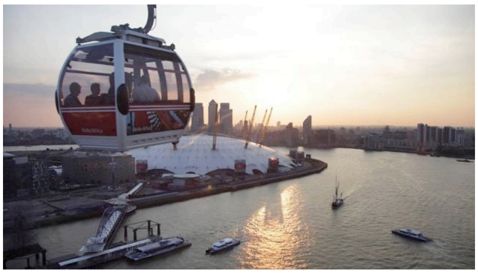
Urban Cable Cars in Flanders

A Study to the Potentials



Thesis Report
8th June 2017

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Graduation Thesis

International Traffic and Transportation Management
NHTV University of Applied Science, Breda, The Netherlands

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Preface

This report is the result of the fourth year curriculum based thesis internship of the study International Traffic and Transport Management at the NHTV in Breda. My research was conducted in cooperation with Doppelmayr in the beautiful Austrian mountains.

During my internship I have been coached by Wolfram Auer as my company supervisor at Doppelmayr and by Don Duikink as my NHTV supervisor.

Not only do I want to thank my NHTV coach Don, but also Wolfram and the other employees of the Doppelmayr who made the internship such an enriching experience.

I hope you will enjoy reading the report,

Jelle Mertens

Summary

Cable car systems have developed rapidly since the rise of ski tourism in the last century. The innovation has led to cable car systems with a higher capacity and higher comfort, this has allowed the systems to be used in an urban environment as public transport. Especially the monocable gondola detachable, aerial tramway and the tricable gondola detachable, or 3S, are very suitable for the use in the urban environment because of their efficiency and service level.

In Europe it is most likely for these urban cable car systems to function as a feeder system or to fill gaps within a public transport network. This is because public transport networks already exist in bigger cities in Europe. The reason why they will develop is because urban cable cars have strengths that other public transport modes do not have.

Cable cars have positive effects on most users satisfaction criteria. Strengths determined are the low operational costs, average speeds of over 40 km/h, a high availability of up to 99,9 per cent and the cable car being the most comfortable and attractive public transport mode. Also the external effects of cable cars have strengths such as low environmental impact, lowest death rate, low noise emission and the opportunity to fly over other transport modes instead of interfering with them. On the other hand are some weaknesses, such as the limited stops that a cable car line can have and the possibility of passengers suffering from Acrophobia.

An analysis on case studies in London, Brest, Koblenz, Groningen, Hamburg and Trier has shown the opportunities and threats of urban cable cars. Especially the positive effect that subsidies can have on a cable car project and the positive effect of close integration with the planning of a big event were determined. Other opportunities out of the literature review showed the opportunity that communication and collaboration could give. Also growing environmental concern and further integrating in a public transport network will have a positive effect on urban cable car projects. Threats identified are the lack of political support, perceived lack of integration in the public transport network, the relation to winter tourism, the scarcity of European examples and the fear of privacy of inhabitants.

Based on a SWOT-analysis and interviews carried out in Flanders has been determined what parts of the SWOT-analysis should be focussed on most. The result are six recommendations for urban cable car projects; extra attention needs to be given to the integration in a public transport network, to attract co-finance, to get stakeholders involvements, to contribute to city goals, to create understanding of the public transport mode amongst stakeholders and to monitoring the effects of the cable car during operation.

Location specific drivers and barriers are related to the organisational structure, the culture and the geographical circumstances. Three potential cable car locations in Flanders are found based on the SWOT-analysis. These are situated in Antwerp, Ghent and Zeebrugge. The cable car has in all three of these locations an added value to the transport network on a spot where there is travel demand. They are also technically feasible, blend in with the urban landscape and there is enough space for the stations and pillars.

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Introduction

The Alps have already been a touristic destination where people could enjoy the mountains since the 18th century. Cable cars were mostly used for transportation of goods by than. The development of tourism in the Alps has led to the development of cable cars as touristic transportation in the 20th century. The oldest cable car still running is situated at the 1613 metres high mountain Predigtstuhl in Bayern, German. The cable car, which was finished in 1928, makes use of 15 person cabins as seen in figure 1, and has a capacity of 180 people per hour per direction (pphpd). The 150 HP motor is operating the system that has a total length of 2.4 km (Predigtstuhl, 2017).

Figure 1; Mountain station (Predigtstuhl, 2017)

Later, in 1937, Doppelmayr built the first draglift of Austria in Zürs am Arlberg, Vorarlberg (LechZürs, 2017). This was the start of the rise of skiing tourism in the Alps. The draglift could now bring skiers uphill, and only had to ski downhill. This saves a long hike up, and allows the skier to make more ski kilometres in a day with less effort.

In the 1960's skiing became a sport that was accessible for a bigger group of people, which resulted in a demand for quicker lifts with higher capacities. Since than ski lifts have been developing rapidly. In 1981, Doppelmayr constructed their first detachable four-man chair in America, allowing skiers to access the chairlift at a low speed. When the chair was departing from the station, it would increase speed and attach itself to the faster moving rope. The speed when travelling between the stations is therefore higher than the speed when passengers are boarding or leaving the chairlift. This has led to a decrease in travel time and an increase of capacity.

The technical development of cable cars has not stopped since. In 2016 the Giggijochbahn in Sölden was opened. The gondola system with cabins for 10 persons has a record capacity of 4.500 pphpd. The engine, with over 2.200 HP, propels the 134 cabins with a speed up to 6.5 m/s. This makes the 2.6 km long stretch possible in less than 9 minutes (Sölden, 2017).

Figure 2; Giigijochbahn Solden (Sölden, 2017)

These modern cable cars do not only offer higher capacities and travel with higher speeds. They also adjust their speed even more in the station so that passenger can enter easier. Modern cabins are also barrier free making it possible for elderly and disabled to enter as well, this can be seen in figure 2. Additionally, cabins can be equipped with communication devices, to have contact with the stations from within the cabins. Furthermore features such as air conditioning, Wi-Fi, TV-screens and seat heating can be integrated into the cabin design. These developments have made the cable car become very fast, comfortable and reliable, making it possible to use it as a public transport mode in the urban environment.

Figure 3; Yellow line, La Paz (Mi Teleferico, 2017)

One of the success stories of the urban cable car comes from La Paz, a city with around 800 thousand inhabitants located in Bolivia, South America. The first cable car stretch in La Paz has been opened in May 2014, the cable car offered travel times that were many times faster than the car. The advantages did not only concern the decease in travel time. The cable car has connected new parts of the city and therefore improved the social inclusion in the (Mi Teleferico, 2017).

In La Paz the cable car had very little competition from other public transport modes due to congested streets and little ground space. In 2020 there will be 9 lines that all have individual colours, for example the yellow line that can be seen in figure 3. In Europe there is a different situation, all bigger European cities have a basic level of infrastructure together with a basic level of public transport. This means that the cable car will not, as in La Paz, become the core of the public transport network, but the cable car is able to support the existing public transport network. A cable car travels in between pillars above the ground and therefore uses the third dimension; this can become an advantage when crossing obstacles such as height difference, but also water, infrastructure or urban areas.

The increasing rate of urbanisation is a challenge in European cities. City planned need to make sure that the cities they work for develop in a sustainable way. A sustainable development of a city means that future generations will be able to enjoy the city in the same way as the current generation does now. Accessibility, environmental impact and the liveability of a city are important indicators for this sustainable development. Mobility has effect on all three of these indicators and therefore has an important role in the sustainable development of a city.

In the last century the automobile has become a backbone of our transport system. The accessibility of cities and shops has grown due to the car. Even though the car has brought growth to cities, it also brought challenges. Increasing investments in car infrastructure have not resulted in a decrease of congestion, whilst the inner cities are dominated by car infrastructure and parking facilities, decreasing the space to work, recreate and live.

Solutions like the promotion of public transport and the improvement of cycling infrastructure are two examples how the accessibility of a city increases, whilst the space to live grows. Public transport modes that are most common in the urban environment are the bus, tram, underground and light rail. Cable car systems offers advantages that the other more traditional public transport modes do not have. The advantages of a cable car system are proven in an increasing amount of cities. Because of this development, it can be expected that the cable car is on its way to become one of the traditional public transport modes.

1.1 Problem Analysis

Doppelmayr is world leader in cable cars and is mostly known for the application of cable cars in mountainous areas for winter tourism. Out of the 108 projects that were carried out in 2015 there were 82 directly relates to winter sport activities. Because of the newer technology that cable cars have, they are very interesting to be used in an urban environment. Doppelmayr is interested in this development and supports the application of cable cars in the urban environment.

Figure 4; Cable car concept in Eindhoven, (Omroep Brabant, 2017)

In Germany and most of the BeNeLux there is already an interest in urban cable cars. In the Netherlands only there have already been projects in Venlo, Groningen, Amsterdam, Eindhoven, Dronten, Roermond, Almere any many more (De Boer, 2016).

In Belgian-Flanders there is less awareness and attention for this type of transportation, even though the advantages and challenges for urban cable cars are most likely comparable to those in the Netherlands. For the transport system within a city it is unfavourable if a certain mode of transport is not included as an alternative when local politicians make decisions.

The assignment is to investigate on the possibilities for urban cable cars in Flanders and to raise awareness amongst the stakeholders. Therefore, information is needed on the applicability of urban cable cars and the best approach to reach local stakeholders and decision makers in Flanders in order to make them aware of the possibilities of urban cable cars.

1.2 Research Objective and Research Model

The objective of the research is: "*To acquire knowledge on the drivers and barriers for the implementation of an urban cable car and to find out the specific drivers and barriers in Flanders.*

This has been carried out in four research steps; firstly, the urban cable cars as a concept are described by looking at the characteristics of cable cars and how they can be implemented in an urban environment.

Afterwards is looked at the cable cars within the transport system. The physical characteristics of cable cars are used and analysed by comparing them with performance indicators of other public transport modes.

In the third step, success criteria are determined of urban cable car projects. This has been done on the base of the strengths and weaknesses of urban cable cars and by analysing projects concerning urban cable cars that were initiated in Europe.

Finally is looked at the application of urban cable cars in Flanders. The general opportunities and threats are described based on the analysis on existing projects. The stakeholder analysis gives an insight in the location specific barriers and drivers and they are used to determine the most suitable project approach.

The mentioned research steps are schematically displayed in the research model in Figure 5.

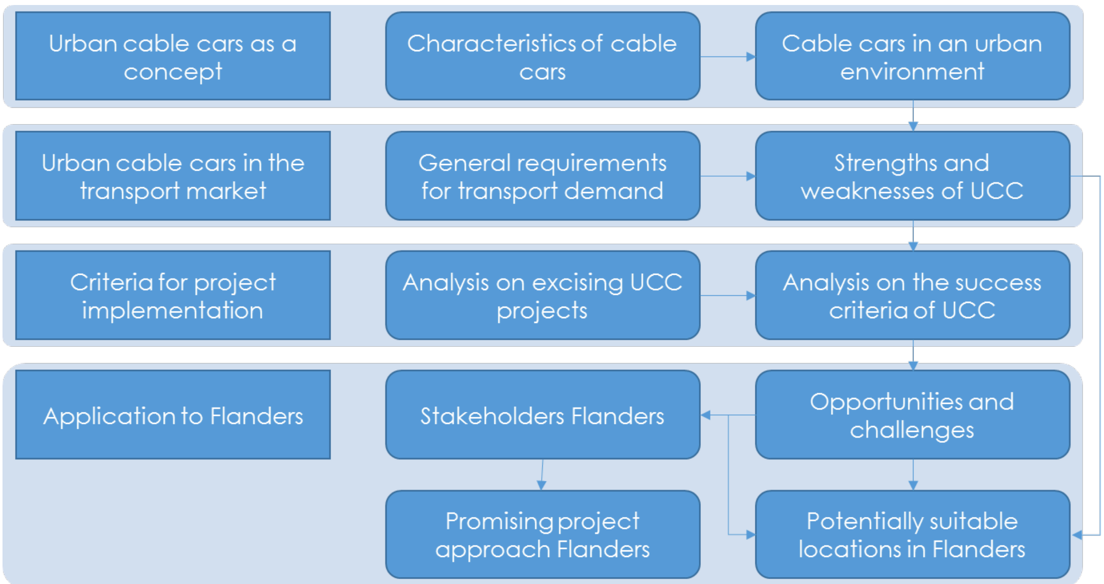

Figure 5; Research model

1.3 Research Questions

The research questions will guide help to reach the objective of the research. These questions are as following:

1. What are the physical characteristics of cable cars and how could they be used in an urban environment?
    a. What is considered to be a cable car?
    b. What different types of cable cars exist?
    c. What is the history of cable cars?
    d. Where are cable cars used the most?
    e. What functions and limitations do cable cars have in an urban environment?

2. What are findings from previously planned urban cable cars and how do these systems function?
    a. Where are cable cars built in urban environments?
    b. How is the usage compared to the expected usage?
    c. Who was the initiator and who were against and for the cable car?
    d. Where were cable cars planned?
    e. What was the reason for not completing the projects?
    f. Who were the stakeholders in these projects?

3. What is the best approach for an urban cable car project initiator to get support from politics and inhabitants?
    a. What different reasons were found in part two that resulted in a failed project and who was the initiator?
    b. What is according to process evaluation literature the best strategy to allow a project to succeed and could this have worked in the failed case studies?
    c. What are the differences in process of the successful and failed projects?
    d. How can an initiator manage, that inhabitants and politics are assessing the option for a cable car as objectives as possible?
    e. Can this be supported by literature or proven by means of surveying?

4. Where do urban cable cars fit best in Flanders and what are the location specific drivers and barriers?
    a. What are local traffic challenges in Flanders than can be tackled with a cable car?
    b. For what challenges could urban cable cars be the solution?
    c. What are the local stakeholders?
    d. How can the answer of RQ 3.d. be used in these specific situations?

1.4 Methodology

Existing urban cable cars are scarce and mostly outside of Europe. Literature describing urban cable cars is therefore limited. The sources that are available are used in this research to describe the characteristics of an urban cable car. The characteristics are compared based on several social cost benefit analyses. This is because they reflect the best on all different aspects and effects that a transport solution has. The outcome of this is used as input for the strengths and weaknesses in the SWOT-analysis.

The implementation process of cable car projects is described in the third chapter. This is to find out who the stakeholders were, what their opinion on the cable car project was and how this opinion was formed. Literature on innovative transport solutions and their implementation process is used as a base reference for comparing the implementation process. The outcome has led to several process factors that are likely to work in favour of an urban cable car project and that work against an urban cable car project. The organisational structure of the projects is important, the structures are compared to the situation in Flanders, to determine potential differences.

The outcome of the literature research on urban cable cars and the analysis on the different urban cable car projects is used as input for the SWOT-analysis. This analysis has lead to recommendations for urban cable car projects.

Local legislation, culture and geographical circumstances have effect on the transferability of an innovative urban transport solution. The outcome of the SWOT-analysis is therefore elaborated on with local factors from Flanders taken into account. The information derives from literature and interviews with local governments, transport authorities and consultancies in Flanders.

The last part of the research is to start testing these approaches in Flanders. This is done by engaging local stakeholders to get involved in the project. The implementation of a cable car system takes longer than the duration of this research. The end result of this research is therefore a preliminary conclusion on the effect of the implementation process, based on interviews with stakeholders and their view on the projects.

1.5 Reading Guide

In the second chapter the physical characteristics of a cable car and their role in the transport network are described. Also factors from a social cost benefit analysis are reviewed on, to determine the general challenges and advantages of a cable car. The outcome is used in the SWOT-analysis as the strengths and the weaknesses.

In the third chapter is looked at a number of cable car projects, these are used to determine the opportunities and threats for the project approach. This is further elaborated on in Chapter 4, where also the complete SWOT-analysis will be performed.

In the fifth chapter is looked at the specific situation in Flanders and how the outcome of the SWOT-analysis can be used to determine an implementation plan for Flanders.

The sixth chapter described a number of specific stretches in different cities in Flanders that can be suitable for a cable car connection. They are ranked using a quick scan based on the SWOT-analysis. The one that resulted as being the most promising will be worked out further in the chapter.

2 Concept of a Cable Car

The definition of a cable car is a transit technology that moves people or good in motor-less, engine-less vehicles that are propelled by a steel rope (Eurist, 2011). Logically most people will think of a cable car as a gondola hanging on a rope, but there are also transport systems supported by rail but that are still a cable car. A rope in this case still propels them.

In this chapter is described what a cable car is and how this transportation system can be used as innovative urban transport solution. In addition, the different functions that a cable car can have within the transport system of a city are described. Finally, the riders' satisfaction criteria and external effects that a cable car has are described.

2.1 Types of Cable Cars

As mentioned before there are different kinds of cable cars, not solely cabins hanging on cables but also rail bound cable cars. These types of cable cars are called bottom supported cable car systems (Creative Urban Project, 2013). Bottom supported cable car systems look like a tram or a metro system, but are propelled by a rope, as seen in figure 6. They are mostly used when the angle of the desired route is too steep for a regular rail bound vehicle. There are more situations though where a bottom-supported cable car is more beneficial compared a metro or tram. The vehicles, for example, do not have engines and can therefore be lighter (Monheim, 2010). They are also autonomous driving vehicles and can have a very high capacity.

Figure 6; Funicular in Caracas, Venezuela (Doppelmayr, 2017)

In this research there will be focussed on the top-supported cable cars. This because they differentiate themselves the most from other public transport modes. They use a separate height compared to other traffic and therefore have no interference with other traffic. The system also needs limited ground space due to the limited amount of pillars that are needed to keep the system up. This way the land usage is minimum while the costs are relatively low compared to other systems that also do not interfere with existing traffic, such as an underground system.

There are various kinds of top supported cable cars. Some of them, such as a draglift and chairlift, are not suitable for the use in the urban environment. This is because ski equipment is needed for using them or that the system does not offer the desired comfort and safety for use in the urban environment.

Two forms of top supported cable cars are suitable for the use in an urban environment; the aerial tramway and the circulating system (Doppelmayr, 2016). Both systems have stations where the cable car either halts or travels at an adjusted speed. This is depending on the type of grip that the cabins have, see figure 7.

Figure 7; Grip of a detachable gondola, the springs put pressure on the haul rope and this pressure is released in the station (Doppelmayr, 2017)

A fixed grip means that the cable car cannot detach itself from the haul rope. This requires the haul rope to stop or travel at a reduced speed when people are entering and leaving a cabin. A cabin with detachable grip decouples itself from the haul rope in the station and the cabin therefore only has an adjusted speed in the station. Some cable car systems also have track ropes, these support the cabins but do not propel them.

All cable cars have at least two stations, a drive station and a return station. Nevertheless it is possible to build intermediate stations where passengers can enter and leave or where the direction of the line can be changed. In between the stations it is not possible for these cable car systems to make adjustments of direction.

2.1.1 Aerial Tramway (ATW)

An aerial tramway is a type of cable car that travels back and forward between two points, see figure 8. Its capacity depends on the track length, the travel speed and the cabin size. Longer installations have a lower capacity compared to circulating cable cars. This is because the system works as a shuttle; longer travel time will therefore lead to a lower frequency.

Figure 8; Aerial Tramway in Blatten, Switserland (Doppelmayr, 2017)

The cabins have a fixed grip to the haul rope and are rolling over two track ropes. The two track ropes make the cabins very wind stable. An aerial tramway can have one or two cabins. When it has two cabins they have to travel at the same time, because the same haul rope propels them. A Funifor is a different type of aerial tramway and has two separate drives and two separate haul ropes. The cabins can therefore travel individually.

The maximum speed of an aerial tramway is relatively high with 12 m/s. This is because the system only needs to adjust speed when the gondola(s) reach a station. The capacity of this system goes up to 2.000 pphpd (Monheim, 2010).

2.1.2 Circulating cable cars

The other type of system is the circulating cable car system. The cable cars are attached to the haul rope with a detachable grip. The haul rope travels at a constant speed and the cable cars are detached in the stations and propelled at a lower speed by rubber tires.
There are four different forms of the circulating cable cars systems, these systems are described in this subchapter.

Monocable Gondola Detachable (MGD)

This is the simplest system that uses a single cable loop to support and propel the cabins. The cabins can carry up to 15 people at the same time. The high interval between the cabins creates a high capacity. The interval can go up to 8 seconds. The system is less wind stable than the others and needs a pillar every 200 metres. This makes the pillars, compared to the other types of cable cars, close to each other.

Figure 9; MGD in Sölden, Austria (Sölden, 2017)

Bicable Gondola Detachable (BGD)

This type of gondola has two ropes, one-track rope and one haul rope. This makes the cabins slightly more wind stable. Also the distance in between the pillars increases to up to 1 km. The biggest BGD was opened in 2006 in Hong Kong. The BGD does have advantages compared to the MGD, but they are in most cases not covering the higher investment and operating costs. Therefore is more often chosen for a MGD or a TGD / 3S system.

Figure 10; The Nyong Ping 360 BGD in Hong (NP360, 2017),

Worlds most important cable car magazine, the International Ropeway Review (ISR) describes the future of the BGD. The ISR describes how the technological development of the MGD and the TGD / 3S have made the BGD out-dated. Added is that there might be specific situations where the MGD needs too many pillars while the TGD / 3S is too big. However they conclude: "a real renaissance of this traditional ropeway system is not to be expected" (ISR, 2017).

Tricable Gondola Detachable (TGD / 3S)

This type of gondola has two track ropes and one haul rope. The two track ropes create a wind stability comparable to the one of an aerial tramway. It can therefore cope with side wind speeds of up to 100 km/h. The cabins can carry up to 35 people and travel with a speed of 7,5 m/s between the stations.

Figure 11; Peak to Peak in Whistler, Canada, TGD / 3S with the longest span of 3.000 metres (Whistler Blackcomb, 2017)

The TGD / 3S technology combines the wind stability and span distance in between pillars from the ATW with continuous flow of the circulating systems. It therefore can span up to 3 kilometres between pillars and the capacity is not dependent on the length of the system.

The TGD / 3S cabins have the opportunity to offer many features that can add value to a public transport experience. They have a wide entrance and space for cyclists and wheelchairs. They also have the opportunity to produce power for during the ride, by putting a dynamo on the wheels that roll over the track ropes.

Funitel

This system has one double looped haul rope and every cabin is supported twice by this haul rope. Therefore it has high wind stability and can make big spans in between stations. The size of the cabins can go up to 24 persons. The cable car system is therefore very comparable to the 3S system. Nevertheless, it uses more energy and has higher operational costs. Because of this the TGD / 3S is very often preferred.

Figure 12; A Funitel in Verbier, Switserland (Funitel, 2017)

The MGD, ATW and TGD / 3S are most interesting for the application in the urban environment; this is due to the technological development. The BGD and the Funitel are both behind in this development and are therefore less suitable. In figure 13 an overview is given of the cable car systems mentioned.

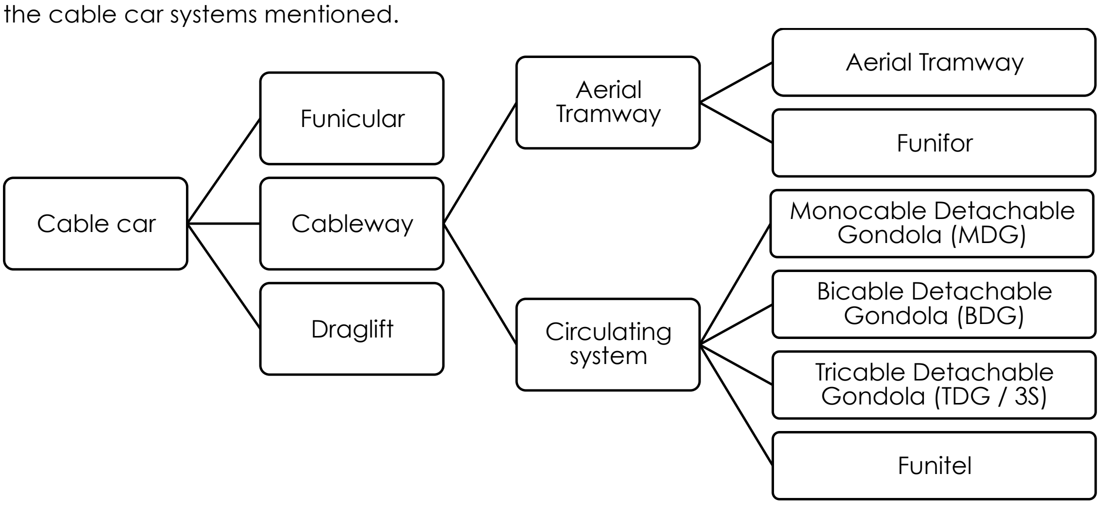

Figure 13; type of cable car systems (Based on Verband Deutscher Seilbahnen, 2017)

In table 1 an overview is made of the six types of cable cars. Compared is the capacity per gondola, the total persons per hour per direction (pphpd), the cruise speed, the maximum span between stations and the maximum wind speed with which the cable car can still operate.

Table 1; Characteristics of different kind of cable cars; based on figures from: (Monheim, 2010), (CUP, 2013), (Hekel, 2015), (Sölden, 2017), (Leitner, 2017), See appendix 1 for detailed references.

	Capacity per gondola	*Maximum Capacity (pphpd)*	*Cruise speed (m/s)*	*Span between pillars (m)*	*Maximum wind speed (km/h)*
Aerial tramway	*250*	*2.000*	*12*	*3.000*	*100*
Funifor	*100*	*2.000*	*12*	*3.000*	*100*
MGD	*15*	*4.500*	*6,5*	*200*	*70*
BGD	*16*	*3.500*	*7*	*1.000*	*80*
TGD / 3S	*35*	*6.000*	*7,5*	*3.000*	*100*
Funitel	*24*	*4.000*	*7*	*1.000*	*100*

2.2 Functions in a Transport Network

Five functions are being given by Doppelmayr for cable cars in an urban environment (Doppelmayr, 2016):

- Fill gaps
- Connect
- Bridge
- Create new transport networks
- Extend
- Relieve

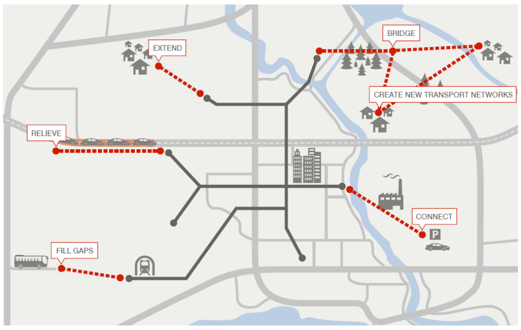

Figure 14; Functions of an urban cable car (Doppelmayr, 2016)

Not all of these five functions are suitable for the use in Europe though. Since nearly all cities in Europe have an existing public transport network, it is unlikely for cable cars to become a backbone of a transport system. It is also not desired to travel over private property in a big extent. Therefore the cable car is most likely to be functioning as a feeder system, supporting the existing network at the edges.

In Europe there is also lots of potential to connect a hotspot such as an airport or to bridge a geographical obstacle such as a river. This means that the urban cable cars can be used in situations where they connect, bridge or extend. The cable car always has a supporting function and operates next to an existing transport system.

There are already several examples of cable cars being used as public transport in European cities. Doppelmayr has already built several urban cable cars in cities in Europe, for example in Koblenz and London. They see a chance to develop even further in this market and expand this innovative transport solution towards more cities

As mentioned before cable cars are a good solution for specific challenges, they can overcome height, need little ground space and function as a pipeline system. In figure 15 the capacity and the possible length of the detachable gondola is compared to other public transport modes.

The system length of a cable car varies from less than 1 kilometre to more than 10, while the capacity per direction per hour varies from 500 until 6.000. This allows the cable car to be competitive to almost all other forms of public transport.

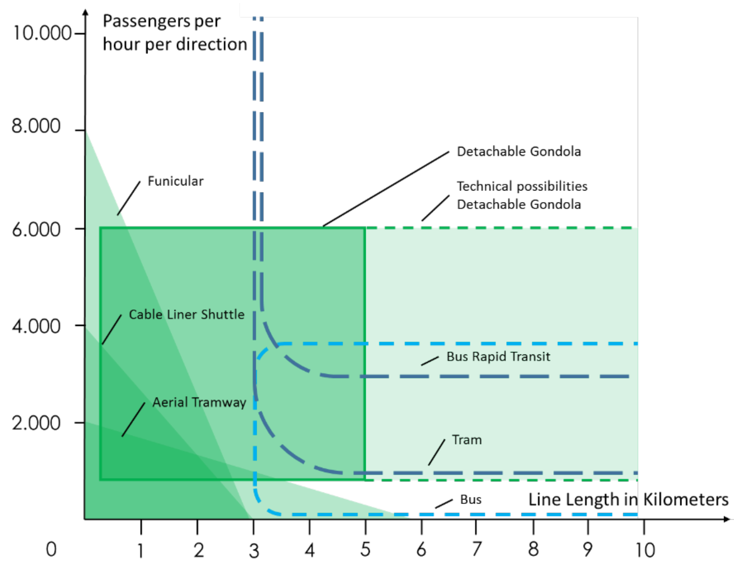

Figure 15; Capacity of cable car systems compared to other public transport Modes, based on: (Doppelmayr, 2017)

2.3 Rider Satisfaction Criteria

A cable car system has some advantages but also some disadvantages compared to other public transport modes. Both of the strengths and weaknesses need to be known to determine the benefit a cable car system can have.

The upcoming two subchapters are subdivided into different factors that have effect on the quality of the urban transport solution. They have been used in social costs and benefit analyses in the Netherlands (Uithoflijn, 2011) and Belgium (Leuven, 2014). The indicators for the costs and benefit analysis have been subdivided into rider satisfaction criteria (subchapter 2.3) and external effects (subchapter 2.4). They are used in these subchapters to describe the advantages and disadvantages that cable cars have compared to other public transport modes.

2.3.1 Costs

First will be compared what the costs of a cable car is compared to another public transport modes. Two types of costs can be differentiated; the operation costs and the investment costs.

The operation costs of cable cars are relatively low compared to other public transport modes with the same operation capacity (Hekel, 2015). This can create an advantage for the public transport operator. The limited operation costs is explained by the limited need for personal because of the autonomous transportation system and the limited use of electricity.

A cable car system consists of six different parts; the cables, the drives & brakes, Mechanical equipment, Vehicles, electro technical devices and rescue equipment (European parliament, 2000). All of these parts have different costs depending on the system and most parts also depend on the lenght of the cable car and the amount of stations. Monheim has tried to give some indicative data in 2010, saying that a station for a TGD / 3S gondola costs around 5 million euros, a pillar up to 2,5 million euros, a kilometre of rope 1,8 million euros. The vehicles used for a TGD / 3S installation were estimated to costs up to 170.000 euros per piece (Monheim, 2010). These costs are indicative and out-dated but show that a cable car will become very competitive to other public transport modes. The cable car become especially competitive in cases where infrastructure is desired for the improvement of other public transport modes or for pedestrians and cyclists

As shown above, a big part of the costs of a cable car construction are the stations (Monheim, 2010). This makes the cable car most effective with a limited amount of stations. A limited amount of stations has a positive effect on the average travel time, but might cause extra pre-trip journey time for travellers.

Another aspect that needs to be taken into consideration is the fixed infrastructure of a cable car. The cable car stretch cannot be adapted during operation. It is also expensive to redesign a certain connection. A bus mostly uses existing infrastructure and can therefore decide for a different route fairly easy, a cable car cannot. Even adding stations becomes difficult because the rope needs to be calculated new. It is therefore important that a cable car line is very well planned and future-proof. If this is not the case and the line needs to be changed, than large investments have to be made.

A unique element of an urban cable car is that it attracts both visitors and commuters (ARCADIS, 2015). This means that more income can be generated and that also the surrounding of the cable car stations will benefit from the extra amount of visitors. A cable car on a good location can be cost neutral or even profitable after a certain amount of operational years.

2.3.2 Travel time

A cable car travels between 21 km/h and 48 km/h. Even though these maximum speeds are not really high, they can lead to very short travel times. This is because the cable car does not interfere with other traffic and therefore is able to make the average speed very close to the maximum speed.

A cable car system uses the third dimension and can reach over obstacles. This means that a cable car especially has travel time advantage in situations where an obstacle needs to be crossed. This is for example the case in Koblenz, where the river Rhine and height difference only allow busses to travel from the centre of Koblenz to Ehrenbreitstein in 25 minutes, where the cable car takes 4 minutes (Doppelmayr, 2016).

The high costs of stations and the long time that it takes a cabin to cross stations makes it most beneficial to have as few stations as possible (Weis, 2015). This means that the cable car is likely to have fewer stops than a tram or a bus. This can again result in extra travel time for the users of the cable car to and from the station.

The frequency of cable cars can go up to an 8 second interval (Sölden, 2017), this means that there is no waiting time on a cable car, as long as the demand is lower than the capacity, so that there is no queue. TGD / 3S cable cars have a slightly frequency, in koblenz leaves a cable car every 55 seconds (Seilbahn Koblenz, 2017). Even though the freqency is a bit lower, there are still cabins available in the stations at all times, so that travellers can enter the cabins at all times. The short waiting time results in a shorter journey time for the users of the cable car.

2.3.3 Reliability and comfort

For users of a public transport mode reliability and comfort is very important. The two both have an effect on the experience of the user in a different way. Using the pyramid of Maslow for public transport they can be subdivided into satisfiers and dissatisfiers (van Hagen, 2013).

Dissatisfiers are parts of the travel that are expected to be fulfilled, if this is the case users feel indifferent-satisfied, if this is not the case users feel frustrated and got less than they had expected (Hagen, 2013). Reliability is one of the dissatisfiers for public transport together with safety and speed. According to Niels van Oort, there are three indicators that measure impacts of unreliable services on passengers, these are: average travel time extension, increased travel time variability and lower probably of finding a seat in the vehicle (van Oort, 2011).

A regular bus service, with a capacity up to 2.500 pphpd, will have the risk of getting a delay due to interruption in traffic. Also the variability of increased travel time will be relatively high because the bus is dependent on traffic conditions, this means it will probably have longer travel times in peak hours (Luke, n.d.). The probability of finding a seat is very dependent on local demand and supply and cannot be generalized.

A prioritized bus with up to 4.000 pphpd or a busway with up to 6.000 pphpd has less or not interaction with local traffic and the reliability will grow accordingly. A tram has a higher capacity with up to 12.000 pphpd but again interferes with local traffic.

A cable car has no interference with local traffic and has a technical availability up to 99.9 per cent (Wuppertal, 2017). This means that the average travel time extension and the variability of travel time extension do not occur as long as the cable car is built with a capacity that is higher than the demand and therefore has no waiting queues. It can therefore be concluded that the cable car, when well planned, will not lead to dissatisfaction due to delays.

The high availability can be reached due to the recovery concept cable car manufacturers. This contributes to the safety and the availability of the cable car. The design is made on such a way, that switching to a backup system can solve a failure in the steering mechanism, engine, coupling or brakes. In figure 16 is seen that both stations have their emergency drive separate from the main drive and directly connected with the rope. Some cable cars even have two main drives, this means that normal operation can continue while one engine is being maintained.

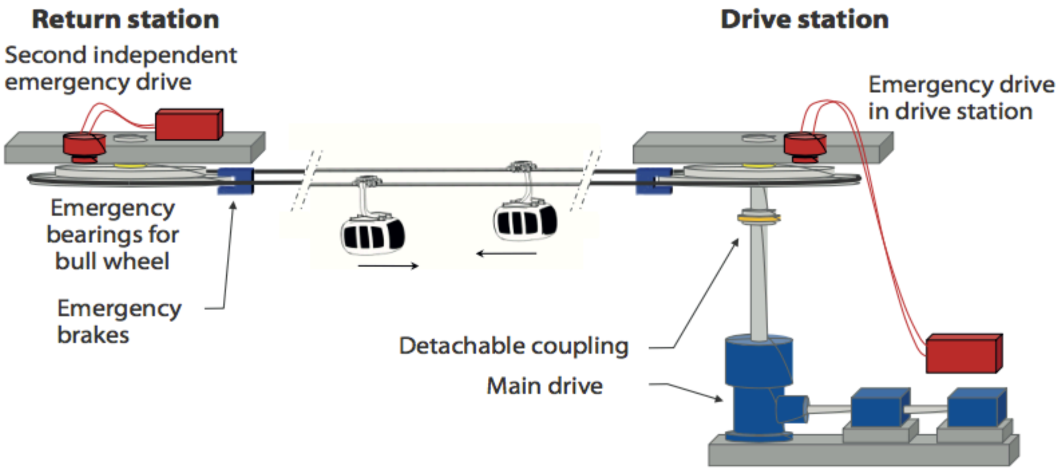

Figure 16; Doppelmayr Recovery concept (Doppelmayr, 2017)

Apart from technical failure there can occur delays due to meteorological aspects or there can be human failure leading to a stall in the system. Cable cars are mostly used in the mountainous areas where summers are hot and winter can be very cold and they can operate here seamlessly. One aspect that can play notable effect on the availability is the wind, therefore an assessment needs to be made on the wind that is present on a project location. This should be taken into consideration when deciding for a type of cable car.

On the other side there are the satisfiers; comfort and experience. These two elements will make the user positively surprised about the experience. Two main factors that play a role in comfort for passengers are the waiting comfort and the ride itself (van Oort, 2011). Due to the interval of a cable car there is no waiting time, and users will therefore notice this. In the cabins itself there is a lot of personal space and, depending on the type of gondola, seats for everyone riding on the cabin. Most of the gondolas, especially the urban ones, are fully suitable for riders with a disability and for cyclists to take their bike.

Figure 17; Luxury cabin by (Doppelmayr, 2017)

The experience of the ride is the second satisfier; in a cable car this experience is unusually high. The cable car consists mostly out of windows and travels at an altitude, providing passengers with a great view over the area. Other services such as Wi-Fi, air conditioning or seat heating can also be integrated into the cabin design. Furthermore luxury cabins are possible with leather seats, a fridge, TV screens and a dining table, an example of one of these can be seen in figure 17. This cabin has been sold in Vietnam to Sun Group and was exhibited at the Interalpin exhibition in Innsbruck in 2017. Even though this is not directly applicable when using a cable car as public transport, it does show the flexibility of the system and the services it can provide.

2.4 External Effects

In this subchapter the external effects of a cable car will be considered. These external effects are the environmental impact, safety, noise pollution and traffic hindrance.

2.4.1 Environmental impact

The environmental impact of a cable car system depends on many different factors and can therefore only be determined on a project base. Especially the comparison to other public transport modes is very hard to generalize.

On a project base can be calculated what the CO2 equivalent emission is. CO2 equivalent is used in this research because it can be compared to other public transport modes. Project details such as type of cable car system and energy source have an effect on the outcome of the energy comparison.

It is best to focus on three factors to determine CO2 equivalent emissions of a cable car. These are: CO2 equivalent for the materials used in the construction of the infrastructure and vehicles, the additional CO2 due to direct effect on nature (cutting down trees for station of pillars) and CO2 produced during operation. The CO2 production during operation should be calculated over a long period of operation. This is because the energy usage of a cable car is less connected to frequency of travel; a bus that travels half the frequency saves relatively more compared to a cable car that uses half the amount of gondolas.

The indicators have been chosen because they contribute the largest part of the CO2 production of cable cars (Nisen, 2016). They can also be very well compared to other public transport modes such as a bus or a tram.

The electrical engine gives the opportunity that it can be powered with renewable energy. It is still so that nearly all countries in Europe produce energy by non-renewable sources. This means that the CO2 per KWH on a local level has an influence on the emissions from the cable car system.

> *An example of an outcome from a CO2 comparison is published in 2009, and concerns the cable car in Koblenz (Dohmen, 2009). The differences in CO2 have been calculated on the 184 days of the Bundesgartenschau 2011. The result was that shuttle busses would travel 105.000 times back and forward for 25 minutes long between the city centre and the event location. This resulted in a CO2 equivalent of 881 Ton CO2.*
>
> *The cable car would produce 271 ton of CO2 together with 132 Ton for the supporting bus shuttles. This 271 ton takes into account the energy consumption of the whole complex and the CO2 costs for the trees that needed to be cut down. It does not include construction related CO2 emissions. For a cable car installation that is in place for 25 years this is about 30 per cent of the total CO2 (Nisen, 2016).*

There are many other factors that could be included, such as CO2 emissions by attracted tourists or extra usage of cars due to fewer bus lines (SFW, 2017). These factors are not measurable but also doubtable. A tourist will most likely produce CO2 while travelling towards a destination. But since tourism is often desired for economic reasons, it is not seen as negative to attract more visitors. Because of this controversy these numbers should not be taken into consideration.

2.4.2 Safety

Cable cars use their own infrastructure, the cable, and travel on an own traffic level without interference with other traffic. They therefore do not cause any unsafety for other transport modes. This specific characteristic is only shared with the metro system.

To determine the exact safety of a cable car compared to other public transport modes there needs to be comparable data; the performance indicators need to be the same.

Switzerland has published such data in 2010. They have ranked the cable car, bus, trolleybus, tram, bus and rail on the bases of injuries and deaths per trip in the period between 2008 and 2009 (OFS, 2010). On the first place concerning both injuries and death rate was the gondola with 3 injuries per 100 million passengers and 0 deaths. Rail and tram ended up as least safe with over 20 deaths per 100 Million passengers for Rail transport.

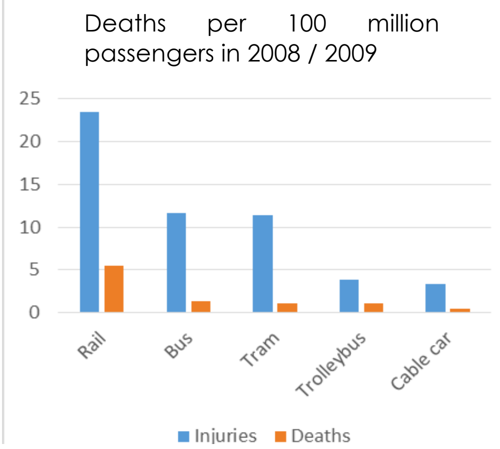

Figure 18; injuries and deaths comparison over 2008 and 2009, source: (OFS, 2010)

Another research compares gondolas to the use of a car. The research shows that per 100 million kilometres travelled 0,08 passenger died by using a cable cars and this was 0,48 for people travelling by car (NSAA, 2014).

Other statistics are based on the time spent in a transport system. In this case the cable car ends up with 29 fatalities per 10 million hours travelled. For railways this is 47 and for the car the result was 11 (Göteborgs, 2016). This relatively high number for cable cars is caused by the low average speed of a cable car, compared to a car and the railways. The other extreme compares the cable car on the base of the trips per fatality. There the cable car scores best with 333 million rides per fatality, where the train has 200 million trips per fatality and the car 26 million trips per fatality (Göteborgs, 2016).

Which statistic is the most suitable is to be discussed. In general trips are short within cities, where the cable car would be used. Therefore could be considered that the statistics per trip are most relevant to this research. In the end it does not matter what indicator is used, the cable car will never come out as unsafe.

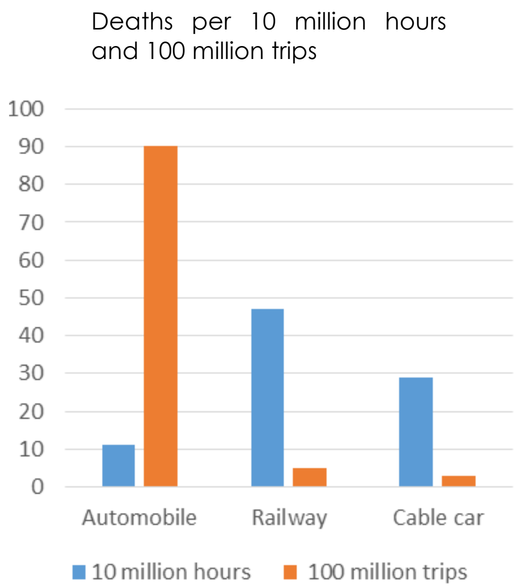

Figure 19; Safety comparison, deaths per 10 million hours and 100 million trips, source: (NSAA, 2014), (Göteborgs, 2016)

2.4.3 Noise emissions

A cable car has an electrical engine that is situated in the drive station. The return station and the individual cabins are not equipped with an engine. The most noise comes therefore from the drive station.

In ski areas it is often seen that the engine is constructed above the height of the rope in the station. This can cause noise emissions of above 65 decibels(Doppelmayr, 2016). It is also possible to construct the engine below the surface, this measure takes away most of the noise produced.

Another location where cable cars cause noise is the pillars. It is measures that a TGD / 3S produces 40 decibels while travelling over a tower (Doppelmayr, 2016). This means that with a 50 metres high tower 12 decibels reach the ground. A human ear cannot hear this, for example, normal street traffic already produces 80 decibels directly on surface (Björkman, 1997). It can therefore be concluded that when the pillars and stations are planned adequately, they do not form noise emissions.

2.4.4 Traffic hindrance

The stations together with the pillars (dimensions can vary) need to be planned on ground that is available or that can be made available. A cable car will, In case neither a station nor a pillar has been planned on existing infrastructure, not have an effect on the traffic flows that it crosses.

A system such as a BRT or an over ground Metro also are not hindered itself by other traffic, but do hinder other traffic that wants to cross the infrastructure. It can therefore be said that the cable car only shares this unique characteristic with an underground metro system.

There is still an important difference between the underground metro system and the cable car. The construction of a cable car system takes less than 18 months, where the construction of an underground can take up to a decade. Also during the construction the cable car will hinder traffic less. As can be seen in Figure 20, the rope of this MGD has not been spanned yet, but the pillar is standing already. The small dirt road next the pillars can be used without any problem. This can also be realised on a larger scale.

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Figure 20; Pillars in construction (Alpinforum, 2007)

2.4.5 Basic requirements for the use of an urban cable car

A limited amount of research is available on the successful implementation of cable car in an urban environment. This is a direct result of that fact that there has been a very limited amount of examples in Europe.

The research that is available for evaluating the usefulness of urban cable cars comes from Rynko, being the decision path criteria. This scheme describes the criteria that need to be fulfilled for a cable car to be technically possible and to contribute effectively to the public transport network in a region.

This scheme is based on Rynko, 2016, but has been adapted on the findings from the different case studies in the next chapter.

- Traffic demand
    - Wish for a public transport / pedestrian / cycle connection
    - 500 to 6.000 passengers per direction per hour
    - Station distance minimum 500 metres and in a straight line
- Physical barriers or advantages above current PT
    - Natural barriers (e.g., water)
    - Anthropogenic barriers (e.g. scarcity of space, traffic hindrance)
    - Advantage because of pipe-line system, short construction, temporarily demand or bad reputation public transport
- Meteorology
    - No frequent wind speeds of over 100 km/h
- Operations
    - Public transport operator or private company present
    - Tariff integration possible
- Finance
    - Eligible for funding or without funding financeable

If these five requirements are met then an initiator can start with planning a cable car line. Also for this process there are requirements, these are that a cable car should be combinable with: nature, city Image, aerial space and land usage.

And finally the inhabitants, politics, public transport users and the directly affected residents should accept it. This acceptance is not only related to the advantages of the cable car or the alternatives, but is dependent on the political climate and local culture. The case studies in the third chapter will help to further analyse this process.

The checklist in appendix 3 is based on the requirements for the use of urban cable cars. This can be filled in by interested stakeholder to determine the feasibility of an urban cable car on a certain spot.

2.5 Strengths and Weaknesses

Based on the rider satisfaction criteria and external effects of cable cars a set of strengths and weaknesses are determined. The strengths and weaknesses are a summary of this chapter and are divided accordingly in table 2. This means that the rider satisfaction criteria are described: costs, travel time, reliability and comfort. Also the external effects are described in the table, these are: environmental impact, safety, noise emission and traffic hindrance.

Table 2; Strengths and weaknesses of cable cars

Type	Strengths	Weaknesses
Costs	Limited need for personal	Line cannot be adapted within the investment period
	Relatively cheap to overcome height or bridge an obstacle	Limited amount of stops is most affordable
	Additional income through tourism	
Travel time	No interruption due to third dimension	Low maximum speed
	Direct line between stations, also in mountainous areas.	Longer pre-trip due to fewer stations
	High frequencies up to a 8 second interval	
Reliability	Low average travel time extension and low travel time variability	
Comfort	No waiting time	
	High amount of personal space	
Environmental impact	Low amount of CO_2 for operation	New infrastructure needed
	Limited CO_2 impact of new infrastructure	
Safety	Least fatalities per trip	Feeling of unsafety due to fear of heights
Noise emission	Low general decibels produces	>45 decibel pillars possible and the drive station
Traffic hindrance	Does not interfere with other traffic	

These strengths and weaknesses of the cable car as urban transport solution give a general overview of the possibilities this system can have. On a local or project base these characteristics can differ.

3 Evaluating Urban Cable Car Projects

In this chapter several cable car projects have been described to find out more about how a cable car can contribute best to a local transport network and what the best project approach is. Three projects that have been constructed; London, Brest and Koblenz, are analyses.

These are taken because they are situated in Europe, and represent the three most important cable car systems for use in the urban environment, namely the MGD, ATW and the TGD / 3S. The other three projects that are in Groningen, Hamburg and Trier have not been constructed.

These three have been chosen because they have been planned to a big extend before was decided against the construction. Therefore much information on the use and the implementation process is available.

Figure 21; Cities analysed, green is in operation, grey is not in operation.

The six cable car connections will all be generally described. After this a quick scan based on the basic requirements of a cable car named in chapter 2.4.5 will be performed. This quick scan is determined based on the components of the basic requirements. This should give an insight if a cable car is a logical option.

The quick scan consists of five elements; travel demand, benefit compared to public transport (PT), nature conservation & city image, technical feasibility and use of space. These elements are chosen because combined they cover all basic requirements out of chapter 2.4.5. For example the metrological aspects are taken into account in the technical feasibility and chance of acceptance by inhabitants and local politics is included in nature conservation and city image.

Not only can be determined if the cable car on this location suites the model, it also makes it possible to find out if the quick scan works. When for example the quick scan shows that there is no possibility for a cable car, but it is already implemented and a success, than a factor is missing in the quick scan. At the end of each subchapter a number of deciding factors will be given.

3.1 London

A cable car connection is fast to plan and to construct. This is what Boris Johnson, former mayor of London, needed for the Olympic games of 2012. Two big venues of the Olympic games needed be connected with a fast to build over ground connection (TFL, 2010).

The Royal docks, which is connected by cable car with Greenwich Peninsula, was developing before 2010 already and needed an additional connection (Eurist, 2015). The cable car therefore was in general beneficial to the public transport network.

Figure 22; Emirates Air Line, London, (The O2, 2017).

In 2011 was announced that the airline Emirates would sponsor the project for 10 years. The Emirates Airline, as it was called due to the sponsorship, opened on June 27th 2012 (telegraph, 2012), 6 weeks before the opening sceremony of the Olympic games.

3.1.1 Basic requirements

Travel demand	
Benefit compared to current PT	
Nature conservation & city image	
Technical feasibility	
Use of space	

There was a traffic demand during the Olympic Games and afterwards a traffic demand was expected between the two development areas. The physical obstacle was the Thames, which does not have any fixed surface river crossings between the royal docks and the tower bridge, for cyclists it is even the only way to cross the Thames here, since bicycles are not allowed on the tube.

The private funding from Emirates has paid for the cable car together with the contribution of TfL. There were no big issues concerning nature conservation or city image, especially because the cable car is rather far out of the city.

3.1.2 Implementation process

The initiator was transport for London and they had decided for this option because it was possible on a short term and was cheaper than an underground line or a high bridge. It also offered an extra attraction for visitors of the Olympic Games. Transport for London itself is owner of the cable car.

The cable car is located in a development area and therefore there were no big issues with local residents. The project had become more expensive than initially expected. This setback, however, did not cause major problems after collaboration with Emirates was established. A private party carries out the operation and (TFL, 2010).

3.1.3 Deciding factors

- Cable car could be needed for a big event (Olympic games of 2012)
- Partly paid by sponsor (Emirates)
- Both contribution to transport network and attraction for tourists
- New development in North-Greenwich

3.2 Brest

In 2013 the planning started for a cable car in Brest, France, a city with 140.000 inhabitants.

Figure 23; Vertical cable car crossing in Brest (telegramme, 2016)

There was a big challenge for the city of Brest when the military sold the land in between development area Capucins and the east side of Brest to the local government. A connection was desired between the two parts of the city, but to connect the distance between Capucins with the east side of the city, the river Penfield needed to be crossed (Antonio, 2017).

The government had compared many different scenarios with each other but all the bridge constructions would have become too expensive. One of the city planners came up with the idea of a cable car. This does not only have as advantage that it is in general cheaper, but the city could also pay it from a different budget, with higher governmental contribution.

A Swiss cable car manufacturer had won the tender with a unique design where the two cabins pass each other vertically instead of horizontally. The system has one pillar with two levels where the cable cars can pass through.

The system has a speed up to 7,5 m/s and can therefore cross the 420 metres within in less than 3 minutes. The system is fully integrated in the public transport network and should attract inhabitants, commuters and visitors of the cinema and bars. Tourists only account for less than 10 per cent of the total users in the planning.

3.2.1 Basic requirements

Travel demand
Benefit compared to current PT
Nature conservation & city image
Technical feasibility
Use of space

A connection was needed between the city centre and the new development area. The aerial cable car offers a capacity of 2000 pphpd but is only expecting 1850 passenger per day with a 17 hour per day operation. This comes down to an average of 54 passengers per hour per direction. In general this would be a low amount of users for a cable car connection, but in this case enough to make it affordable. Also an increasing amount of users are to be expected (Antonio, 2017).

The cable car stretch did not cause any difficulties with nature conservation, urban conservation or air traffic. The land that has been used for the pillar is from the French marines and has been given allowance without big difficulties.

3.2.2 Implementation process

In 2015 a public survey has been conducted under a limited amount of residents; 30 of them came with a critical response, 11 were supporting the project and 17 were neutral (Departement du Finistere, 2015). These critical aspects have been assessed but the advantages were bigger according to the city. Therefore the project has been continued.

The public was, according to Victor Antonio, very positive about the project. The first sceptical reactions came just before the city council elections. It could therefore be that those reactions were a political statement rather than an objective opinion on the project.

There was some negative publicity after the system suffered from some teething problems, in the end the opinion turned positive again. The cable car has more users than expected and over 60 per cent of the travellers to Capucins travel with the cable car (Antonio, 2017).

3.2.3 Deciding factors

- Option cheaper than a bridge over the same stretch
- The budget for public transport could be used instead of the budget for infrastructure

3.3 Koblenz


Figure 24; Cable Car in Koblenz (Seilbahn Koblenz, 2017)

Koblenz is a small scale city with approximately 110.000 inhabitants, situated at the Rhine in Germany. On the one side of the Rhine there is the old inner city and on the other side of the Rhine there is the Ehrenbreitstein Fortress, a UNESCO World Heritage Site with over 680.000 visitors in 2015 (DieFestungEhrenbreitstein, n.d.).

In 2011 the Federal horticulture show (Bundesgartenschau) was organised in Koblenz and within the four months 2 million visitors were expected (Nigsch, 2017). These visitors needed to be brought to the Ehrenbreitstein Plateau where the exhibition took place. The bus connections had too limited capacity to cope with this amount of visitors. The cable car, that could cross the Rhine and fly up the mountain, could handle this demand.

The planning for the cable car started in 2006 and was initiated by the city of Koblenz. It was decided for a cable car because travel times would be reduced from 25 minutes to 4 minutes. Also the ecological footprint of the cable car was much less than shuttle busses.

The Federal horticulture show was a big success with 3,6 million visitors and 3,2 million of those used the cable car (Bundesgartenschau, n.d.). It was decided in 2014 that the cable car would be allowed to run until 2026, without the fortress losing its status of UNESCO world heritage (UNESCO, 2012).

3.3.1 Basic requirements

Travel demand
Benefit compared to current PT
Nature conservation & city image
Technical feasibility
Use of space

Two main difficulties occurred with the Koblenz cable car. This was because the Ehrenbreitstein is UNESCO world heritage, this status was in question when the cable was first planned. Also the space for the station at Deutsches Eck was very small. The city of Koblenz had agreed with UNESCO that if the cable car would be temporarily used for three years and deconstructed afterwards, the fortress would keep its status (UNESCO, 2012). The station at Deutsches Eck has been built very small, so that it fits in the limited space.

3.3.2 Implementation process

The Bundesgartenschau 2011 has taken the initiative to find an alternative way to transport visitors from the inner city of Koblenz to the Ehrenbreitstein Fortress. In 2007 they have created a tender to find the best cable car company to finance and operate a cable car between 2010 and 2013. The cable car company would also be responsible for operation and ticketing.

In 2013 has been decided to keep the cable car until 2026 (UNESCO, 2012), this was a direct result of citizen initiatives opting for keeping the cable car. This way, national and local governments supported the cable car, which was stimulating the decision of UNESCO to allow the cable car to be kept for a longer period.

3.3.3 Deciding factors

- Cable car needed for big event (Bundesgartenschau)
- Originally temporary planning
- Support of citizens to keep cable car

3.4 Groningen

Figure 25; sketch of station at Sontplein in Groningen (DvhN, 2016)

Groningen has approximately 200.000 inhabitants and is situated in the North of the Netherlands. The city has a big catchment area because it is surrounded by few other cities. This creates a big amount of visitors in the weekends.

The main hospital of the province, UMCG, is located in Groningen and has over 12.000 employees. The local entrepreneurs, together with the UMCG, the local government and Groningen Marketing formed a project group that created the plan to connect the park and ride at the Euroborg stadium with the park and ride at Sontplein, the UMCG and the inner city. The line would have a station at each of these venues, thus four stations in total (ProjectKabelbaanGroningen, 2006).

3.4.1 Basic requirements

Travel demand	
Benefit compared to current PT	
Nature conservation & city image	
Technical feasibility	
Use of space	

The public transport connection is a logical contribution to the current public transport network and would have enough demand.

The benefit of the transport network however, was not significant. Busses currently serve the connections and Groningen has one of the highest cycle rates in the Netherlands. Also the physical obstacle was not present, this leads to less advantage for the cable car. The planned route was going over private property and into the inner city, local parties have never discussed this issue, but there are some difficulties identified.

3.4.2 Implementation process

The project group as named before has released a first feasibility study in 2006. This feasibility report investigated on a cable car stretch leading from the nowadays-existing train station Europapark, to the IKEA and into the inner city of Groningen. (ProjectKabelbaanGroningen, 2006)

The report gave as advice to the deputy major to further investigate the option of a cable car. In 2011 the foundation Flyover Groningen had been founded with the goal to implement a cable car in Groningen. The foundation had the same members as the project group in 2006. They have hired Arcadis to create a supporting feasibility study for the cable car stretch that was finished in 2015 (Arcadis, 2015).

The reaction from the deputy mayor was that the cable car would compete with the public transport and that a cable car connection is therefore not allowed during the current concession (RTVnoord, 2016). The reaction from the deputy mayor was a big surprise to the foundation Flyover and to other parties in the city council. They opted that all of the arguments that have been given could have already been given in 2006 (Gemeente Groningen, 2016).

The arguments where that the cable cars competes with existing public transport, that it changes the city image and that the expected amount of visitors is to uncertain. The oppostition finds this especially weird because in the earlier report there was a higher amount of visitors expected, and this was not questioned.

3.4.3 Deciding factors

- Competition with current public transport
- City image
- Lack of political support

3.5 Hamburg

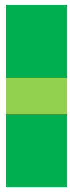
Figure 26; Sketch Cable Car Hamburg (shz, 2014)

One of the biggest harbours in Europe is situated in Hamburg. The harbour in Hamburg is still operating relatively close to the inner city, where other harbour cities such as Rotterdam and Antwerp, have let the harbour grow more towards the sea. This results in big differences between the north of the Elbe and the south of the Elbe (Eurist, 2015). In 2013 the International Architecture Exhibition and the international horticultural exhibition took place In Wilhelmsburg. A cable car manufacturer had presented a plan in 2007 with a cable car connection from St. Pauli to Wilhelmsburg. The plan was to accommodate accessibility for the expected 3.2 million visitors (TAZ, 2013). This plan was further developed in 2010 when a theatre owner on the south side of the Elbe got involved (Reichenback, 2016). The stretch would now consist of three stations, one being directly on the other side of the river.

The harbour authority decided shortly after the middle stop had been integrated in the plan, that a stretch from the theatre on the south side of the Elbe to Wilhelmsburg would not be feasibility because of exciting harbour legislation (Eurist, 2015). That is why only the shorter stretch from St. Pauli to the musical theatre was further discussed.

3.5.1 Basic requirements

Travel demand
Benefit compared to current PT
Nature conservation & city image
Technical feasibility
Use of space



The Elbe forms a big obstacle in Hamburg between the North and the South. There is only one underground driving to the south of the Elbe and an extra connection would have been beneficial. Also the theatre itself attracts many visitors and could make use of the cable car. The cruise terminal that is situated on the south side of the Elbe would also benefit from the connection. The new cruise terminal, Cruise centre Steinwerder, opened in June 2015. There is a big parking lot for 1.500 cars, but the terminal is less well connected with public transport (Cruisegate hamburg, 2017).

The cable car line was designed high above the ground, with pillars up to 100 metres high. This was because of the sea vessels that needed to be able to pass underneath the ropeway. One of the main arguments against the cable car was the changing skyline because of this.

3.5.2 Implementation process

In Hamburg there were local partners and a feasibility study was carried out. The cable car would have been affordable and able to run without public money. The main problem was that the politics and a few residents thought a cable car would not fit in the cities skyline.

Other concerns where that the cable car was too much lead by a private initiative. Because of this the project lost trustworthiness. They also strongly doubted the contribution to the public transport network and the project was seen as a solely touristic attraction. According to the opposition this was especially a problem because St. Pauli already has a large amount of tourists (Rühling, 2017).

The politics of the district Hamburg Mitte had decided against this project together with an inhabitant initiative. There were also initiatives for the cable car; they have opted for a referendum concerning the cable car (Abentblatt, 2014). Only the 200.000 residents within the neighbourhood St. Pauli were allowed to vote and they voted against (City of Hamburg).

3.5.3 Deciding factors

- Negotiable contribution to public transport network
- Changed city skyline
- Big involvement of private companies

3.6 Trier

Trier is a city in Germany with around 115.000 inhabitants. The university and a part of the city called Petrisberg are situated on a hill 120 metres above the city centre, where also the railway station is.

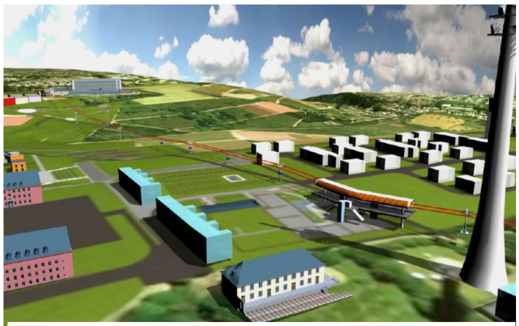


Figure 27; proposed route for Cable Car Trier (Auer, 2007)

There are several bus lines driving up the hill to serve the University and the other parts of the city. These busses take, relatively to the cable car, a long time to reach their destination. A cable car could connect these areas in a straight line and have a shorter travel time.

There have been several different case studies; most of them travel from the station directly towards the University. There has also been a study that investigated the connection towards the other side of the valley.

The idea of connecting the university and the inner city with a cable car had already been investigated in the 1970's. It was decided against though, and since then the discussion comes up every couple of years. In 2004 the Landesgartenschau was organised in Trier but also this event was not reason enough to replace the bus lines running up the mountain (Auer, 2007).

3.6.1 Basic Requirements

The height difference between the train station and the city centre offers great opportunity for a cable car system. The busses are travelling a longer distance and take time to drive up the mountain. Especially the first stretch from HBF to the Wissenschaftspark would save public transport users a lot of time, 4 minutes instead of 15 (Auer, 2007).

Travel demand	
Benefit compared to current PT	
Nature conservation & city image	
Technical feasibility	
Use of space	

The cable would, however, have fewer stations than amount of bus stops at the moment. This means that from several neighbourhoods travel times might actually increase. That is why not all parties did agree with the benefit the cable car would have compared to existing public transport.

3.6.2 Implementation process

The city council of Trier has shown interest in 2009 to a new view on the cable car variant to Petrisberg. DB international GmbH concluded that a new bus connection will have better effects on the transportation, but added that a financial comparison still needs to be made to confirm this (Reichenback, 2016).

This has not been done and the city council has decided against the cable car. An interview with Stadtwerke Trier, the local public transport operator, has revealed that there might have been other concerns as well. This bus line to Petrisberg is namely the most profitable (Reichenback, 2016).

3.6.3 Deciding factors

- Bus connection was a better traffic solution because it had more stops
- Local politicians had a sceptic point of view on the cable car

A further analysis on the outcome given in this chapter is described in chapter 4. The implementation process and deciding factors are taken over into the opportunities and threats of the SWOT analysis

4 Optimised Implementation Process

The findings in Chapter 3 will be used to determine trends in case studies that have a negative or a positive influence on a cable car project. This outcome will be elaborated on to determine opportunities and threats for cable car projects. Literature on implementation of urban cable cars is used as well. The outcome of this chapter will be a performed SWOT-analysis for the use of a cable car as public transport mode in European cities and recommendations for the implementation process of urban cable cars.

4.1 Opportunities and Threats

This first subchapter is divided into three parts; firstly an analysis is performed on the case studies of out of chapter 3. After this is described what literature is already available regarding the implementation process of cable cars and finally will be concluded what the determined opportunities and Threats are for urban can car projects.

4.1.1 Analysis on the case studies

Each of the six case studies is concluded with a number of deciding factors that had a mayor influence on the decision that was made. The factors have been summarized in table 3. Two opportunities have been determined on the base of the case studies; firstly that in all projects that are operational there was a subsidy or co-finance involved. Furthermore can be seen that both in Koblenz and in London the construction was linked to a big event that was expected to attract many visitors over a shorter period of time.

Aspects that were seen in the three projects that are not operational were the lack of political support and perceived lack of compatibility with exciting public transport. Both of these aspects were found back in all three case studies.

Table 3 Case studies summary

- Koblenz:
  - Cable car needed for BUGA
  - Temporarily planned
  - Support from Citizens in 2011
  - Private investor
- Brest
  - Option cheaper than a bridge
  - Budget from higher government used for PT
- London
  - Cable car needed for Olympics
  - Emirates sponsor
- Groningen
  - Competing with exciting public transport
  - Local politics give no response to citizen initiative
- Hamburg
  - Negotiable contribution to PT network
  - Changes city skyline
  - Big involvement private companies
  - Local politics actively against cable car
- Trier
  - Bus connection better traffic solution
  - Skeptical position of local politics

Oppertunities

- Other subsidies attracted
- Tourist attraction for big event

Threats

- Lack of political support
- Not compatible or contributing to PT

The findings out of the case studies will be used as addition to the literature review in the next subchapter.

4.1.2 Literature on implementation process of urban cable cars

Three main sources will be used that have described the implementation process of urban cable cars. These are from F. Kremer, J. Hamborg and M. Volz.
In 2015 Kremer has carried out three expert interviews on the theme urban cable cars as innovative solution in the public transport market and their stakeholders. The interviews were carried out in German with M. Kaindl, E. Assmann and G. Kayser. A brief summary of the most important quotes during the interviews is translated underneath.

> *"Because many of the sceptics never made experience with urban cable cars, and because the cable car is not the tradition underground, nobody can blame them for judging."*
>
> *"There is strong civil movement in Europe that can work strongly against or for a project. It is often a Not in My Back Yard Syndrome to be noticed: the inhabitants would in general support a project, but as long as they are not directly affected by it."*
>
> *"The politics tends to be careful with developing big urban projects. Recent projects such as Stuttgart 21 have shown the discrepancy between the will of the politics and the inhabitants."*
>
> *"Even though the interest of the media in the cable car as urban solution has grown in the last years, there is still a majority of the stakeholders that connects the cable cars solely with ski-tourism."*
>
> *"The preconception of a cable car belonging in a ski resort is so strong, that until now the cable car has very rarely been seen as a serious mean of transport."*
>
> *"A higher extend of awareness is to be realized."*
>
> *"Mobility solutions are not only determined by theoretical or scientific research, but very much based on success stories. There are not that many of these success stories in Europe at the moment, they are mainly in South-America and Nord-Africa."*

Two main issues are coming back in every of these interviews: users and policymakers are not aware of the European examples to relate to when conceptualizing urban cable cars and (therefore) still relate them solely with alpine transportation.

Kremer has described several approaches on how this general problem could be solved. This can be by attracting attention on fairs, attracting attention directly from decision makers in cities but also potentially by cable car construction companies collaborating with each other. This last option has some strong difficulties because of the competition between them and the potential fear of cartel formation. It could, however, be useful for the market to collaborate and use the scare literature and examples of all systems.

Also J. Hamborg has done research on the barriers for cable car projects (Hamborg, 2015). He has done this on the base of three recent urban cable car project in Germany, namely in Koblenz, Hamburg and Wuppertal. The cable car in Koblenz is operational, in Hamburg is decided against the cable car and in Wuppertal the decision is still to be made.

The outcome of his research are six hypotheses that are confirmed on the bases of the three case studies. The hypotheses are:

- City planners, politicans and inhabitants do not have enough knowledge about the concept of an urban cable car. The lack of knowledge leads to sceptic view on the public transport mode
- A strong connection between the cable car, the mountains and tourism makes it hard for the cable car to be seen as public transport mode
- It lacks European examples of a urban cable car being used mainly as part of the public transport network
- There is a concern of inhabitants because the cable car would interfere with their private atmosphere
- Inhabitants fear that the appearance of the city skyline and landscape will be changed due to the visual impact of the pillars and the gondolas

A couple of the same findings were noticed in the case study research of F. Kremer. Nevertheless, there are also different findings, such as the concerns about city skyline and the urban landscape.

The third research by M. Volz has been carried out on the potential for cable cars in the future. One of his conclusions is that people in general are getting more aware of enviornmental challenges and therefore are more interested in sustainable urban mobility solutions (Volz, 2013). He sees an opportunity for the cable car to fulfill this need.

He also described that innovations in the cable car stations will help to further integrate cable cars in existing public transport networks. The stations could than allow cable cars to only stop when passangers would like to exit. This would give a traveltime advantage for the users.

The biggest obstacle mentioned is the lack of knowledge about the advantage of the system. Especially the inhabitants, politicians, local governments and other decision makers are mentioned. This should be solved by giving more transparancy about the advantage and therefore get more support.

All the findings out of the literature review in the previous subchapter are collected and combined together with the findings of the case studies in subchapter 4.1.1 The result of this can be seen in table 4.

4.1.3 Opportunities and Threats derived

Seven opportunities have been determined on the basis of the case studies and the literature review. The first opportunity is the effect of subsidies, it was shown in all three case studies that are operational, that subsidies or investments from a third party were involved.

Also the combination with a big event has had a positive influence on the decision and the public opinion of urban cable cars, this is therefore the second opportunity. An opportunity derived from the literature review is the communication via exhibitions and the direct communication with governmental organisations. The communication strategy will help get more political support, but will also help stakeholders to understand the role that a cable car can have in a public transport network.

The next opportunity comes from the F. Kremer, who suggests that cable car manufacturers can learn from each other. Especially in this developing innovation it is important that all knowledge available is taken into consideration, even without active collaboration. F. Kremer also names the growing environmental concern that inhabitants have. This is a good opportunity to get more support from inhabitants as well as from politicians.

The first two last opportunities relate to the public transport integration and the technological development. These two opportunities come from M. Volz, who claims that with more technological development an even better integration is possible into the public transport network.

The two threats are derived from the case studies out of chapter 3. In all three cities it was the local politics that was actively against the cable car. One important reason was the perceived lack of integration in the existing (public) transport network.

The next two threats both came out of all three interviews carried out by F. Kremer. This relates to the lack of knowledge that stakeholders have of cable cars and the strong relation to winter tourism. Both of these threats are directly connected to the next one, the scarcity of European examples of urban cable cars. Also this came back in all three interviews.

Finally there is the fear of inhabitants that a cable car will interfere with their privacy and that it will have a negative effect on the city skyline and the urban landscape.

All of these opportunities and threats are combined in table 4. This table will be used as input for the SWOT-analysis in the next subchapter.

Table 4; Opportunities and threats

Opportunities	Threats
Effect of subsidies	Lack of political support
Integrated in planning for big event	Perceived lack of integration possible in existing transport network
Communication via exhibitions and governments	Relation to tourism and winter activities
Field wide collaboration	Very few knowledge about the cable car
Growing environmental concerns	Scarcity in European examples
Public transport integration	Inhabitants fear for privacy
Technical developments in stations	Changed city skyline and urban landscape

4.2 SWOT-Analysis

The strengths and weaknesses as described in subchapter 2.6 together with the opportunities and threats described in chapter 4.3 results in the following SWOT-analysis.

Table 5; SWOT-Analysis

Type	Strengths	Weaknesses
Costs	Limited need for personal	Line cannot be adapted within the investment period
	Relatively cheap to overcome height or bridge an obstacle	Limited amount of stops is most affordable
	Additional income through tourism	
Travel time	No interruption due to third dimension	Low maximum speed
	Direct line between stations, also in mountainous areas.	Longer Pre-trip due to fewer stations as a bus or tram.
	High frequencies up to a 8 second interval	
Reliability	Low average travel time extension and low travel time variability	
Comfort	No waiting time	
	High amount of personal space	
Environmental impact	Low amount of CO_2 for operation	New infrastructure needed
	Limited CO_2 impact of new infrastructure	
Safety	Least fatalities per trip	Feeling of unsafety due to vertigo fear of heights
Noise emission	Low general decibels produced	>45 decibels possible at pillars and drive station
Traffic hindrance	Does not interfere with other traffic	
	Opportunities	**Threats**
	Effect of subsidies	Lack of political support
	Integrated in planning for big event	Perceived lack of integration possible in existing network
	Communication via exhibitions and governments	Relation to tourism and winter activities
	Field wide collaboration	Very few knowledge about the cable car
	Growing environmental concerns	Lack of knowledge about the European examples
	Public transport integration	Inhabitants fear for privacy
	Technical developments	Changes city skyline and urban landscape

This table shows all the factors that are taken into account in the recommendations for the implementation. This implementation diagram is described in subchapter 4.3.

4.3 Recommendations for Implementation

In this subchapter will be looked at the implementation process of urban cable cars. General literature on infrastructure and policy planning will be used together with the results of the SWOT-analysis in subchapter 4.2.

4.3.1 Integration of the SWOT-analysis in the project implementation

The proposed project approach is determined based on a publication by Eurist (Eurist, n.d.) and the general participation approach derived from the SUMP guidelines (Eltis, 2013), but also on the opportunities and threats determined for urban cable car projects. The checklist numbers 1 until 6 are recommendations that need to be taken into consideration in the project approach.

They are based on the SWOT-analysis but also on the interviews carried out in Flanders and the Netherlands. These interviews were carried out with Arcadis, De Lijn, Netwerk Duurzame mobiliteit, the local government of Ghent, The local government of Antwerp and the province of Zeeland. Their opinion has been asked to determine what parts of the SWOT-analyses they can relate to the most. The following has been threats and opportunities were mentioned most during the interviews, and are therefore used in the recommendations.

Number	Applies to:	
1.	Threat	Integration in existing network
2.	Opportunity / Strength	Effect of subsidies / Integrated in planning for big event
3.	Threat	Lack of political support
4.	Opportunity	Political support / growing environmental concern
5.	Threat	Relation to tourism and winter activities
6.	Opportunity	Scarcity in European examples

4.3.2 Find a suitable spot

The first step for an urban cable car is to find a stretch where the cable car has a notable benefit. To do this planner first needs to look at general traffic challenges in the region that is being looked at.

Local traffic and transport plans can be used to find locations where improvements to accessibility are needed. The plans state where there is a wish for improvement but often also contain more specific projects where a preferred public transport mode is already mentioned. It can still be beneficial to compare the cable car to this public transport mode, and see which one is more suitable.

One of the strengths of the cable car is the capability to use the third dimension and therefore not to interfere with other traffic and obstacles such as a river or a mountain. This means that both man-made and natural obstacles need to be identified, these can lead to a desired transport connection that cannot be tackled by other public transport modes.

A quick scan can be performed of different variants to see which one should be investigated more. When the quick scan has been carried out and the cable car comes out as suitable public transport mode, than the user satisfaction criteria and external effects have to be determined. These aspects are costs, travel time, reliability, environmental impact, safety, noise pollution, construction time, negative impact during construction and overall impact on traffic. The result should be an overview of the added value of a cable car system.

1. Has the added value to the PT network been determined?

In the review of the four cities is seen that events have been a trigger for the implementation of an urban cable car multiple times. It is therefore also needed to look at big events that will take place in a region. Big festivals, sport events or other exhibitions can be the trigger for a city to invest in infrastructure even though demand was already there. Also can be looked for possible subsidies that apply to the public transport mode. This subsidy can come from an event, but also from a budget for (sustainable) infrastructure, electrification or public transport.

2. Does the stretch apply for a subsidy or co-finance?

4.3.3 Develop the plan with local stakeholders

The projects as described in chapter 3 all have different stakeholders. Very roughly can be said, that cable car projects have an initiator, a transport authority or local government, a cable car manufacturer and externally interested stakeholders (Frieder, 2015).

The initiator has the first idea of the urban cable car. This can be the local government (Brest), the transport authority (London) but also a private investor such as the cable car manufacturer (Koblenz). The transport authority or local government has as goal to improve a connection or to attract more tourists.

The cable car manufacturer is further responsible for the detailed planning and for fulfilling all technical requirements. The transport authority or local government needs to make sure that the planning of the cable car will be reachable for the cable car manufacturer, for the users and for the external parties.

The users are those that will use the cable car as daily public transport mode or as an attraction. The stretch that will be covered should improve an existing connection. This can be an improvement in travel time, travel costs or a better comfort for the travellers.

Finally there are the externally interested parties that are affected by an urban cable car. In the case of a cable car these are extra important because the cable car uses a new dimension in the urban environment. For inhabitants, politicians and other interested groups this is a new urban phenomenon that can results in complicated debates.

For a cable car project it is very important that all of these stakeholders collaborate on a proper manner with each other. That is why the plan, as develop in subchapter 4.3.2 should be worked out and discussed in collaboration with all stakeholders.

First needs to be determined with the transport authority, the local government, the inhabitants and the involved entrepreneurs what the benefit of the improved connection would be. This can be done with the help of environmental organisations, transport planners or other research institutes that relate to the project.

3. Do all stakeholders support the goal of the cable car?

During the meetings with the city and the external research parties can be determined if the cable car also supports other goals that are not directly related to a specific budget, but do have political interest. This can for example be the percentage of public transport usage, additional tourist attracted, or the percentage of electric transport in the city.

4. Does the cable car support other goals that the city or government has?

During the meetings between the stakeholders it can be useful to visit an urban cable car that is already operational. Also workshops or visualisations of urban cable cars can help to develop understanding of the principle. This will lead to more understanding of the system and will help to progress further discussions.

5. Is there a clear view of an urban cable car present at the stakeholders?

When the goal is determined and the added value of a cable car has been agreed on, than needs to be chosen for the most suitable technology and the precise location of the system. This includes locations for the stations as well as the pillars. In some cases has been chosen to leave the technology undefined in the concession, so that there is more freedom for the cable car manufactures in the tender phase.

4.3.4 Finance of the cable car

In this phase the stretch is determined and the support for the cable car should be given. A feasibility study needs to be carried out that predicts the amount of visitors and the income that can be derived from that.

Cable cars distinguish themselves from other public transport modes because they have the possibility to attract extra travellers that are willing to pay for the experience. This results in more oppertunities for the financing compared to other public transport modes.

In Koblenz it is a private operator itself that designed, constructed, financed, operates and maintains the cable car. The local government of the city of Koblenz has provided the required land but did not invest in the cable car itself.

In Brest it was the local government that initiated the project and who also co-financed the project. Because of the function as public transport the local government could apply for local and regional subsidies that supported the investment. The operation of the cable car in integrated by Keolis Brest, the public transport operator in Brest.

It is important to have a bankable feasibility study. When the project comes out as profitable, than a tender can be started to find the cable car manufacturer.

4.3.5 Engage local stakeholders to stay involved

It is important that an urban cable car is supported by the local residents and that the project is promoted towards potential visitors of the city. This can lead to awareness in other cities, so that they can consider the cable car also as alternative in their city. This means that the usership should be monitored and published. A good example of this is Mi Teleferico in La Paz. Their annual report presents in an attractive and detailed way what the usage is and what the effect of the cable car is. This includes the improved urban mobility, contribution to health, the environment, the economy and a number of social factors. This way of monitoring an urban cable car project can lead to more awareness for the existing cable cars, but also provides a change to share the story with other cities.

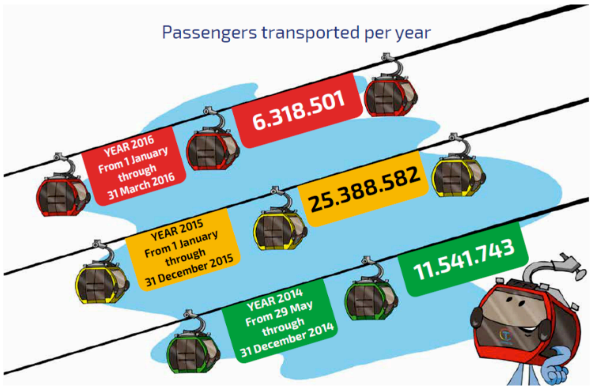


Figure 28; Annual publication La Paz; (Mi Teleferico, 2016)

6. Will the performance be published in an attractive way?

4.3.6 Implementation process

The four steps: Find a suitable spot, develop a plan with local stakeholders, tender and engage local stakeholders to stay involved, are combined in the process model in table 6. The table shows for each of these what can be done to proceed with the project to the next step.

The opportunities and threats determined are now integrated in this process model, so that the project benefits. A project that takes these checklist questions into account is now well prepared to cope with the opportunities and threats determined.

Table 6; Process model urban cable car

Find a suitable spot for an urban cable car	• Determine traffic challanges on a regional and local level • Determine the geographical opportunities • Create scenarios using a cable car technology • Assess the alternatives using Volz' success criteria • Give expected result for traffic based on the social costs benefit analysis
Develop plan with local stakeholders	• Identify local stakeholders: transport auhority, the city, inhabitants, involved entrepreneurs and environmental organisations • Create interest at stakeholders through workshops, visits to cable cars and visualisations • Define and analyse the best technology • Disscuss and develop alternatives with stakeholders
Tender cable car line	• Define best stretch • Plan feasibility study • Tender cable car route
Engage local residents to stay involved	• Frequently updates regarding usership • Surveying attracted visitors and estimate additional income for the city • Keep frequent user cards for residents

5 *Project Approach Flanders*

There are many similarities between cities in Europe and the European transport system is becoming more integrated. Apart from this integration there are still big differences between the countries, for example on the decision-making processes, the culture and the geography. This chapter aims to combine the local characteristics of Flanders with the characteristics of the cable car; this leads to recommendations for a local implementation strategy in Flanders.

5.1 Decision Making Process and Local Stakeholders

First is described how the organisational structure of Flanders looks like. This will lead to important stakeholders that need to be consulted.

In 1993 Belgium has become a federal state, a number of powers are left at the federal level, these are: Foreign affairs, defence, justice, finance, social security and partially public health and internal affairs.

The three regions are Flanders, Brussels and Wallonia. The regions have power over the economy, employment, housing, public works, energy, transport and the environment (BPCEU, n.d.).

Mobility and Infrastructue is the responsibility of the department of mobility and Public Works (mobiliteit en openbare werken, MOW). Together with the Department Martimime & Coast and Roads & Traffic they form the Flemish ministerie of Moblity and Public Works. Together with exernal parties such as public transport operator De Lijn, De Scheepvaart and waterways and canals they form the policy domain mobility and public works (Department MOW, 2017). An organisational chart is shown in figure 29.

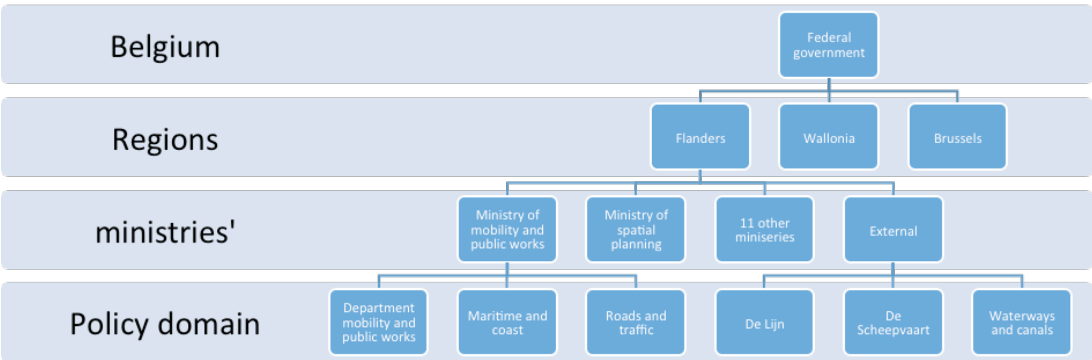


Figure 29; Schematic structure of legislation on mobility in Flanders (based on Department MOW, n.d.)

5.1.1 Federal government and region of Flanders

Cable car legislations including urban cable cars fall under the Cableways Regulation by the Federal Public Service Economy, SMEs, Self-employed and Energy of the federal government of Belgium (FPS, 2017). The act is based on the EU legislation (European Commision, 2017), and mainly regulates the safety aspects that a cable car should fulfil.

The Region of Flanders and the ministry of Mobility and public works are responsible for policies concerning traffic and transport and also to divide budgets amongst cities and to external parties such as De Lijn (Department MOW, 2017). This power distribution results in much power for the Region. One of the side effects is the effect of the political climate in higher government on the local mobility decisions (KVS, 2010). The budgets have to come from these higher governments and therefore political will needs to be created by cities.

The Flemish government has started the STOP-principle project. This should promote the use of "**S**tappen, **T**rappen, **O**perbaar vervoer en de **P**ersonenauto", translated this means to prioritize walking, than cycling, public transport and as last the personal vehicle.

It is noticed is that communication between different departments of the government does not go seamlessly. It is often vague who is leading a project, who is responsible and who the contact person is (KVS, 2010). The commission Investingsprojecten has been asked to do research on how decisions can be made easier in complex projects. The result has been published in 2010 and described three main challenges regarding decision making in complex projects; the long process times for permits, the lack of public support and the legal protection of citizens that can easily delay a project (Comissie Investeringsprojecten, 2010).

5.1.2 De Lijn

De Lijn is the overall public transport authority that is responsible for public transport in Flanders with as main stakeholder the region of Flanders. De Lijn is for 82 per cent owned by the Flemish region, 11 per cent by Flemish local governments, 6 per cent by Flemish provinces and the remaining parts are owned by the region of Brussels and individuals (De Lijn, n.d.).

The headquarters are situated in Mechelen where the budgets are being divided, strategy reports are created and where annual reports are discussed with the shareholders. The regional level has responsibility over daily operations and has contact with local stakeholder in 16 different areas.

De Lijn has to decide on policies and public transport connections that are needed on a local level. This system allows the transport authority to plan without political boarder and to create an integral public transport network. It also gives less power to the cities as Antwerp, Ghent, Bruges, and they are for a big extend dependent on decisions made on higher governmental levels. This can become a problem when cities do not have enough influence anymore on their own cities (KVS, 2010).

5.1.3 Cities

Finally there are the cities itself, most of the cities in Flanders have formed a mobility plan that published local bottlenecks and solutions to cope with these (Mobielvlaanderen, 2016). The cities itself have the best feeling about what are desired improvements.

Figure 30; Velo sharing bikes in (Antwerpen, 2017)

In bigger cities such as Antwerp and Ghent there is a desired to improve cycling infrastructure and to promote the use of public transport. They can also take initiative themselves and do not need to wait on policies from MOW or De Lijn. For example in Antwerp the Velo bike sharing scheme has been developed by the city in cooperation with third parties. The city of Antwerp itself invests 32 million Euros in the project over 10 years and is trying to get extra funding (Antwerpen, 2013).

The cities in Flanders will also have an important role in urban cable car projects. It is important to engage them before engaging others.

5.2 Culture

The culture of a country, or part of a country, can be of great importance when assessing implementation approaches of innovative urban solutions.

To get an insight in the cultural aspects of Flanders a model by Hofstede is used. The five Hofstede dimensions are used to compare the Netherlands to Belgium. The two biggest differences are the masculinity and the uncertainty avoidance. The score for masculinity is a lot higher in Belgium than in the Netherlands. This could play a role when a politician is more interested in his own performance and considers the public interest less. It is not assumed though that this will play a big role in the decisions made by Flemish politicians.

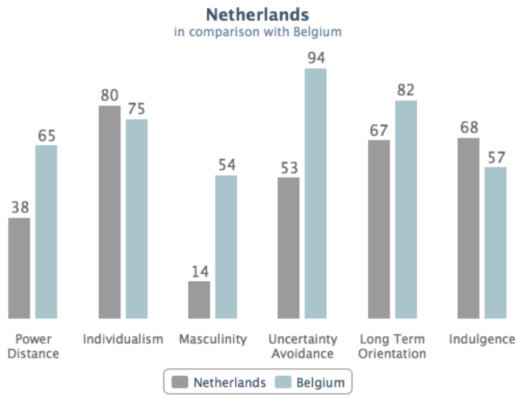


Figure 31; Result Hofstede's Country comparison (Hofstede, 2017)

What could be important is the uncertainty avoidance in Belgium. This is significantly higher than the Netherlands and this has a direct effect on the implementation of innovative urban transport solutions. Also during the interview at Arcadis in Hasselt has been stated that with more existing examples, especially from the Netherlands, the uncertainty will decrease which will make it easier for Flemish decision makers to become convinced. A solution could be to focus more on the proven concept of the cable car technology and to elaborate on the existing examples in- and outside of Europe.

Another cultural difference that will be of importance is the "open curtain" culture that there is in the Netherlands, but not in Flanders, according to Miguel Vertriest, employee of Netwerk Duurzame mobiliteit. He meant with this that Dutch people seam to have their curtains always open, and therefore have and need less private space. He explained how privacy and private space is very important in Flanders. This means that a cable car route over private property is even less desired in Flanders. This should be taken into consideration and the lack of privacy that is perceived to be connected to a cable car system should be clarified to local stakeholders.

5.3 Geography

One of the drivers for this research was the question why there is more initiative for urban cable car in the Netherlands, compared to Flanders. One reason for this could be the geographical features; this could for example be landforms or settlements.

Neither in Flanders nor in the Netherlands is there much height difference. Both areas are fairly flat with highest points being at 280 metres above sea level in Flanders and just 40 metres higher in the Netherlands (Quaeldrich, 2017). The amount of waterways is comparable. The Schelde is connecting Antwerp with the North Sea and several channels are connection cities as Ostend and Bruges with the sea.

The model split in Flanders is very different though compared to the Netherlands, the car usage is respectively 62 and 48 per cent (Vos, n.d.). Two geographical features are determined; the difference in urban sprawl and the infrastructure density.

The difference in urban sprawl dates back to the 19th century during the industrialisation. In Flanders has been chosen in that time to implement train services with cheap tickets towards the cities. This was to prevent the dirty and unhealthy cities to get overpopulated (Vos, n.d.).

In 1972 has been started with the urbanisation strategy in Flanders, this is a policy that should make sure more people move to the cities to prevent the spread of inhabitants. The problem was that was calculated with a too big inhabitant growth. The areas that were considered as housing area are therefore still not dense.

In the Netherlands this has been done differently, the industrialisation came later and more people stayed in cities due to good regulations of the government. Also immediately after the second world there were policies regulating the spatial development.

This passive spatial development strategy in Flanders had a big effect on the percentage of the land being built on. This urban sprawl can be one of the reasons that the model split is different. The distances are bigger and walking and cycling is therefore not always an option.

The other difference is the density of infrastructure; in the Netherlands there are many less kilometres rail and motorway per square kilometre of land compared to Flanders. This is a result of the lower rate of urbanisations. In the Netherlands is built on 14,5 per cent of the land, this is 26,4 per cent in Flanders (Vos, n.d.). Also this has as effect on the model split that the car gains percentages while walking and cycling get less interesting.

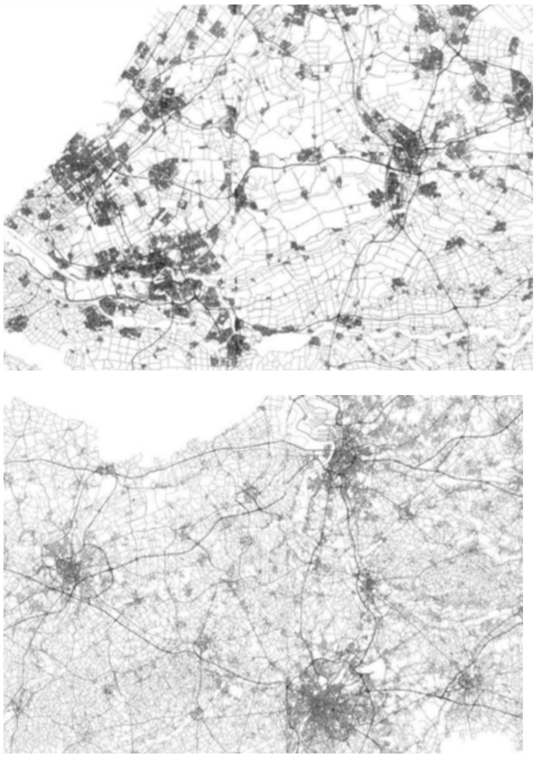


Figure 32; spread of infrastructure in a port of the Netherlands (top picture) and a part of Flanders (bottom) (Vos, n.d.)

It can therefore be considered that it will be harder in Flanders to find a location where the demand for transport is concentrated enough for an urban cable car. Especially because a cable car requires a high demand between to points, instead of distributing everybody to their own destination.

However is desired by the Flemish government to promote the use of slow modes of transport and public transport. Therefore they have started the STOP-principle, as explained in chapter 5.1.1. This strategy should prioritise the use of walking, cycling and public transport above the use of the car. A cable car can be used for pedestrians, cyclists and public transport users and fits very well in this strategy. The cable car is especially for making walking, cycling or using public transport more attractive the best option.

5.4 Local Implementation and Communication Recommendations

Especially for Flanders it will be most beneficial when cities themselves become enthusiastic and convinced about an urban cable car in their city. They can get this further to higher government and can spread the word.

The concept of a cable car as public transport is not completely new anymore and has been proven in different locations around the world. Flemish people tend to be more careful with trying out new technologies. It can therefore be said that explanation and maybe even visits to these urban cable cars will help to develop understanding of the system.

Strategies regarding the promotion of walking, cycling and public transport can also be used during the development of a cable car project. The Flemish cities and governments are having serious problems with the share of car users and will find it interesting if the cable car can improve a connection and moreover change the image of public transport and slow means of transport.

6 *Promising Locations Flanders*

The questioning in this report concerns the use of urban cable cars as a part of the transport network within a city. It is important that the cable car solutions mentioned in this report will have an added value to the transport chain and are not solely tourist attractions.

Cable cars therefore need to have a function within the transport chain. Cable cars are a specific type of transport system that travellers with a constant speed and a straight line between stations. The route is inflexible but is able to fly over obstacles. Their high capacity and continuous flow together with the flying ability allows the cable car to contribute to this chain.

Looked will be if the cable car can be a good alternative compared to other public transport modes or other infrastructure. The missing links identified will then be elaborated on using the same quick scan method as in chapter 3.

These are the traffic demand that is to be expected, the benefit that the cable car stretch has compared to current public transport, to what extent problems are to be expected with nature conservation & city image, what the technical feasibility is and if there is enough space that is needed for the stations or pillars. Each of these points will again be ranked by colour from one (red) until five (dark-green).

This is the first quick scan that should end up in a number of cable car stretches that could be of added value to a transport system, and that seem technically possibly and could be acceptable for local stakeholders.

6.1 Comparison of the Variants

In total 12 locations are analysed with one ore more variants per locations. Three locations are included in the report itself, these were the three best scoring ones. The other 9 can be found in the appendix 2.

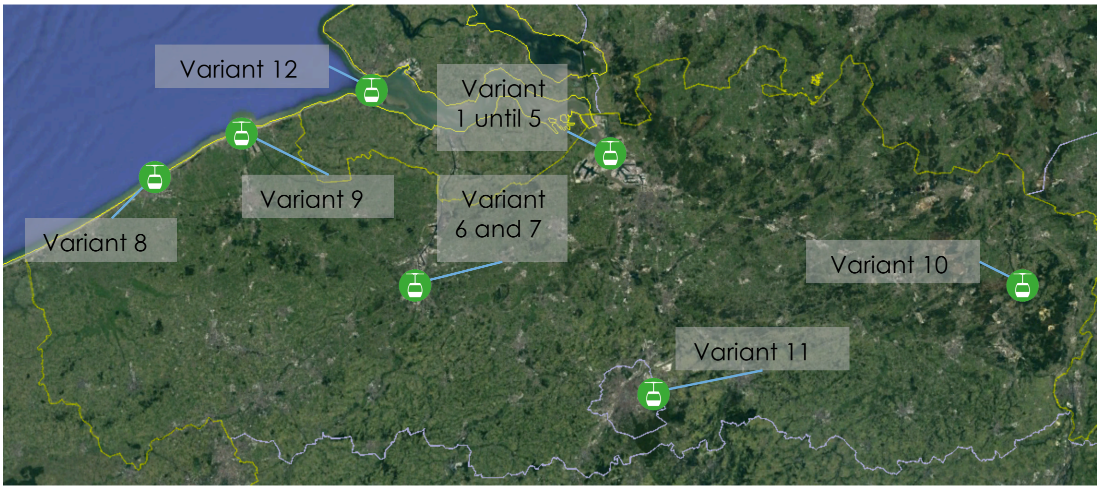


Figure 33; overview of the variants described in the report and appendix

All of the variants that have been looked at can be found back in table 7. The three variants locations that are further described in this report are the variants 4, 6 and 9. These are determined based on the quick scan, but also on existing interest from local governments and other stakeholders.

The variant 4.2 in Antwerp came out of the quick scan as single best and is therefore worked out in more detail. Stakeholders are analysed and potential clients are determined. Also a preliminary business model and the effect for travellers are determined.

Table 7; all variants with their scores of the quick scan

	1. Zwijndrecht	2.1 Olympiade	2.2 Schoonselhof	3.1.1 Hemiksem	3.1.2 Hemiksem station	3.2 Hemiksem Harbour	4.1 Schoonbekeplein	4.2 MAS	5.1 Hoboken Harbour	5.2 Tram Kioskplaats	6.1.1 Technologiepark	6.1.2 Technologiepark	6.2 UZ Gent
Travel demand													
Benefit compared to current PT													
Nature conservation & city image													
Technical feasibility													
Use of space													
Length (km)	3,5	9	6,5	3	2,5	2	1,2	1,2	1,5	2,5	1,5	1,5	1,2
Stations	3	4	3	3	2	2	2	2	2	3	2	3	2

	6.3 Zwijnaarde	7.1 Dampoort	7.2 Tolpoort	8.1 Beach	8.2 Oostende Station	9.1 Vaart	9.2 Sluice	10.1 Over Kuilen	10.2 Around Kuilen	11 Zaventem	12.1 Centre	12.2 Vlissingen Station
Travel demand												
Benefit compared to current PT												
Nature conservation & city image												
Technical feasibility												
Use of space												
Length (km)	1_ 2	2,5	1,5	2,5	1,5	0,7	0,2	1,9	1,6	3,7	7,3	6,2
Stations	2	3	2	3	2	2	2	3	2	2	3	2

6.2 Antwerp

Inhabitants 517.000

Public transport available: Bus, Tram, Metro tram

Policy Papers used:
-Masterplan 2020 (Gemeente Antwerpen, 2010)

Cycling network

Antwerp is working on its cycling network to be even more competitive and attractive. The modal split for cycling is a bit more than 10 per cent (Mobielvlaanderen, 2016), but there is still improvement possible. Many cycle paths are already in construction or being planned.

Less attractive connections are those to Linkeroever; the Kennedytunnel and the Sint-Annatunnel. They are built in the last century to connect the two city parts, but look highly unattractive and in the last months there have been many issues with the access to them (De Morgen, 2017).

Two measures are proposed by the cities municipality to improve this connection, these are; a ferry from MAS to Linkeroever and a system of water boats that connects various points in the city.

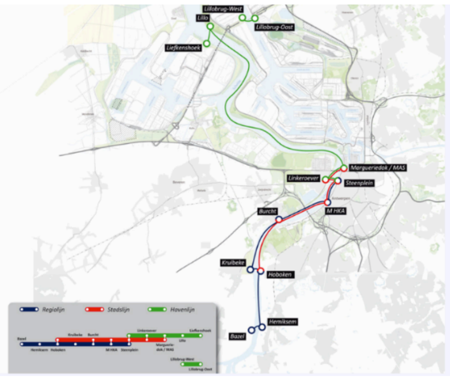


Figure 34; Waterboatlines (Port Of Rotterdam, 2016)

Rob can de Velde, inner-city coordinator of Antwerp, has announced that he thinks Antwerp needs a pedestrian and cycle bridge (Gazet van Antwerpen, 2015). The bridge does need to be able to open for ships, because otherwise the bridge needs to be approximately 100 meters high. This also applies for possible cable car connections.

Tramlines

De Noorderlijn is at the moment being build and will connect the neighbourhood "Het Eilandje" and the north of the city with the tram network.

There are also connections that are in the mobility vision but are not in the planning phase yet. They are located in figure 35.

Figure 35; White are present lines, Blue is desired in 2006 and Orange is desired in 2010

These orange missing links are desired by the inner city since 2010 but are not in planning yet, the cable car could be an advantage in either of these proposed connections.

MAS – Linkeroever

That cable car would make a connection to the Linkeroever. The first scenario would be from the MAS museum and the second one over the current tunnel.

Figure 36; Variant 4.1 and 4.2

Travel demand

There is going to be a waterbus and possibly a ferry in between the MAS and Linkeroever.

Linkeroever is a developing neighbourhood that is currently reachable by two car tunnels and a third is to come. Also two different cycle and pedestrian tunnels connect Linkeroever with the city centre. The tunnels are highly unattractive and the waterbus will have a low frequency.

Benefit compared to current public transport

The obstacle is the Schelde that is currently subdividing the city into two parts. The cable car will be able to cross this obstacle in 4 minutes, being much faster than the tunnels.

Figure 37; visualisation of variant 4.2

Nature conservation and city image

Especially in the scenario that lands at the Schoonbekeplein, issues might occur with local residents because the cable car would need to land in the park, not only taking away the view but also the privacy of the houses nearby.

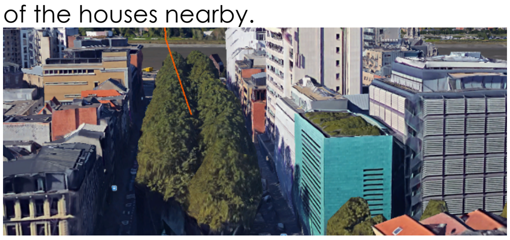


Figure 38; View on Schoonbekeplein with variant 4.1

Technical feasibility

There might be technical difficulties for constructing the cable car stations and pillars on top of the current car tunnel that is going under the Schelde. Both lines would have to be high for ships to be able to pass (approx. 100 Meters). Enough space for landing needs to be checked on the MAS scenario, especially because of the harbour that is close to the landing location.

Use of space

For the Schoonbekeplein Scenario a part of the park needs to be used, for the MAS scenario a parking lot needs to be used that is not city owned.

Conclusion

	4.1 Schoonbekeplein	4.2 MAS
Travel demand		
Benefit compared to current PT		
Nature conservation & city image		
Technical feasibility		
Use of space		
Length (km)	1,8	1,2
Stations	2	2

6.3 Ghent

Inhabitants	260.000
Public transport available:	Bus, Tram
Policy Papers used:	Strategische mobiliteitsvisie Gent, 2020 (2015)

Ghent is a city with many students that is very forward thinking and active to become a sustainable city. The city has already started several participation strategies and is innovative with measures like free electrical bus shuttles in the inner city.

Public Transport

Ghent is in the planning phase for a tramline from train station Ghent-Sint-Pieters to Ghent Dampoort and therefore replacing the current busline 7. The tramline will lead through the old parts of the city and replace a couple a heavily used bus lines.

Cycling

No big challenges where found in the city of Ghent concerning cycling that could be solved by a cable car.

Spatial Development

In the spatial development strategy plan of Ghent nine project areas are outlined together with their mobility needs. Number 3, Oude Dokken and number 8 & 9 being Eiland Zwijnaarde and Ghelamco with wholesale area are not connected yet by tram but do have high potential for passenger growth.

These development areas are further invested to see what opportunities could be there for an urban cable car.

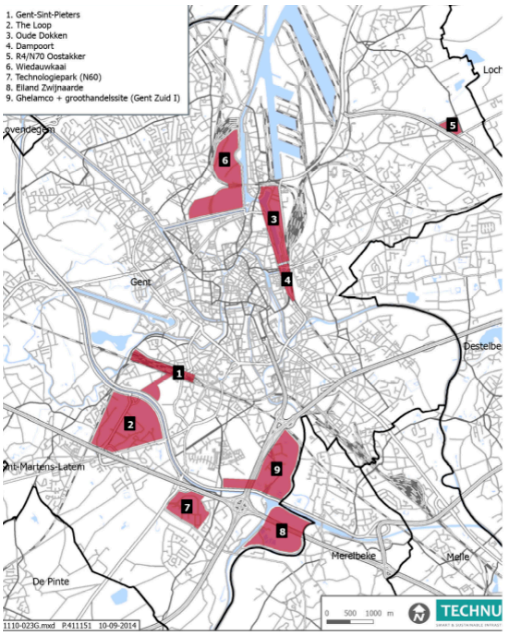


Figure 39; Spatial developments Ghent

UZ Gent – Stadium – Eiland Zwijnaarde – Technologiepark

The variant 6.1.1 connects the Technologie-park with the stadium. Without variant 6.2 this would not make sense, because no further connection to the public transport network would be realized. Option 6.1.2 aims to connect both the stadium and Technologiepark to the tram network, Variant 6.2 would than not be necessary anymore.

Variant 6.2, as mentioned before, will connect the tram station at UZ Gent to the Stadium. In this case an extension to Technologiepark (6.1.1) and Zwijnaarde (6.3) is possible.

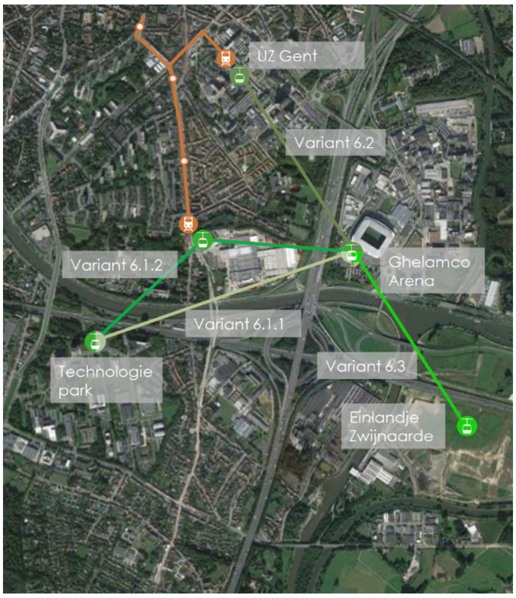


Figure 40; Variant 6.1, 6.2 and 6.3

Travel demand

Better connection to the stadium is named in the policy paper of 2015, also the option to prolong the tramline from UZ gent to the Ghelamco Arena. For the Technologiepark innovative public transport is desired as well as for Eiland Zwijnaarde.

The obstacle or advantage

There is water, a highway and a highway intersection on the routes. There are bridges but the cable car will allow for direct access without big infrastructural changes.

Nature conservation and city image

There are no big issues with nature or city image identified. One important aspect is the integration with the stadium, because this can be seen as a landmark for football supporters.

Technical feasibility

No technical difficulties were noticed,

Use of space

The variant 6.1 would make use of the air above the Coca Cola factory. For the middle station of variant 6.1.2 the parking place from Coca Cola would also be needed. The variant 6.2 takes space from the UZ Gent and the variant 6.3 would fly over Vandemoortelen.

Conclusion

	6,1,1 Technologiepark	6,1,2 Technologiepark	6,2 UZ Gent	6,3 Zwijnaarde
Travel demand				
Benefit compared to current PT				
Nature conservation & city image				
Technical feasibility				
Use of space				
Length (km)	1,5	1,5	1,2	1/2
Stations	2	3	2	2

6.4 Zeebrugge

Inhabitants 3.865

Public transport available: Bus, Coast Tram

Policy Papers used: Nieuwe Zeesluis (Sociaal economische raad van Vlaanderen, 2016)

Zeebrugge is a small village on the Belgium coast. There are two train stations in the city; Zeebrugge Village and Zeebrugge Beach. Goods trains also pass through to city to the harbour port.

A cruise terminal is situated near the train station Zeebrugge Beach. Destinations in the Netherlands and England can be reached from there(Direct Ferries, 2017).

There is also the coast tram driving through Zeebrugge. The coast tram in Flanders drivers nearly all the way from the French boarder to the Dutch boarder with a total distance of 68 km (De Lijn, 2017).

Zeebrugge furthermore has a very important harbour and is the biggest car harbour in the world(Port of Zeebrugge, 2017).

SHIP-project

The Flemish government has decided that one of the sluices used in Zeebrugge should be replaced with a new one. This should increase the capacity of the harbour and keep the connection up to date.

The new sluice should be 40 metres wide and have an inner length of 310 metres (Zeebrugge Open, 2017). There are several options for the location of the new sluice. One of the challenges is to allow the coast tram, the access road, the distributor road, pedestrian and cycle connection and freight trains to cross the new sluice.

Figure 41; project location for the new Sluice (Zeebrugge Open, 2017)

The best for the traffic flow would be to create a tunnel for each of these transport modes. This will become very expensive and is also not attractive for cyclists and pedestrians to use.

Zeebrugge

The harbour of Zeebrugge is the biggest car harbour in the world and to allow for growth it is necessary to enlarge the current sluice. A national road, a local road, a cycle path and the Belgian coast tram make use of this sluice. A case study by Arcadis has compared design variants for implementing the new sluice.

One of the options is to replace the current sluice with one just behind the existing gone and create a sea channel in between Zeebrugge Village and Zeebrugge Station. This plan involves a tunnel for the coast tram as for pedestrians and cyclists. The variants 9.1 and 9.2 allow passengers from the tram to interchange in the cable car and board a tram on the other side again. Also pedestrians and cyclists will benefit from this over ground solution to cross the future sea channel.

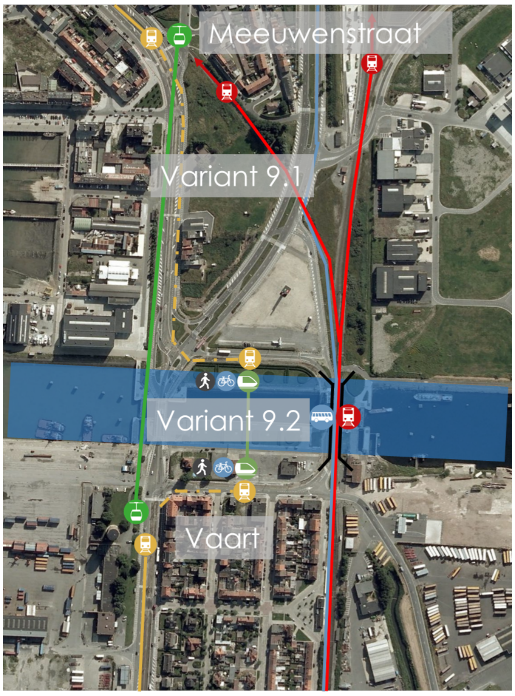


Figure 42; variant 9.1 and 9.2

The obstacle or advantage

The creation of the see channel will be an obstacle between station neighbourhood of Zeebrugge and the village of Zeebrugge. The cable car option will create an overground connection for public transport users and slow means of transport. For public transport users this does mean that they need to interchange. In variant 9.1 there is a slightly higher advantage for cyclists and pedestrians, because the cable car brings them closer to Zeebrugge Village.

Nature conservation and city image

The variants will be situated in between the two city parts and will not cause much trouble in the region. Variant 9.1 has a slight disadvantage that it will land near buildings on the Vaart side.

Technical feasibility

Both variants will have to cross the sea channel, this means they need to travel on proper height. This should not be an issue when the cable cars are planned on the proper height.

Use of space

In both situations there seems to be enough space available for a cable car system.

Conclusion

	9.1 Vaart	9.2 Sluice
Travel demand		
Benefit compared to current PT		
Nature conservation & city image		
Technical feasibility		
Use of space		
Length (km)	0,7	0,2
Stations	2	2

6.5 Case Museum aan de Stroom, Antwerp

The most promising variants analysed is the connection between the east and the west side of the Schelde in Antwerp. In this subchapter will be elaborated on this option to further investigate the option.

6.5.1 Stakeholders

The city of Antwerp is very active in the promotion of walking, cycling and public transport and has invested in the quality of the infrastructure. At the moment the Noorderlijn is being build that will connect the neighbourhoods in the North of Antwerp with the tram network.

Later this year is expected that a waterbus and/or ferry will be in operation on the Schelde, to offer more accessibility of the harbour, Linkeroever and the city parts in the south. The city also has invested in the bike sharing system Velo and is looking for improvements in the cycling network. This is very important that the city is interested in promoting the use of sustainable transport modes. The city might find it important that the cable car connection is affordable. A first estimation of the investment costs, operational costs and earning have therefore been made in subchapter 6.5.3.

Another important stakeholder is the population of Linkeroever and Antwerp. They should have a benefit in this connection in time and comfort. In subchapter 6.5.2 the effect on accessibility is therefore determined. This should clarify the travel benefits that the connection offers.

6.5.2 Expected effect on accessibility

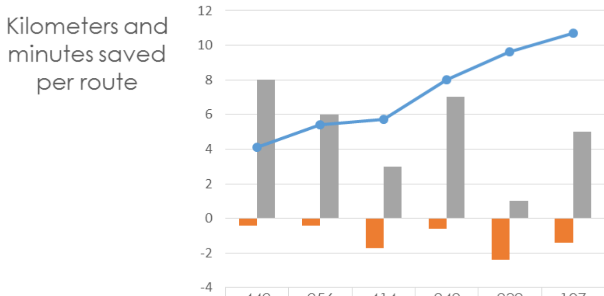
The cable car will have an effect on several target groups within the transportation system in Antwerp. First of all there are the inhabitants or visitors of Antwerp that try to cross the Schelde towards Linkeroever. At the moment there are two opportunities to cross the river making use of the Sint-Annatunnel or the Kennedytunnel. The Sint-Annatunnel is a historical tunnel constructed around 1910. The tunnel still has many of the historical structures such as the sides of the tunnel, the signs, the entrance and exit buildings and the escalators.

Figure 43; Different connections crossing the Schelde

These elements do give the tunnel a special kind of allure but also cause several problems. These problems are mostly related to the escalators or elevators that are not working. A broken escalator at the Sint-Annatunnel means that people need to get in line for the elevator and when the elevator breaks down at the Kennedytunnel it means that travellers need to use the long stairs, also when they are travelling by bike. The problem occurs so often that the Flemish government has launched a website that shows users of the tunnel which elevators actually work (Agentschap verkeer & wegen, 2017).

This extra effort makes cycling towards Linkeroever very time consuming. During a trip to Antwerp a measurment has been performed measuring the time it takes to cross the river via the Sint-Annatunnel. The total time including waiting for the elevator, cycling through the 500 metre long tunnel and going back up by wooden escalator took 12 minutes. This long time together with the high uncertainty makes this connection very unattractive.

Not only can the cable car be a reliable and attractive alternative, it can, because of the long time it takes to get through the tunnel, also result in reduced travel times for pedestrians and cyclists. The data out of the European Cycle Challenge 2015 have been used to determine how long the trip would have been using the cable car. All six trips that were measured during the challange and led to the west side of the Schelde have been taken into account. This has resulted in the travel time saving as seen in figure 43. The data behind the graph can be found in appendix 4.



	442	256	414	242	239	107
KM saved	-0,4	-0,4	-1,7	-0,6	-2,4	-1,4
Minutes saved	8	6	3	7	1	5
Origional cycling km's	4,1	5,4	5,7	8	9,6	10,7

Figure 44; travel time and distance (European Cycle Challange, 2015)

6.5.3 Preliminary business model

In this report will just be briefly estimated if the cable car could be profitable for a private investor without public subsidies. A very defensive estimation has been made assuming that half of the 2.8 million users (A Nieuws, 2011) of the Sint-Annatunnel will use the cable car one way, and that 50 per cent of the 650 thousand visitors (MAS, 2017) of the MAS will take a return ticket. This is excluding users of the Kennedy tunnel, additionally attracted commuters and other tourists in the city. There is calculated with a ticket price of 1 euro for commuters and 5 euros for visitors.

A standardized cost-sheet has been used to estimate the costs for the cable car. The total costs for this cable car is estimated to be underneath 50 million euros. Being 35 million for the cable car equipment, 5 million for the foundations and building and a sum for project development and engineering.

The result is that the cable car is profitable after 25 years, whilst having a life cycle of up to 40 years. So even with the low amount of users that is calculated can be a viable project.

6.5.4 Visualisation

In figure 44 one example can be found of an exported picture out of Google Earth. The KMZ link can be found on: https://drive.google.com/open?id=0B-Lcap0upNPCaEgydE1CRmRjc2s

Figure 45; one angle on the visualisations in Antwerp

Conclusion

Three cable car types are most suitable for the use in an urban environment; these are the monocable gondola detachable, the aerial tramway and the tricable gondola detachable. The desired capacity and length of the connection are two important factors that help determine the most suitable system for a location.

The outcome of the analysis on rider satisfaction criteria only differs slightly between the different types of cable cars. This means that the advantages regarding the costs, travel time, reliability and comfort do count for all three types of cable cars. The differences are for example in the cabin design; an ATW and a TGD are more suitable for the use with bicycles and wheelchairs compared to the MGD.

The weaknesses that there are do not seem to have a significant negative effect on the usability of a cable car. Some of the weaknesses just need to be taken into consideration while planning. For example the long time that it takes for a cabin to get through a station. This means that many stations lead to long travel time, therefore can be chosen for a hub system, having less stations with more kilometres but less travel time.

The six cases analysed have shown that three cable cars that are not in operation had several difficulties with their project development even though they would have contributed positively to the transport system. The political decisions did not completely match the analysis on the usefulness of the cable cars. Especially in Hamburg there was a controversy between the political decision and the actual benefit the cable car connection would have had. All indicators of the quick scan were in favour of the cable car connection, but the decision makers of Hamburg Mitte did not see the advantages of the cable car connection. The cable cars that are in operation all showed similar results compared to each other. Especially the integration with the planning of an event can be a good trigger for an urban cable car project.

The challenges determined based on the literature review are recognizable in the general opinion of cable cars and have been confirmed by interviewed decision makers in Flanders and the Netherlands. Noticed is especially that stakeholder are not aware of the already operational urban cable cars the general possibilities them. But also the opportunities out of the literature review were confirmed during the interviews. The growing concern about the environment and the possible integration in the public transport network are indicators that were mentioned during the interviews.

The six questions that have been determined will give help to a project initiators to increase the chance for a successful cable car implementation. The project initiator should be able to answer all the questions with a yes. The questions are related to the added value of a cable car to the public transport network, the co-finance or subsidy, the approval of stakeholders, the contribution to general mobility and sustainability goals, the awareness of stakeholders of the system and the monitoring of the system.

It is concluded that in Flanders focus should be extra on the support from cities. This is because projects via De Lijn and the federal government can take up many years. A city can perform projects on a shorter base and get support from the other stakeholders. It is noticed that also the cultural differences between Flanders and the Netherlands can have a role during the implementation of an urban cable car. Especially the uncertainty avoidance, where Belgium scores very high, can have a significant influence. This has also been confirmed during several interviews in Flanders.

More emphasis could therefore be laid on the advantages that the cable car has and which are already proven in existing urban cable cars. The project approach has not been tested yet, but can be tested on one of the three project variants that have been discussed in the report. Especially the variant connecting MAS with Linkeroever in Antwerp has a great potential. It is shown that the cable car will lead to travel advantages such as increased comfort as well as a travel time benefit. Also has been concluded that a business model for this cable car could be bankable.

Recommendations

For Doppelmayr is recommended to further investigate in the options for urban cable cars in Flanders. The report has shown that there is a big potential in Flanders for crossing rivers, channels and infrastructure. The cable car also suits the desire of cities to promote walking, cycling and public transport. Further awareness rising will make it possible for city planners to consider this option and see the urban cable car as a competitive alternative of the traditional public transport modes.

Also for cities itself it is recommended to study the variants that can be found in this report but also to consider the cable car in other projects. It is important that city planners develop an understanding for the system so that the possibilities and impossibilities of urban cable cars are known.

In Flanders should be considered carefully how a potential cable car connection could be further developed. The strengths, weaknesses, opportunities and threats out of this report can help with this, but also the location specific drivers and barriers can be considered.

Overall can be concluded that the cable car can offer many advantages in urban public transport and that they should therefore be considered in more cities than is done now. Only than can be achieved that the cable car will not be an innovative urban solution anymore, but one of the traditional public transport modes.

Literature

Interviews

Antiono, V. (15.03.2017). Interview management of Mission tramway et Telepherique.

Dusart, C (07.04.2017) Coordinator Mobiliteitsonwikkeling at De Lijn Centrale Diensten.

Geurts, J. (07.04.2017). Business Development Manager at Arcadis

Hoosemans, M (31.05.2017) Senior Beleidsmedewerker Provincie Zeeland

Keppens, M. (07.04.2017). Project manager at Arcadis.

Lauwers, F. (11.04.2017). Kabinetchef van het kabinet van de schepen voor ruimtelijke ordering, stadsontwikkeling, groen en erfgoed in Antwerpen.

Nigsch, E. (14.03.2017). Manager Seilbahn Koblenz at Doppelmayr.

Rühling, K. (02.03.2017). Member of Kein-Seilbahn Hamburg .

Seghers, B. (07.04.2017). Deskundige Verkeersmodellen at De lijn Centrale Diensten.

Steppe, S (31.05.2017) Project manager at Rebel Group

Vanderhenst, M. (11.04.2017). Kabinetchef van het kabinet van de schepen voor financien, mobiliteit, toerisme, binnengemeentelijke decentralisatie en middenstand in Antwerpen.

Vergeldt, T. (10.03.2017). Projectmanager for Kab elbaan Groningen at Arcadis.

Publications

Auer, W. (2007). *Der Einsatz von Luftseilbahnen als öffenliche Verkehrsmittel in urbanen Räumen.*

Arcadis. (2013). *Business Case Flyover Groningen "Er gaat iets boven Groningen".*

Antwerpen. (2013). *Jaarverslag Antwerpen.* Retreived from: https://assets.antwerpen.be/srv/assets/api/download/9355d0be-9bae-46c3-9e39-ee4a4988d65c/Jaarverslag_2013_Parkeerbedrijf_Antwerpen.pdf

Björkman, M. (1997). *Maximum noise levels in city traffic.* Retreived from: http://www.sciencedirect.com/science/article/pii/S0022460X97910191

Creative Urban Project. (2013). *Cable Car Confidential.*

Eurist. (2011). *Urban Cable Propelled Transit Systems.* – "High Flying Solution" to Urban Transport Problems? .

Eurist. (2015). *Urban Ropeways in Europe.* Creating oppertunities in Urban Development.

Eurist. *10 steps to your Urban Ropeway Project.* From Idea to Implemenation in 24 months.

Eltis. (2013). *Guidlines SUMP.* Developing and implementing a sustainable urban mobility plan .

European parliament. (2000). *DIRECTIVE 2000/9/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.* Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000L0009&from=NL

Doppelmayr. (2016a). *Ropeways in the urban environment.*

Doppelmayr. (2016b). Urban References.

Departement du Finistere. (2015). Enquete Publique. Sur le projet de Reaslisation d'une liaison telepherique urbaine entre le bas de siam et les ateliers des capucins a brest.

Fiedler, J. (2016). Urban Cable- A Policy Option. *Journal of Traffic and Transportation Engineering, 4* .

Freisberg, R. (2015). *Urbane Seilbahnen als Innovationssprung für Stadtgesellschaften.*

Frieder, K. (2015). *Innovation Seilbahn.* Potentiale für den urbanen personennahverkehr und Positionen der Beteiligten Akteure.

Investeringsprojecten, Comissie. (2010). *Cathy Berx, Marc Boes, Norbert De Batselier, Kurt Deketelaere, Filip De Rynck, Marc Dillen & Hans Ides, Naar een snelle en betere besluitvorming over complexe projecten.* Verslag van de Commissie Investeringsprojecten.

Göteborgs, S. (2016). *Cable car safety memo.*

Hamborg, J. (2015). *Seilbahnen als urbanes Verkehrmittel.* Potentiale für den öffentlichen Personennahverkehr und Barrieren in der Projektimplementierung.

Heiner Monheim, C. M. (2010). *Urbane Seilbahnen.* Moderne Seilbahnsysteme eröffenen neue Wege für die Mobilität in unseren Städten.

Hekel, M. (2015). *Urbane Seilbahnen.* Die innovative Lösung im öffentlichem Verkehr.

Kremer, F. (2013). *Innovation Seilbahn.* Potentaile für den urbanen Personennahverkehr und positionen der beteiligten akteure.

KVS. (2010). *Kenniscentrum Vlaamse Steden, Publiek-Publieke samewerking in Vlaamse stadsprojecten.* Van Diagnose naar Remedies.

KSH. (2017). *Kein Seilbahn Hamburg.* Ist die Seilbahn Okologisch Sinnvoll.

K Hoffmann, N. Y. (2012). *A contribution on the history of Ropeways.* Exploarations in the history of the machines and mechanisms.

Leuven. (2014). *Maatschappelijke kosten-baten analyse binnen de case Leuven 'in'F' – Eindrapport.*

Mi Teleferico. (2016). *Figures of Mi Teleferico.* Two years of an extermely rewarding job.

Mobielvlaanderen. (2016). Fietsbeleidplan.

M van Hagen, P. B. (2013). *ENHANCING THE EXPERIENCE OF THE TRAIN JOURNEY.* Changing the focus from customer satisfaction scores to one on the emotional experience of the customer.

Nisen, L. (2016). *Impact environnementaux, Economiques et social lies a limplantation dun telepherique urbain a Bruxelles.* Bruxelles: Cas des une liaison Bruxelles-Nord - Tour & Taxis.

OFS. (2010). *Office Federale Satistique.* Safety ranking of public transport modes by accidents, injuries and deaths.

Oort, N. v. (2011). *Service Reliability and Urban Public Transport Design.* Proefschrift.

ProjectKabelbaanGroningen. (2006). *Haalbaarheidsonderzoek Kabelbaan Groningen.*

S. Luke, M. M. (n.d.). *Public Transport Mode Selection:.* A Review of International Practice.

SFW. (2017). *Seilbahn Freies Wuppertal.* Bund: Deutliche Kritik an Seilbahnplaenen.

SHZ. (2014). Elbe-Seilbahn: Hamburger Bürger sagen Nein.

Rynko, S. (2016). *Weiterentwicklung eines Kriterienkataloges zur beurteulung von urbanen Seilbahnprojekten.*

Reichenback, M. R. (2016). *Praxis urbaner luftseilbahnen.* Arbeitsbericht Nr. 1.

Richard Dohmen, T. K. (2009). *Ökobilanz einer Seilbahn für die Bundesgartenschau in Koblenz.*

RTVnoord. (2016). *Stad ziet geen heil in kabelbaan.*

TAZ. (2013). *Gartenschau im Sommerloch.*

Uithoflijn. (2011). *Maatschappelijke Kosten en baten Analyse Uithoflijn.*

UNESCO. (2012). *Report on the ICOMOS Advisory Mission to the Upper Middle Rhine Vallye,.*

Wuppertal. (2017). *Vorstudie Wuppertal.*

Weis, M. (2015). Masterarbeit, Die Stationslogistik urbaner Seilschwebebahnen mit flexiblen Kapzitäten durch Variantion der Fahryeuganyahl -. Analyse und Visualisierung.

Verband Deutscher Seilbahnen. (2017). *Überblick über die verschiedenen Seilbahnsysteme.*

Volz, M. (2013). *Luftseilbahnen als Ergaenzung der Staedtischen nahverkehrsmittel.*

Vos, J. D. (n.d.). *Vlaanderen vs. Nederland Invloed van de ruimtelijke planning op mobiliteit.*

Online sources

A Nieuws. (2011). *Geschiedenis van de Antwerpse voetgangerstunnel.* Opgeroepen op 06 06, 2017, van http://www.anieuws.be/Geschiedenis-van-de-Antwerpse-voetgangerstunnel

Abentblatt. (2014). *Jetzt entscheiden die Bürger über die Elbe-Seilbahn.*

Alpinforum. (2007). *Neues in Sauerland.* Opgehaald van http://www.alpinforum.com//forum/viewtopic.php?f=12&t=2011&hilit=landal&start=650

Antwerpen. (2017). Opgehaald van http://Antwerpen.be

Antwerpen. (2013). *Jaarverslag Antwerpen.* Opgehaald van https://assets.antwerpen.be/srv/assets/api/download/9355d0be-9bae-46c3-9e39-ee4a4988d65c/Jaarverslag_2013_Parkeerbedrijf_Antwerpen.pdf

ARCADIS. (2015). *Gemeente Groningen, College brief naar aanleiding haalbaarheidsonderzoek Arcadis.* Opgeroepen op 03 20, 2017, van http://stadgroningen.vvd.nl/uploaded/stadgroningen.vvd.nl/files/575fd8db269d1/b-v-160518-bespreekpunten-flyover.pdf

Bundesgartenschau. (2017). Retrieved 03 08, 2017 from http://bundesgartenschau.de/buga-iga/bisherige-gartenschauen/buga-koblenz-2011.html

BBC. (2011). *Emirates sponsors Thames cable car.*

Bobo. (2017). *Bewoners organisatie Binnenstad oost, kabelbaan nieuws voor omwonende.*

Boer, T. d. (2016). *Fictieve kabelbanen in Nederland*. Retrieved 03 20, 2017

BPCEU. (2017). Retrieved 02 20, 2017 from Structure of the Belgian federal state: http://www.eutrio.be/structure-de-letat-federal-belge

City of Hamburg. *2014.*

Citypopulation. (2017). Opgeroepen op 03 01, 2017, van www.Citypopulation.be

Cruisegate hamburg. (2017). Cruise centre Steinwerder. Opgeroepen op 20 05, 2017, van https://www.cruisegate-hamburg.de/de/terminal/cruise-center-steinwerder

European Cycle Challange. (2015). *Data mei 2015.* Opgeroepen op 04 06, 2017, van http://opendata.antwerpen.be/datasets/fietsgebruik-mei-2015

DvhN. (2016). Kabelbaan Stad haalbaar en betaalbaar. Opgehaald van http://www.dvhn.nl/groningen/Kabelbaan-Stad-haalbaar-en-betaalbaar-21117512.html

De Lijn. (2017). Opgeroepen op 06 06, 2017, van https://www.delijn.be/de/kusttram/

De Lijn. (2017). *Bestuursorganen*. Retrieved 02 20, 2017 from https://www.delijn.be/nl/overdelijn/organisatie/organisatie/bestuursorganen.html

De Morgen. (2017). Veerboot voor fietsers op komst in Antwerpen. *De Morgen* .

De Morgen. (2017). Veerboot voor fietsers op komst in Antwerpen. *De Morgen* .

Department MOW. (2017). Retrieved 02 20, 2017 from http://departement-mow.vlaanderen.be/nl/het-departement-mobiliteit-en-openbare-werken-wij-bewegen/over-het-departement-mobiliteit-en

DieFestungEhrenbreitstein. (2017). Retrieved 03 08, 2017 from http://www.diefestungehrenbreitstein.de/index.php?id=41581&tx_ttnews%5Byear%5D=2015&tx_ttnews%5Bmonth%5D=11&tx_ttnews%5Btt_news%5D=21342&cHash=b4e0d77248adb21b78ad0b5abd6630e8

Direct Ferries. (2017). Retrieved from http://www.directferries.de/zeebrugge_hull_faehre.htm?utm_source=google&utm_medium=cpc&gclid=CjwKEAjwpdnJBRC4hcTFtc6fwEkSJABwupNiNJpScDo-FaL4E3shUeEP7HEKs1Kc5rzAc0Cj16aKsxoC_FLw_wcB

Doppelmayr. (2017). Retreived https://www.doppelmayr.com/produkte/

Funitel. (2017). Opgehaald van https://www.funitel.de/anlagenportraets/funispace-les-attelas

Gazet van Antwerpen. (2015). Stad heeft Fiets- en Wandelbrug over de Schelde nodig.

Gazet van Antwerpen. (2015). Stad heeft Fiets- en Wandelbrug over de Schelde nodig.

Gemeente Antwerpen. (2010, Maart). Masterplan Antwerpen 2020. Retrieved 03 01, 2017 from https://d201gzvprbtpxy.cloudfront.net/sites/default/files/documents/masterplan_2020.pdf

Gemeente Antwerpen. (2010, Maart). Masterplan Antwerpen 2020. Opgeroepen op 03 01, 2017, van https://d201gzvprbtpxy.cloudfront.net/sites/default/files/documents/masterplan_2020.pdf

Gemeente Groningen. (2016). *Bespreekpunten VVD en Christenunie, Flyover.*

ISR. (2017). Retrieved from http://en.isr.at/news-en/article/have-bicable-gondola-lifts-got-a-future/

Hofstede. (2017). Retrieved from https://www.geert-hofstede.com

Kennisnetwerk Detailhandel. (n.d.). *Interprocinciale studie Detailhanel. Rapport Provincie West-Vlaanderen Kaartenboek*. Retrieved 02 20, 2017 from http://docplayer.nl/22123629-Interprovinciale-studie-detailhandel-rapport-provincie-west-vlaanderen-2012-2014-kaartenboek.html

LechZürs. (2017). Opgehaald van http://www.lechzuers.com

Leitner. (2017). *Drei und zweiseilumlaufbahnen*. Opgeroepen op 03 31, 2017, van https://www.leitner-ropeways.com/de/produkte/drei-und-zweiseilumlaufbahnen-1/

NP360. (2017). Retrieved from https://www.np360.com.hk/en/

NSAA. (2014). *NSAA ski lift safety fact sheet.*

MAS. (2017). *Over het MAS.* Opgeroepen op 06 06, 2017, van http://www.mas.be/nl/content/over-het-mas

Mi Teleferico. (2017). Retrieved from http://www.miteleferico.bo

Omroep Brabant. (2017). Retrieved from http://www.omroepbrabant.nl/?news/252076892/Stadskabelbaan+in+Eindhoven+zweven+tussen+station+en+Strijp-S.aspx

Quaeldrich. (2017). *Hagelstein pass.* Retrieved on 06 06, 2017, from http://www.quaeldich.de/paesse/hagelstein-pass/karte/

Port of Zeebrugge. (2017). Retrieved on 06 06, 2017, from https://www.portofzeebrugge.be/en/port-authority/about-us-0

Port Of Rotterdam. (2016). Watermobiliteit.

Port Of Rotterdam. (2016). Watermobiliteit.

PRB. (n.d.). *Population Reference Bureau*. Retrieved 02 20, 2017 from http://www.prb.org/Publications/Lesson-Plans/HumanPopulation/Urbanization.aspx

Predigtstuhl. (2017). Retrieved from http://www.predigtstuhlbahn.de/startseite

Seilbahn Koblenz. (2017). *Zahlen und Fakten*. Retrieved on 03 31, 2017, from http://www.seilbahn-koblenz.de/zahlen-und-fakten.html

Sociaal economische raad van Vlaanderen. (2016). *Ship-Project.* Opgehaald van https://issuu.com/vlaanderen-be/docs/02a6b0d7-27cb-4e2b-983d-4b2836c8a7fc

Sölden. (2017). Opgehaald van https://www.soelden.com/nl

Sölden. (2017). *Giggijoch Gondola*. Retrieved 03 31, 2017 from https://www.soelden.com/giggijoch-gondola

telegramme, l. (2016). Brest. Téléphérique : tous en cabine ! . Opgehaald van http://www.letelegramme.fr/finistere/brest/penfeld-un-telepherique-bien-urbain-19-11-2016-11298074.php

telegraph. (2012). *London's Emirates Air Line cable car service launhces.*

TfL. (2010). *Plans unveiled for a new Thames crossing with London's first cable car system.*

The Brussels journal. (2017). Crisis in Belgium: If flanders secedes Wallonia Disintegrates. Retrieved 02 20, 2017 from https://www.brusselsjournal.com/node/2433

The O2. (2017). retreived from http://www.theo2.co.uk/visit-us/getting-here/cable-car

UMCG. (2017). *Feiten en Cijfers.*

Zeebrugge Open. (2017). *Nieuwe Zeesluis SHIP.* Opgeroepen op 06 06, 2017, van http://www.zeebruggeopen.be/projecten/nieuwe-zeesluis-ship/

Zeitung, K. (sd). Interalpin: 26.400 Besucher aus 86 Nationen. Retrieved on 05 11, 2017, from http://www.krone.at/tirol/interalpin-26400-besucher-aus-86-nationen-zufriedene-bilanz-story-566857

Whistler Blackcomb. (2017). Retrieved from https://www.whistlerblackcomb.com/discover/360-experience

Woldbank. (2017). *Data.Worlbank*. Retrieved 02 20, 2017 from http://data.worldbank.org/indicator/SP.POP.TOTL

verkeer, A. w. (2017). Status Fietsersliften Antwerpen. Opgeroepen op 05 17, 2017, van http://fietsersliften.wegenenverkeer.be/

Visit Britain. (2017). The Emirates Air Line: Take a flight over London on the Thames Cable Car. Opgehaald van https://www.visitbritainshop.com/world/articles/visitor-oyster-card-thames-cable-car/