

Assessment of Innovative Transport Concepts Using Cost Benefits Analyses: The Superbus case

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Summary

Since the year 2000 the Netherlands are using a new guideline for assessing the costs and benefits of transport systems. This guideline has been used several times now to assess transport systems using existing transport modes like trains. This paper reports on the first time this guideline was used to assess an innovative transport concept, the Superbus, a possible option to connect the North of the Netherlands to the Western urbanized part, the Randstad. The innovative character of the Superbus concept and the fact that it is under development made it difficult to assess this concept. In the assessment the costs of infrastructure, the demand driven logistics and the environmental aspects played an important role. The assessment caused major challenges with respect to the costs of infrastructure, the demand driven logistics and the environmental aspects. From the Cost and Benefit Analysis (CBA) performed it showed that in comparison with the other transport alternatives the Superbus has the lowest costs and the highest benefits. It is concluded that that is has been possible to assess the innovative Superbus concept by using the Dutch guideline for CBA assessments. The most important lessons learnt were the following:

- It has been possible to assess the cost of infrastructure based on a combination of a toolbox of infrastructure elements, possible trajectories and adding costs for uncertainties.
- Modelling the demand driven logistics has also been possible within the framework of the National Modelling System.
- Environmental assessment of the concept has shown to be possible in this early stage of the development as well.
- The assessment of the indirect benefits due to the innovative nature of the Superbus has not been possible
- A CBA assumes a fully developed system. In case of an innovative system the end of the road towards maturity has not yet been reached. A CBA should be able to take this into account. An approach for this is presented.

The authors conclude that in a future assessment of such an innovative concept, the assessment of the potential benefits of innovation, including factors determining success and failure, requires more research since they now have not been taken into account.

1 Introduction

Since 2000 the Netherlands are using a new guideline for assessing the set-up of large infrastructural projects. This so-called OEI guideline (Eijgenraam *et al.*, 2000) has been consistently used since then. At this moment a new project is under consideration. This project is the so-called Zuiderzee connection. The intention of the Zuiderzee connection is to connect the densely populated Western part of the country, Amsterdam and its surroundings, with the more rural parts of the country in the North, the province of Groningen.



Figure 1.1: The Zuiderzee connection, connecting Amsterdam and Groningen

This connection is already under consideration since the end of the 20th century. Recently the second Cost and Benefit Analysis (CBA) for the Zuiderzee connection has been published (Ecorys, 2006). This new assessment was needed in order to help the decision making process. One of the important changes with respect to the earlier CBA of the Zuiderzee connection was the addition of a new transport alternative, the Superbus concept. The Superbus concept is innovative for a number of reasons. Not only the vehicle technology applied is new but also the logistic concept used (demand driven transport). For further detail on the concept see section 3.

Experience with up front assessment of transport concepts is limited. Therefore it is not an easy task to compile a CBA. The assessment of the Superbus concept in the framework of the CBA can be seen as an example, a case study. The method used is that of participating observation. Both authors have been involved in supplying information for the assessment.

Section 2 will discuss the CBA methodology according to the OEI guideline in general and the assessment of innovative concepts in particular. Section 3 describes the Superbus concept.

Section 4 discusses the assessment of the Superbus concept in the framework of the CBA / Structural Vision of the Zuiderzee connection. Section 5 shows the results of the CBA and gives an overview of the lessons learned. Finally section 6 summarizes the main conclusions of this research.

2 Methodology of CBA and innovative concepts

In essence a CBA is an overview of all advantages and disadvantages (costs and benefits) of a particular project. Benefits are being quantified as much as possible and then translated into an equivalent amount of money. The price tags being used are generally based on market prices and consumer preferences. An exception to this rule are some of the environmental effects, like CO₂ emissions. Consumers generally speaking will be less willing to pay for a reduction of this emission than the value the government would give it. The results are presented in the shape of a limited number of parameters like Net Present Value (NPV), benefits minus costs and Return On Investment (ROI).

The so-called OEI guideline shows how a CBA for an infrastructural project in the Netherlands has to be performed. This guideline is in line with mainstream international insights in this matter, for instance see Hayashi en Morisugi, 2000. Based on experience gained in applying the guideline during the first couple of years, additions have been published in December 2004, (see www.minvenw.nl/oei). The OEI guideline has been discussed in literature several times (see for instance: Tavasszy and Renes, 2003; Oosterhaven *et al.* 2005) and will not be the topic of this paper.

The application of the CBA methodology assumes that the most important costs and benefits are known in a quantitative sense and can be (largely) expressed in terms of money. But what if this is not the case? Both the costs and benefits of innovative concepts are less well known than that of more common, often applied types of projects. Many of the costs and benefits cannot be quantified, and if this were the case the margin of uncertainty would be relatively large. Next to that this margin is not centred symmetrically around the most likely value. It is skewed to the right. This means the likelihood of a budget overrun is larger than the likelihood of a stroke of luck, even more than in “usual” projects (Flyvbjerg *et al.*, 2003). Furthermore innovative concepts can create positive spin-off but it is very hard to determine whether this is indeed the case. And if so, to what extent. This makes innovative concepts less easy to assess in the framework of a CBA.

3. The Superbus concept

In this chapter the Superbus concept will be described. It will focus on that part of the concept needed to be able to judge the concept in the framework of the CBA. Aspects that have shown to cause difficulties in the judgement will be highlighted.

3.1 Innovations: vehicle, infrastructure and logistics

The innovative character of Superbus has four main aspects: (1) the vehicle, (2) the infrastructure, (3) the logistics and (4) the combination of these three in a transport system. The innovative character of the Superbus concept primarily can be found in a smart combination of existing technologies. The technologies themselves are not new but the combination in one vehicle is. The Superbus technology is based on a combination of aerospace technology and ICT. The aerospace technology can be found in a refined aerodynamic shape and a light weight structure.

Secondly the use of infrastructure is innovative. Superbus will partly make use of its own dedicated lightweight infrastructure for high speeds but will also use existing roads where it will obey the current speed limits. Thirdly the scheduling is innovative: the demand driven logistics will be highly ICT supported. Finally the combination of these aspects is innovative. The concept also allows evolutionary growth. One can start simply and gradually extend the system, it is not limited by the requirement of a fully finished new infrastructure.



Figure 3.1: Artist impression of the Superbus

3.2 The Superbus

Superbus aims to be an innovative and sustainable road driven high speed vehicle for public transport. The concept was invented in 2004 by prof. Wubbo Ockels of the Faculty of Aerospace Engineering of Delft University of Technology (TU Delft) in the Netherlands. The concept consists of an advanced vehicle capable of driving 250 km/h, a dedicated light weight infrastructure called Super track and the application of ICT for logistics, handling, comfort and safety. The Superbus itself will be an electrically driven vehicle with a seating capacity of 20 to 30 passengers. With respect to measures it complies with current regulations for buses, no longer than 15 m, no wider than 2.55 m. The height is limited to 1.7 m what reduces frontal area and with that the aerodynamic drag and energy consumption. Passengers will board the vehicle like they do in BIVEC-GIBET Transport Research Day, April 3rd 2007

normal card via doors on the side of the vehicle. For this the vehicle body will be raised by 35 cm. By means of a combination of streamlining and a relatively small frontal area the power required for this vehicle at 250 km/h is comparable with that of a normal bus at a speed of 100 km/h. The concept has been described in Ockels (2004) and Melkert (2006c).

3.3 Infrastructure

Since the Superbus drives on rubber tires and meets current regulations with respect to sizes it can reach inner cities as well as local roads and highways. Where the Superbus will use its high speed dedicated infrastructure will be required from a safety point of view. The Superbus is a relatively lightweight vehicle (axle loading less than 3 tonnes) and the high speed infrastructure will exclusively be used by similar vehicles. That means a relatively simple and light weight infrastructure will be sufficient. This high speed infrastructure has been named Super track. It for instance could exist of a relatively simple concrete structure.

3.4 Logistics

The Superbus logistics is based on a demand driven transport. Demand driven transport has been applied and investigated several times. Terminology often used for these type of systems is Demand Responsive Transport (DRT). Other terms used are dial-a-ride or dial-a-bus. Enoch *et al.* (2000) give an extensive overview based on 74 examples. Many applications can be found in the transport elderly and disabled people in rural areas. Evers (2005; 2006) also gives an overview of applications realised. He concludes that a cost effective operation requires some combination of demand in one vehicle. This poses problems for the operator since he will not always be able to combine demand either because the demand itself is too small or the system cannot match supply and demand fast enough.

Mageean and Nelson (2003) conclude that dial-a-ride systems are often confronted with high costs, a lack of flexibility in route planning and an inability to handle high traffic flows. They argue that these downsides can be overcome with the use of information and communication technology (ICT). In the framework of the European programs SAMPO (System for Advanced Management of Public Transport Operations) and SAMPLUS (System for Advanced Management of Public Transport Operations Plus) they developed a telematics-based DRT system. They conclude that the wide use of ICT has a beneficial effect on the operation.

In the Superbus system wide use of ICT for the combination of supply and demand will be used. Still sufficient demand will be a key issue for the cost effective operation of the system. Only connecting rural areas with each other will not lead to a cost effective operation. In the Superbus system customers could indicate their wishes via internet or SMS. A central server would couple these demands to the available vehicles and make the customer one or more offers. Where there would be a constant demand a constant supply with a fixed schedule could be offered.

3.5 Combination of aspects and possibilities for evolutionary growth

The combination of three different areas of innovation is innovative in itself: vehicle technology, infrastructure and logistics have been combined in this concept. Next to that Superbus also offers the possibility of an evolutionary growth. In a railway system the vehicles can start driving only when the complete dedicated infrastructure has been completed. The Superbus logistic concept allows to start right away using existing infrastructure and gradually extending it with new dedicated infrastructure. For other aspects like logistics this holds as well.

Due to the fact that the vehicle drives on rubber tires, it can use existing infrastructure although in that case its speed will be limited to current speed limits. The high speed infrastructure can be built gradually and over time the average speed of the vehicles during a trip can increase. Depending on the success of the concept and the available budgets a phased extension of the high speed infrastructure can be realised. This approach has financial benefits in large infrastructural projects because it reduces the risks with respect to a realisation all at once.

The economic life span of a Superbus vehicle is estimated at 3 to 4 years (Melkert, 2006d). This economic life span has been estimated based on the life span of conventional buses. Their life span is based on a number of kilometres driven. This number has been used for the Superbus as well. Since the production of kilometres per unit of time is relatively high the life span is relatively short. In practice this will mean that some part of the vehicle, like drive train will have reached their technical end of life while some other parts like the chassis could be used for longer periods. For the time being it is assumed that the whole vehicle has to be replaced after reaching the number of kilometres set. This conservative approach increases the vehicle costs for a service but it also allows replacing vehicles by more modern ones relatively easy. This makes it possible to technologically advance and innovate continuously. In this way the speed on the high speed infrastructure can be increased in smaller steps over time. For instance the system could start at a speed of 150 km/h and gradually move towards the target speed of 250 km/h.

3.6 Superbus and the Zuiderzee connection

A new concept brings new chances but also many uncertainties. In that sense a unique chance was given to the concept mid 2005. The Superbus concept was given the opportunity to take part in the assessment of the Zuiderzee connection in the Netherlands (Verkeer en Waterstaat, 2006a). The Zuiderzee connection is a 200 km connection between the Amsterdam and Schiphol Airport area in the West of the country and the province and city of Groningen in the North-East of the country which is under consideration since the late nineties.



Figure 3.2: The Zuiderzee connection

The majority of Parliament asked the Minister of Transport and Public Works to officially add Superbus to the list of possible alternatives being investigated for this connection. Other alternatives under consideration were a magnetic levitation train, a high speed train and upgrades of existing rail road connections. This has given TU Delft a unique opportunity to bring this concept to the test in a relatively early stage of its development. It must be taken into consideration that TU Delft is to be considered the developer of the concept, not an interest group or a company who would like this to happen. TU Delft will never start the production of Superbus vehicles or start a public transport service with Superbuses. Therefore TU delft played a neutral role in this assessment of the Zuiderzee connection. During the assessment the other alternatives were optimized as far as possible. This could be done because an earlier CBA performed in 2000 had shown both strong and weak points (NEI, 2000). For Superbus such an optimization was not possible since the concept is in an early stage of its development.

3.7 Superbus development overview

Although not directly necessary for the assessment of the Superbus concept in the framework of the Zuiderzee connection it is useful to give an overview of the development of the concept. The concept was invented in 2004. The development started with an assessment of the feasibility of Superbus at the conceptual level. This has been done by means of interviewing 35 experts from industry and universities. They were presented the concept and asked for their opinion and suggestions for improvement. This resulted in a report called "dossier Superbus" (Ockels ad Melkert, 2004). In this report the authors concluded that the concept *in principle* is feasible. The improvement suggestions of the experts have been used for further development.

TU Delft now plans to build a full scale experimental demonstration vehicle. It s intended to have this vehicle ready in 2008 and show it to a world wide public during the 2008 Beijing Olympics.

With this demonstration vehicle it is the intention to show the technical feasibility of the vehicle itself. This is done because experience has shown that many people have the tendency to react in a sceptical way when confronted with a new innovative concept. If one takes the time to study the concept more thoroughly normally scepticism reduces. However experience has taught that people can only be convinced when they are able to touch and feel the product.

4 Results CBA – Superbus

According to the OEI-guideline both costs and benefits have been determined. All effects mentioned in table 4.1 have been taken into account. These effects have been expressed in terms of money or in qualitative terms

Table 4.1: Overview of effects studied in the CBA (*=only qualitatively)

| <i>Direct effects</i> | <i>Indirect effects</i> | <i>External effects</i> |
|--|---------------------------------|----------------------------|
| a. Reductions in travel time | a. Effects on the labour market | a. Soil and water* |
| 1. reduction in travel time car | b. Other effects* | b. Culture en archaeology* |
| 2. reduction in travel times train | | c. Landscape* |
| 3. reliability* | | d. Nature* |
| b. Costs of infrastructure | | e. Noise* |
| 1. investments | | f. Noise on houses |
| 2. yearly operational and maintenance costs | | g. Emissions |
| 3. Investments avoided | | h. Safety |
| c. Chance in the exploitation result of conventional train and new service | | |

Figure 4.1 shows the costs and benefits as presented in the CBA. Figure 4.2 gives an insight in how far the benefits cover the costs expressed as a cost covering ratio.

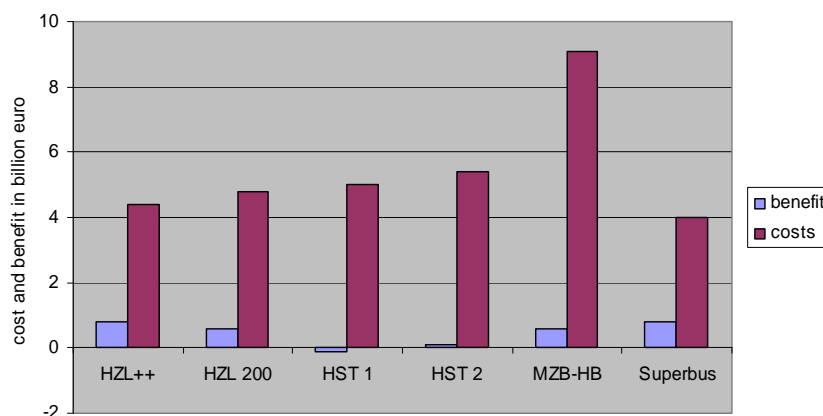


Figure 4.1: Costs and benefits of the alternatives investigated (Ecorys, 2006)

(HZL++ and HZL 200 = upgrading of existing rail road connections, HST1 and HST 2 = high speed trains, MZB-HB = magnetic levitation train)

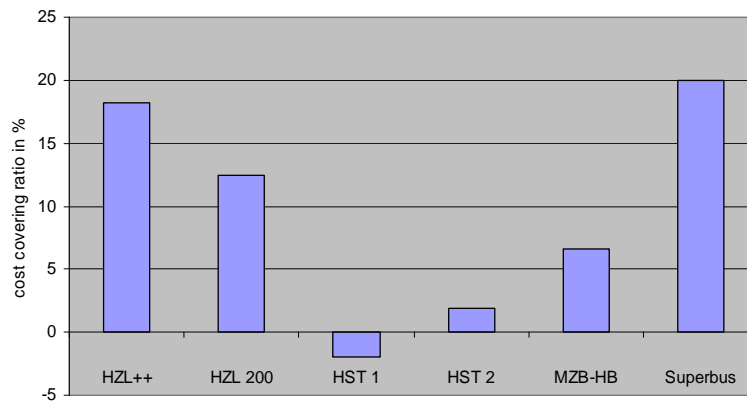


Figure 4.2: Cost covering ratio of the alternatives investigated (Ecorys, 2006)

(HZL++ and HZL 200 = upgrading of existing rail road connections, HST1 and HST 2 = high speed trains, MZB-HB = magnetic levitation train)

The results from the CBA show that in all cases the costs are much larger than the benefits. Superbus has the best score. It scores best on all aspects of costs, benefits and cost covering ratio. This is despite the fact that the other alternatives have been optimized and Superbus has not because of lack of time. The graphs also show that in all cases the cost covering ration remains far below 100%. This is caused mainly by the relatively low benefits. In its assessment of the CBA the Dutch Central Planning Agency (CPB, 2006) writes that this is mainly caused by the relatively low demand for transport on this connection. The agency blames this on the many alternatives for this connection available already now, both via road and railway.

5 Experience with the assessment in the Structural Vision and lessons learned

5.1 Introduction

TU Delft was given the unique opportunity to take part in the assessment procedure for the Structural Vision with the Superbus concept. The uniqueness was found in two ways. Firstly the fact that a transport concept still under development was taken into account and secondly that a university was invited to take part in such a process. In the assessment the CBA played a key role. All costs and benefits had to be estimated in time and order to complete the assessment within the given timeframe. This required a serious design effort for the transport concept and all the aspects involved (infrastructure, logistics, environmental impacts) next to the design effort for the vehicle itself.

In the process several things have caught the eye. In this section the most remarkable things will be reported as well as the lessons learned. For TU Delft this assessment caused a shift in the focus of the work. In the beginning the focus was on the development of the Superbus vehicle. It shifted towards aspects like infrastructure, traffic value and environment. For the other alternatives studied much of these aspects had been studied before.

The starting points for taking part in this assessment were the following

1. The time schedule was fixed, the results had to be delivered by April 1st 2006
2. The methods used were determined by the Ministry of Transport and were used in the same way for the assessment of all transport modes under consideration
3. The models used were also determined by the Ministry and again the same for all transport modes assessed
4. TU Delft was required to supply the necessary data for the assessment being performed by the Ministry on time and in the correct format

In earlier CBAs (amongst others NEI, 2000) all other transport modes had been assessed before. This resulted in a different approach for them. It made it possible to optimize them. In this chapter we put the focus on the way in which the Superbus has been approached. Next to that a comparison with the earlier CBAs will be made.

5.2 Infrastructure and uncertainty: cost estimation of infrastructure that does not yet exist

The Superbus partly makes use of existing infrastructure and partly makes use of dedicated high speed infrastructure. Especially this dedicated high speed infrastructure had to be designed. For this a so-called “toolbox” filled with infrastructure elements has been designed. This toolbox contained all necessary elements like road surfaces, bridges, fly-overs, fences, etc. The costs of the infrastructure have been based on the “toolbox” (Melkert, 2006a) in combination with a possible trajectory. Since the available time was limited (the Superbus alternative was added to the list of alternatives in a relatively late stage) only one trajectory has been studied. The trajectory chosen, has been coupled closely to existing highways on the route from Schiphol to Groningen. This will result in a minimal impact on the landscape and additional noise produced by Superbuses to be negligible in comparison with other traffic (Verduyckt, 2006).

The toolbox filled with infrastructure elements has been developed in cooperation with three engineering firms. Since the axle load of the Superbus is relatively low the infrastructure can be relatively simple. On the other hand the Super track has to be accessible for emergency and maintenance services as well. For the design of roads a system of so-called traffic classes is being used in the Netherlands. The traffic class determines the use of the roads. Traffic class 30 = only cars, traffic class 45 = cars and trucks but no heavy trucks, Traffic class 60 = cars and heavy trucks) (CROW, 2004). The dedicated Superbus infrastructure was designed for the so-BIVEC-GIBET Transport Research Day, April 3rd 2007

called traffic class 45. In the toolbox all kinds of provisions have been included like a system that keeps the roads free of snow and ice in winter, noise screens and fences. All elements have been price tagged and combined along the trajectory. Finally a probabilistic cost estimate for the whole of the trajectory has been made (CROW, 2002 and Melkert, 2006b).

In the probabilistic cost estimate, uncertainties in both cost of the elements as well as in the number of elements have been taken into account. This results in a spread of the possible outcomes which in general is skewed to the right. This means that the chance that the total costs will be higher than the estimated costs will be higher than the chance that the total cost will be lower than the estimated costs. Therefore in the final presentation of the estimated costs a penalty for skewness will be added. This penalty was 23% of expected costs. Next to that a reliability interval has been given. The method used is as is being described in literature for instance by Ashmore and Harris (2000).

In practice this cost estimate was made by first having costs experts estimating the costs. In this estimate both the technical aspects and commercial aspects were being taken into account. Commercial aspects are for instance the availability of large supplies of raw material needed for such a project and the effect this would have on the price. Next the expected margin in both costs per type of element and the number of each element needed were estimated. Finally by applying the computer programme @risk (at risk) (Palisade, 2007) the probabilistic cost estimate was finalised.

The infrastructure elements used in the design have been used on a wide scale before. All apart from the geothermal heating of the road used for ice and snow protection. This system has been tested successfully on a small scale on a number of test tracks. Since there is no certainty on effects a large scale application will have on the costs a large margin has been used. The probabilistic cost estimate used a upper limit of 300% of the estimated price. The margins used in both the prices and the numbers have been reported in Melkert (2006b).

One of the disadvantages being mentioned often in the process of applying a CBA to the Superbus system is the fact that it does not yet exist. Therefore larger margins have been taken into account in many of the design and costs variables. For instance a margin for “unforeseen” costs of 30% has been taken into account where other alternatives use 20%, the maximum speed on the Super tracks has not been set to the target speed of 250 km/h but to 180 km/h, etc.

During the process of cost estimation it became clear that the cost experts behave very cautiously. Most probably this is given by the fact that two earlier large infrastructure projects in the Netherlands (Betuweroute and HSL-Zuid) went over budget considerably. Next to that the Temporary Committee on Infrastructure (TCI) that was established by Parliament to investigate BIVC-GIBET Transport Research Day, April 3rd 2007

this had been very critical towards the cost estimates. In practice this resulted in a systematic tendency to rounding number in upward direction and adding additional allowances on unit prices. Obviously one would not take the risk to be confronted again with budget overruns.

The authors however argue that it would be better to substantiate the allowances used in a better way and make use of more systematic methods for cost estimates (Flyvberg and COWI, 2004). Furthermore the authors state it would not be better to communicate the risks of a budget overrun as determined when using a probabilistic cost estimation method instead of making use additional allowances.

5.3 Transport benefits: modelling of demand driven transport

The Ministry had decided to compare all possible alternatives with respect to transport volumes using the National Modelling System (NMS). In consultation with the ministry it was decided to use the NMS for Superbus as well. It was decided not to develop a new way of modelling. This made it possible to at least make a relative comparison between the possible alternatives. In this paper the authors will not focus on the characteristics of the NMS.

The NMS is a state-of-the-art four step trip based model. Contrary to older generations of such models mode choice and destination are modelled simultaneously. Validations show that in general the model performs quite well, the modelling of public transport being considerably weaker than modelling car use.

To model mode use the NMS uses four main categories of input. These are: travel times (network characteristics including speeds / travel times), frequencies offered (in case of public transport) prices and the so-called alternative specific constant which gives an indication of the attractiveness of the means of transport at given costs and travel times.

In the NMS the Superbus has been modelled as an ordinary train. The Superbus was not modelled as a bus. Several reasons led to that choice. First of all because buses used in the NMS have not been modelled in a network structure. For the Superbus this is required. Secondly the envisaged quality of the Superbus is much better than a standard bus. A better comparison can be found in trains.

One important aspect of the Superbus is that it is demand driven. However the NMS and other comparable models cannot handle this. In order to model the demand driven nature as much as possible first the envisaged quality has been determined. It was decided to express this quality in an average waiting time of 5 minutes (10 minutes interval). The Superbus has therefore been modelled as a network of trains with a frequency of 6 times per hour. This frequency models the average 5 minutes waiting time.

Another problem was the translation of the demand driven character to stops for boarding and disembarking the vehicle that had to be connected. The stops were chosen such that the transport from the point of origin and to the final destination from these stops is minimized. In total 29 of these points have been identified. In principle this would lead to a network of 28×28 connections when these points would have to be connected with each other. This is not a sensible approach for two reasons. Firstly the NMS is not able to handle a network of this size capacity wise. Secondly the transport demand will be very small (one or two persons per vehicle) such that a profitable operation would be impossible. Therefore an approach was chosen in which the stops were connected to each other in strings. In each string a number (maximum three to four) stops at the beginning of the journey will be connected to a number of stops at the end of the journey. The Superbus vehicle will stop a couple of times at the beginning of the journey and at the end of the journey. In between it will not stop in order to achieve an acceptable average speed over the long distance (Van Nes, 1999).

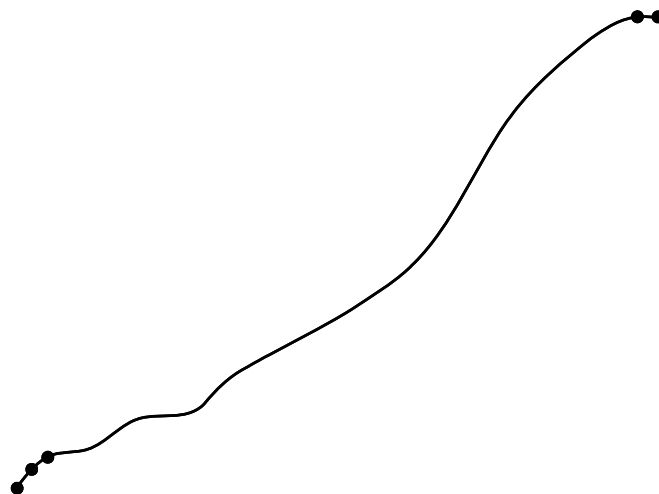


Figure 5.1: Modelling of strings with a limited number of stops

The ticket price used in comparing all transport alternatives has been kept equal to that of current train tickets. This has been modelled as a starting price of 1 euro and an additional 10 eurocents per passenger-kilometre. The total travel time has been calculated by dividing the trip into parts in cities, on the highways and on the Super track. For every part a different speed has been assumed. The speed on the Super track has been set to 180 km/h instead of the target speed of 250 km/h. Next to that for every stop an additional two minutes has been added.

In this stage of the development it is impossible to determine via Revealed Preference (RP) data the value of the alternative specific constant for Superbus. And even Stated Preference (SP) research is hard to perform since the Superbus is a yet non-existing means of transport.

Therefore no SP-research has been performed. Superbus is aiming at the comfort level of a limousine with chauffeur. Therefore it is supposed that choosing the alternative specific constant

of a train will give a safe approximation. This choice has both advantages and disadvantages. A normal train is less attractive than a car, a high speed train or a magnetic levitation train and therefore will attract less passengers, assuming equal travel times and costs. On the other hand a normal train is more attractive than an ordinary bus. This resulted in the fact that the model predicts that passengers would take the Superbus to travel within a city instead of using the standard city bus. The results had to be corrected for this. The correction needed resulted in a reduction of the predicted number of passenger-kilometres by 3.9%.

In a limited sensitivity analysis (Verkeer en Waterstaat, 2006c) the effect of price and frequency offered has been investigated. Increasing the price by 30% resulted in a decrease of the number of passenger-kilometres of 12%. The elasticity of the price with respect to the demand for passenger-kilometres therefore is approximately -0.4. The elasticity of the frequency offered with respect to the demand for passenger-kilometres is approximately -0.5. Reducing the frequency offered from 6 times per hour to 4 times per hour (-33%) resulted in a decrease of the number of passenger-kilometres of 16%. When the price is increased the business case for the operator becomes better by 15% in case of a frequency change the business case hardly changes.

5.4 Strategic Environmental Assessment: early insight in environmental effects

Next to the infrastructure and the transport value the impact on the environment is considered of prime importance when deciding on a new project. Therefore the Strategic Environmental Assessment (SEA) has been an integral part of Structural Vision of the Zuiderzee connection (Verkeer en Waterstaat, 2006b). The results of the SEA have been taken into account in the CBA. Most of the results have been taken into account in a qualitative sense. Effects on noise, emissions and safety have been quantified. Figure 5.1 shows the result of the calculation on energy consumption. The energy consumption has been expressed in terms of Wh per seat-kilometre. This graph therefore does not take into account the effect of occupancy rates of these modes of transport. It shows that the Superbus offers the lowest energy consumption per seat-kilometre in the given speed range.

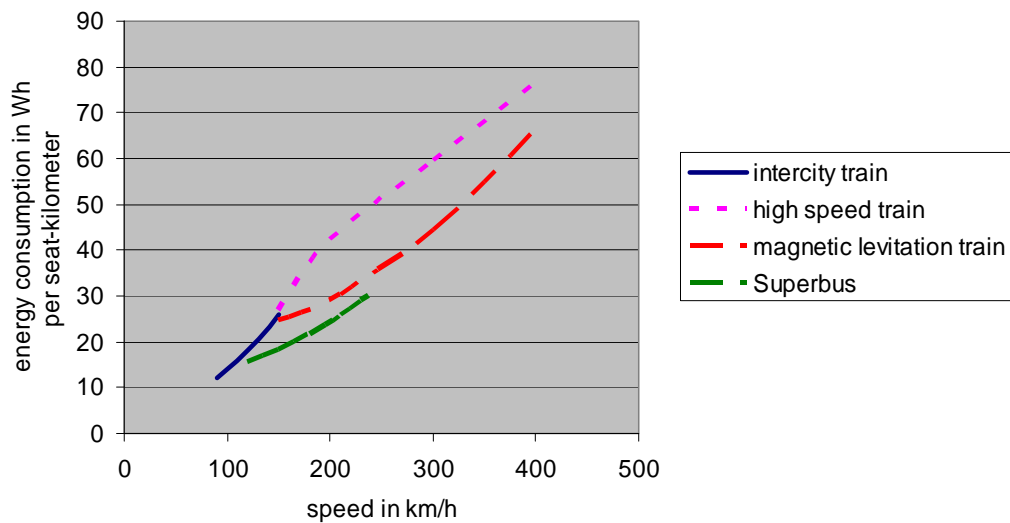


Figure 5.1: comparison of energy consumption of several public transport alternatives for a typical distance of 50 km (Van den Brink, 2001 and Verduyck, 2006)

5.5 Benefits of innovation: translating innovation into money not yet possible

It is a difficult question how to determine the benefits of innovations and how to take them into account. A CBA offers the possibility to do so; a CBA as a matter of fact in essence is an overview of cost and benefit. When the benefits of innovation are known, they can be taken into account. Possible benefits are the development of new technology, the consecutively selling of it and with that acquiring a leading position in a certain branch (Balzat, 2006). However no commonly accepted methods exist with which these benefits can be estimated. In the CBA for the Zuiderzee connection this resulted in the fact that potential benefits that result from the innovative character of both the magnetic levitation train and the Superbus have not been taken into account. This is an underestimation of the benefits. This is remarkable since the European Union in her so-called Lisbon declaration has indicated to strive for becoming the world's most innovative society by 2010. By not taking into account potential benefits and by taking into account only the potential penalties, often traditional systems will show better results in a CBA and will be preferred.

5.6 The role of Parliament

Next to the discussion of the four main aspects with respect to the assessment the authors would like to report on the procedure followed by the Dutch Parliament. The reason for this being the fact that previous large infrastructural projects significantly went over budget and Parliament demanded a change in the procedure. After the discussion on the report of the Temporary Committee on Infrastructure (TCI) Parliament demanded that a decision on the Zuiderzee connection had to be done on the basis of a TCI-proof Structural Vision. Parliament has discussed the possible alternatives to be investigated with the Minister before she started the BIVEC-GIBET Transport Research Day, April 3rd 2007

research. On the basis of the outcome of the Structure Vision the government reported to Parliament that they feel no need nor see the necessity for the realization of the Zuiderzee connection. The temporary Minister wrote this in a letter to Parliament in which she stated that the government intended to stop the Zuiderzee project. This intended decision was not appreciated by the provinces in the north of the country and they decided to oppose the intended decision. At that moment the majority of Parliament seems to be sensitive to this lobby from the north and decides not to accept the outcome of the Structure Vision. Only a few of the political parties in Parliament are willing to accept the outcome of the Structure Vision.

5.7 The effect of evolutionary development

In a CBA it is generally assumed that the concept assessed has reached a stable stage in its development. In the case of the Superbus the development has not reached the fully mature stage yet, in fact the development is in its early stages. More importantly, it is currently unknown how the mature version of the concept will look like, when it will be reached, and how the system evolves to that mature status. Because of these uncertainties it is inherently impossible to include the concept in a CBA framework comparable to conventional transport system changes such as (high speed) rail or new motorways. The authors expect that the development will progress in an evolutionary way in which continuous improvements will be made. The authors propose an approach in which a number of development paths will be sketched and assessed. In the assessment of these development paths a stochastic analysis, an analysis of the effect of uncertainties and a sensitivity analysis can be made in order to see the effects of possible development trajectories. With the outcome of this assessment even the development path can be shifted towards the most promising path.

6 Conclusions and recommendations for further research and development of methods

The most important conclusions from this paper are:

- A CBA primarily is an overview of quantified advantages and disadvantages and the translation into terms of money. Costs and benefits of innovative concepts are hard to quantify, let alone be translated into money. This makes a CBA a less useful method for the assessment of these concepts up front. The core of the problem is not the CBA itself but the fact that it is hard to map the costs and benefits of these concepts at all. If this were possible it would well be possible to include them in a CBA.
- Superbus is an innovative concept where the innovations can be found in vehicle technology, infrastructure, logistics and the combination of these three.
- Despite the fact that the costs and benefits were not fully known when the CBA and related research was performed it has been shown to be possible to assess the Superbus concept in the framework of the Zuiderzee connection. It has been shown that it was possible to come up with an estimation of several unknown cost and benefit categories in a short time span. This type of approach has been proven to be sufficiently robust,

amongst others by use of larger allowances for uncertainties in comparison with other alternatives being assessed. This type of approach is inherent to the innovative character of the concept.

- The most important problems in estimating the benefits are on the one hand the translation of the logistical concept to a commonly used modelling method like the NMS and on the other hand the estimation of the positive spin-off of innovation.
- While estimating the costs a relatively cautious approach has been taken. This may have been triggered by the TCI. The word “relatively” refers to the way this, in our opinion, would have been performed if this would have been done before the TCI presented their report (December 2004) and in comparison with the way the costs of the other alternatives have been estimated.

In order to be able in the future to assess innovative concepts in a CBA in a balanced way more research is needed. This would involve:

- The effect of having more time available for addressing all aspects.
- The benefits of innovations, including success and fail criteria for these benefits.
- The cost estimates of relatively unknown technologies for infrastructure and transport means.
- The way in which innovative transport systems could be modelled, be it in dedicated models or in more common models like the NMS.

Finally the authors expect that a phased approach will be the best way to success for Superbus. In the development process all aspects of the concept can be tested before they are applied on a larger scale. In the mean time TU Delft started the first step of this development by designing and building a full scale experimental demonstration vehicle.

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