a large detour
Easy transfer <i>The transfer itself</i>	Easy to navigate Transfer not stressful	Short waiting times Short walking distances
Satisfied with the interchange <i>The design of the interchange</i>	Protection against weather Safety A pleasant environment	Good service facilities Information easily accessible

The main factors making the transfer and the interchange environment a pleasant experience, is that there rarely is any delay, that using public transport is a quick option, that it is easy to navigate, that the transit is not stressful, that there is protection against weather, and that the interchange area offers a safe and pleasant environment. Other important factors are many departures, that it is not overcrowded, not too many transfers between modes/carriers, not a large detour, short waiting times, short walking distances, good service facilities and that information is easily accessible.

Which characteristics contribute to quick, secure and efficient operations through the public transport interchange?

It is important that interchanges have solutions that work well for operators and drivers. Well-designed interchanges have resolved issues related to alien traffic, so that this is not a hindrance for buses passing through. It can be challenging to change or develop nearby infrastructure, and especially in areas outside the interchange area. Still, these are challenges that should be continuously scrutinized and improved, as they can have a huge impact on how efficiently the interchange can be used by operators and perceived by passengers. How the public transport network structure is planned (with coordinated transfer, transfers based on frequency or no planned transfer opportunities, and whether the buses terminates or passes through the

interchange) will affect the requirements for infrastructure and demand for land in the interchange. Compact interchanges that consume less land are often perceived as better, as they contribute to short walking distances between modes. At the same time, this solution is best suited for frequency-transits, since coordinated transfer between several lines require larger areas. There will be trade-offs between how much land to be used for the interchange, and how network and frequency are planned to support efficiency at the interchange. If an interchange serves hourly departures on most routes, it is perhaps more important to ensure good transit opportunities for passengers by fixing routes, rather than trying to achieve the lowest possible land take.

It is important that actors involved in planning and operating at the interchange in different ways have arenas for cooperation and dialogue. One can often get a better utilization of resources by allowing the various public transport services and operators to complement each other. This requires cooperation between management companies and the various operators using the interchange. Furthermore, a good cooperation with the Norwegian Public Roads Administration (NPRA) can contribute to a high standard on the infrastructure in and around the interchange. By having a good dialogue and coordinate changes in the public transport network and at the interchange with the NPRA, changes in infrastructure can happen more seamlessly.

Lastly, bus drivers are an essential piece of the public transport service, and good working conditions for them are important. This includes satisfying solutions to rest rooms- and toilet conditions. In some instances, old infrastructure and driver facilities are located in non-optimal places. The question is whether current facilities should define planning of the public transport network, or if it should be the other way around. This requires considerations between drivers' needs, costs of developing new infrastructure and the optimum location with respect to the route structure.

Which characteristics affect how travellers with disabilities perceive and are able to use the public transport interchange?¹

A common denominator of good interchanges for disabled, is that information and designing should be uniform and consistent, with logical solutions throughout.

Information should be easy to attain and understand, for users with different disabilities. It should be easy to find the right transport mode and the right stop or platform. When transiting from one mode to another, switching between terminals, acquiring a comprehensive overview of the interchange and its possibilities can be challenging. Ideally, information for the whole interchange should be coordinated for all transport modes in a common information system.

Orientation and design can further be challenging when different providers use different design templates and standards. For the visually impaired, it is difficult to follow the signs and tactile guidelines if the design differs. A common standard for interchanges can thus make it easier to orientate at multiple destinations. Furthermore, a joint ticketing system can make it easier to acquire a ticket as all machines are similar, and as it is easier to buy a ticket for the entire journey.

¹ This question is entirely dealt with by Krogstad and Skartland (2016) in TØI report 1470/2016. Here, we will just reiterate the main findings from this study.