1 INTRODUCTION

This paper outlines some basic principles of best practice in public transport network planning. It is based on the authors’ work for a Best Practice Guide on Public Transport Network Planning (Nielsen et al 2005), published by the INTERREG IIIa (North Sea) HiTrans project in September 2005.

Our intention has been to show that network planning and design can be a decisive factor for public transport success. We also recommend some important elements of planning philosophy and design principles for the public transport network.

However, what constitutes good practice or bad solutions depends on the context. Therefore, there is no definite recipe for success. In this paper, the emphasis is on high quality public transport that is able to replace car use as a significant measure to create a more sustainable and environment friendly city region on a long-term basis. In most urban regions in the developed world, this is a major concern of transport policy. Therefore, by high quality solutions we mean solutions for public transport systems that are able to be a competitive alternative to the motor car for urban travel. This is a far-reaching quality ambition, which means that it is difficult to find practical examples that fully live up to the expected level of quality for all components of the public transport system.

In order to fund the quality needed, the public transport system must also be cost-efficient. The costs of operation also influence the level of fares that users must pay. Therefore, both efficient use of resources and high quality service to the passengers is required.

Good network planning can make a very significant contribution towards both objectives. On the other hand, there are a number of very serious pitfalls that decision-makers might fall into, if they do not reflect properly on their planning philosophy and network design strategies. Making the right or wrong choices at a strategic level can decide between success and almost complete failure. Statistics on public transport trends and market share in urban regions
indicate that at least some wrong choices have been made in most urban regions.

The HiTrans Best Practice Guide discuss a number of aspects of public transport network planning in small and medium sized cities, including the planning process, the need for good understanding of user requirements and travel demand factors, project assessment and, most thoroughly, institutional and political factors. Here we concentrate on network planning philosophy and design principles. The institutional aspects of such planning have been commented upon in an earlier paper (Mulley, Nelson and Nielsen 2005).

2 OVERVIEW

In the public transport network planning process it is useful to reflect on (at least) four pitfalls of principles that are easy to fall into, and the alternative principles that we would recommend. We place the pitfalls and the alternative approaches at this strategic level under the following headings or labels:

- The ‘Bangkok model’ pitfall vs. the ‘Zürich model’ approach
- ‘The Direct line’ pitfall vs. the ‘One section - one line’ approach
- The ‘Tailored-made’ pitfall vs. the ‘Ready-to-use’ approach
- The pitfall of ‘Hundred flowers blossom’ vs. the ‘Make it simple’ approach.

Given the planning philosophy outlined, we can also offer some more detailed and practical advice on public transport network design. We can present even these principles as a number of pitfalls, and discuss them in relation to alternative approaches.

We have identified no less than fourteen issues to take up in the discussion of network design. For all these issues we can find examples of good and bad practice, in addition to the theoretical analyses offered or available from other research. Many public transport planners are well aware of these principles, but often the importance of the principles are not adequately understood among decision-makers and other participants in the planning and design process. However, time and space only allow for a full discussion of the first four major principles, and some very brief comments on the other fourteen aspects of network design.

3 RECOMMENDATIONS ON NETWORK PLANNING PHILOSOPHY

3.1 The ‘Bangkok model’ pitfall

Our attention to the importance of the contrasting principles of the Bangkok and the Zürich models was stimulated by reading Paul Mees’ interesting book: ‘A very public solution’ (2000).

Obviously public transport planning must cater for the different users’ demand for travel. Planning should be based on a very thorough understanding of the different segments of the market. However, the market and user oriented focus of public transport planning might lead to some serious misconceptions. Mees describes them as the consequences of the ‘Bangkok’ model of urban transport planning, which he connects with the idea of a liberal, unregulated market economy for urban transport.
The Bangkok model is a school of thought that has heavily influenced public transport planning for many years, and contains several basic ideas about public transport as summarized in Figure 1. We tend to agree with Mees that this set of ideas is responsible for much of the failure of public transport to keep its position in the urban transport market. The most important effect of this approach is the segmentation of the public transport market. The idea of market differentiation and tailoring services to various groups of customers will easily lead to a disintegration of the public transport system into separate, unco-ordinated and competing services with their own marketing, branding, information and fare systems. Each of the services might be “ideal” for a particular segment of the travellers in the region, but of little use for the majority of the potential customers.

<table>
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<tr>
<th>The demand-oriented “Bangkok model” vs The supply-oriented “Zürich model”</th>
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<td>The segmentation of the public transport market.</td>
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<td><strong>Demand and supply</strong></td>
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<td>Demand controls supply. Deregulation and competition will</td>
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<td>best satisfy demand, with little need for public financial</td>
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<td>support. Public transport services should be strongly</td>
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<td>differentiated for different market segments, as in the car</td>
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<td><strong>The role of public transport</strong></td>
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<td>Public transport can only compete to/from city centre and</td>
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<td>a few other heavily developed business districts, mainly for</td>
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<td>journeys to work. The car must take most of the travel market</td>
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<td><strong>Dominant vehicle size</strong></td>
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<td><strong>Parallel lines and modes</strong></td>
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<td>Parallel operations are OK. Plan for competition between bus</td>
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<td><strong>Important service characteristics</strong></td>
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<td>Emphasis on strong peak period express services. Adjustment</td>
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<td>of timetables to working hours and peak loads.</td>
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<td><strong>Interchanges</strong></td>
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<td>Develop only a few, large scale interchanges, including park</td>
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<td>&amp; ride sites in the suburbs with special lines to the city</td>
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Figure 1: Comparison of the characteristic ideas of the Bangkok and Zürich models for public transport development and provision.

The philosophy looks upon the motor car as the ideal form of urban transport, and tends to overlook the economy of scale in public transport and underrate the disbenefits of scale of the car system in urban settings. This influences the kind of solutions chosen for the public transport network. It has also inspired many technology-led research projects attempting to develop public transport.
systems that strive for services that are similar to the private car. For at least some 40 years automated Personal Rapid Transit (PRT) systems with small, car-sized vehicles has been presented as The Solution to the urban transport problem.

The main reason for us not having the PRT type of transport solutions in our cities today, 30-40 years later, is not due to technological shortcomings or the lack of suitable institutions and tax incentives, as the proponents of such systems usually claim. The main explanation lies in the fact that the idea of individual travel in small vehicle units is not conducive with the conditions of the built-up city and urban region. This way of travelling simply requires so much space and expensive infrastructure that it cannot compete with the combination of the traditional modes of walking, cycling, buses and light rail systems and the motor car.

3.2 The ‘Zürich model’ approach
As a contrast to the ‘Bangkok model’, Mees recommends the development of the public transport system according to the supply-oriented planning model of the Zürich region, which is considered a leading city in public transport development and an example of market success in a modern, rich economy. Here the basic aim is to develop a planned and integrated network of services covering the whole urban region, and designing all elements so that the services function as one, total system which is accessible and attractive for all potential users.

The Zürich model approach emphasizes a set of planning principles that are very different from the ideas of the Bangkok model, as indicated in Figure 1. To be successful public transport must make use of it’s basic idea of inducing people to travel together in space-efficient vehicles on efficiently used infrastructure. A network strategy for meeting the challenges of urban public transport should take account of the fact that the essence of a public transport system is the concentration of passenger flows onto specific lines of movement. This leads on to some implications for network design that we highlight below. It also leads to the conclusion that interchange is an inescapable feature of many of the journeys that can be made by public transport. Consequently, how the network is developed and interchanges are designed, and how services are organised and presented, is at the heart of the overall strategy of improving public transport.

3.3 Balance between demand and supply oriented network planning
Good practice in public transport planning requires awareness of this dichotomy of thinking about how the transport system should be developed, finding the right balance between demand and supply oriented planning.

The choice of balance should reflect the major ambitions and objectives for public transport. If the main interest lies in keeping a low level of public finance and other government involvement in public transport development, the strategies indicated by the demand-oriented ‘Bangkok’ model are likely to be useful. If, however, the aim is to develop public transport as a replacement for the car in the development of a sustainable city, the ‘Zürich’ model is an inspiring prototype.
In small and medium sized cities the co-ordinated development of one, total system, and not a differentiated collection of customer-tailored services, will be the only main alternative available for high quality public transport. The reason for this is the small size of the total market and the dispersed pattern of journeys, both in space and time. Co-ordination and combination of different travel demands is the only way of taking advantage of the economies of scale and the almost universal accessibility that are public transport’s reasons for existence.

3.4 The ‘Direct line’ pitfall

Ideally, the public transport network should offer fast, direct links from everywhere to everywhere, just as the car does for those who have this option. This is often supported by research that shows that interchanges between lines and modes are important barriers to the use of public transport. In practice, public transport must work by concentrating passengers onto selected corridors, and inevitably this leaves some journeys without a direct connection.

The idea that the ideal public transport service is a direct link between zones of origins and destinations is widespread, but has such negative consequences that it can be considered a potential pitfall in network planning, see Figure 2.

The ‘direct line’ strategy leads to a network that is complicated for the users, complex to plan and operate and vulnerable to operational disturbances. As long as the operational resources are the same, these disadvantages are unlikely to be offset by the benefits of more lines that offer direct travel opportunities without change. In addition, the aim of a long term stable line structure is very difficult to achieve if one is working with the ‘direct line’ principle.

The only advantage of the ‘direct line’ strategy for the user is that diagonal journeys between certain branches of the network may be made without transfer, if the user is able to learn the timetables and adjust her/his activities to this. But this is achieved to the disadvantage of the high frequency for journeys between other areas at either side of the interchange or city centre.

An evident effect of the ‘direct line’ strategy is that operational disturbances on one of the route sections cause more disturbances in the rest of the network.

When route sections are served by several lines that run to different areas, there are problems of timing the departures on different lines. Even if there are many departures per hour on a route section, big ‘holes’ very easily develop in the timetable for the common section. This results in longer waiting times for many passengers, and often uneven use of the capacity of different departures, i.e. less efficient use of the operational resources.

In bus operations, where the supplied capacity per departure is small, the uneven timetable on the common route sections often leads to the creation of ‘convoys’ of vehicles. This causes congestion and delays at bus-stops and often confusion among passengers about which bus to board, passengers running to catch the right bus, etc. The more common route sections we make, the more interdependencies we create between lines in the network.
scheduling and the more difficult it will be to design a network where the operational resources can be used to produce real high frequency services. The long common route sections also make more difficult the fine adjustments of frequency against demand for each line that are necessary to optimize the use of operational resources.

Figure 2: A simple comparison of the two different network principles of ‘Direct connections – no transfer’ and the ‘One section – one line’ approach.

3.5 The ‘One section – one line’ approach

The opposite network design principle to the ‘direct line’ approach is the ‘one section – one line’ approach, which we recommend because it supports the development of a robust, flexible and cost-efficient network, see Figure 2.

This network strategy has very real advantages in that it creates a much simpler and a much more stable public transport network for the users. This is important in order to achieve the positive effects of the public transport network on peoples’ long term travel and location decisions, as well as on land use. Every city has a range of possible public transport modes and service types, each of which offers a different combination of characteristics such as speed, capacity, ride quality, ability to penetrate different types of areas, and cost. Use of the ‘one section – one line’ principle creates the best possible conditions for the selection of the most appropriate mode, size and
type of vehicles, and type of operation for different sections of the network. This will contribute towards the optimal use of resources for network operation. Unnecessary parallel running of buses and rail services might be avoided, and the number of buses and/or trams on inner city streets might be kept below strict traffic and environmental capacity limits.

For the public transport passengers it can be highly advantageous to substitute a fast mode (such as rail) for part of their journey, instead of a slow mode (such as bus). Indeed, only by the combination of different modes and service types can public transport offer an acceptable alternative to the private car. Data gathered by Tarzis and Last (2000) suggest that there is some association of higher levels of transfer with higher public transport modal shares.

Even when the ‘direct line’ strategy is abandoned, line structure and timetables can be designed so as to give the best direct and high frequency services to the opposite travel corridors, so that transfers will only be necessary for the less common combinations of origins and destinations.

In many practical cases some common route sections for different lines will be the best solution, but only when there are some definite reasons for departing from the ‘one section – one line’ principle.

3.6 Avoiding unnecessary transfers and reducing the barrier effect of interchanges

As a consequence of selecting the ‘one section – one line’ principle, it is important to focus on measures that keep the need for transfers at a reasonable level and to make arrangements for easy transfers between different lines and modes.

The most important measure than can be taken to reduce the need for transfers, is to create long lines that connect important travel origins and destinations such as densely developed housing areas, local and regional centres, concentrations of work places, etc. By connecting two such lines in a well designed interchange, a significant additional part of the region can relatively easy be reached by one transfer only. Two groups of long lines crossing each other may in theory cover all origins and destinations in a region by a combination of direct journeys and journeys with one transfer.

In practice, urban form and development, topography and infrastructure will force modifications of the network. The public transport system has several modes and lines with different stopping patterns to cater for the different demands of the short and long distance travellers. Very different capacity demands in various parts of the region also require the splitting up of the network into different types of lines and modes.

Reducing barriers to interchange will enable individual passengers to gain more benefit from the public transport system, and will increase the attractiveness of the public transport service relative to the car.

The key role of transfers and interchange points must be fully recognised and given high priority in public transport development. This point has been stressed by the GUIDE project (Tarzis and Last 2000). They ascertained that interchange between services is an inescapable feature of public transport.
Hence, GUIDE developed guidelines for the design of interchanges that will significantly reduce the barrier effect of transfers, and offer new opportunities for further development of the market for public transport.

In many cities improvements of all aspects of interchanges stand out as one of the most cost-efficient ways of increasing public transport ridership and market share. According to Tarzis and Last (2000) the key benefits from the systematic improvements of interchanges are:

- Reductions in disutility from reducing unpleasantness of individual interchange experiences of existing users.
- Reduced journey times from rerouting where previously interchanges discouraged use.
- Fulfilling a necessary condition to make possible an increase in public transport mode share, especially where it is traditionally least competitive such as for orbital movements.
- Reduced pressure on crowded radial sections.
- Increased flexibility for operators and planners to offer a mix of public transport modes to suit local circumstances.

More theoretical and empirical analysis of the relative merits of the two network strategies of ‘Direct connections – no transfers’ and ‘One section – one line’ is desirable, including studies of their practical applications in different urban regions.

### 3.7 The ‘Tailor-made’ pitfall

The principles of the ‘Bangkok’ and the ‘direct line’ approaches are closely associated with the pitfall of attempting to create ‘tailor-made’ public transport. Attempts to offer tailor-made transport similar to the individual use of the motor car cannot succeed in the long term. Special services for particular, small groups of people may be created and can be very popular for a short period of time. However, the customers and their travel demands change rather quickly, and some months or years after their introduction, the tailored service has to be adjusted. With many different types of special services in a region a very complicated mixture of services will be offered. Still, the complete set of services is unlikely to cater very well for the major travel volumes of the city region.

### 3.8 The Ready-made approach

The alternative we recommend is the ‘ready-made’ approach. Instead of attempting to make public transport as similar to the car as possible by the tailoring of services to different continuously changing travel demands, it is more fruitful to look upon the role of public transport as similar to the role of the road network in the city.

Public transport planning should be focused on the task of providing access to all parts of the city region for all those who cannot or prefer not to use their own motorised transport, at the time of their own choice. This implies ‘mass production’ of a public transport service for the whole urban region, hence the term ‘ready-made’ approach.
3.9 Towards a two-tier network strategy

It is interesting to note that in Swedish public transport planning, there has been a move in planning advice from the demand-oriented towards the supply-oriented model of network development. A planning advice paper by Holmberg, Börjesson and Peterson (no date) has been revised to accommodate this change of view within the profession. They acknowledge that the 1980’s idea of tailoring the services to different groups of users at different times of the day has stimulated the market orientation of public transport planning. But taken too far, the principle leads to a complicated service supply and inefficient use of the total resources for the public transport system.

At the end of the 1990’s a different strategy had become very clear, which now can be found in planning advice from other countries as well. This implies the development of a two-tier system of urban public transport networks. HiTrans has also found support for this principle in evidence from city case studies.

The first level is the development of heavy trunk line services with high frequencies, priority measures and heavy travel demand. This requires the concentration of routes and often somewhat longer distances between stops than traditional bus services. All main transport corridors should be served by a combination of urban and regional trunk lines. They should be seen as a permanent element of urban structure and therefore run with a high standard of service at all operating times.

The second level of service must serve the rest of the city and region with a more flexible and dispersed form of operations that will provide improved public transport access also for elderly and disabled persons. Often minibuses are used and operations vary from traditional line haul traffic with medium to low frequency to demand responsive services, even using taxis.

A major task in network development is to find the right balance between the two types of services, in space and time.

A challenge is to integrate the two levels of the network into a single public transport network that caters for the different demands of the various groups of users. Integration of all lines and modes should be achieved through the development of high quality interchanges located at nodes in the urban structure. Co-ordinated scheduling, ticketing, traffic control and information systems will ensure that the public is offered seamless public transport between all parts of the region.

3.10 The pitfall of ‘Hundred flowers’ blossom

The last pitfall of network planning ‘philosophy’ we will draw attention to, can rather ironically be named after one of Chairman Mao’s slogans of the Chinese ‘cultural revolution’. From the 1980’s a similar idea gained foothold in public transport policy: Take away regulations and other institutional barriers, and let entrepreneurs and innovators be free to develop new transport solutions in response to the users’ needs and the demands of the travel market.
Now we can look back and learn from the results of the ‘cultural revolution’ in public transport, and we can obviously conclude that the results were not as catastrophic as those of Mao’s revolution.

‘On-the-road’ competition is the closest that public transport comes to a totally open market. This allows operators to compete directly with each other for customers, with or without restrictions. This has been implemented in a number of urban bus environments, most notably in the UK and South America, but the initial heavy competition has typically been followed by consolidation and a reduction of innovation. This has led to authorities re-entering the regulatory framework, at least to ensure the fundamental network, integration and quality of service. In practice, while open competition exists in the coach and private hire markets, it has been rare in the urban sector in developed countries.

We also note that the introduction of on the road (more or less) market competition in the UK outside London since 1986, has not resulted in general improvement in services or turn-around of the continuing decline in bus patronage (Passenger Transport Executive Group 2003). A 42% fall in bus passengers from 1982 to 2001 was registered for the passenger executives of the large conurbations outside London. On the contrary, the London region where a more regulated institutional framework remains, is the only large urban conurbation in the UK with a significant long term growth in bus usage: 38% growth from 1982 to 2001. Also overall public transport patronage increased in the London region.

From a passenger perspective, the lack of integration of light rail with the bus network is seen as the least attractive aspect of light rail development in the UK. In contrast to mainland Europe, it is the institutional framework of deregulation and the distinction between commercially operated bus services (over which the planning authority have no control) and tendered services (which are provided under the banner of socially desirable services not provided by the market) which prevents further integration (National Audit Office 2004).

A study of the organisational aspects of the light rail system of Tyne and Wear drew a number of conclusion (Veeneman 2002):

- The focus on the free market has made it hard for public and private actors to co-operate, leading to a rather passive public role for the responsible authority in public transport provision.
- Co-ordination between operators at the level of scheduling becomes focussed on individual market share rather than on collective market coverage.
- Risk aversion and market control can limit the operators’ customer orientation.
- A free market does not guarantee a competitive bus market.

Other studies of market competition in Scandinavia and other countries have shown that the transport authorities have typically retained the initiative for the planning of the network, integration of services, and specifying the quality of the transport product. This confirms our claim that a free market environment cannot provide the type of competitive, high quality public transport that most cities of the developed world are looking for.
3.11 The ‘Make it simple’ approach

Instead of focusing on free, on the road market competition, we recommend public transport planners and politicians to focus much more on how to simplify the public transport network, and to make the system much more accessible and easy to understand and use for all groups of potential customers.

We believe that the importance of the ‘make it simple’ approach is grossly underrated in much of current public transport planning and development. There are several reasons why simplicity should be an important consideration in the design of the public transport network.

At a particular point in time, a large part of the users are new to the system, and the turnover in the market is high. Some operators (like Oslo Public Transport) work on the assumption that annually, even with a stable total demand, some 10 percent of their customers leave the system and are replaced by new users. In addition, potential users are most inclined to change their travel habits when they have moved to a new place of residence or changed work. This means that the large section of the population who are changing their travel patterns and habits, are those most sensitive to new information and least informed about the public transport system they might choose to use.

Dziekan (2003) has shown that the use of public transport requires a large emotional and intellectual effort of information collection and problem solving during all stages of the journey. For all non-users this is a significant barrier against the use of public transport, especially for the non-routine journeys.

Tarzis and Last (2000) point out that the way in which the network is presented to the public can significantly affect the system’s effectiveness. At the extreme, if passengers are not told about interchange opportunities, they will not plan their journeys to make use of them. More subtly, the way in which the public transport network is promoted to the public, and the role set out for interchange within the network, will have a profound influence on how passengers use the system. The design and promotion of the network can thus highlight, or alternatively downplay, the scope for interchange at particular locations, and hence guide passengers as to where barriers to interchange are least.

Based on current research on user orientation in public transport systems, Dziekan and Thronicker (2004) have proposed an extensive checklist to assist the planners in the development of simplicity and information in public transport. They state that it is necessary to have a single, comprehensive and easy to read map (or diagram) to give the user an overview of the total system with all modes, lines, stops and interchange points that serve the urban area, irrespective of the operator.

This requirement is crucial, since it is impossible to fulfil if the system consists of a large number of lines on the same or parallel routes in a dense network with many different types of services, express routes, special peak period services and so on. The importance of this point is underlined by the additional user requirement to combine public transport information with
orientation information about the city and the need for detailed street and stop information during travel.

Even general psychological research into the reactions of people to the freedom of choice, supports the idea of simplifying public transport choice situations and to dismiss the idea of the ‘Hundred flowers’ blossom’ as interpreted above. When there are available many alternatives with complex sets of properties, consumers come into a type of stress situation (Kirkeboen 2006). This might lead to a dismissal of alternatives, and a reliance on earlier habits and old choices. Here we might have a good explanation for why simplifying the product or service is a key to successful branding in the consumer industry – and in public transport.

In addition to this user perspective, there are good operational reasons for simplifying the network, so this has become an important trend in high quality network development in recent years. Examples of good practice may, for instance, be found in the bus systems of cities such as Copenhagen and Lemgo as well as in many modern light rail systems elsewhere.

4 PRINCIPLES FOR NETWORK DESIGN – PITFALLS AND RECOMMENDED ALTERNATIVES

Space and time will not allow for a detailed discussion of our remaining principles of network design. However, a very short explanation of the potential pitfalls and recommended alternative principles of network design is offered. They form the link between the recommendations on planning philosophy and more practical applications of network design.

**Line definition:** The basic building block of the public transport service is the line. Before starting to develop the public transport network it is crucial to have a clear understanding of this key element, and define the different properties of a line.

**The line map pitfall vs. the service frequency analysis:** The planner should not rely on the traditional public transport map for information on the public transport coverage of the urban area, which often is very misleading because of the lack of information about service frequencies and times of operation for specific lines, or on the detailed scheduling on route sections operated by several lines. Rather detailed analysis of the frequencies on different lines and route sections is recommended even at the level of strategic network planning. Frequencies also influence strongly the number of vehicles needed in the system, and hence much of the operating costs.

**The flexible line pitfall vs. the stable geography - flexible frequency approach:** The planner should not develop a network that changes significantly over short time periods, including a large number of special lines and services with very few departures during the day. To provide a robust structure for urban planning and development, and for the building of confidence and long term branding of services, the major geographical elements of the public transport network should be left unchanged for long periods of time. The necessary flexibility in relation to travel demand and available resources for service operation should mainly be attained by the flexible adjustment of service frequencies of individual lines and end sections of lines with the weakest travel demand.
The pitfall of neglecting the network effect vs. designing a line structure that exploits the network effect: Traditional public transport planning tends to focus on single lines or route sections and transport corridors, and to analyse the pros and cons of different alternative solutions in this context. This approach tends to neglect the network potentials of the system, and to look upon interchanges as barriers to travel that should be avoided by all possible means. Instead, focus should be on the opportunities for creating a true public transport network of highest possible quality and exploits the new opportunities for travel that high quality interchanges can provide when combined with the right high frequency line structure.

The pitfalls of low and high frequencies vs. optimal network frequencies: Due to a combination of low transport demand and faulty line structure, large parts of existing public transport systems have too low frequencies to be looked upon as an interesting alternative to car use. Often other sections of the network have so high frequencies that congestion, disturbances of operations and negative environmental effects are created on inner city streets, without much gained in the form of shorter waiting times for the customers. Planners should aim at a form of optimisation of frequencies in relation to travel demand, and adjust the line structure and roles of different modes accordingly.

The pitfall of adding new lines vs. the principle of concentration of resources: When improvements to existing services are discussed, very often the adding of one or more new lines is the main proposal. This may easily result in less efficient use of resources. To achieve the much needed increase in service frequencies, operational resources should instead be concentrated to as few high frequency lines as possible. This even improves the benefits gained from money used for infrastructure improvements.

The pitfall of low density of demand vs. the co-ordinated pulse timetable approach: It is unrealistic to achieve high frequency services in low density areas and small towns and villages. The recommended solution in such situations is to develop a network with co-ordinated pulse timetables. Infrastructure improvements might be needed with the aim of facilitating and improving the efficiency of such solutions in a particular area.

The central terminal pitfall vs. the pendulum line approach: Many cities operate services with lines terminating in the city centre or at suburban centres and interchanges. This line structure should be replaced by a network of pendulum lines running between areas on either side of the central terminal or interchange. This will improve significantly service quality to travellers, the use of vehicle and street capacity in the inner city, and the efficiency of the system.

The short walking distance pitfall vs. the quality access strategy: Many bus systems operate a network with a primary aim to keep the walking distances to the bus stops very short. In combination with a local road network not primarily designed for efficient public transport, this leads to very long and costly routes and long travel times for bus users. Instead, a more direct route line network design is recommended, which will improve journey times for the majority of customers and save resources for an increase in service frequency. Trips from areas at some distance from the bus stops should be
catered for by the improvement of access quality for pedestrians, cyclists and car users, and through the provision of special local public transport services.

The satisfy everybody pitfall vs. the two-tier system approach: Traditional attempts in bus transport planning to create lines and services that try to satisfy all users with one type of ‘flexible’ line service tend to dissatisfy a majority of potential customers. Instead, a two-tier approach of network structure is recommended: First, a strong and stable high frequency network catering for the majority of users. Second, a local, flexible set of services that cater for very local journeys and provide access to the main network.

The pitfalls of conventional road traffic planning vs. the fast operation approach: To facilitate fast, efficient and attractive public transport a number of traditional design ‘rules’ should be abandoned and replaced by infrastructure and traffic management solutions that prioritize public transport operations and users. All possible measures to improve speed and stability of operations should be used, within reasonable limits of traffic safety and security. This should also include measures inside the public transport system itself, such as appropriate ticketing systems, vehicle design, customer information and management, and driver education.

The cheap road solution pitfall vs. the shortest route strategy: Often road infrastructure built to facilitate safe and fast motor traffic creates barriers for passengers and diversions for public transport lines. Road investments for the benefit of public transport can help significantly to reduce operational costs and improve patronage.

The pitfall of separating public transport from land-use planning vs. the integrated approach: Very often the requirements of public transport are neglected in the planning and development of urban land. Integrated land-use and public transport planning can make a big contribution to the creation of public transport success.

The technological pitfall vs. defining the problem before the solution: Quite often public transport planning improvement is thought of in terms of developing some new technological solutions, be it new propulsion systems, clean fuels, or advanced information and control systems. In most cases new technology can make only very marginal contributions to the competitiveness of the public transport system, and the technological fascination diverts resources, planning capacity and the attention of decision-makers away from potentially far more effective network planning measures.

The light rail pitfall vs. the modal integration approach of the Zürich model: Discussions of light rail solutions often dominate the planning debate on public transport. Even if a large number of successful light rail projects have been realised around the world, light rail should not be considered as The Solution to the high quality public transport challenge. This is illustrated by the rather successful development of the public transport system in the Zürich region. Even if the city is most renowned for its light rail strategy and solutions, most of the region is served by bus. A modal and regional integration and systems approach that includes coordination with land use and transport policy, is the main explanation for the success of Zürich in relation to the goal of competing with the motor car.
5 CONCLUSION

The key to public transport success in the competition with the motor car lies in good network planning and development. Having the right network planning philosophy as well as applying the right network design principles can stand between outstanding success and complete failure for public transport in small and medium sized cities and regions.

The main practical recommendation is to use all available planning means to create a simple high frequency integrated network for all modes and services with high quality infrastructure, vehicles and service operations. This should form a public transport structure that is fixed and stable enough to form the backbone of urban land-use planning and development, and the basis for long-term branding and marketing. Adjustments in line frequency should be the main tool for the short term balance between travel demand and service provision, given the available resources from ticket revenue and public funds. A second tier access system of flexible public transport and improved accessibility to stopping places and interchanges by foot, bicycle and car should secure the full geographic and social coverage of the public transport system.

BIBLIOGRAPHY


NOTES

1. The authors were the main consultants and authors of the HiTrans Best Practice Guide on Public Transport Network Planning (Nielsen et al 2005), published by the INTERREG Illa (North Sea) HiTrans project in September 2005. The other members of the international team of consultants and HiTrans’ expert and editorial advisors also made significant contributions to the Best Practice Guide.

The Lead partner of the HiTrans project was Rogaland County Council, Norway. Other partners were the city or public transport authorities and operators in Aarhus, Edinburgh, Helsingborg, Newcastle upon Tyne, Oslo and Sunderland, and the national road and railway authorities and railway operator in Norway. More information is available at the project website, [www.hitrans.org](http://www.hitrans.org).

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2. The idea of presenting the principles in the format of pitfalls and alternative approaches was developed for the final presentation of the results of the HiTrans project, and revised and extended for this paper. This structure was not used in the Best Practice Guide, but the basic material and references for our recommendations will be found in the Guide.