Assessing Integration of Bus Networks with Non-Motorised Access and Egress Modalities

Case Study:

Bus Network Integration with Access and Egress Modalities in Amstelland-Meerlanden

Summary

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Introduction

Demand for transportation is subject to change influenced by technological, spatial, societal and demographic aspects. The political environment, together with financial and spatial constraints limit the possibilities to address transport issues arising from growing demand through the construction of new infrastructure. Upgrading of existing services and improving integration over the entire trip chain are two options that can address these transport issues. However, there is a lack of (scientific) insights in the influence of service upgrades on the performance of the bus system, and a lack of (scientific) knowledge into the characteristics of the transport system that influence transport network integration. Hence, to be able to assess and improve integration in bus networks, insight is needed in:

- The differences in performance and effects between conventional and high quality bus services
- The causes and effects of network integration in Bus-NMT transport systems;
- The assessment of the performance of the entire transport chain as the result of transport network integration, considering the interaction of the transport network with its environment.

To be able to address these issues, a framework, with which transport network integration can be assessed, has to be developed, leading to the research question:

What are the main characteristics of the transport system and its environment that influence transport network integration, how do these characteristics relate to differences between conventional bus systems and high quality bus systems, and how can these characteristics be assessed using a framework?

Transport Network Integration

To be able to develop the assessment framework, insight is needed in the different concepts of integration and the elements and characteristics of the transport system. In this research, integration is described as *the combination of individual elements (links) of the transport chain, from a travellers' origin to its destination, thus combining different transport networks in one system, with the aim to positively influence effects of the transport system. This combination entails the integration of the different links through improvement of mode specific characteristics that influence integration, taking into account the environment of the entire system.*

The 'system' mentioned in the description of integration, needs to be explained in more detail. A system can be described as *'a collection of elements that is discernible within the total reality'*. The outcomes of the system, or 'emergence' is *'the principle that whole entities (groups of elements) display characteristics that are not only meaningful when they are assigned to the whole and can not be reduced to the individual elements'.* In this research, the integrated transport system consists of:

A. The Transport Chain
Which is the entire trip from origin (O) through the access node (AN) and egress node (EN), using the bus link, to the destination (D).

B. The Spatial and Demographic Elements
Which are the elements from the environment of the system, that influence the system, and as such are drivers of the system that determine the outcomes (effects).

C. The Effects of the Integrated Transport System
Which is the 'outcome' of the system, the effects of the system on travellers (e.g. total travel time) and society (e.g. emissions), which presents the way the integrated transport system influences the environment.

These different elements and their characteristics are the building blocks of the assessment framework.

Framework Development

Based on the literature research into transport network integration and the different elements of the integrated transport system, three different prerequisites have been identified that need to be captured in an assessment framework. These prerequisites (considerations) are:

- *The influence of network specific characteristics on transport network integration;*
  Implies that the framework should be able to identify and assess different characteristics of the system elements, and should be able to determine the influence of these characteristics on network integration.
- *The influence of the integrated transport system on (societal) effects;*
  Implies that the framework should be able to determine the effects of a system, and should be able to determine the influence of network integration on these effects.
- *The assessment and comparison of different systems in terms of characteristics and effects.*
  Implies that the framework should allow for the comparison and improvement of different bus systems.

To be able to address these considerations, the framework that has been developed consist of three individual parts that are influenced by one another, being:

- *Bus Line Performance Assessment;*
  Which involves the assessment of the different system elements and their characteristics of different (types of) bus services, including a comparison between different bus lines.
- *System Effect Assessment.*
  Which involves the assessment of the effects of the (optimised) integration of the individual systems, including a comparison between bus lines.
- *Integration Assessment,*
  Which involves the assessment of the manifestation of integration in transport networks and the related integration effects.

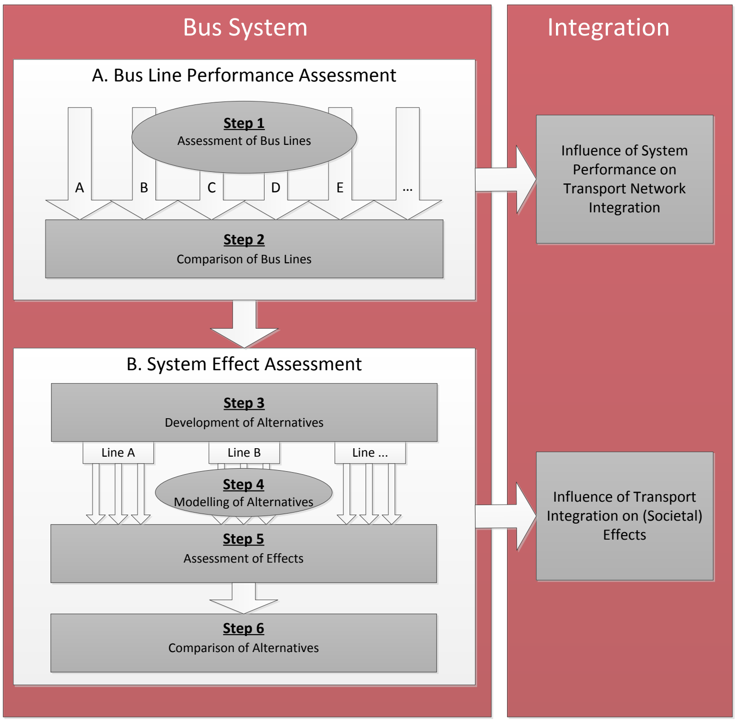

Figure 1: The Assessment Framework

The considerations, the building blocks (elements and their characteristics) and the three different parts of the assessment framework lead to the framework is presented in Figure 1**Fout! Verwijzingsbron niet gevonden.**. This framework is tested using a case study.

Case Study: Assessment of Integration in Amstelland-Meerlanden

The case study has been carried out for the concession area Amstelland-Meerlanden of Stadsregio Amsterdam. Each step of the framework represents a different step in assessment.

Step 1: Assessment of Bus Lines

The first step involves the assessment of individual bus lines. The different bus lines are assessed on elements and characteristics, and are compared using a scorecard in step 2. General survey outcomes give a chance to give a general overview of system performance of the 10 assessed bus lines. The break-down of use of access and egress modalities for the bus lines is most important. This break down emphasises the need for more detailed knowledge in the use of access and egress modalities for bus networks. The bicycle is an important modality on the access side, whereas its share on the egress side is much smaller. This can be explained by the fact that on the access side of a trip, people often have more modalities at their disposal, and thus have a larger choice of modalities. On the egress side, these modalities are often not or less available. Furthermore, walking is more important on the egress side, suggesting distances on this side of the trip are often shorter, hence allowing for walking. These outcomes stress the importance of the bicycle on the access side, where for bus systems, walking and cycling are very often considered as one modality. Hence, the high use of the bus on both the access and egress side suggest that other bus services are important as feeder services to faster or last-mile bus services. Opportunities might exist on the egress side of the trip (last-mile) if these distances are short, for instance through the supply of cycle-hire facilities, thus aiming for competition between bus and bike for short last-mile distance.

Step 2: Comparison of Bus Lines

The bus system (lines) are compared in three different ways: by bus type, by bus line, and by stop.

The bus type comparison compares Comfortnet (conventional bus system) with R-Net (high quality bus-system). Striking is that for R-Net, the share of the bike, both for access and egress trips, is much higher than the share in Comfortnet lines (25% versus 11% access, and 10% versus 5% egress). One explanation could be that people accept longer trips for R-Net services due to the positive performance differences between R-Net and Comfortnet (e.g. higher speeds, higher frequencies). The accepted distances for access and egress for walking and cycling have been assessed in more detail. For R-Net, distances are often higher than for Comfortnet, with the exception of the bicycle use on the egress side.

The line based comparison allows for a more detailed comparison of the ten assessed bus lines. Characteristics per element are assessed. Using the equation for total travel time, the travel times per line can be determined for an in-vehicle distance of 10 km, hence allowing to compare the differences in speed, frequency and access and egress times. Using the outcomes of the bus line comparison, relations that determine integration can be assessed. Two significant relations for characteristics that influence integration have been found, being the speed of the service (commercial speed) and the frequency of the service.

A stop based comparison allows to consider elements from the environment that influence travel choice and integration. Three assessment have been conducted, the assessment of spatial levels, the assessment of activities, and the assessment of type of bus stop (access or egress). A regression analysis has shown that there is a relation between the spatial level (1 for extremely urbanised, 5 for rarely urbanised) and the catchment area of the bus stop. The directions of these relations are different for Comfortnet and R-Net. For Comfortnet, the catchment radius increases when the spatial level decreases, for R-Net, this is the other way around. The assessment of activities has shown no significant relations. The final assessment, the type of bus stop, has shown that for access stops, people travel longer distances by foot (not that this is the activity based side), probably because of the lack of availability of other modalities. On the egress side (home-based), distances for egress stops are shorter than for non-classifiable stops.

Step 3: Development of Optimisation Alternatives

The previous steps have shown that two characteristics contribute to an increase in integration. For two bus lines in Amstelland-Meerlanden, one Comfortnet line and one R-Net line, alternatives are developed to determine the influence of the identified characteristics (integration) on the effects of the systems. For the Comfortnet line, six alternatives are considered (base alternative, frequency increase, speed increase, decrease in stop density, speed and frequency, and finally speed, frequency and stop distances). For the R-Net line, three alternatives have been generated (the base alternative, the express service alternative (skipping stops) and the tunnel alternative (allowing for a higher service speed)).

Step 4: Modelling of Alternatives

The different alternatives are modelled and assessed using a traffic model. The traffic model used is the transit model of VENOM, the regional model of Stadsregio Amsterdam. OtTransit is a class of OmniTRANS that is used for two main purposes: the assignment of traffic to the network, and the generation of transit costs (skims). The model has first been validated for use. By comparing the number of passengers (Qlik data of March 2015) with the modelled number of passengers, the model is validated based on outcomes. By comparing the usage of bus stops (GOVI data) with the usage of bus stops in the model, the behaviour of the model is validated.

Step 5: Assessment of Effects

The different alternatives are modelled and compared. This comparison allows for the calculation of total travel times, using the previously mentioned total travel time equation and the equations for the catchment area. This leads to the travel times as presented in **Fout! Verwijzingsbron niet gevonden.**. These travel times will be used in a Cost-Benefit Analysis (CBA) in step 6 to compare the effects of the different alternatives. The assessment of effects has also shown that when the characteristics that influence integration are altered, the number of passengers increases.

Step 6: Comparison of Systems

The performance of the different alternatives, in terms of travel time and number of passengers, is done using a Cost-Benefit Analysis (CBA). This CBA allows to assess the alternatives on societal viability by taking into account both the costs of implementation of these alternatives (e.g. operational costs, implementation costs), as well as the benefits (travel time savings, increase in operational income through the increase in number of passengers). This analysis shows that for line 172, the frequency alternative and the speed alternative give a positive outcome. For line 300, both developed alternatives are positive, but the express service alternative has shown a tremendous increase in monetise benefits as compared to the base scenario.

Conclusion and Recommendations

The research question of this thesis has been stated as follows:

What are the main characteristics of the transport system and its environment that influence transport network integration, how do these characteristics relate to differences between conventional bus systems and high quality bus systems, and how can these characteristics be captured in a framework that assesses integration effects of the entire transport chain?

This research question is answered in three different steps. The first of the research question, *'What are the main characteristics of the transport system and its environment that influence transport network integration'* can be answered with the fact that bus line characteristics influencing integration have been identified, being commercial speed and frequency, and two environmental characteristics, being the spatial level around the stop and the typology (access of egress) of the stop, that influence the catchment area, and as such the integration of the system. With large qualitative competitive characteristics that drive the success of R-Net as a high quality bus service (speed, frequency), the catchment area of a stop is positively influenced: the competitive advantage of the system as a result of these characteristics makes that people travel longer distances to a stop (and as such answers the second part of the research questions *'How do these characteristics relate to differences between conventional bus systems and high quality bus systems').* Catchment radius around high quality bus stops (R-Net) is much larger than that for conventional lines (Comfortnet), both for walking as well as for cycling access and egress links.

The final part of the research questions *'How can these characteristics be captured in a framework that assesses integration effects of the entire transport chain'* has been answered by the incorporation of the three identified prerequisites into the framework. With the framework, integration can be assessed, both by the analysis of different characteristics of the different bus lines, as well as by the comparison of different bus lines belonging to different types of bus services (e.g. conventional lines and high quality lines). Furthermore, the framework allows to go even deeper into the understanding of integration, by not only analysing characteristics responsible for integration, but by also assessing the effects of altering these characteristics to allow for improved integration in the entire trip chain. As such, the framework is capable of assessing and identifying characteristics responsible for integration, as well as assessing the effects of the transport system. Apart from these scientific contribution of the framework, the framework is also useful for concession authorities and public transport operators to help assess the performance of their bus system, and to help indicate which characteristics could be improved in order to create a positive CBA outcome that benefits both the concession authority as well as the passenger.