Public Transport of the Future

Assignment 2 for CIE5825 APTOM. Group 10: Hugo Odijk (4945824) & Tim de Ridder (4937961)

1 Introduction

It is March 2020, COVID-19 has set its foot in The Netherlands and the Dutch government announces the first measures to prevent the virus from spreading (Ministry of General Affairs, 2020). A lockdown is the result: closed schools and shops, working from home; all having a big impact on society. Travel patterns where significantly changed and as a result public transport saw a drop in passengers of around 90% during the first lockdown (Statistics Netherlands, 2022). Although all major restrictions have been lifted as of spring 2022, the world is not the same as it was. People are travelling to the office less, people travel less in the rush hour peak, among other changes in travel patterns (van Elferen, 2021). The COVID-19 crisis can be seen as a major reset of the mobility system, so now it is the perfect time to rethink this system. This report will discuss our opinion on what the post-COVID-19 transport concept for the Netherlands should look like in the future. We will only look at transport within the Netherlands, so international connections will not be discussed.

The goal of the mobility system is not only to transport people from A to B, which is its main goal, but it has its value at other aspects as well. To describe these effects the 5 E's were introduced: Effective mobility, Efficient city, Economy, Environment, & Equity (van der Bijl, Maartens, & van Oort, 2016). Efficient mobility is about travel time and passenger numbers, but also about robustness, flexibility and reliability of the network and comfort for the traveller. Secondly, as the name already suggests, Efficient city is about efficient use of the confined urban space. Public transport can bring lots of people to their destination, while using much less space than cars. A good public transport connection can also stimulate growth in the Economy of a city or neighbourhood. Furthermore, sustainability is becoming more and more important in the world and active modes and public transport have a leading role in this, as it is almost at zero emission. Environment is also about the liveability of the city which can be improved by reducing emissions, nuisance and safety. The last E, Equity, is about making transport available for everyone, which improves the social cohesion between different classes of society. An important dilemma with mobility is the trade-off between passenger and society. Do you make decisions based on what is good for the individual person, or do you make them based on the value for society? In line with the 5 E's, described in the previous paragraph, we think that it is more important to look at the value for society than the individual person's travel time for example.

The structure of the remainder of this report is as follows: Chapter 2 describes one of the most important problems with the transport system of today: the car. In the next chapter, Chapter 3, the important technology trends that will influence the transport concepts of the future are described. We will give our transport concept for the future in Chapter 4, where we first discuss some general concepts and after that we will look at the transport system at various scale levels. This all will be followed by the conclusion in Chapter 5. Chapter 6 gives the list of references.

2 The problem of the car

In the Netherlands, the car is the most used mode. When looking at the number of trips, car trips form almost 50% of the total trips in the Netherlands, as can be seen in Figure 2.1 (Statistics Netherlands, 2021). This can also be seen in Table 2.1. What can be concluded here, is that in most areas for most distances the share of car users is the highest, only for distances under a kilometre the share of cars is low.

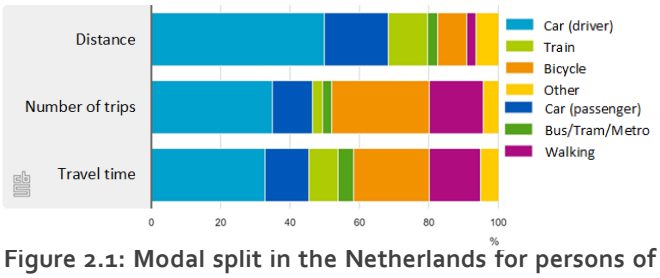

Figure 2.1: Modal split in the Netherlands for persons of six years and older (Statistics Netherlands, 2021).

The popularity of the car can be explained by the fact that it is a convenient mode for the door-to-door trip, since there are no waiting times involved. Furthermore, the car gives often quick journey times on a high-quality road network in the Netherlands. Another aspect is that many people appreciate the fact that they do not have to share the car with other people. Lastly, the use of a car is a habit for most people in the Netherlands, and for almost everyone it is very difficult to break with your habits.

Table 2.1: Modal share in the Netherlands of different modes for different distances in different areas (Jonkeren, Wust, & de Haas, 2019).

	Distance [km]	Car Driver	Car Passenger	Train	BTM	Bicycle	Walking	Other
Highly Urban	0-1	10%	7%	0%	0%	28%	53%	2%
	1-7	28%	15%	0%	5%	35%	13%	3%
	>7	47%	20%	10%	8%	10%	2%	3%
Low Urban	0-1	15%	8%	0%	0%	33%	42%	1%
	1-7	35%	19%	0%	2%	31%	11%	2%
	>7	52%	23%	5%	4%	10%	2%	3%
Rural	0-1	12%	7%	0%	0%	38%	42%	1%
	1-7	34%	18%	0%	1%	35%	11%	1%
	>7	58%	24%	4%	2%	8%	2%	2%

However, while the car might be convenient for the individual, it has many negative impacts on society. The first thing we want to bring up is the space efficiency of the car. Figure 2.2 shows the space usage of various transport modalities. The difference between the shown modalities can be called shockingly big. A driving car, which many times only has the driver in it, takes up on average 140 m²/person, while a tram occupies only 7 m²/person. For parked vehicles, compared to parked bikes, the same shocking image is visible. What can be concluded is that when there is a modal shift from car to public transport, walking and cycling, a lot of valuable space can be used for other purposes in relation to Efficient city.

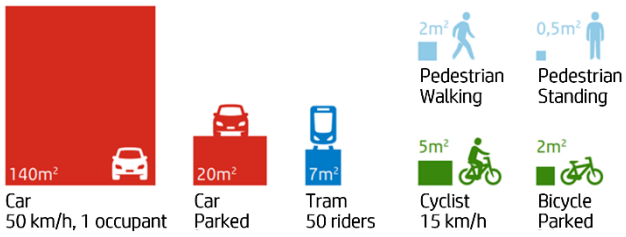

Figure 2.2: Space usage of various transport modalities (Harms & Kansen, 2018). For the driving car, tram and the cyclist the space usage is per person.

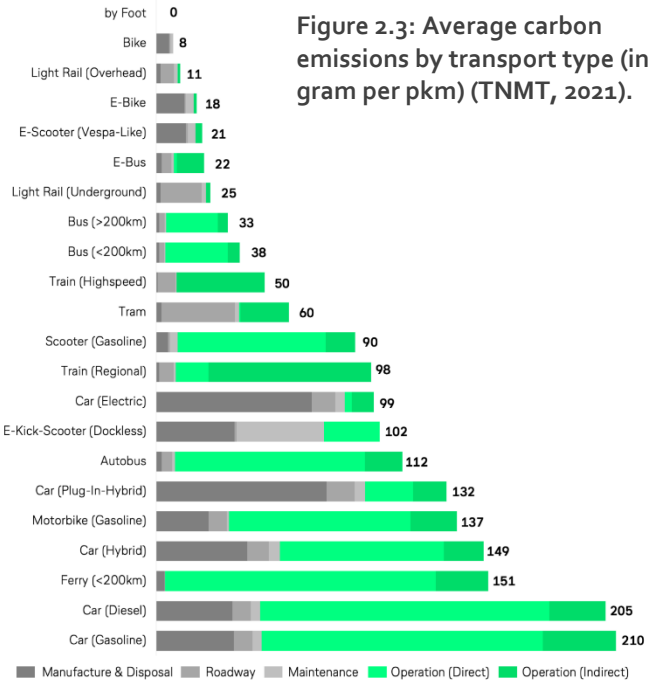

Figure 2.3: Average carbon emissions by transport type (in gram per pkm) (TNMT, 2021).

It is known that the car is one of the most polluting transport modalities, which is also shown in Figure 2.3. Gasoline cars have 210 grams of carbon emissions per person-kilometre, 26 times as much as a bike. Moreover, it has also a lot more emissions than all public transport modalities. As the Environment is getting under pressure more and more, it is very important that we make a change to more environmentally friendly modes.

Cars do not only cause a lot of harmful emissions, but they also have a negative impact on the liveability of streets. In San Francisco, research was done into the liveability of three streets, which were similar, but with different traffic levels. The researchers concluded: "All aspects of perceived liveability – absence of noise, stress, and pollution; levels of social interaction, territorial extent, and environmental awareness; and safety – were found to correlate inversely with traffic intensity. Traffic increases were also accompanied by the departure of families with children from these streets." (Appleyard & Lintell, 2007). Another aspect corresponding to the liveability, is the road safety. On roads there still are too many people injured or even killed. This number is much higher than with for example rail traffic. With most severe accidents, a car is involved. The safety of cyclists and pedestrians is highly influenced by cars as well and 85% of pedestrian casualties are caused by motorised traffic (Staes, 2014).

The last negative impact we want to cover is the costs of the car. These costs do not only include the cost of the car itself, but more costs are involved during its lifetime. Car owning is not cheap, on average, a car will cost a Dutch resident €5,000 per year (NIBUD, 2021). With the increase of oil prices in recent times and the scarcity of fossil fuels this price will only rise in the future. Next to this, cars produce societal costs, for example the construction and

maintenance of roads. In the Netherlands, these costs are approximately €7.3 billion per year (Verkade, 2018). Furthermore, it is estimated that the societal costs due to traffic safety of cars is around €14.5 billion each year (Verkade, 2018).

To conclude, although the car is very convenient for many people and it still has its place in the future transport system, the use of the car in the Netherlands should be significantly reduced. Therefore, we want to achieve a modal shift away from the car to the other transport modalities where possible. What can be done to achieve this shift, is further elaborated in Chapter 4.

3 Technology trends

Currently there are many trends within the mobility space. For a start there is a major shift starting towards automation. The railway sector is making steps, but especially the self-driving capabilities of the car are improving more and more. There are many pilots of cars which can even drive without supervision from a human, like what can be seen with the company Waymo in Phoenix. However, the technology is far from perfect. In order for the cars to be self-driving, a lot of information on the geometry of the roads has to be pre-programmed, cars cannot drive in extreme weather conditions and still accidents happen (Nicholas, 2021). Therefore relying on such technology is quite a risk. In our eyes tasks can be simplified with technology, but in the majority of cases the essence of a mode still stays the same and will not have huge effects on the usefulness of such mode and its space in the transport world. Also, the introduction of automatic shuttles only currently has very specific uses and a broader implementation is still not reality. We believe that the opportunities mostly lie within metro systems where the driver can be fully removed, and operational costs can be reduced, since this system disconnected from the environment around it.

Another trend, which is largely a result of the environmental issues we face, is the electrification of modes. With electric vehicles emissions can be greatly reduced, especially during operation as seen in Figure 2.3. Not only will global problems like the greenhouse effect be inhibited, but it can also greatly contribute to better air quality in cities (Barisione, 2021). However electrifying all cars does not take away half of the problems of this mode as described in Chapter 2. Therefore electric cars should be the last resort, after reducing the number of car movements. However electric scooters, electric buses and battery trains are great technologies which should be used in our opinion. Also electric bikes can be a major tool to get people from the car into the bike. Yet, a major caveat is that enough attention should be given to realising enough charging facilities for these modes.

Furthermore, we see the digitalisation of information and services. Instead of looking up timetables or calling for a cab, most of us receive our information from a screen with dynamic information nowadays. Particularly within transit this can help riders to be better informed on their trip and makes planning also a lot less complex. Also it makes it a lot more convenient to arrange a service. The possibilities of this can be found in concepts like Mobility as a Service, which also involves the sharification-of-services trend. You can then for instance order a shared bike at a station from the same place as where you planned your train trip (Ministry of Infrastructure and Water Management, 2019). Sharing assets can also make the system more efficient. Unimodal trips are always very attractive, but the transition between legs of multimodal trips can be made as seamless as possible. Although we do not expect a huge modal shift due to these innovations, we think that every little aspect that can make transit more appealing, which does not cost much, should be strived for.

4 The Concept

4.1 General concepts

First of all, we think that the conventional modes that exist nowadays will still be the backbone of the transport system in the future. They will be mixed with the emerging modes. However, we believe that not every emerging mode that is being developed will play a (big) role in the future system. The role of the conventional modes and emerging modes will be more elaborated in the subsections of the scale levels.

New modes do not have to compete with conventional modes, but they can also complete the system. You have many tools in the toolbox and a mode should mainly be used where it works best. There is only one major public enemy and that is the car. The use of the car can be minimised where viable by introducing attractive alternatives.

Yet, in many trips the car still has its place, hence the number of cars should not be banned. However transitioning to multimodal trips requires special attention to all legs of the trip to make it work.

When thinking about (new) transport concepts, the link with urban development has to be made. Where people live, work and relax, there is a need for transport. This also corresponds to two of the five E's, Equity and Economy, as can be seen with the distribution of knowledge and capital over the Netherlands. Nowadays, most Dutch people live in the Randstad area in the west and this is also where most businesses are located. People that are born in the north, south and east of the country even leave their birthplace for the Randstad. The Randstad is the most prosperous region of the Netherlands (Content & Thissen, 2022). The Dutch government wants to do something about this. To create more Equity in the Netherlands, they want to attract more people to the northern, southern and eastern regions. To make the regions more attractive and to improve the liveability and economy of the regions, it is important that the regions are well accessible (Ministry of General Affairs, 2021). The transport system of the future should accommodate for this and how we think this can be done is further explained in the following sections.

The last general concept is about making public transport and sharing services more attractive. This needs to be done to have the modal shift away from the private car. The first way this can be done is to make it cheaper, possibly for certain groups which are less well off in the name of Equity. A good example is making public transport cheaper for children, which could also result in parents taking transit more often as for them it becomes less expensive than to own a car.

Another way to make it more attractive is to implement one general payment system for all public transport services. When you have to change trains between different operators, for example, you now have to check out at the train station and check in again. It would make the multimodal trip more convenient if this is not necessary anymore. Too make it even more convenient, the sharing services, like the shared bikes and e-scooters, should be included in this one payment system as well. Using your smart card to unlock a shared bike is already being implemented in the Netherlands (NS, s.d.).

4.2 National

For transport on national level, we expect the car and train will (still) be the modes to use. A major modal shift is maybe not on the cards since not all door-to-door trips can easily be made with the use of a train, but still improvements can be made. Enhancements to train service that we think would help are improvements to speed, frequency and reliability. This often comes with a major price tag, but the societal benefits can often improve the business case of such railway projects.

Nowadays, there is only one high-speed line in the Netherlands which links Amsterdam, Schiphol Airport and Rotterdam to Belgium. This was mainly built for international travel, but domestic trips can also gain from such infrastructure. We think that the number of high-speed lines in the network can be expanded to all corners of the country, not only for the transport value, but Equity and Economy play an important role here as well. If the remote parts of the country, like the northern provinces and the south of Limburg, are well connected to the Randstad, this will boost their economy and it improves the equity as everyone has a convenient and fast connection available to the Randstad (Ministry of Infrastructure and Water Management, 2021). Cities that could be connected to the Randstad are Leeuwarden/Groningen in the north, Enschede in the east and Eindhoven/Maastricht in the south of the Netherlands. Since distances are still on the low side, speeds of 200 km/h would already suffice. The train has to only compete with the car and not with an aircraft after all. Research should determine if building new lines or upgrading current lines is more effective.

One of the most talked-about modes that might come up in the future is the Hyperloop. However, we do not expect that the Hyperloop will play a role in the Netherlands, especially not for travel within the Netherlands. Due to the technical characteristics and costs of the Hyperloop it is not a feasible option for distances less than 500 kilometres apart, according to Bas Govers of Goudappel Coffeng, because it then has no significant advantage compared to existing modes (Arendsen, Hoekstra, Krantz, & van der Veen, 2017). As all distances between cities in the Netherlands are less than those 500 kilometres, we do not think introducing the Hyperloop as a national travel mode is effective.

4.3 Regional

The regional scale level includes all trips within a region, a province, or from one province to the next. These trips do not cross the whole country, which are national trips. Here, the car is the main mode of transport, as described in Chapter 2. Mostly these are private vehicles, but in the future shared vehicles might get a bigger share as well as carpooling. This can be stimulated by creating more locations where shared vehicles are available and where carpool parking is convenient.

For regional transport on rail, the Sprinter services are most important. They connect smaller stations in the region to the bigger cities. Improved services might trigger a modal shift. An example of an improved Sprinter service is the German S-Bahn principle, which will be explained in more detail in Section 4.4 and could be extended into the region somewhat more. However, we do not think that more regional rail connections should be built, because of the fact that the investment costs for these are too high compared to the benefits. These 'missing' connections could be made with a high-quality bus line, which will cost a fraction of the costs of a new railway line, but can achieve similar results. These bus lines could run quick services from one major train station to another or towards other transit hubs which are poorly connected, with limited stops in between to serve major towns.

Another solution for the regions around bigger cities like Amsterdam, Rotterdam, The Hague and Utrecht is to expand the metro, light rail and/or tram system. This will improve the connections from the metropolitan area to those cities, from which passengers can also travel further. Light rail is a less expensive alternative then heavy rail and can still provide high capacity, swift and reliable services. The conversion of former railway lines around Rotterdam to metro operation has shown the benefits, and new projects like the extension of the Amsteltram from Amsterdam and Amstelveen to Uithoorn will most likely do the same (van Kuijeren, 2019) (Transport Authority Amsterdam, 2016).

Although we want to reduce car traffic as much as possible in all parts of the country, we especially want to reduce the number of cars in town and city centres. We believe that an important measure to achieve this is the introduction of Park and Ride facilities at the edge of towns and cities. These facilities would be located close to motorways or other major roads, so they are well reachable from the region by car. Furthermore, they are located next to existing frequent transit lines that run into the city. The facilities require some space so they should not be built on valuable land. A good example is P+R Hoornwijck in The Hague, which is located directly next to the highway, and it is connected to the city centre via two tram lines and a bus line (HTM, s.d.). Another example of a P+R facility located at a major public transport hub is Station Driebergen-Zeist, which again is close to the highway. It is located at the train station, which has quick connections to the cities in the region and it is connected to a lot of bus lines (NS, s.d.). Another great thing about the latter example is that it has also many amenities for modes such as bikes making it even more attractive as a hub.

For a P+R to work, parking fees should be much lower compared to the prices in the city centre. Otherwise the alternative is less attractive by design. As mentioned, the P+R should ideally be placed next to a frequent transit line towards the city, but new transit services can also be introduced if a P+R is constructed elsewhere. Connections to the city centre can even be serviced by an autonomous shuttle, like the ParkShuttle, a shuttle service that connects the P+R facility and metro station at Kralingse Zoom in Rotterdam to the business park Rivium in Capelle aan den IJssel (transdev, s.d.).

One important aspect of planning is that people often choose their travel mode according to their habits. If they always travel by car, then the chance is very high that this time they choose the car again. People's habits influence their attitude towards certain modes. Research into travellers in the Amsterdam region showed that 63% of the car travellers did not see public transport as a reasonable alternative, mostly because of the higher perceived travel time (de Haas, 2017). However, that research also showed that, on average, car travellers' perceptions of public transport travel time exceeded objective values by 46% (Van Exel & Rietveld, 2009). So, to achieve a modal shift away from the car, we have to change those habits.

One way to do this is by governmental campaigns, where certain travel behaviour is rewarded and other behaviour is discouraged, as with congestion tax. However, we have another idea to reach that modal shift. Research has shown that important life events, such as moving to a new house or switching jobs, are moments where habits can be broken (Schäfer, Jaeger-Erben, & Bamberg, 2012). Therefore, we want to implement Transit Oriented

Development (TOD) in the Netherlands more often. "TOD means integrated urban places designed to bring people, activities, buildings, and public space together, with easy walking and cycling connection between them and near-excellent transit service to the rest of the city." (Institute for Transportation and Development Policy, 2019). Whenever a new neighbourhood or business district needs to be developed, the planning begins with the walking, cycling and public transport connections. This can be done by building a neighbourhood close to a train station, or by connecting it to the city with a (new) high-quality transit line. When these connections are high-quality from the beginning, all people that will come to live and/or work in the new neighbourhood are encouraged to make use of the transit, cycling and walking opportunities. An example of a new neighbourhood, that from the beginning was designed with a high-quality transit line, is IJburg in the east of Amsterdam. Services were already running with 10-minute frequencies before the bulk of houses were delivered, resulting in people not using a car from the start (Amsterdam, 2016).

Finally, another mode that can be used for regional travel are taxis. They are mostly used within cities, but the principle is the same for all scale levels. Although they can be quite expensive, they are still used for people to get from A to B. They are also sometimes used as a last mile solution. In the Netherlands, a distinction can be made between regular taxis and Uber-like services. The major difference from a transport engineering perspective is that regular taxis are often standing still to wait for customers, whilst Uber drivers are constantly driving in preparation of the next client. The second leads to additional nuisance which should be avoided. We still believe taxis have a place in future on all scale levels besides all other modes, but public transport and smaller vehicles should be promoted. Also the number of unnecessary (empty) movements should be kept to a minimum through proper regulations.

4.4 Suburban

For suburban travel we look at the trips which are from the city centre to a suburb and trips between suburbs. The length of these trips highly depends on the size of a city. For the more minor cities the car and the bicycle are currently the main modes that are used for such trips, especially the former as can be seen in Table 2.1 in Chapter 2 (Jonkeren, Wust, & de Haas, 2019). In the biggest cities of the country you also see that transit is often used such as buses, trams and metros. However, we find it still mind boggling that more than 10% of the trips under a kilometre are made by car. We believe that a modal shift can be achieved from the car to other modes with a restructuring of the current transit services and improvements to cycling infrastructure.

To start off, for suburban travel trains can be used. Current Sprinter services have limited stops within cities, but if the number of stops is increased, they can also be better used for suburban travel. For example Eindhoven currently only has 2 stations. If this number is increased, it is much more attractive to take the train from a suburb to other destinations in the city. Also, if service is improved by increasing frequencies to every 10 minutes, a service is established similar to the German S-Bahn success formula. A metro-like train service is created with a fraction of the costs of building a new metro line; the saved capital costs can be better spent elsewhere to improve services. Regional passengers may have longer trip times due to the extra stops, but it could also be that a new station is closer to their destination. However, we think that more people benefit from the extra station than are disadvantaged by the slower trains since in general more people live within the city.

Since the railways do not run throughout the whole city, extra high-quality transit lines (HQTL) should be created. With high quality you get frequencies of at least 6 per hour per direction during weekdays to create a turn-up-and-go service, you never have to wait too long for the next service (Transport for London, 2012). In the weekend and in the late evening this can be reduced to a reliable frequency of 4. In essence, busses from low-frequency services can be bundled to these new HQTL, increasing Efficiency. The speed of the vehicles, together with the reliability, should be higher than ordinary transit services to make it Effective and compensate for the longer access and egress times created with wider stop spacing. We envision that this system works best if people can access a stop which is a maximum of around a kilometre distance from their origin or destination. This is in line with the policy of multiple agencies which believe that the maximum distance to a HQTL should be 800 metres for walking only (Amsterdam, 2020) and 1150 metres if the bike is also used (van der Blij, Veger, & Clasien, 2010).

The last mile solutions to the stops that should be in place are discussed in Section 4.7. As mentioned, acceptable distances to stops become larger with proper cycling infrastructure and facilities and therefore these should be in

place. Since not everyone is willing to travel a kilometre before they reach a stop like elderly and physically impaired, also local services should be maintained for Equity reasons. We see a high potential in on-demand transit services. We believe that a bus which you can order 15 minutes prior to travel is much better than a scheduled bus that runs every 30 minutes. Also if there are no passengers, the transit agency is burning money. Therefore on-demand transit can save a lot of money during less busy periods.

A great example of demand responsive transit is in Sevenoaks in England where you can order a ride and in which the transit agency determines the most efficient ride to transport as many people as possible within reasonable travel times. It is not quite a taxi service yet as you can only travel between predetermined stops, but these stops are still tightly spaced. All regular services where axed in favour of this system. This has reduced the number of vehicles required for service, reduced waiting times significantly and increased ridership (Via Transportation, 2021). This could also be applied in a Dutch context. To make the service efficient mostly multiple people have to be picked up an dropped off, but at different places. This could mean that routes are less direct to be efficient, increasing trip times. However, if travel times are important, you can always catch a HQTL.

A HQTL can be a bus, tram, light rail or metro depending on the demand and required capacity of the line and the investment costs. For instance, light rail can give shorter journey times and is operationally more efficient with higher passenger volumes, but requires much more investments costs compared to high quality bus infrastructure. Besides capacity, the only real problems with buses are that they are less energy efficient and have higher emissions. The latter can already mostly be tackled by investing in electric buses and charging infrastructure. In most cases the bus is adequate, as long as the mode does not get stuck in traffic and is sufficiently quick due to dedicated lanes and infrastructure, people will use the service over the car.

Also for suburban trips, and mostly inter-suburban trips which are less well served by public transit, the bike and scooter can be major players. This can be both with private as well as shared vehicles. These shared vehicles will be further explained in Section 4.7, as it is expected that they can play a more important role in urban mobility. Also with the surge of electric bikes, distances within a city can be better covered. It is found that people within the Netherlands are willing to travel on average 30% further with an E-bike compared to a regular bike (Harms & Kansen, 2018). It is however important that there is proper cycling infrastructure within the city. This entails safe, direct routes with wide lanes and as little crossings and traffic lights as possible. The bike should be prioritised over scooters due to the smaller space footprint, but you rather want a scooter over a car for the same reasons. Therefore scooters are not bad in design, but they should not be the be-all-end-all. Also the speed differences between cyclists and scooters can be a problem, as well as with e-bikes, hence the wider infrastructure necessary.

Not only can car travel be reduced by making alternatives more attractive, but also other methods can also be used to make a car trip less convenient. To start, by reducing the number of parking spaces in the city centre, which also creates viable space, it is less convenient to take the car. Also streets can be designed for local traffic only and detours can be created to increase travel times. This will be further discussed in Section 4.5.

4.5 Urban

Urban trips are the short trips within a city to for instance a grocery store close by. These are the first trips where in the Netherlands the car does not have a major model share, unlike what is still seen in other countries. This is mainly due to the high walking and biking share seen here which are perfect for short trips and the fact that all amenities are close by due to adequate zoning policies. Mobility and zoning are in close relation since increasing the distances between origin and destination can have a huge influence on the mode choice of people (De Vos, 2015). If something is close by, getting into your car and parking it somewhere can be more time consuming than just getting on your bike or walking. The current zoning policies should therefore be maintained.

Also transit can play a major role for urban trips. HQTL can also be applied in an urban context. Due to the higher density, more lines are viable and also higher frequencies can be set improving the service. Also less demand driven transit is necessary due to the higher ridership. In that case it might be more efficient to only allow demand driven transit from an isolated place to a hub, from which the passenger can further travel through the city, instead of allowing them to be dropped off at any stop in the network. Hubs are naturally created at the intersection of HQTL.

This also allows for the placement of major facilities for bike parking and shared mobility. Within a high-density environment shared mobility is also more efficient, also as last mile option as will be explained in Section 4.7.

Since cars play less of a role for urban transport, the streets and public spaces should also be designed in such a way. Currently a high portion of streets is designed for the car in the city, whilst there are more pedestrians and cyclists. Not only the roads take up a lot of space, but also on-street parking as was discussed in Chapter 2. Designing for active modes can increase the liveability also, together with the safety of other modes.

Figure 4.1: Mauritskade in Amsterdam, which is a major route for cars. The street lies parallel to the Sarphatistraat of Fout! Verwijzingsbron niet

To further improve safety and reduce trip times, different traffic flows should be separated and disentangled. By creating networks for multiple modes in different parts of the city, the number of crossings reduces. An example of this can be seen in Amsterdam, where they have different main networks for different modes (City of Amsterdam, 2013). Within one street not all modes have to fight for space, but traffic flows are better distributed. To the side you can see an example of such principle. The street of Figure 4.1 is a major car route whilst the parallel street in Figure 4.2 is a major route for cyclists and public transit only with local car access. This can be easily deduced from the street design. Having to accommodate all vehicles in one street leads to many conflicts.

Figure 4.2: Sarphatistraat in Amsterdam, which is a major route for trams and cyclists. The street lies parallel to the Mauritskade of Fout! Verwijzingsbron niet gevonden. **(Google, 2021).**

There is a particular challenge in creating HQTL in a city centre. For HQTL in cities you often need dedicated infrastructure or separated lanes in conjunction with priority at intersections. Most of the time space is limited, which could mean that cars have to be banned from a particular street to speed up transit, or underground infrastructure should be built as seen with for instance metros. However building underground is very costly, as with metros in general. We believe that minor improvements to a transit network might be more beneficial for the whole system, instead of building one high quality line. We are also of the opinion that first the low-hanging fruit such as priority at intersection should be optimised before major money is spend in grade-separated intersections. Each euro spend on a major project cannot be spend elsewhere so proper research should be performed in where money is best used.

The same holds for parking garages for cars. To increase liveability, removing cars from the streets is a good thing, but maybe reducing the number of cars in general which access the city is a cheaper solution and also has additional advantages. We believe that the number of cars in the city centre can not only be greatly reduced by eliminating parking spots. Also by introducing 'cuts' in the car network, through traffic will be redirected to the ring roads only leaving the local traffic. Again Amsterdam is a major forerunner in this principle. Within one area they reduced car traffic by 70% by optimising traffic circulation (City of Amsterdam, 2019). The whole of the city centre should only be used by people who must be there. It could be that residents by car have to take a detour, but congestion is also reduced which does not directly imply longer travel times.

4.6 Rural

Rural trips are often the trips between villages or from a village to a nearby city. For these trips, the car is currently often used as can be seen in Table 2.1. Lower potential ridership of low-density areas leads to less transit service and therefore the car becomes more convenient. Also there are hardly any parking restrictions for cars in the countryside. Although the potential is lower, we still think offering high quality transit services leads to less car usage.

In the Netherlands quite a few larger towns are connected by train to the closest city. The reliability and speed of such services is relatively high. We think that towns with a population of over approximately 10 or 15 thousand which are not close to a railway should also get a HQTL to the nearest major town. Due to the longer distances, a frequency of 4 buses per hour on weekdays is adequate, which can be reduced to 2 buses per hour on weekends. The bus service is not turn-up-and-go, but if distances are longer people will accept longer waiting times (Jordan-Detamore, 2016). We explicitly say buses since we believe that investing in rail transit for these trips is not on the table due to the investment costs. Also buses can easily make use of existing national highways without extra investments. Since the reliability and speed should be high, we also think that the bus should make use of the national highways as much as possible to compete with journey times of the car. Only then is it possible the reduce the number of cars. The bus should never be stuck in traffic and therefore we are of the view that bus lanes should be constructed next to the national highway where traffic jams have a high likelihood of occurring. This will further improve the competitiveness of the bus.

Since national highways in the Netherlands are often built outside of the build-up area, this means that access times to stops become bigger. Only if the detour through the town is minimal, the bus should run through the town. At the bus stops, hubs and Park and Rides are constructed. Here you can conveniently store your bike or scooter, as well as your car. Also sufficient shared mobility is offered as will be discussed in Section 4.7 of the last mile. For people who cannot access the bus stop on their own, there still will be demand responsive transit as mentioned in Section 4.4. Also for villages which are smaller than the set threshold, alternative bus services should be in place.

With the bus network you mostly serve the village to city trips, but not the village-to-village trips. These can be served with the demand responsive buses, but also trips with bikes and scooters should be promoted. Also the E-bike is a very powerful tool in the toolbox which can be used to increase the reach of the bike even further. Therefore, the infrastructure for these modes should be improved. Wide and safe cycle paths are necessary with smooth pavement, like the new bicycle highways seen in the Netherlands. These can be seen in Figure 4.3. Since national highways are often the most direct routes between towns, cycleways are often placed next to them. This is not ideal, but measures like extra trees between the cars and the bikes can improve the feeling of safety and the attractiveness of the route. However, ideally cycleways and through roads should be separated. A mix with residential traffic is much less harming for the attractiveness of a route, and paths through forest can even increase the attractiveness of a route and should be strived for (van Galen & Remmits, 2021).

Figure 4.3: Bicycle highway near Tilburg in the Netherlands (Wagenbuur, 2021).

We believe that shared mobility also has its place within village-to-village trips. Especially the E-scooter can be a viable alternative for a car. The only problem is that quite a few E-scooters should be placed in a town to have one within walking distance of around 400 metres or less. This is approximately the largest distance that people are willing to walk to reach a shared vehicle (CROW, 2021). Since these scooters will not be used consistently, this makes these scooters not financially viable. The government should therefore analyse if subsidising shared mobility in rural areas is worth the costs compared to the societal benefit of less cars.

4.7 Last mile

The last mile in a multimodal trip is often seen as the least straightforward leg. You are often met with still quite a distance, which may be too long to walk, but you do not have a mode of transport easily at your disposal. For transport planning this is often also one of the most difficult tasks to solve.

In the Netherlands there are quite a few people who have an extra bike stored at their destination train station to cover the last mile, but this is not a solution for everyone since you destination might not be consistent. Also with our proposal to move to a fine meshed transit system, more people cannot just walk to their transit stop anymore. We reckon that shared mobility is the prime solution for the last mile problem.

Shared mobility ensures that it is not necessary to have a secondary mode of transport at your destination, since there already is one. At major stops around the HQTL, especially in rural areas, sufficient vehicles should be

available. The possibility of shelters to keep the vehicles dry are also things that could be thought of the increase the attractiveness of the multimodal trip. Also there should be enough parking for private vehicles, also with amenities for charging. If the parking is next to a stop, this makes the transfer as convenient as possible. In rural areas where space is not as much of an issue also minor Park and Ride facilities can be constructed for cars.

We think that within rural areas the (E-)bikes and the E-scooters should be made available, whilst in the towns the emphasis should be on regular bikes and electric steps to give passengers the choice between active modes and non-active modes. Since trips within the city are often shorter trips, steps can also be sufficient. A major advantage of the step over the scooter is the space efficiency. Also whilst driving, but mainly when stationary they are more efficient which is preferred in space confined spaces such as cities. We think that a free-floating system works the best, as it can also be used for access, but policies should be in place to avoid nuisance due to poorly parked vehicles. Currently you have vehicles which are just parked randomly without much thought, whilst private vehicles are often neatly parked (Stadszaken, 2021). A policy could be that people who see a badly parked vehicle can note that in an app, such that the previous user is notified. This will increase the social surveillance. Also law enforcers can access such app and with multiple offences the user can be fined, giving an incentive to be mindful of incorrect parking. Another possibility is to switch to a station-based system with designated parking areas, but we believe the potential of shared mobility is being negated.

Another problem of a free-floating system is that you are not guaranteed to have a vehicle close by. Therefore it should be policy that the vehicle provider should relocate vehicles such that they are well distributed, also in rural areas. This might come with a higher cost, but we think that this is worth it if less people use the car for their trip.

Finally, it should be mentioned that shared mobility can not only be used as last mile mode, but it can also fully replace the transport trip. The goal of shared mobility is complementing and not competing. The introduction of a shared bike in The Hague provided by the transport operator was rarely used as a last mile alternative, but instead rather as a convenient mode from A to B (van Marsbergen, Ton, Nijënstein, Annema, & van Oort, 2022). The question is if these is favourable. In our opinion this is not a problem per se since the bike and public transport are better than the use of cars. The only important remark is that the transit agencies might make less profit if services have to stay the same (to be HQTL) and ridership drops. The government should look how the agency can be compensated in such scenario. However, if the quality of the transit lines is significantly improved, we believe that the competitiveness of transit will be increased either way. This will lead to more people using transit who previously took the car or the bike.

5 Conclusion

In this report a restructure of the mobility system is proposed. In our proposed solution the conventional modes still are the backbone of the future system, but there is also room for some upcoming modes. Currently many trips are made by cars since this is very convenient for the individual, but the societal costs of the car are enormous. They are very inefficient in space usage and emit a lot of harmful emissions, among other problems.

However the car cannot simply be banned, but the use of the car should be minimised as much as possible. This is both done by making car ownership less attractive with for instance higher parking fees, together with making alternatives such as active modes and public transport more competitive. We propose overall improvements to these modes such as the introduction of high-quality transit lines throughout the country in conjunction with demand responsive transit and enhancements to cycling infrastructure. Also emerging modes could help the modal shift away from cars as for instance shared bikes, steps and scooters can solve many of the problems with last mile transport. They can be for example be placed at transit hubs or park and ride facilities to make the transition between transit and other modes as smooth as possible.

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