A. (ARNOUD) DE JONG

4693914

BACHELOR THESIS

FINAL REPORT

Supervisors:

Dr. Ir. A.M. (Maria) Salomons
Dr. Ir. Y. (Yufei) Yuan

15 June 2020

TU Delft

FAST CYCLE NETWORK IN AMERSFOORT

Preface

This report is the graduation thesis from my bachelor of Civil Engineering at the TU Delft. This thesis has been done at the faculty of Transport and Planning and is also a preparation for the master Transport and Planning that I hope to do after my bachelor.

In this report it is explored how fast cycle networks can be developed in urban areas, with the goal of making cycling over longer distances and cycling at higher speeds more attractive. An application was subsequently made to the bicycle network of the city of Amersfoort, whereby a new fast cycle network was introduced. Readers interested in the design of a fast cycle network in an urban area I refer to chapter 3. Those that are interested in how to deal with speed-pedelecs in urban areas I refer to chapter 3.2 and chapter 5.8. Readers interested in the redesign of the bicycle network of Amersfoort and the adjustments that have to be made I refer to chapter 5 and appendix C.

I thank my supervisors Dr. Ir. A.M. Salomons and Dr. Ir. Y. Yuan, for thinking along during the research, for providing relevant information and for the suggestions to improve my work. Certainly, in this time of off-campus studying, where it was not possible to meet in Delft, I am grateful that this bachelor thesis still could take place. I also thank my fellow students J. Groenewegen, G. van der Horst, L. Snoeks and M. Sterk for reviewing my work and the valuable discussion sessions we have had recently.

Amersfoort, June 2020

Arnoud de Jong

Summary

Due to an increase in bicycle usage and due to the introduction of faster and electric bicycles suitable for driving on a longer distance, the need has arisen for introduction of connections like the bicycle freeway. In the city of Amersfoort, which will grow by 20,000 inhabitants in the coming 20 years, is a demand for improvement of the current bicycle network (Gemeente Amersfoort, 2016).

In this study it is investigated how cycling over longer distance and cycling at higher speed can be made more attractive by introducing a fast cycle network in Amersfoort. It has resulted in a redesign of the bicycle network of the chosen research area. It was examined how this fast cycle network can optimally function within the city of Amersfoort and within the region Utrecht. In addition, it is investigated how this network can be made suitable for all types of bicycles. So, although this fast cycle network is meant for cyclists on longer distances and with relatively higher speeds, the network has to remain usable for slower cyclists as well.

This report focuses on the following question: How can a fast cycle network be implemented in Amersfoort, suitable for long-distance cycling and for different types of bicycles? It is investigated what the requirements are for a fast cycle network and how such a kind of network should be designed. In addition, the current bicycle network of Amersfoort was mapped and the use of the network was analyzed. Based on these results, a redesign of the bicycle network of Amersfoort was made.

Research into literature and reference projects showed that wide bicycle paths are most suitable for urban fast cycle routes. A minimum number of conflict points with other traffic should be pursued. If a road section also serves as an access road for cars and there is no space for separate bicycle paths, the bicycle boulevard can be applied best. To enable overtaking by faster cyclists (like the user of a speed-pedelec), the bicycle paths must have a minimum width of 4 meters (CROW, 2016). Thanks to good pavement and clear signage, a bicycle connection can be made more attractive and allows cyclists to maintain a higher speed.

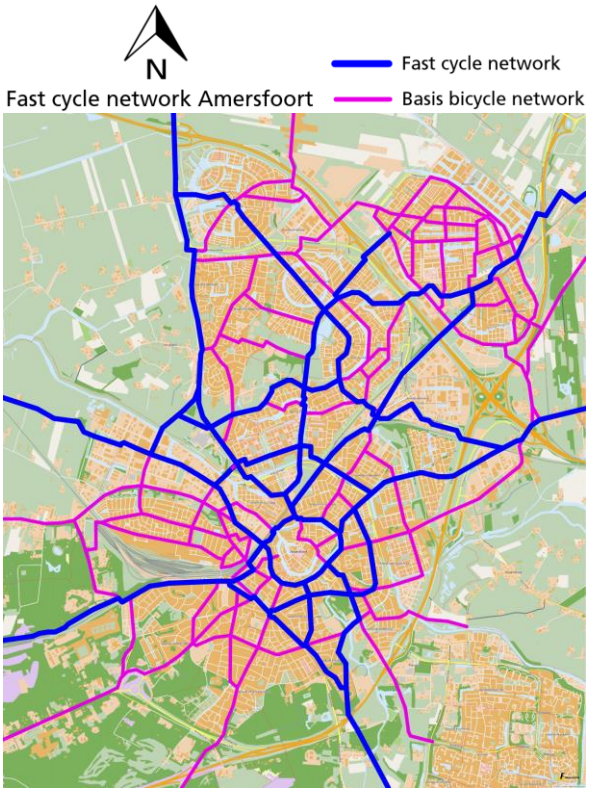


Figure S.1: Fast cycle network Amersfoort

An analysis of the current structures of the Amersfoort bicycle network showed that there are already some bicycle connections that meet the criteria of a fast cycle route. However, these routes are parallel to each other and do not form a coherent network. In addition, the provincial fast cycle routes to other places are not fully integrated in the bicycle network of Amersfoort.

In the last stage of the research, the Amersfoort bicycle network was redesigned. This showed that some parts of the city are not suitable for a single fast cycle route, because a fast cycle route would detract from the existing structure of the bicycle network there. For this reason, in addition to a collection of fast cycle routes, which together form a fast cycle network, a basis network has been designed that is less focused on higher speed, but which connects all parts of the city to the fast cycle network. The final design of the fast cycle network and the basis bicycle network is shown in figure S.1.

Table of contents

1. Introduction

In the last decades cycling has become more and more popular. In the Netherlands bicycle use has increased from 13,9 billion kilometers in 2000 to 15,5 billion kilometers in 2016 (OVG, 2016). This increase can partly be dedicated to the e-bike growing in popularity. The e-bike makes it possible to travel a longer distance on average by bicycle. In the last decades there have also been new developments in bicycle infrastructure. The bicycle boulevard is an example of a new type of infrastructure. These boulevards make cycling in urban areas more attractive and safer (Fietsberaad CROW, n.d.). Another example is the bicycle freeway, connecting different places in a fast, direct way (Fietsersbond, 2015a). At higher scale, new fast cycle networks are (to be) enrolled, like in the province of Utrecht (Provincie Utrecht, n.d.). In most cases construction of new infrastructure results in an increase of bicycle usage, which reduces the pressure on road networks (Andringa, 2019).

1.1 Goal

In this bachelor final project (BEP) a study is done on how making cycling over a longer distance and cycling with a relative higher speed more attractive, in the city of Amersfoort. The goal of the study is to design a fast cycle network through the city, complementing the current bicycle network. The following three spearheads have been included in the design of the fast cycle network of Amersfoort:

- The bicycle network of Amersfoort has been integrated in the bicycle freeway network of the province of Utrecht (Provincie Utrecht, n.d.). Cyclists must be able to move fast through the city to the fast cycle paths towards other places.
- In addition, the network is made more attractive for rides within the city. The network is designed in a way that all parts of the city are well connected. The municipality's bicycle plan was also used in this redesign (Gemeente Amersfoort, 2016).
- Finally, the network is made suitable for all kinds of bicycles. Two new modern bicycle types are the speed-pedelec and the cargo bike.

1.2 Main research question

The goal stated in chapter 1.1 can be summarized into the following main research question:

How can a fast cycle network be implemented in Amersfoort, suitable for long-distance cycling and for different types of bicycles?

The main research question can be split up in the following sub-questions:

- What does a fast cycle network look like and what is needed to make a network suitable for modern bicycles?
- What does the current bicycle network of Amersfoort look like and what are the movements within the network?
- Which adjustments have to be taken to create a fast cycle network in Amersfoort?

In chapter 2 the sub-questions are explained and the relationship between them is described. This chapter also contains the methodology, assumptions and demarcation. In chapter 3 it is described what is needed to realize a fast cycle network. Information about the bicycle network of Amersfoort is provided in chapter 4. Chapter 5 contains the final redesign of the bicycle network of Amersfoort. Chapter 6 includes the discussion. Chapter 7 provides the conclusion and recommendations.

1.3 Project area

The wide project area is the entire region around Amersfoort, where long-distance cyclists come from. In this regional network, bicycle routes and freeways going to Amersfoort are regarded. These fast cycle routes are integrated in the main bicycle network of the city see chapter 1.1. The research of G. Andringa about the network of Utrecht (Andringa, 2019) and the announced regional fast cycle network of the province of Utrecht (Provincie Utrecht, n.d.) are used to define this network.

Figure 1.1: Bicycle network of Amersfoort defined by the municipality (Gemeente Amersfoort, 2016).

The core of the project area, the area where most of the research is done, is the city of Amersfoort. The size of the city with maximum radius of 10 km, makes the area suitable for this study, because relatively longer distances can be traveled through the city and this range is manageable for the size of this study. Also enough online information about the plans of the municipality is available. In the coming years a growth of the population of the city with 20,000 inhabitants is expected. This results in new challenges for the future. New infrastructure projects are announced by the municipality. In 2016 the municipality of Amersfoort published a document about steps to be taken to make the bicycle network future-proof (Gemeente Amersfoort, 2016), see chapter 3.5.

1.4 Stakeholders

In this chapter a short analysis of the stakeholders is included.

Cyclists - The primary users of the fast cycle network are cyclists who move between different parts of the city or cyclists who have their destination outside the city. The fast cycle routes have to give these users the opportunity to move fast and smooth through the city.

Figure 1.2: Speed-pedelec (Fietsersbond, n.d.)

In addition, there are also special bicycles that will make use of the fast cycle network. The speed-pedelec is an example of a special bicycle that is suitable for cycling at 45 km/h. In this study it is investigated how to handle with this type of bicycle and how this type can be allowed on a fast cycle route.

There are also cyclists who have a destination close to their origin. In general, these people are not using the fast cycle network. For this reason, this group was included to a limited extent in the study. However, the design of the fast cycle network has strived to ensure that these cyclists experience as little hindrance as possible from fast cycle traffic.

Municipality of Amersfoort - The municipality is aware of the change in the traffic market and is promoting the usage of bicycles. In their bicycle plan an upgrade of the network is announced and also introduction of new provisions like new bicycle storages (Gemeente Amersfoort, 2016). All announced plans by the municipality have been included in this study.

Province of Utrecht - The province promotes the use of bicycles. It has the ambition to become the bicycle region of Europe (Provincie Utrecht, n.d.). Various fast cycle routes have been announced by the province that connect the places in the province in a fast and direct way. In the redesign of the bicycle network of Amersfoort this provincial fast cycle routes are integrated in the urban network.

Third parties interested in fast cycle networks – Because this study examines the application of urban fast cycle networks in general (chapter 3), this study can also provide information for other cities that are interested in fast cycle networks. The conclusions drawn as a result of the redesign of the bicycle network of the city of Amersfoort may also be applied to other cities. In addition, this study can contribute to the knowledge available at the Fietsersbond and the CROW.

2. Methodology

In this chapter the methodology is declared. This research is roughly divided into 3 parts, forming 3 main steps in the research.

1. literature research – gaining relevant information regarding fast cycle networks
2. analysis and mapping research area – mapping the current network of Amersfoort
3. redesign – design fast cycle network in Amersfoort

In chapter 2.1 the sub-questions (based on the triplet stated above) are declared. This chapter provides also information about what is done in each step and what the final result is like. In the chapters 2.2, 2.3 and 2.4 for every step it is declared how the research is done. Also a division is made in sub-steps. In chapter 2.5 made assumptions and in chapter 2.6 a demarcation are included.

2.1 Sub-questions

From the main question stated in chapter 1.2 and from the 3 main steps stated above the sub-questions are derived.

Q1: What does a fast cycle network look like and what is needed to make a network suitable for modern bicycles?

In this part of the research it is determined what is needed for realization of a fast cycle network in urban area. This part of the research consists mainly of literature research. The demands of the design of a bicycle network are elaborated. In addition, an answer is found on how to introduce bicycle freeways, or alternatively introduce bicycle boulevards or apply other types of roads. Furthermore, knowledge is gained about how to make a bicycle path suitable for all types of bicycles (especially speed-pedelecs and cargo bikes). A study on reference projects is included. Finally, the demands and ambitions of the governments (province and municipality) are listed.

This question results in a list of requirements and assessment criteria relevant for the redesign of the network in Amersfoort (sub-question 3). This list can be found in appendix A.

Q2: What does the current bicycle network of Amersfoort look like and what are the movements within the network?

In this part of the research, the current situation of the bicycle network in Amersfoort is examined. It determines the location of the main bicycle network, which bicycle infrastructure is currently available and at which locations users cycle at higher speeds. In addition, the use of the network is visualized by mapping important trip generators and connecting them. In addition, important regional bicycle routes (the fast cycle routes announced by the governments) are mapped.

This question results in an overview of bicycle corridors within Amersfoort, where the most important corridors are highlighted as candidates for an upgrade to a fast cycle route.

Q3: Which adjustments have to be taken to create a fast cycle network in Amersfoort?

In this part of the research, the answers from the first sub-question are applied on the second sub-question. This results in a redesign of the bicycle network of Amersfoort, in which a fast cycle network is created.

In addition, a direction is offered on how this designed fast cycle network should be realized. This has led to an enumeration of hard and soft measures. It is determined what kind of adjustments have to be made to the infrastructure, like priority schemes at intersections or introduction of traffic lights. All these measures are listed in appendix C.

In addition, two corridors (fast cycle routes) in the designed fast cycle network are selected and an more detailed design is made. The design of these corridors serves as a prototype for the design of the other fast cycle routes.

2.2 Step 1: Criteria fast cycle network

In the first step of the research, relevant information about fast cycle networks is found by literature research and by study on reference projects. Already in this stage design choices are made if more possible design options are available. The demands defined by governments are summarized. The outcome of this step is a list of requirements and assessment criteria relevant for the network design (they can be found in appendix A).

Step 1.a - Finding requirements for bicycle networks
This step provides an answer on how bicycle networks can be improved regarding 5 design criteria for a network according to the 'Ontwerpwijzer Fietsverkeer' (CROW, 2016). These criteria are:

Cohesion – Network completeness
Directness – Minimal detours and delays
Safety – Measures making the infrastructure safer
Comfort – Easy wayfinding and comprehensibility
Attractiveness – Pleasant surroundings and social safety

Step 1.b - Finding requirements making a network suitable for modern bicycles
This step provides an answer on how bicycle paths can be made suitable for the cargo bike and the speed-pedelec. Former researches to usage of speed-pedelecs and reports of governments are used.

Step 1.c - Application of modern road types
This step provides information about the application of infrastructure belonging to a bicycle network. The usage and application of bicycle freeways and bicycle boulevards are regarded.

Step 1.d – Research to reference projects
This step consists of a study to comparable projects where bicycle freeways are introduced within urban areas. The bicycle freeway F35 in Twente and the RijnWaalpad are analyzed using Google Maps.

Step 1.e – Investigate demands of governments
Demands stated in the bicycle plan of the municipality (Gemeente Amersfoort, 2016), being the basis requirements for the network design, are listed. Also the future projects announced by the province of Utrecht are included.

2.3 Step 2: Analysis and mapping current network

This part of the research results in an overview of bicycle corridors within Amersfoort. The most important corridors are highlighted as candidates for an upgrade to a fast cycle route in the redesign.

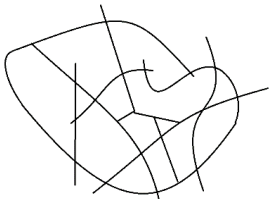


Figure 2.1: Mapping main cycle network

Step 2.a - Mapping of the current main bicycle network
In this step the current main bicycle network is mapped. As a basis the main bicycle network defined by the municipality of Amersfoort (Gemeente Amersfoort, 2016) is used. In addition some extra routes are added to come to a mesh width of about 300 to 500 meters (CROW, 2016). Announced projects are included in the map.

The map (background of the figures) is retrieved from the Fietsersbond (Fietsersbond, 2020). These map highlights bicycle paths in red, which makes finding locations of the bicycle paths less complicated.

The map is processed in the program Microsoft Visio. In Microsoft Visio, different layers can be used. Therefore, it is simple to compare or combine different maps, which helps during the design stadium.

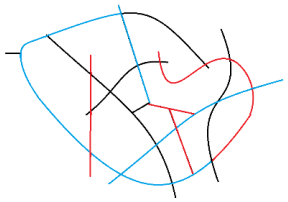


Figure 2.2: Characterizing links bicycle network

Step 2.b - Characterizing links in the current network
In this step all existing bicycle infrastructure is investigated and is included in the map. A division is made between the following road categories:

- Bicycle path
- Bicycle boulevard
- Road with separate bicycle paths on both sides
- Road with separate bicycle path(s) in two directions
- Road with bicycle lanes

The division between the roads is made by use of the information given on the map by the Fietsersbond (Fietsersbond, 2020), by use of Google Maps aerial view and Google Maps street view. The map provides insight in the location of the bicycle infrastructure.

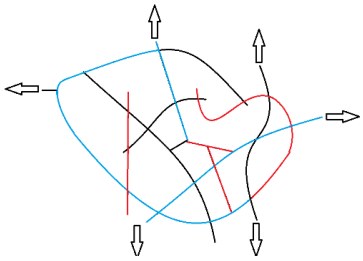


Figure 2.3: Define connection higher scale network

Step 2.c - Define connection with the higher scale network
The connections to the higher scale network are included in the map. Announced fast cycle routes by the province of Utrecht (Provincie Utrecht, n.d.) and by the local government are highlighted. If the trace of the fast cycle route is unknown (in case of the fast route to Baarn, Bunschoten and Veenendaal) a logical choice is made based on the shortest route between the cores of both places and the available infrastructure. These choices are motivated in the text.

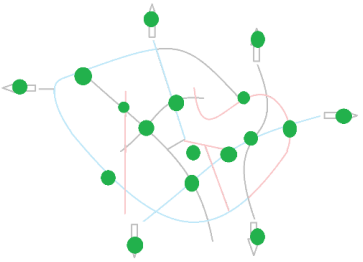


Figure 2.4: Highlight important trip generators

Step 2.d - Define important trip generators within the network
Public Transport-nodes (PT-nodes), public buildings, schools and shopping centers are mapped. The entire city center as important destination was highlighted. Relevant information of the locations is found by Google Maps.

Step 2.e – Investigating the use of the network
In this part of the research the use of the network is investigated. This is done by connecting the important trip generators found in the previous step with each other and with the provincial fast cycle routes found in step 2.c. These connections are made with the help of the route planner of the Fietsersbond (Fietsersbond, 2020). This step has resulted in a map with all cycling routes that are now an important part of the current cycling network.

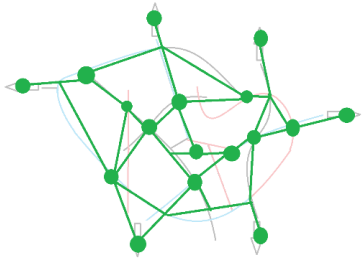


Figure 2.5: Connect important trip generators

In addition, it is examined which links in the network are already being driven at a higher speed (> 20km/h). These routes are determined by making use of the data provided by the Nationale Fietstelweken in 2016 (Fietstelweken, 2016).

2.4 Step 3: Redesign bicycle network Amersfoort

Figure 2.6: Design fast cycle network

Step 3.a - Redesign network
In the last step of this study, a redesign of the bicycle network in Amersfoort was made. The requirements found in step 1 were included in this redesign. The major outcome of this step was the development of a fast cycle network throughout the city of Amersfoort. This led to a network, (1) which is connected with the provincial network, (2) which connects the entire city smoothly and (3) which is accessible for all bicycle users.

In finding a suitable location for fast cycle routes, map material from the previous steps is used. A bicycle route was upgraded (1) if already good bicycle infrastructure is available and (2) if a bicycle route forms an important connection within the city or towards other places. For the fast cycle routes, it is roughly determined what type of infrastructure is necessary to meet the requirements.

During the design, the program Microsoft Visio is used. The new design is made in a new layer on top of the other maps.

This step results in an overview (a map) displaying redesigned bicycle network and in an concise list summarizing the adjustments that have to be made in the infrastructure sorted by hard measures and soft measures.

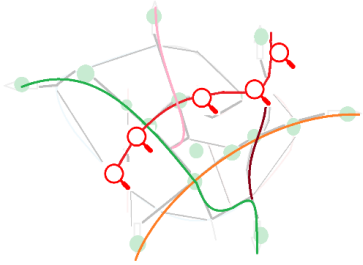


Figure 2.7: Design fast cycle route

Step 3.b - Redesign at corridor scale
In this part of step 3 it is investigated how the fast cycle network can be realized and how this network should be designed. This was done using the map with the current infrastructure (found in step 2.b) and using Google Maps. An extensive list of measures which can be found in appendix C has been made with exactly what must be done where.

In addition, two fast cycle routes are chosen and a more elaborated design of these fast cycle routes are made, as prototype for the other fast cycle routes. In this design the guidelines stated in appendix A are used. The infrastructure required is examined, such as the introduction of traffic lights, priority schemes or bicycle tunnels.

The product of this step is an overview listing required infrastructure needed for every examined fast cycle route and some explanatory maps.

2.5 Assumptions

In this project some assumptions are made beforehand.

Bicycle freeways of the province of Utrecht stated in the plans of the province (Provincie Utrecht, n.d.), are considered as already constructed. These bicycle freeways are integrated in the redesign of the network.

For announced projects in the municipality of Amersfoort the same holds. Projects planned to be realized before 2025 (they are listed in chapter 3.5), are regarded as completed.

2.6 Demarcation

In this study, other networks like the Public Transport network (PT-network) and the road network are considered in a limited way. The impact of the construction of a fast cycle network on the use of these networks will not be examined. However, the PT-network is regarded at places where a

transfer is offered between public transport and bicycle traffic (for example at the stations). The road network is regarded in case that a road section is part of the bicycle network (like access roads).

The main research is done on network scale. In the last stage of the project, at corridor scale only 2 fast cycle routes are regarded. This study mainly focuses on a larger network scale, so elaborate details at crossing levels are not worked out (only a direction is provided which type of roads needs to be used).

Because this study focuses on cyclists over a longer distance (trips to another neighborhood or even further) and with higher speeds, cyclists over the short distance (staying within the same neighborhood) are disregarded. However, the design of fast cycle routes has strived to limit the nuisance of cyclists over the short distance (such as children going to school). The fast cycle routes are designed in such a way that these users can also use the fast cycle route if they need them.

This research is a traffic engineering approach. No research has been done into the costs of constructing a fast cycle network.

3. Criteria required for fast cycle network

This chapter mainly consists of research into relevant literature and information on the subject. It also includes design choices that are made in case more design options are possible. These choices are indicated in the text by means of an arrow (➔). The final assessment and design criteria are summarized in a clear list. This list can be found in appendix A.

The points, fast cycle network, accessibility and bicycle infrastructure are successively elaborated in the order of the steps described in chapter 2. Chapter 3.4 describes the lay-out of to two different bicycle freeways going through build-up area. Chapter 3.5 contains an explanation of the requirements of the municipality of Amersfoort, derived from the bicycle plan (Gemeente Amersfoort, 2016) and from the province of Utrecht.

3.1 Design fast cycle network

The goal of this study is to realize a fast cycle network through the city of Amersfoort. This bicycle fast network complements the current main bicycle network and must ensure fast connections throughout the city.

The main requirements belonging to the success of a bicycle network are cohesion, directness, safety, comfort and attractiveness (CROW, 2016). In the design of an urban network, the different design aspects have a different priority. The order of priority is: Safety, Directness, Cohesion, Comfort and Attractiveness (Mobiel Vlaanderen, 2017).

➔ In this study, a fast cycle network is designed. For a fast network the design aspect *directness* is the first parameter taken into account when starting designing. Therefore the following order of focus is used: Directness, safety, cohesion, comfort and attractiveness. This is about the focus, safety must in any case be guaranteed first!

Directness – Directness can be regarded in two ways: directness in distance and directness in time. The directness in distance can be determined by the detour factor (dividing the travel distance by the distance as the crow flies). For main bicycle routes a maximum detour factor of 1.25 should be maintained. The directness in time is the degree of smooth flow on the intersections. Speed reduction can be caused by curves, traffic lights and intersections where cyclists have to give way (CROW, 2016).

Safety - Safety at networks can be realized taking the following into account: Avoiding conflicts with crossing traffic, separate vehicle types, reduce speed crossing traffic at conflict points, recognizable road categories and uniform traffic situations (CROW, 2016). For fast cycle networks the following 4 points can be derived. (1) Number of intersections with other traffic has to be minimized, (2) priority at the bicycle route, (3) uniform layout of a recognizable road network and (4) bicycles not on the car lanes, but separate bicycle paths.

Cohesion - Cohesion stands for the degree to which the network is complete and coherent. The mesh size (the distance between different links in the network) is a good indicator for this. To reach as many addresses as possible, a low mesh size is ideal. On the other hand, more input points lead to more intersections. The optimum for main bicycle routes is a mesh size of 300 to 500 meters (CROW, 2016).

Comfort - The comfort of a network depends on several variables: First of all, the road pavement should provide sufficient comfort. A wide bicycle path with a generally flat pavement is preferred (Fietsberaad CROW, n.d.). In addition, it is important that finding your way through a network is less complicated. This means the structure of the network has to be understandable (CROW, 2016).

Figure 3.1: Blue line marking the course of the route (Mobiliteitsplatform, 2018)

This can be done by means of landmarks during the route through which users create a 'mental map' (CROW, 2016). Signaling at crossings should be clear and visible. In addition, at intersections the route of the fast cycle route must be immediately visible to users (Fietsberaad CROW, 2016). As an example, this can be done by the blue line that marks the route (Mobiliteitsplatform, 2018).

Attractiveness - Attractiveness is achieved through good social safety and an attractive environment, which make the use of the bicycle route more pleasant. In addition, efforts should be taken to make noise levels as low as possible (CROW, 2016).

3.2 Accessibility road users

One of the 3 spearheads in this study is to make a bicycle network suitable for all types of bicycles. Exceptional vehicles are the speed-pedelec and the cargo bike. In particular for the speed-pedelec, there are separate regulations which are regarded in this chapter.

Speed-pedelec - The speed-pedelec is a fast e-bike that can reach speeds of up to 45 km/h. For this reason, this bicycle is legally categorized under mopeds. This means these bicycles are not allowed on bicycle paths in built-up areas and have to drive on the carriageway (Gelderen, 2017). Speed pedelecs driving on carriageways regularly lead to aggressive reactions by fellow road users (Adviesraad Snelfietsroutes Provincie Utrecht, 2020). That makes the use of this bicycle unattractive. In the province of Gelderland, these regulations have been partially reversed and speed-pedelecs are allowed on bicycle paths with a 'speed-pedelecs toegestaan' sign (Keypoint Consultancy bv, 2018). As an alternative to the car, the speed-pedelec fits in the policy of the municipality of Amersfoort. To accommodate users of the speed-pedelec, the municipality has initiated a research to allow these bicycles on the bicycle path (Kreekel, 2020).

Figure 3.2: Speed-pedelec allowed on bicycle path (Rottier, 2019)

The province of Utrecht, in collaboration with the cyclists' union, ANWB and Veilig Verkeer Nederland, published a brochure for municipalities with advice on how to deal with the speed-pedelec. They advise to allow the speed-pedelec on the main bicycle routes, only if the bicycle path is wide enough to allow safe overtaking (2.5 meters wide for one direction, 4 meters wide for 2 directions) and if there is no safe alternative route available. A safe alternative route is a route where the speed-pedelec driver does not have to detour too far and where 85% of motorists drive slower than 45 km/h (Adviesraad Snelfietsroutes Provincie Utrecht, 2020).

- ➔ One of the spearheads of this study is to introduce a network available for all types of bicycles. Therefore, a network has to be available suitable for the speed-pedelec. All fast cycle paths meeting the criteria stated above, have to be provided with the sign "speed-pedelecs toegestaan". Only where the bicycle path does not meet the criteria of the province, the speed-pedelecs are not allowed on the bicycle path. The aim is that the speed-pedelec can use a complete and safe network in the city.
- ➔ On the fast cycle routes the speed-pedelec has a speed limit of 30 km/h. This speed limit holds also for mopeds on a moped and bicycle path (Scooterbelang, n.d.).

Cargo bike - In the bicycle plan of the municipality of Amersfoort, the cargo bike is also mentioned. The cargo bike is an old means of transport, but it has certainly not disappeared from the streets. Cargo bikes are nowadays used as a replacement for the car, for example, to be able to do the shopping or bring children to school. The municipality promotes new innovations such as the use of the cargo bike, e.g. for parcel delivery service (Gemeente Amersfoort, 2016).

For cargo bicycles it is important that the bicycle paths are wide enough for safe overtaking or passing. In addition, research into cargo bicycles in the city of Ghent shows that, due to the poorer maneuverability of the cargo bike, as much efforts as possible should be made to obtain high-quality bicycle infrastructure separated from car traffic in order to create more safety and comfort (Ronse, 2012).

3.3 Bicycle infrastructure

Bicycle boulevard – The bicycle boulevard is a type of road where the bicycle is more important than the car. This means that the bicycle boulevards provide a safe and good flow of higher numbers of cyclists and also provides access for cars (Fietsberaad CROW, 2016). Bicycle boulevards are most common in main bicycle networks going through 30 km/h zones. At these routes the intensity of the cars has to be low and the intensity of bicycles high. In this way car drivers are already forced to drive with a lower speed (Fietsberaad CROW, n.d.).

Figure 3.3: Example of bicycle boulevard (Fietserbond Friesland, n.d.)

The layout of bicycle boulevards can differ. The following criteria apply to the design of bicycle boulevards. The bicycle boulevard is profitable if the car intensity is below 2500 vehicles per 24 hours. Furthermore, the layout of the boulevard is important. The rebate strip (the gray space at the edges of the roadway) affects the location of the bicycle on the road. A wide rebate strip makes cyclists ride more to the center, making overtaking for cars less easy. A narrow rebate strip makes cyclists ride more to the side, which makes overtaking easier resulting in higher speeds for cars.

➔ To make fast cycles able to overtake, a narrow rebate strip (50 cm) is used in the design. To limit overtaking by cars, a black central strip can be introduced on wider bicycle boulevards, like shown in figure 3.3. This strip is built up from asphalt and not from brick, to prevent cyclists from falling because their wheels get caught in the strip.

At intersections with minor roads, priority is primarily given to the bicycle boulevard. However, if the traffic intensity is too high on the bicycle boulevards, traffic lights have to be used. Parking, loading and unloading has to have special facilities, next to the bicycle boulevard (Fietsberaad CROW, n.d.). Uniformity among the bicycle boulevards is important. In Amersfoort, the sign L51 with the text “fietsstraat, auto te gast” is used. This sign is used in 59% of the cases in the Netherlands (Mobiel Vlaanderen, 2017).

Bicycle freeway - The bicycle freeway is a new type of infrastructure with wide bicycle paths with predominantly priority situations (Moed, 2012). The bicycle freeway is usually seen as a means of promoting the bicycle as an alternative to the car, with the aim of contributing to traffic congestion problems (Andringa, 2019). Most bicycle freeways in the Netherlands have been built between multiple cities. Examples are the F35 in Twente, the F59 between Den Bosch and Oss and the RijnWaalpad between Arnhem and Nijmegen.

All bicycle types are allowed on the bicycle freeway, so you are allowed to drive slowly, but the infrastructure is aimed at allowing you to cycle on smoothly. The design of bicycle freeways can differ.

In addition to the term bicycle freeway, the term fast cycle route is also used. It is often a political choice which name is best to use, since the term bicycle freeway is more reminiscent of straight bicycle paths with viaducts, while the term fast cycle route sounds 'softer' (Moed, 2012).

Although these fast cycle routes are intended to move in a fast way over a longer distance (for example between different places), they are not comparable to the Dutch long bicycle routes (LF routes). Like the fast cycle routes, these LF-routes are also intended for cycling between different places, but they have a more recreational character (Nederland Fietsland, n.d.). For this reason, these routes often deviate from the shortest cycling route and are therefore not suitable for fast cycle traffic.

In the province of Utrecht, the more cautious name 'fast cycle route' has been used more (Provincie Utrecht, n.d.), although the fast cycle route Amersfoort Utrecht has been given a bicycle freeway number F128 (Hendriksen & Boshouwers, 2017).

➔ Within urban areas it can be very difficult to realize a full-fledged bicycle freeway, consisting of 4-meter-wide bicycle paths. In line with the province of Utrecht, the safer term 'fast cycle route' is used.

3.4 Reference projects

In this chapter some comparable projects, with bicycle freeways through urban area, are regarded. Two examples are the F35 in Twente at Almelo and the 'Rijn Waal pad' between Arnhem and Nijmegen.

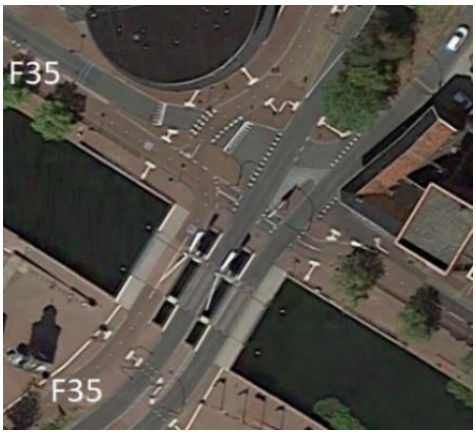


Figure 3.4: Example intersection F35 (Maps, 2019)

F35 – The F35 through Almelo is part of the F35, a connection between Nijverdal/Vriezenveen and Oldenzaal/Glanderburg via Almelo, Hengelo and Enschede. The F35 is already at an advanced stage. A large part of the route had to be completed by 2020 (Fietssnelweg F35, 2015).

The bicycle freeway through the city of Almelo mainly consists of a 4 meters wide bicycle path. The trace to Vriezenveen goes along the main road and the trace to Borne goes along the railway line. At crossings with main roads traffic lights are applied. At crossings with other types of roads, cyclists on the bicycle freeway have priority. Also at intersections with other bicycle paths users of the F35 get priority. Figure 3.4 shows an example of an intersection with the F35.

On one single road section the bicycle freeway is also an access road for cars. This road section is constructed as one-way street for cars. The red asphalt alerts people they are on a bicycle freeway.

The F35 can be recognized by the red asphalt, the blue columns at the start of every road section and the blue marking F35 on the asphalt. Along the entire F35 speed-pedelecs are allowed. This can be seen by the sign 'speed-pedelec toegestaan'.

RijnWaalpad – The 'RijnWaalpad' is a bicycle freeway between Arnhem and Nijmegen. This freeway consists mainly of wide bicycle paths. In urban areas some interruptions occur: In Nijmegen (Lent) the bicycle freeway has been constructed as bicycle boulevard. At the crossing

with the N325 (at the railway station) a bicycle tunnel is located. In Arnhem (South) the bicycle freeway is constructed on top of an old dyke. This part serves also as an access road for cars.

Figure 3.5: Signage RijnWaalpad (BicycleDutch, 2015)

The RijnWaalpad can be recognized by the everywhere wide bicycle paths with the red asphalt and the clear signaling along the route (see figure 3.5).

➔ From this study on reference projects some aspects are considered, which are included in the design: (1) Bicycle freeways through urban area are made clearly recognizable. In addition to the comfortable red asphalt, bicycle freeways are made recognizable by roadside signs and signposts. (2) The course of the road remains clearly visible to the user, and the user has no difficulty at intersections to continue to follow the bicycle freeway. (3) In places where cars still have to come, the aim should be to minimize the number of cars for example by introducing one-way traffic.

3.5 Demands of governments

When redesigning the bicycle network of Amersfoort, announced projects have to be taken into account. First of all, the vision and bicycle plan of the municipality are summarized. In addition, the underlying plan of the province is taken into consideration.

Municipality of Amersfoort - The municipality of Amersfoort expects to grow from 150,000 to 170,000 inhabitants within 20 years. To keep the city livable, the municipality wants to improve bicycle traffic. This is described in the bicycle plan of the municipality (Gemeente Amersfoort, 2016). According to the plan, it is envisaged that within the city ultimately 60% of the journeys will be by bicycle (currently 52%). Movements to destinations outside the city have to grow from 10% to 20%. This must be achieved by the following points of attention.

- Realization of a complete bicycle network, which connects residential areas, work areas, public transport hubs, school locations, crowd pullers, the city center, the hospital, sports complexes and surrounding places. To achieve this, (1) missing links are being realized, (2) an investigation has been initiated into through-routes along the city center, (3) small bicycle bottlenecks have been tackled, (4) a signage plan has been drawn up and (5) bicycle-friendly traffic lights have been introduced. The municipality also wants to connect the network to the regional bicycle network.
- Improve bicycle facilities. The range of guarded parking facilities will be increased in the city center and at the public transport hubs.
- Increase safety and vitality. The number of bicycle crashes must be reduced. Social safety on bicycle routes must be guaranteed.
- Cyclists priority in design of new projects. The next major projects will be realized in the near future. These plans are included in this project.
    - Construction Veentunnel as part of the fast cycle route Amersfoort – Nijkerk (Gemeente Amersfoort, 2019).
    - Westelijke ontsluiting. This plan provides an improved connection between the Stichtse Rotonde and the Amsterdamseweg as last part of the ring around Amersfoort. This plan includes a new bicycle viaduct over the railway line Amersfoort – Utrecht (Gemeente Amersfoort, 2017).
    - Project knooppunt Hoevelaken. A large-scale project is the approach of the Hoevelaken junction. Included is also the widening of the A1 and A28 around Amersfoort. This plan includes a new bicycle path between industrial area De Hoef

and sport complex Amerena. Bicycle tunnels are also being constructed at A1 exit 14 (Rijkswaterstaat, 2018).

Province of Utrecht – The province of Utrecht has the ambition to become bicycle region of Europe, to catch up the expected increase of inhabitants and the pressure on the road and PT-network (Provincie Utrecht, n.d.). The following fast cycle routes are announced (Provincie Utrecht, n.d.):

- Utrecht – **Amersfoort**
- Utrecht – Woerden
- Utrecht – IJsselstein
- Utrecht – Veenendaal
- **Amersfoort** – Baarn – Hilversum
- **Amersfoort** – Bunschoten-Spakenburg
- **Amersfoort** – Veenendaal

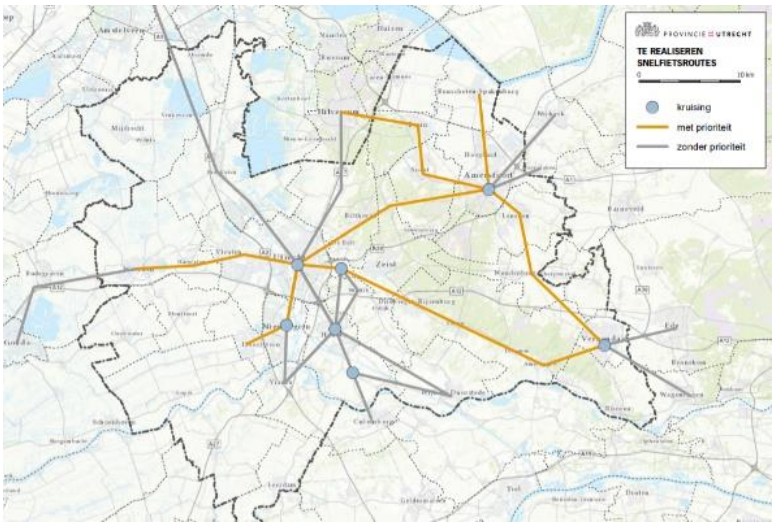


Figure 3.6: Announced fast cycle routes in province of Utrecht (Provincie Utrecht, n.d.)

4. Current bicycle network

This chapter provides knowledge and information about the location and use of the current main bicycle network in the city of Amersfoort. The maps shown in this chapter are also included in appendix B, on A4 scale.

4.1 Main bicycle network

In figure 4.1 the current main bicycle network is shown. This map also projects the routes with average speed higher than 20 km/h, according to the measurements of the Nationale Fietstelweken in 2016 (Fietstelweken, 2016).

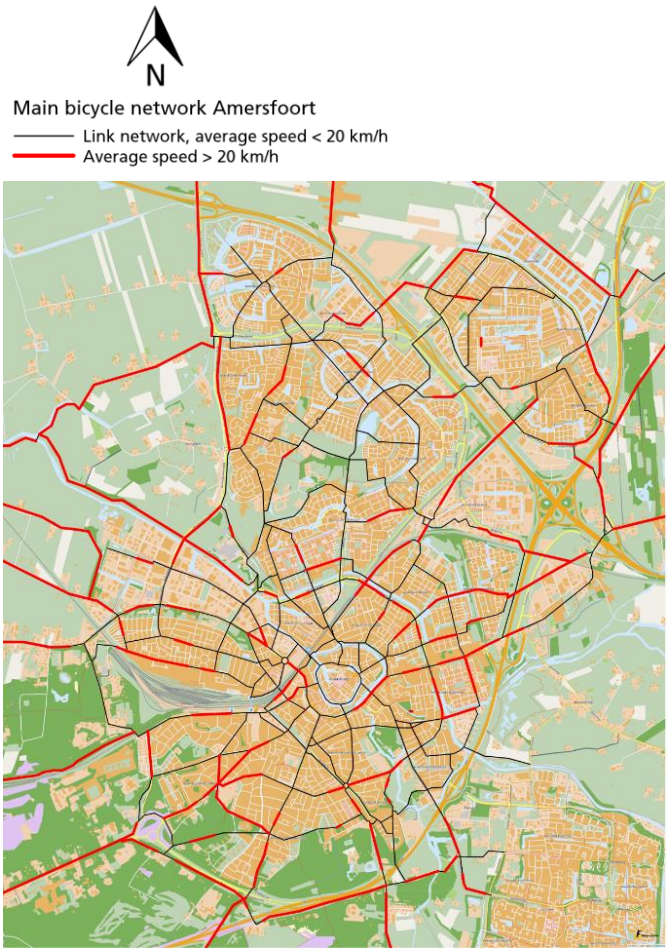


Figure 4.1: Main bicycle network Amersfoort

From the map it can be derived that the structure of the network is ring-radial (Nes, 2018) in the southern parts of the city. In the northern parts of the network the structure of the network consists of longer bicycle routes going towards the center. The quarter Vathorst (in the North-East) has its own radial structure and is poorly connected with the rest of the city.

It can be concluded that the railway line through the city and the freeway around the city form a barrier between the different parts of the city.

The red lines in figure 4.1 are the routes with average speeds of bicycles higher than 20 km/h. Most of these lines are outside the core of the city. Also in the city there are several spots with a high average speed. When comparing with figure 4.2, it appears most red lines are located on roads with bicycles driving on the car lanes. A reason for this could be that cyclists on these roads move within the faster car traffic and therefore drive faster. On busy bicycle paths with less available space, the average speed of bicycles is lower.

4.2 Bicycle infrastructure

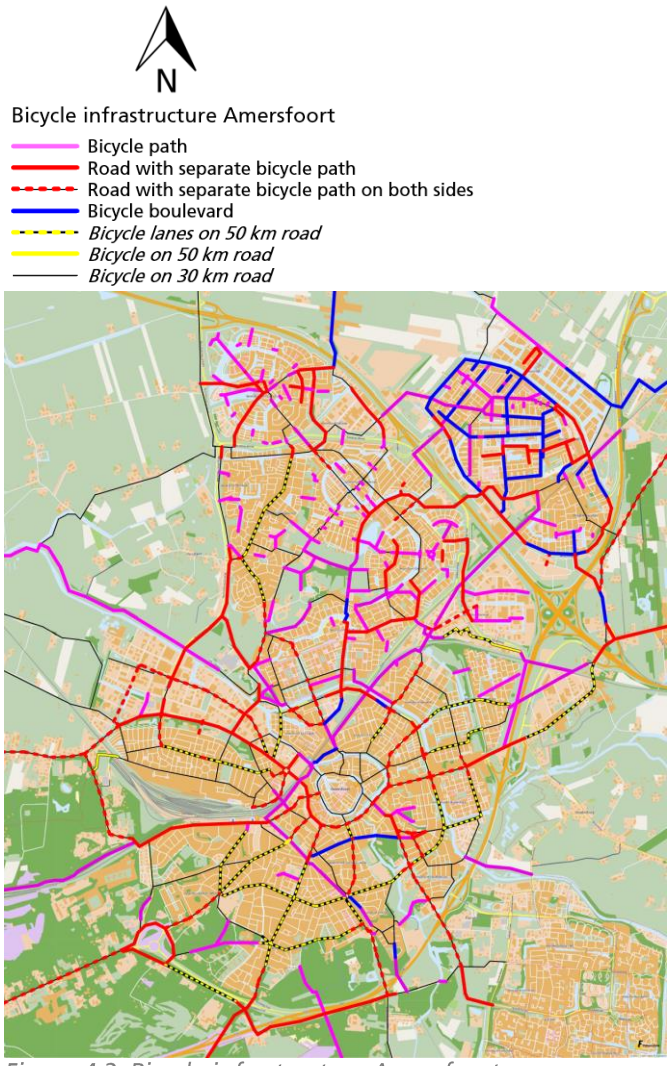


Figure 4.2: Bicycle infrastructure Amersfoort

In figure 4.2 the dedicated bicycle infrastructure in Amersfoort is highlighted. Bicycle paths and roads with separate bicycle paths are regarded as dedicated bicycle infrastructure. Also bicycle boulevards are added to this category because car drivers are forced to drive with a low speed. At the other corridors no dedicated infrastructure for bicycles is available and bicycles have to drive amongst the other traffic.

In this map, bicycle routes through the city can be recognized where a lot of bicycle infrastructure is already available. This is particularly the case with the axis between the center and quarters in the north of the city. Especially in the southern part of the city, cyclists have to drive within other traffic and only bicycle lanes are available.

4.3 Use of the bicycle network

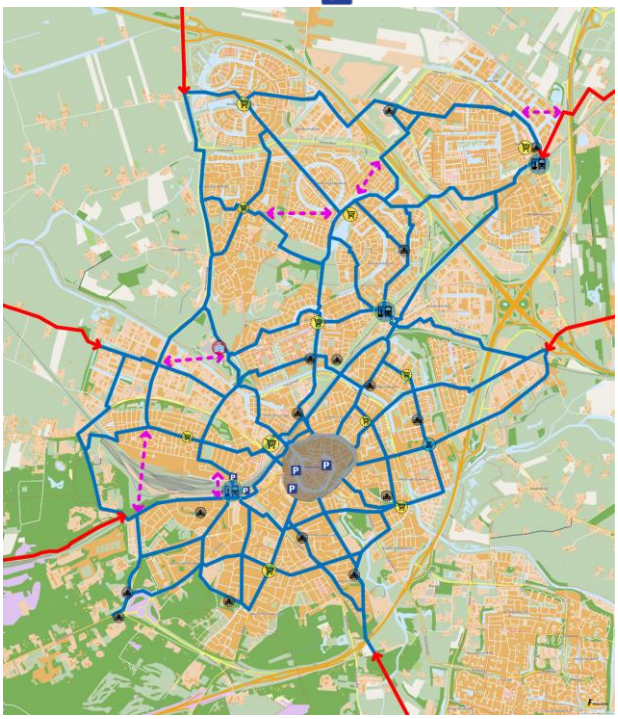


Figure 4.3: Use bicycle network Amersfoort

Figure 4.3 outlines the use of the network, indicating the main routes connecting these points. Important origins and destinations within the city are made visible (see also figure B.3).

The blue lines are suggested important routes connecting the origins and destinations via the current bicycle network. A global hierarchy is made in the origins and destinations in the following order:

- Fast cycle route Utrecht
- City center
- PT-nodes
- Shops
- Other destinations
- Schools

City center – At the city center a high number of cyclists is expected. Therefore, the entire city center is highlighted figure 4.3. The guarded bicycle storages in the center are visualized.

PT-nodes – The only regarded Public Transport nodes are the stations Centraal, Schothorst and Vathorst. Stations are important transfer spots between train and bicycle. Large parking facilities for bicycles are available. Amersfoort Centraal and Amersfoort Schothorst are equipped with a guarded bicycle storage. All stations have OV-fiets facilities.

Bus stops are not included, because most bus passengers walk to the bus stop or cycle not that long.

Shops – To include every quarter of Amersfoort, in figure 4.3 the shopping centers or supermarkets in the core of each quarter are visualized.

Schools – Schools marked in figure 4.3 represent secondary schools and high schools. A high amount of the students come by bicycle. Primary schools are not included, because most children go to school in the neighborhood and do not cycle that long.

Other locations – Other important hotspots in Amersfoort are the Amerena (a sports and swim complex) and the hospital Meander. At both locations bicycle storages are available.

Fast cycle routes Utrecht - The regional fast cycle routes going to Amersfoort are indicated in figure 4.3 with red arrows. Figure 4.4 is a map of the region of Amersfoort, showing exactly how these provincial fast cycle routes go. The province of Utrecht has already determined where these fast cycle routes have to come, however, for not every route the trace is known. Choices made about the trace of these routes are set out below.

- Utrecht - For the route from Utrecht, the trace was taken from the fast cycle route F128 (Hendriksen & Boshouwers, 2017).
- Leuden/Veenendaal - The trace of the fast cycle route from Veenendaal and Leusden has not yet been determined. Previous studies have shown that a route along the former Amersfoort - Veenendaal railway line is a reasonable option. Local politicians are already discussing the construction of a bicycle freeway along the railway line (Leusderkrant, 2019). Because this trace also fits in well with the current main network, this trace is chosen.
- Hoevelaken - The current trace is used for the fast cycle route with Hoevelaken. This route is the only bicycle connection between both places.
- Nijkerk - The fast cycle route to Nijkerk is largely realized. The necessary infrastructure is also available on most parts of the route (Gemeente Amersfoort, 2019).
- Bunschoten - The trace of the fast cycle route towards Bunschoten is not yet known. Two routes are available between the locations: the route via the provincial road and via the Zevenhuizerstraat. Both routes are bicycle boulevards and suitable to become fast cycle route. However, the higher intensity of cars on the Zevenhuizerstraat makes this road unsafe (AD, 2019). Therefore, the route along the N199 is selected as fast cycle route to Bunschoten.
- Baarn/Hilversum - The trace of the fast cycle route towards Baarn and Hilversum via Soest is not yet known. Because the A.P. Hilhorstweg along the railway line forms a direct connection with Hilversum and Baarn, this trace is regarded as a fast cycle route. This route also fits in well with the current bicycle network.

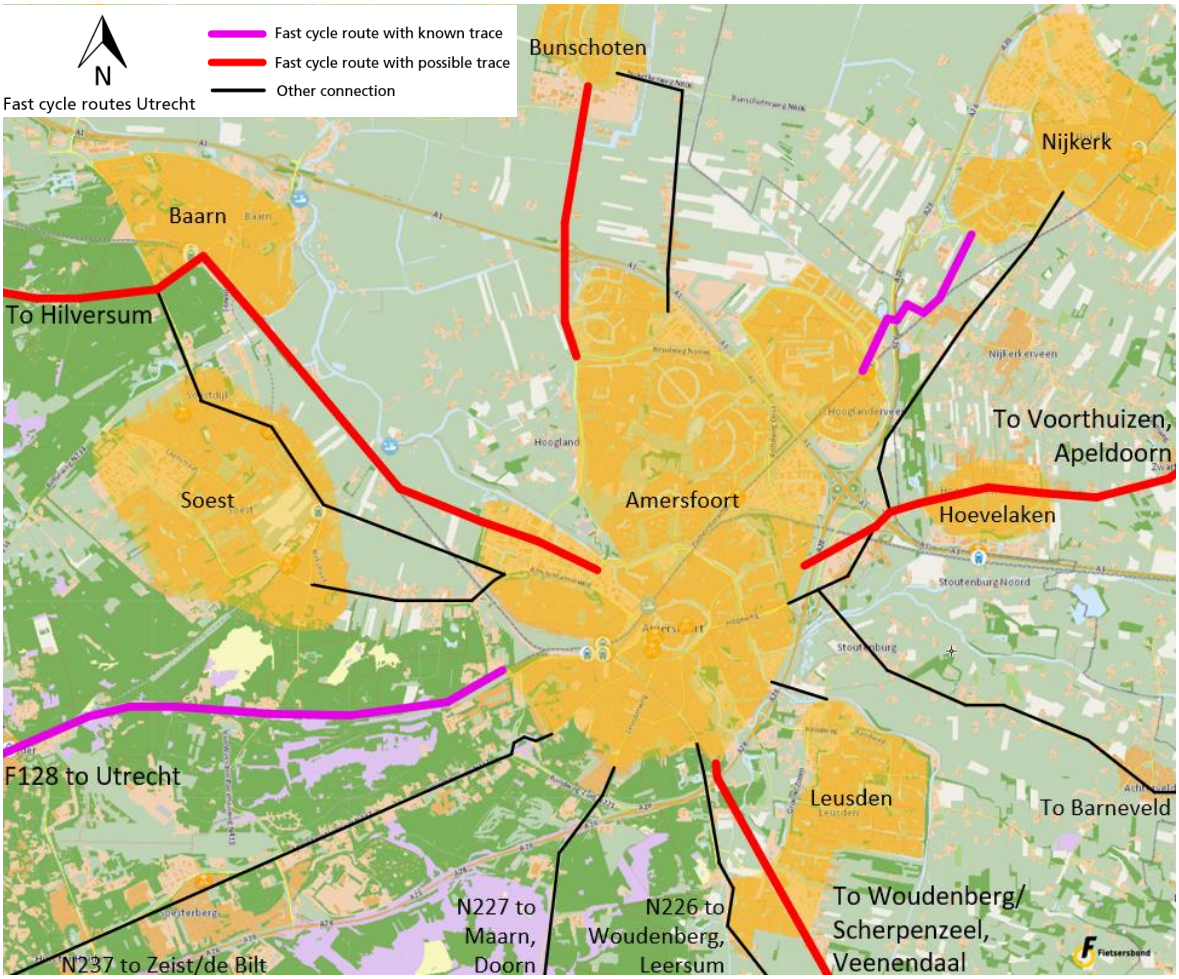


Figure 4.4: Fast cycle routes province of Utrecht

5. Redesign bicycle network Amersfoort

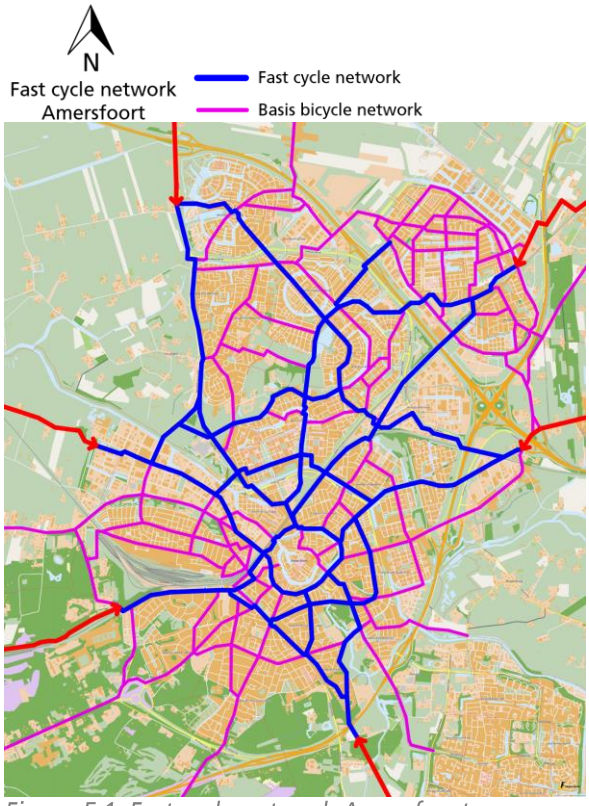


Figure 5.1: Fast cycle network Amersfoort

This chapter presents the redesign of the bicycle network of Amersfoort. In figure 5.1 this redesigned network is shown. It was decided to build the main bicycle network from two different levels: the *fast cycle network* and the *basis bicycle network*. The fast cycle network has been designed according to the design criteria stated in appendix A and is further explained in chapter 5.1. The basis bicycle network was introduced in case a fast cycle route is unsuitable. This network supplements the fast cycle network. More details about this network can be found in chapter 5.2.

Chapter 5.3 motivates design choices that have been made. In chapter 5.4 all measures that have to be done to realize the fast cycle network are listed. In chapter 5.5 the signage is discussed. Two fast cycle routes are elaborated more into detail in chapter 5.6 and 5.7. Chapter 5.8 contains information about the admission of speed-pedelecs on the fast cycle network.

The maps shown in this chapter are also included in appendix B, on A4 scale.

5.1 Fast cycle network

The fast cycle network is the backbone of the main bicycle network through Amersfoort. It is structured according to the three spearheads described in chapter 1. (1) The network is integrated in the fast cycle network of the province of Utrecht, (2) it connects all quarters of Amersfoort and (3) it is suitable for all types of bicycles. In addition this network meets the design criteria for fast cycle networks found in chapter 3.

This network is built up form routes meeting the following criteria:

- Sufficient bicycle infrastructure is available according to the design criteria.
- The bicycle route forms an important connection within the city or towards other places.

To create a complete network, these connections have been supplemented by several other fast cycle routes only meeting the second criteria. All parts of the fast cycle network have a detour factor lower than 1.25.

By connecting the different links in this fast cycle network, 9 fast cycle routes going through Amersfoort can be created. These routes form together the entire fast cycle network. These routes are shown in table 5.1 and figure 5.4. In table 5.1 it is shown for each route what the detour factor is.

Number	Length (km)	As the crow flies (km)	Detour factor	Fast cycle route
0	6,5	-	-	Centraal Station - Euterpeplein - Neptunusplein - Schothorst Zuid - Isselt
1	6,1	5,4	1,13	Baarn - Isselt - Centrum - Vermeerkwartier - Leusden
2	9,8	8,6	1,14	Bunschoten - Nieuwland West - Hoogland West - Meander Hospital - Centrum - Randenbroek - Leusden
3	4,5	4,1	1,10	Vathorst - Kattenbroek Emiclaer - Schothorst - Centrum
4	8,9	7,9	1,13	Nijkerk - Vathorst Station - Schothorst Station - Centrum - Centraal Station - Bergkwartier Noord - Utrecht
5	4,6	4,2	1,10	Hoevelaken - Rustenburg - Liendert - Neptunusplein - Centrum
6	7,6	6,1	1,25	Hoevelaken - Schothorst Station - Schothorst Noord - Meander Hospital - Isselt - Baarn
7	5,4	4,6	1,17	Bunschoten - Nieuwland - Kattenbroek - Zielhorst - Schothorst Station
8	3,9	3,3	1,19	Nijkerk - Vathorst Station - Vathorst - Kattenbroek Emiclaer

Table 5.1: Fast cycle routes going through Amersfoort

5.2 Basis bicycle network

The basis bicycle network forms, together with the fast cycle network, the main bicycle network of Amersfoort. The basis bicycle network has been introduced because it turns out to be impossible to provide all parts of Amersfoort with suitable fast cycle routes. Basis bicycle routes are introduced in the following cases:

- In the context of directness, it has often been decided to plan a fast cycle route around a residential area and not via the core of the residential area. The core is made accessible via a basis bicycle route.
- The structures of the residential areas were created in such a way that there is no single main bicycle corridor, but cyclists pass through the neighborhood via various through routes. These through-routes are included in the basis bicycle network.
- There are many bicycle routes and movements near the center of Amersfoort. Allocating certain fast cycle routes will result in an uneven distribution of cyclists over different routes (which is not beneficial for the fast cycle route). For this reason, the center is accessible by various basis bicycle routes.

The basis bicycle network is intended to feed the fast cycle network, but also to keep slower bicycle traffic off the fast cycle routes. In addition, the basis bicycle network contributes to good connections within a neighborhood. Because of the different functionality other criteria apply.

Intensity is normative for the lay-out of a basis bicycle route. In terms of design, the main bicycle network has to resemble bicycle connections that are common in the Netherlands:

- There is less need to strive for the absolute separation of cyclists from other traffic. If safety permits, bicycle lanes on the roadway are sufficient.
- The speed-pedelec, which needs special infrastructure, will not be allowed on bicycle paths of the basis bicycle network. The driver of the speed-pedelec has to make his way along the road to the fast cycle routes that are designed for the use of the speed-pedelec.
- Because the basis bicycle network is intended for relatively short distances and lower speeds, good pavement is not mandatory, but recommended. The same holds for the width of the bicycle paths.
- The basis bicycle routes do not necessarily have to have priority at intersections. At the connections between the fast cycle network and the main bicycle network, the fast cycle network has priority.
- It is important that the course of route is indicated, so one can find their way e.g. towards the fast cycle network (see chapter 5.5).

5.3 Design choices

Several design choices have been made to create a network according to the design criteria. In this chapter these choices are included and explained.

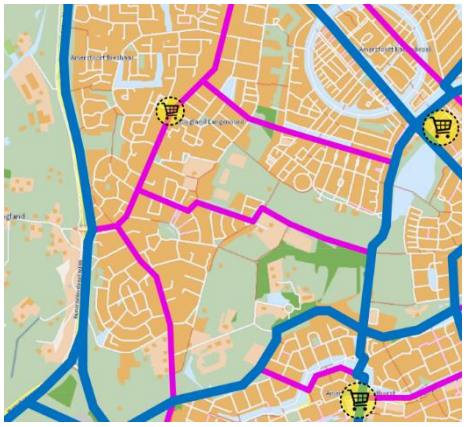


Figure 5.2: Fast cycle route around Hoogland

Around residential areas - The starting point for the design of a fast cycle network was the directness parameter. In the design, a choice was made to plan the fast cycle route around a residential area where possible, rather than through a residential area.

As an advantage this would lead to less slower bicycle traffic (such as children going to school) on the fast cycle route which makes driving with higher speeds easier. In addition, the bicycle route has fewer network access points and more space for a separate safe bicycle path is available. As a disadvantage this would lead to less convenience for cyclists with an origin or destination ín the neighborhood. To please this group, the core of this neighborhood will be connected then via the basis bicycle network.

Figure 5.3: Basis network applied in Vathorst

Existing road-structures in a residential area - The new quarter Amersfoort Vathorst (to the north of the A1) is constructed bicycle-friendly according to figure B.2. The structure of this bicycle network is mainly focused on trips through the neighborhood. Apart from the fast cycle connections to Nijkerk, this district will nót be provided with fast cycle routes, because this will detract the structure from its own bicycle network. The district will be connected via the current bicycle network (which will become part of the basis bicycle network) to the fast cycle network.

The same holds for the modern districts in the north of Amersfoort, Nieuwland and Kattenbroek, and for the network in the south of Amersfoort. The introduction of (many) fast cycle routes will contribute in a moderate way to fast cycling.

Center - Many bicycle connections converge in the center of Amersfoort. Figure C.1 shows that the average speed of cyclists in the center is low, which makes the center unsuitable for introduction of fast cycle routes. However, figure C.2 shows that there is a lot of bicycle infrastructure around the center (in particular the 'Stadsring').

In order to relieve the pressure on the center, a fast cycle route in a ring around the city center has been introduced. This ring must ensure that through-bicycle traffic will have to go as little as possible via the center. Instead cyclists can drive faster via the less used ring avoiding the city center. More about this ring can be found in chapter 5.6.

The other connections to the center are part of the basis bicycle network and will not become part of the fast cycle network.

Bicycle connections to other places - All fast cycle routes to other places have a direct connection to the fast cycle network of Amersfoort. However, there will also remain connections that form an important connection between Amersfoort and another place, which will not be converted into a fast cycle route. These bicycle routes are connected to the main network, which connects to the fast cycle network further down the city.

5.4 Measures to realize fast cycle network

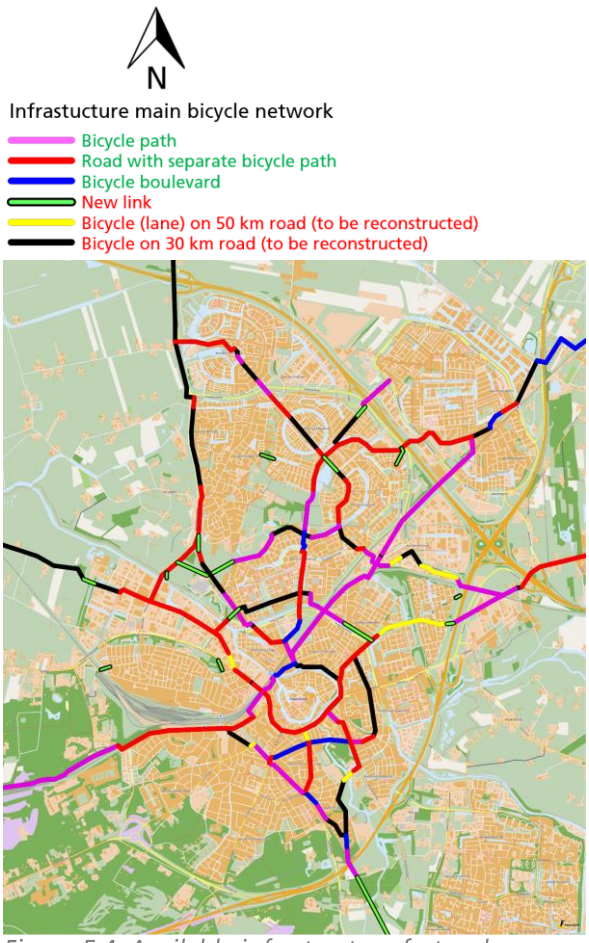


Figure 5.4: Available infrastructure fast cycle network

The fast cycle network is designed according to the requirements of a fast cycle network found in chapter 3. These criteria are also summarized in appendix A. As figure 5.4 shows, a large part of the network meets these requirements. Parts of the network have already been implemented as bicycle boulevards. Other parts of the network consist of separate bicycle paths. However, some of these bicycle paths will need to be adjusted if they (1) are not wide enough or if (2) they are not properly paved.

There are also parts of the network that have not yet been implemented in accordance with the requirements. The 50 km/h roads with bicycle lanes (shown in yellow in figure 5.4) have to be provided with separate bicycle paths. The access roads (shown in black in figure 5.4) have to be converted (1) into bicycle paths if cars can be banned, (2) into bicycle boulevards if the road must remain an access road for cars or (3) into a road with separate bicycle paths if the intensity of cars is high, for example an access road to a residential area. The aim should be that cyclists have to drive as little as possible within other traffic.

Al these described adjustments on the network and on the infrastructure can be summarized into hard measures and soft measures which are declared in table 5.2.

Hard measures
Introduction of missing links In other to complete the fast cycle network some new links have to be introduced. These links are made visible in figure 5.4. New links are introduced to limit detouring or if a needed road section fails. These new connections consist of 4-meter-wide bicycle paths designed according to the requirements. More details about the missing links with clarifying figures and explanation can be found in appendix E. Transformation of road sections Another hard measure is the transformation of road sections. In most cases access roads have to be converted either to bicycle boulevard or to a road with separate bicycle paths. This measure ensures that bicycle traffic is more often separated from other traffic Transformation of intersections In some cases, intersections have to be transformed. At the intersection of the Bunschoterstraat and the Boetzelaerlaan a new bicycle tunnel has to be constructed to let cyclists on fast cycle route 2 Bunschoten – Leusden pass this intersection without delay. At the roundabout connecting the Laan der Hoven with the Jonkvrouw Foeytweg, the bicycle paths have to be adjusted in a way that cyclists on fast cycle route 7 Bunschoten – Schothorst, can better pass the roundabout. The intersection of the Brouwersstraat and the Stationsstraat has to be redesigned because in the Brouwerstraat all cars will be banned. In the design the fast cycle route will be prioritized and the connection to the basis network will be improved.

Replace of pavements on road sections At some roads suitable infrastructure is available, but the pavements or the width do not match the criteria. This means that the pavement must be replaced here. Because this measure is relatively expensive, it is possible to wait until the economic life of the current road surface has expired when replacing the pavement.
Soft measures
Adjustments of priority schemes A soft measure is the adjustment of priority schemes. At some intersections, the designed fast cycle routes do not yet have priority on side roads. The priority system at these intersections must be adjusted if the intensity of traffic on the side road permits. Adjustments at traffic lights The design of the fast cycle network has attempted to minimize the number of conflicts with other traffic. At locations where conflicts arise, there is not always space to create a bicycle tunnel or a priority situation for cyclists, which means that there is a need to make use of (existing) traffic lights. By adapting these traffic lights to bicycle traffic, for example by using improved sensor techniques, the flow of cyclists can be significantly improved (Sterk, 2020). Introduction signage To achieve a network where all users can easily find their way (according to the comfort requirement), it is important that good signage is used. By clearly indicating the route course, one can pass intersections without slowing down. More information about signage can be found in chapter 5.5.

Table 5.2 Measures to complete the fast cycle network

In appendix C all the necessary measures to construct the fast cycle routes are listed in tables sorted on these types of adjustments (except for the adjustments at traffic lights and introduction signage).

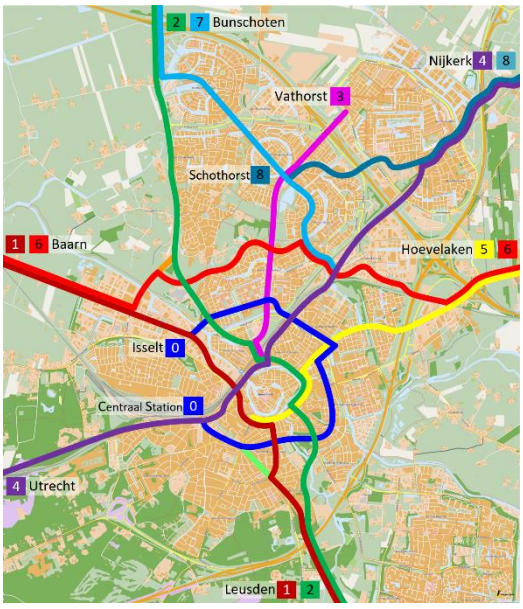


Figure 5.5: Map fast cycle network with numbers

5.5 Signage

According to the design criteria wayfinding has to be less complicated. This can be done by numbering the different fast cycle routes that go through the network, as is also common in bicycle cities such as Nieuwegein and Houten (Fietsersbond, 2015b). These numbers return on the signposts, so that one can easily follow a number. Information boards with the map (as shown in figure 5.5) can be placed at various points (for example at the access points of the network). In addition, the route numbers return at the lampposts (see figure 5.6). In this way people know exactly where they are.

Intersections must be provided with signage that is clearly visible when approaching the intersection (like the signs used on the RijnWaalpad). In this way, the cyclist can make a choice in advance which direction to take, which makes him able to focus on the other traffic at the intersection. In this way the cyclist has to reduce as little speed as possible.

Figure 5.6: Signs at lamppost with the number of the fast cycle route (Fietsersbond, 2015b)

Basis bicycle network – In the basis bicycle network it is also important that users can find their way. At intersections, it must be clear by means of signposts how the cyclist must proceed towards his destination or towards a fast cycle route.

5.6 Design fast cycle route Amersfoort Centraal – Euterpeplein – Isselt


Figure 5.7: Fast cycle route 'Circle'

The fast cycle route, which is indicated as route 0 in figure 5.5, goes in a semicircle around the city of Amersfoort (see also figure E.1). This route is intended to keep through-bicycle traffic from the center. In this way, through-bicycle traffic can pass the center without too much delay via this fast cycle route.

Because the fast cycle route goes in a circle, the route cannot be tested for directness.

As shown in figure 5.4, new bicycle paths have to be constructed on two parts of the route. Some other parts of the route have to be converted into bicycle boulevards. Some of these bicycle boulevards will be constructed as one-way road to reduce the number of cars.

Due to the round shape of the fast cycle route, at junctions with other fast cycle routes cyclist will turn off more often than cyclists continue the route. For this reason, this fast cycle route will always give priority to other fast cycle routes.

At the intersection with main roads with high intensity of cars, such as the Hogeweg and the Heiligenbergerweg, it was decided to give the main road priority on this fast cycle route. This is to prevent serious nuisance from car traffic. However, these intersections will be provided with speed bumps to slow down car traffic and refuge islands to make crossing easier. Various other intersections with main roads have already been equipped with a traffic light installation. By placing the right sensors and good coordination of the system on these intersections, too much delay for cyclists can be prevented. Cyclists have priority at intersections designed as roundabouts.

More detailed information about which adjustments have to be done on road sections and intersections is available in appendix D.

5.7 Design fast cycle route Leusden – Center – Baarn

The fast cycle route, which is indicated as route 1 in figure 5.5, connects the fast cycle route to Baarn with the fast cycle route to Leusden via the city center of Amersfoort (see also figure E.1). In this way this fast cycle route is also part of the provincial network of Utrecht as this route

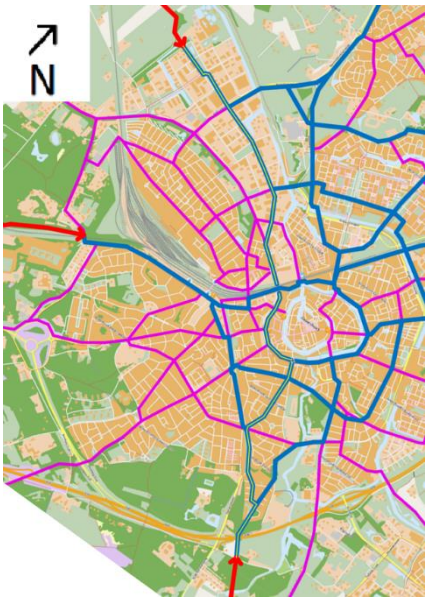


Figure 5.8: Fast cycle route 1 Leusden – Center - Baarn

connects Veenendaal, Woudenberg and Leusden with Soest, Baarn and Hilversum. In addition, this fast cycle route with a length of 5 km connects different parts of Amersfoort with the city center.

The total length of the fast cycle route is 6,1 km. The direct distance is 5,4 km, which gives this fast cycle route a detour factor of 1,12.

As can be seen in figure 5.4, a large part of this fast cycle route has already been constructed with separate bicycle paths. However, some parts of the route such as on the Nijverheidsweg-Noord, the pavement must be replaced and the bicycle path broadened.

On the Amsterdamseweg and on the Stadsring, the fast cycle route consists of a 4-meter-wide bicycle path. This bicycle path is located on the north side of the main road to minimize the number of conflict points with other traffic. Due to the high intensity on this part of the route, this part is less suitable for cycling at higher speeds. However, this part is still included in the fast cycle network because it is an important part of the network and there are no alternative routes available without too much detour.

In Dorrestein the bicycle path uses the access roads Dorresteinseweg and Diamantweg. These roads connect the bicycle path along the Kersenbaan with the bicycle path towards Leusden (see figure D.3). The Dorresteinseweg and Diamantweg will be reconstructed as bicycle boulevards with predominantly priority situations.

More detailed information about which adjustments have to be done on road sections and intersections is available in appendix D.

5.8 Admission speed-pedelec

As explained in chapter 3.2, the speed-pedelec is allowed on bicycle paths of the fast cycle routes, if no alternative route is available. An alternative route is a road where the average speed of car lies lower than 45 km/h and the intensity is low (Adviesraad Snelfietsroutes Provincie Utrecht, 2020).

Bicycle path - A large part of the fast cycle routes consists of bicycle paths. In some cases, these bicycle paths are located along a distributor road. Because these roads are often driven at 50 km/h, these roads cannot be seen as alternative and speed-pedelecs are therefore allowed on the bicycle path here. On these bicycle paths speed-pedelecs have to drive with a prescribed maximum speed of 30 km/h (Scooterbelang, nd). Some bicycle paths run along roads with an average speed of less than 45 km/h, like the Nijverheidsweg-Noord, the Vermeerstraat and the Paladijnenweg. On these roads, the speed-pedelec is not allowed on the bicycle path of the fast cycle route.

Bicycle boulevard - Another part of the fast cycle routes consists of bicycle boulevards. Because normal car traffic can also drive on this route, speed-pedelecs are allowed here. However, speed-pedelecs must adhere to the applicable speed limit of 30 km/h.

6. Discussion

In this chapter the results found in the previous chapters are discussed. Chapters 6.1, 6.2 and 6.3 criticize the research approach, discussing the predetermined goal, assumptions made and the use of data. The final result is criticized in chapters 6.4, 6.5 and 6.6. Chapter 6.7 provides a summary of this entire chapter.

6.1 Predetermined goal

In this study, which led to the redesign of the bicycle network of Amersfoort, it was established in advance that a fast cycle network should be created that had to meet certain requirements, as stated in chapter 1. From the focus to promote long-distance cycling at higher speeds, this redesign has arisen. This has led to the starting point of the redesign of the network being the design aspect *directness* as stated in chapter 3.1. Another approach of the research, for example how to make the city more accessible by bicycle, without a focus on creating fast cycle connections, could possibly have led to a different final design.

6.2 Assumptions network use

In chapter 4.3 in a qualitative way the use of the bicycle network in Amersfoort is determined. Important origins and destinations have been identified, such as schools, shopping centers, bicycle storages and PT-nodes. By connecting these a rough estimate has been made of the traffic flows through Amersfoort. This can be done because the design of a network is not primarily about numbers, but more about how cyclists move through a network. However, this approach remains gross because it can be argued that other places in the city, such as industrial areas, libraries and cinemas could also have been included. To achieve a more reliable result of the network use, measurements of the numbers of cyclists on important road surfaces, could have given a better image of the use of the network.

6.3 Design fast cycle routes based on more data

In the last stage of the research it has been determined per road section (as part of the fast cycle network) how it could be designed and what needs to be adjusted. This has led to the list of adjustments to be made, which is included in appendix C. These adjustments have been determined based on the requirements found for the design of a fast cycle network. To a limited extent the intensity of other traffic has been considered, for example at intersections. The feasibility of the alleged adjustments (for example due to height difference or due to insufficient space) has also been tested to a limited extent.

6.4 Speed-pedelecs in practice

As described in chapter 3.2, the speed-pedelec is allowed on bicycle paths of the fast cycle network if no safe alternative route is available. Speed-pedelecs do have a speed limit of 30 km/h on bicycle paths. However, it is not clear whether users of speed-pedelecs keep these rules. Introducing speed bumps on the fast cycle routes could ensure that users of the speed-pedelec drive below the maximum speed. Introducing speed bumps will make the fast cycle route less pleasant for other users. Another solution could be to enforce or adjust the rules of speed-pedelecs to provide the desired security and comfort to the users of the network. This could be done with camera's because speed-pedelecs have a license plate.

6.5 Unsafe situations at intersections

The starting point in the redesign was the design aspect *directness*. However, the safety aspect was guaranteed above all. Still there are situations in which safety can be jeopardized, such as at uncontrolled intersections where cyclists can pass at a relatively higher speed. At these

intersections, car traffic will have to be made more alert or bicycle traffic will have to be slowed down slightly by, for example, speed bumps. If an intersection cannot guarantee safety enough, it should be considered to introduce an alternative priority scheme or to introduce traffic lights.

In addition, it may also happen that cyclists leaving the fast cycle network (and, for example, continue driving via the basis bicycle network), unconsciously continue to drive as they did on the fast cycle route. This can lead to less alert participation in traffic and, for example, forgetting to give way. By changing the layout of the road, for example, (the color of) the pavement, cyclists can be made aware that they are no longer driving on the fast cycle network.

6.6 Use of the fast cycle network

In principle, the fast cycle network should be accessible to everyone. Nevertheless, efforts have been made to keep the fast cycle routes outside the neighborhoods as much as possible to keep bicycle traffic within a quarter away from the fast cycle route. In this way, through-bicycle traffic, cycling at a higher average speed, can remain separate from, for example, children going to school or elderly on their way to the supermarket.

Nevertheless, several fast cycle routes go through neighborhoods or are part of a bicycle route to the school or the supermarket. It remains inevitable that slower bicycle traffic makes use of the fast cycle route. At peak hours this will lead to a lot of overtaking on the fast cycle routes with large speed differences. This should not be a problem in the spacious design of the fast cycle routes, however it will still cause discomfort and irritation at the users.

To be able to offer the desired safety and comfort to all users, a route planner app could be released which avoids fast cycle routes if desired. In this way, slower bicycle traffic can arrive at the destination via a safe detour and the fast cycle route remains available for the faster through-bicycle traffic. However, it remains a choice for the slower cyclist whether to use the fast cycle route or not. The fast cycle routes are designed in such a way that these cyclists can also use the route.

6.7 Summary

The research to the bicycle network in Amersfoort was done from the starting point to realize a fast cycle network. A different starting point could have led to a different result of redesign of the network. In addition, several assumptions were made during the investigation in determining the use of the network, which could possibly have led to other choices regarding the location of the fast cycle network. Regarding the design (lay-out) of the fast cycle routes, other choices could possibly have been made, based on data that were not included in this study.

In addition, practice should learn whether the designed fast cycle routes will work as intended. For example, it may happen that the speed-pedelec is driven faster in practice than the legal maximum speed of 30 km/h. It may have to become clear whether safety can be guaranteed everywhere, for example at intersections where motorists can be surprised by the fast riding bicycles. In addition, it will have to become clear whether the fast cycle routes can be used for what they are intended for, for example if too many slow traffic uses the routes.

7. Conclusion and recommendations

The redesign of the bicycle network of Amersfoort has led to a design of a fast cycle network that connects almost all parts of Amersfoort. In 9 fast cycle routes a coherent network is formed that connects all parts of the city with each other and with the surrounding places with the best possible directness (with as little delay as possible).

It turned out that not all parts of Amersfoort are equally accessible via this fast cycle network. Therefore, a basis bicycle network is developed. This basis bicycle network serves in addition to the fast cycle network as a connection between a fast cycle route and a residential area. This basis network promotes bicycle traffic within a district and keeps the slower bicycle traffic off the fast cycle route.

The fast cycle routes have been made suitable for all users. Thanks to the width of the roads, there is sufficient space to allow slower bicycle traffic on the fast cycle route if necessary, so that they too can benefit from direct connections throughout the city. The fast cycle routes that run through the city have been made suitable for long-distance rides at higher speeds. This has been done by several hard measures, such as replacing road sections and intersections in which bicycle traffic is separated from other traffic. A number of road sections must also be replaced in order to offer sufficient recognizability and comfort.

In addition, several softer measures have been taken, such as adjusting priority situations at intersections, adjusting traffic light installations and introducing a good signage system. These measures aim to improve the flow of fast cycle traffic.

In further research, the impact of a fast cycle network on the pressure on other networks such as the road network (less people by car, but more by bicycle) and the public transport network (more people by bicycle towards the station) could be examined. This modal shift could possibly lead to a more accessible Amersfoort, which underlines the necessity of constructing a fast cycle network.

This research can also be supplemented by initiating an investigation into the improvement in driving times by bicycle. The intensity over the various bicycle routes can be included here, which may indicate that the fast cycle routes may become slower due to the closer approach to the capacity limits (for example during rush hour when many students are on the fast cycle network).

This design is a global design and is carried out on a network scale as indicated in the demarcation. In a follow-up study, a more detailed elaboration could be made of the different fast cycle routes that have become the result of this research. During this design at road and intersection level, the intensity of car and bicycle traffic can be taken into account to come to a better motivated decision on how to design a road section or an intersection.

In addition to this research, an investigation can be carried out into the costs that a fast cycle network entail. A ranking can be made between the relevance of the proposed measures and the benefits that these measures bring. In this way it can be determined which measures must be taken first and which measures can be postponed because they yield relatively little.

References

AD. (2019, March 3). *Zevenhuizerstraat in Bunstchoten-Spakenburg wordt omgevormd tot fietsstraat*. Retrieved from https://www.ad.nl/amersfoort/zevenhuizerstraat-in-bunschoten-spakenburg-wordt-omgevormd-tot-fietsstraat~a71eb1e3/

Adviesraad Snelfietsroutes Provincie Utrecht. (2020). *Advies: hoe om te gaan met de speed pedelec.*

Andringa, G. (2019). *Optimalization on the bicycle path network around Utrecht.* Delft.

BicycleDutch. (2015, September 29). *Rhijnwaalpad - Fast Cycle Route Arnhem - Nijmegen*. Retrieved from youtube: https://www.youtube.com/watch?v=EswgdPL3fuc

CROW. (2016). *Ontwerpwijzer fietsverkeer 2016.*

Farah, D. I. (2020). Design for Vulnerable Road Users: Pedestrians & Cyclists. Delft.

Fietsberaad CROW. (2016, November). Discussienotitie fietsstraten binnen de kom. Utrecht, Nederland.

Fietsberaad CROW. (n.d.). *Fietsstraten in hoofdfietsroutes.*

Fietserbond Friesland. (n.d.). *Leeuwarden krijgt fietsstraten.* Retrieved from fietsersbondfryslan: http://fietsersbondfryslan.blogspot.com/2015/06/leeuwarden-krijgt-fietsstraten.html

Fietsersbond. (2015a). *Fiets filevrij.* Retrieved from fietsfilevrij.nl: http://www.fietsfilevrij.nl/downloads/

Fietsersbond. (2015b, July 16). *Verdwalen is passé in Houten*. Retrieved from Fietsersbond: https://www.fietsersbond.nl/nieuws/verdwalen-is-passe-in-houten/

Fietsersbond. (2020). *Routeplanner fietsersbond*. Retrieved from fietsersbond.

Fietsersbond. (n.d.). *Speed pedelec*. Retrieved from https://www.fietsersbond.nl/de-fiets/fietssoorten/speed-pedelec/

Fietssnelweg F35. (2015). *Fietssnelweg F35 in Twente*. Retrieved from Fietssnelweg F35: http://www.fietssnelwegf35.nl/

Fietstelweken. (2016). Resultaten fietstelweken.

Gelderen, T. v. (2017). *Safety of speed pedelecs on car lanes and bicycle paths.* Delft.

Gemeente Amersfoort. (2013). *Verkeer en vervoersplan 2030.* Amersfoort.

Gemeente Amersfoort. (2016). *Fietsplan Gemeente Amersfoort.* Amersfoort.

Gemeente Amersfoort. (2017). *Westelijke ontsluiting*. Retrieved from Amersfoort: https://www.amersfoort.nl/project/westelijke-ontsluiting-1.htm

Gemeente Amersfoort. (2019). *Snelfietsroute Amersfoort centrum - Nijkerk*. Retrieved from Amersfoort: https://www.amersfoort.nl/project/snelfietsroute-amersfoort-centrum-nijkerk.htm

Hendriksen, B., & Boshouwers, R. (2017). *Masterplan Snelfietsroute F28.* Utrecht.

Keypoint Consultancy bv. (2018). *Rapportage effectmeting uitzonderingsmaatregel speed-pedelecs.* Enschede.

Kreekel, A. (2020, January 28). *Supersnelle e-bikes in Amersfoort mogelijk op het fietspad.* Retrieved from AD.nl: https://www.ad.nl/amersfoort/supersnelle-e-bikes-in-amersfoort-mogelijk-op-het-fietspad~a78bc3c0/

Lauwers, p. i., & Gillis, i. (2014). *Fietsen in de stad: de kracht van het netwerk. Een doorlichting van Gent.* Gent.

Leusderkrant. (2019). *CDA wil Ponlijn fietssnelweg Leusden - Amersfoort maken.* Retrieved from Leusderkrant: https://www.leusderkrant.nl/deeljenieuws/nieuws/193127/cda-wil-ponlijn-fietssnelweg-leusden-amersfoort-maken-562982

Maps, G. (2019). *Google Maps.* Retrieved from Google: https://www.google.nl/maps

Mobiel Vlaanderen. (2017). *Vademecum fietsvoorzieningen.*

Mobiliteitsplatform. (2018, May 22). *Dit is de nieuwe markering voor doorstroomroutes.* Retrieved from mobiliteitsplatform: https://www.mobiliteitsplatform.nl/artikel/dit-is-de-nieuwe-markering-voor-doorstroomroutes

Moed, C. (2012). *De fietssnelweg, hype of handvat?* Nijmegen.

Nederland Fietsland. (n.d.). *Wat is een LF-route.* Retrieved from NederlandFietsland: https://www.nederlandfietsland.nl/lf-routes/wat-is-een-lf-route

Nes, d. i. (2018). *Dictaat CTB 1420 Transport & Planning.* Delft.

OVG. (2016). *Fietsgebruik.*

Provincie Utrecht. (n.d.). *Fiets.* Retrieved from provincie-utrecht: https://www.provincie-utrecht.nl/onderwerpen/mobiliteit/fiets#fietsnetwerk

Rijkswaterstaat. (2018). *A28/A1 Knooppunt Hoevelaken.* Retrieved from Knooppunt-hoevelaken: https://knooppunt-hoevelaken.nl/

Ronse, W. (2012). Zijn de Gentse wegen klaar voor de bakfiets? *Verkeersspecialist*, 26-29.

Rottier, J. P. (2019, October 9). *Speed-pedelec nu ook in Groningen op fietspad.* Retrieved from VerkeersNet: https://www.verkeersnet.nl/fiets/30743/speed-pedelec-mag-nu-ook-in-groningen-op-fietspad/

Scooterbelang. (n.d.). *Regels voor brommers en snofrietsen.* Retrieved from Scooterbelang: https://www.scooterbelang.nl/nl/brom-en-snorfiets-regels

Sterk, M. (2020). *Bicycle sensor networks of Dutch municipalities.* Delft.

Appendix A: Requirements fast cycle network

The list of requirements is derived from the results found in chapter 3.

Fast cycle network
- Network accessible from PT-nodes, stations, schools, shopping-centers and public locations
- Detour factor of main bicycle routes lower than 1,25 (CROW, 2016)
- Minimize conflicts with other traffic
- Relieve bicycle routes via the city center
- Wayfinding through the network less complicated
- Network comprehensible
- Strive for mash width 300 to 500 meter in main bicycle network (CROW, 2016)

Fast cycle route
- At intersections:
  - Preferably priority at fast cycle routes
  - Reduce the delay
  - Signaling clear and visible
  - Route course visible
  - Reduce speed other traffic
  - Uniform traffic situations

- Infrastructure:
  - Use dedicated bicycle infrastructure separating bicycles from other traffic
  - Recognizable road categories with uniform layout
  - Pavement provides sufficient comfort

  - Cycle path:
    - Width 4 m (2,5 meter in one direction) (Adviesraad Snelfietsroutes Provincie Utrecht, 2020)
    - Speed-pedelec on bicycle path if no alternative route available

  - Bicycle boulevards:
    - Rebate strip 50 cm
    - Introduction visual center strip (if space available)
    - Width matches with the intensity
    - Provide with sign L51 'Fietsstraat, auto te gast'
    - No parking, loading & unloading on the carriageway

Appendix B: Maps

Figure B.1: Main bicycle network

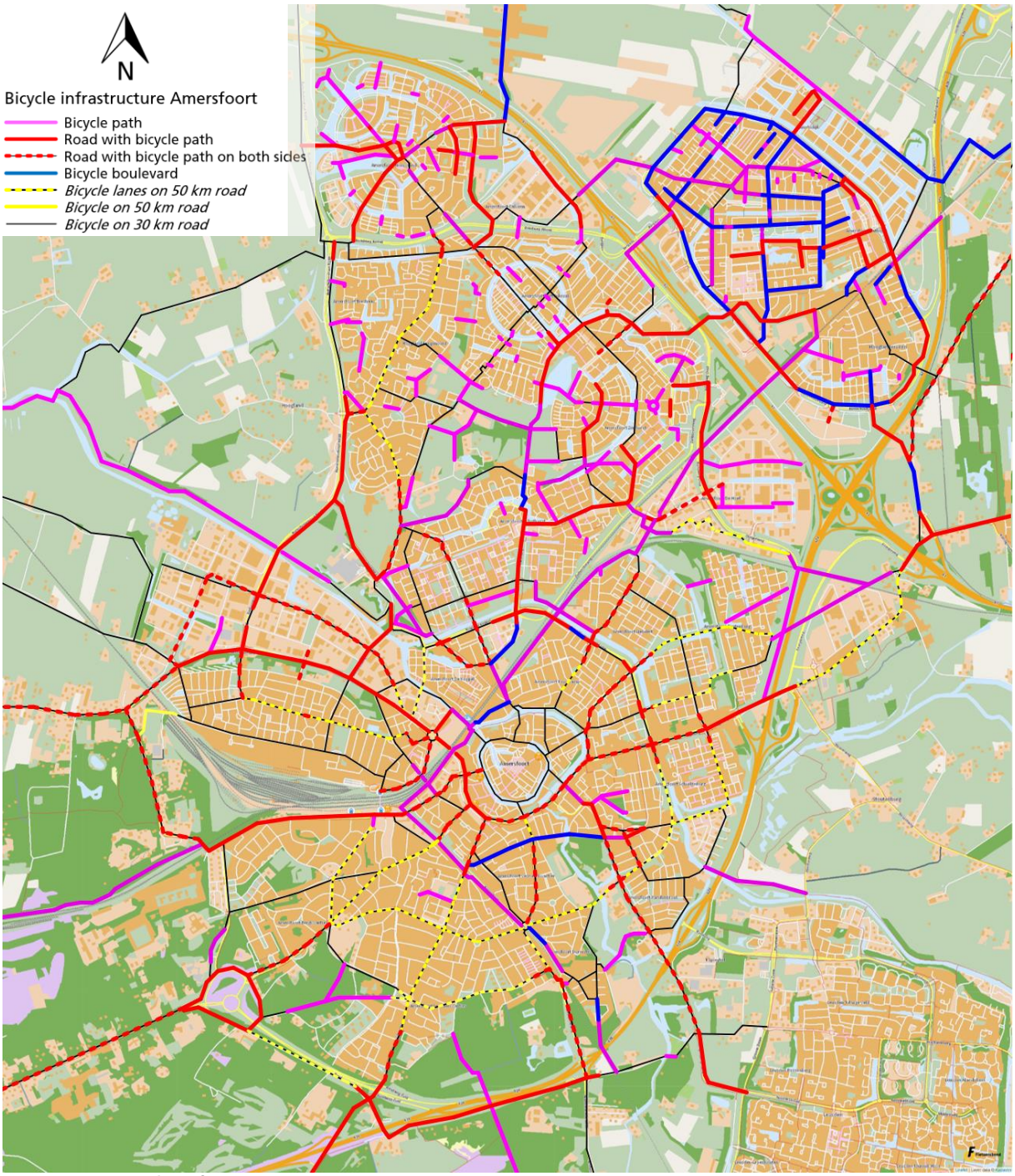


Figure B.2: Bicycle Infrastructure

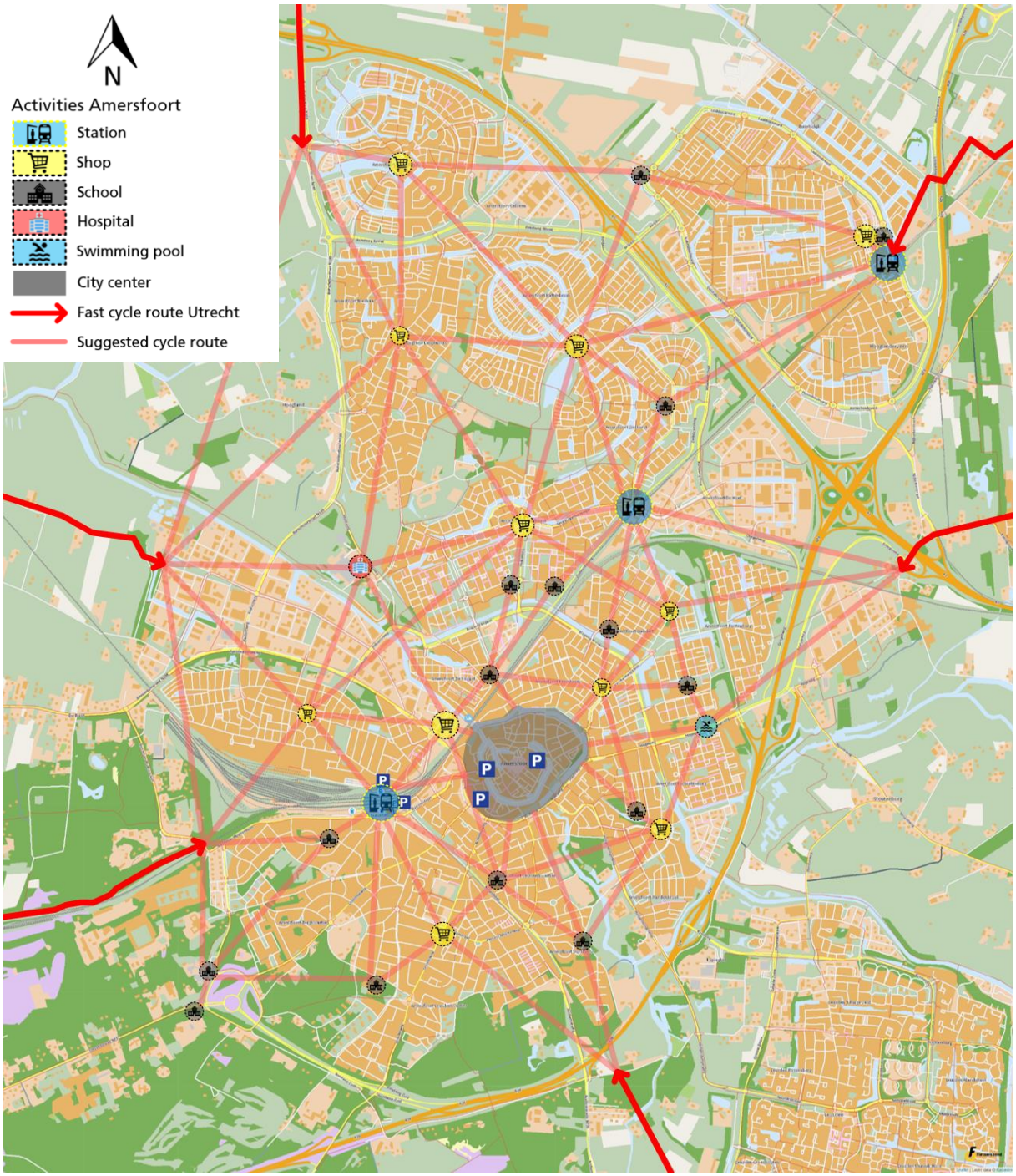


Figure B.3: Activities Amersfoort

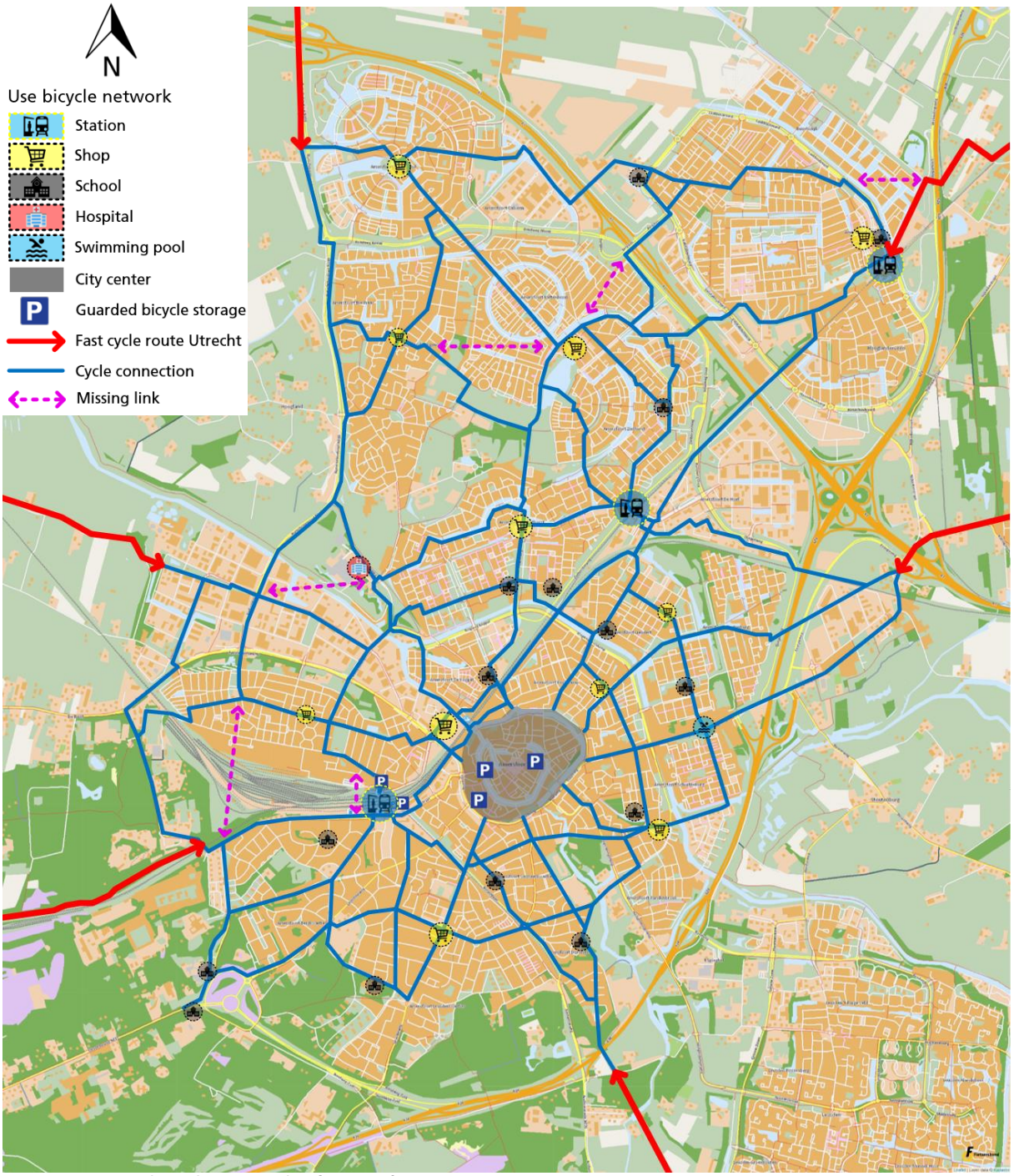


Figure B.4: Use bicycle network of Amersfoort

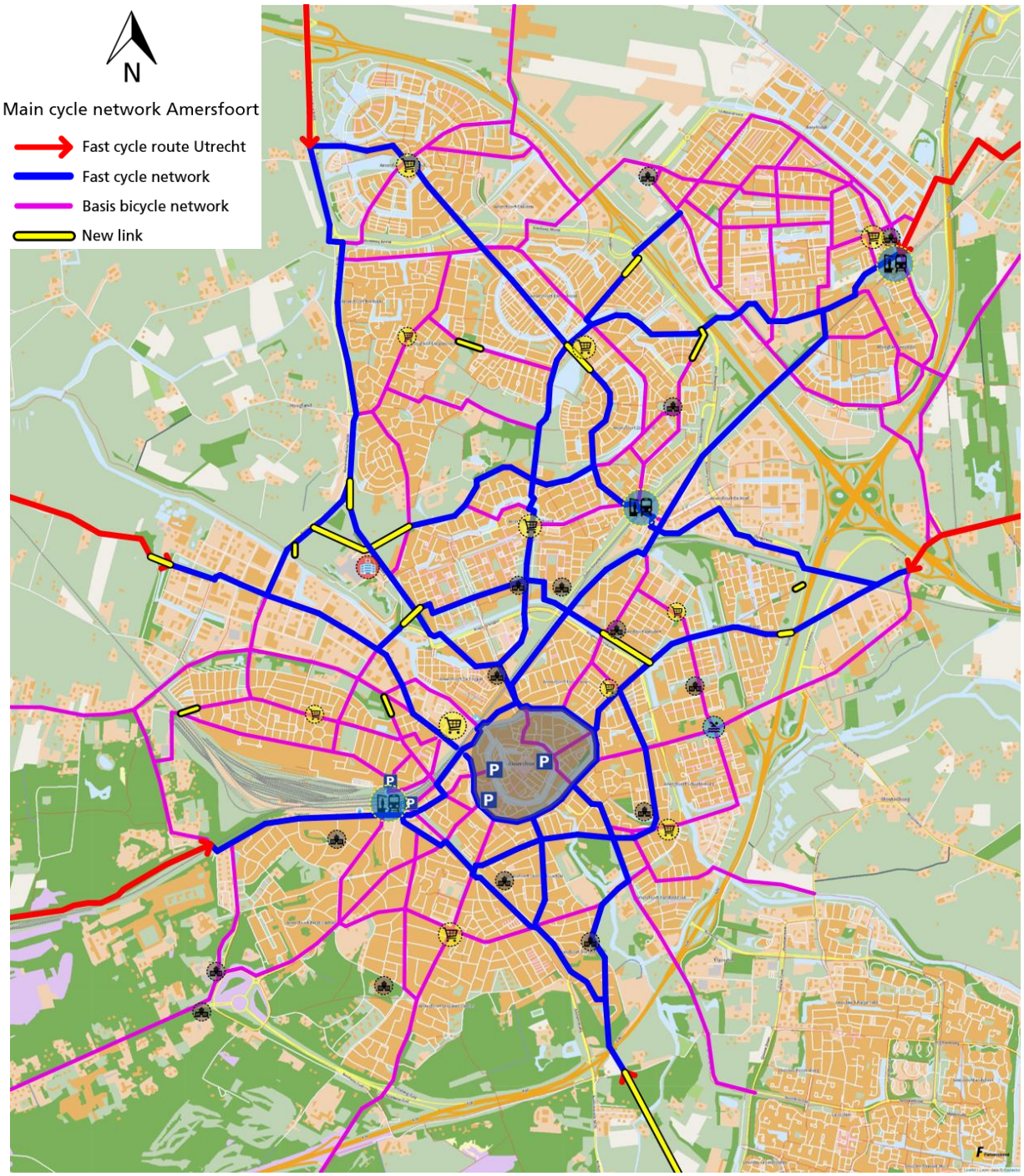


Figure B.5: Redesigned main bicycle network Amersfoort

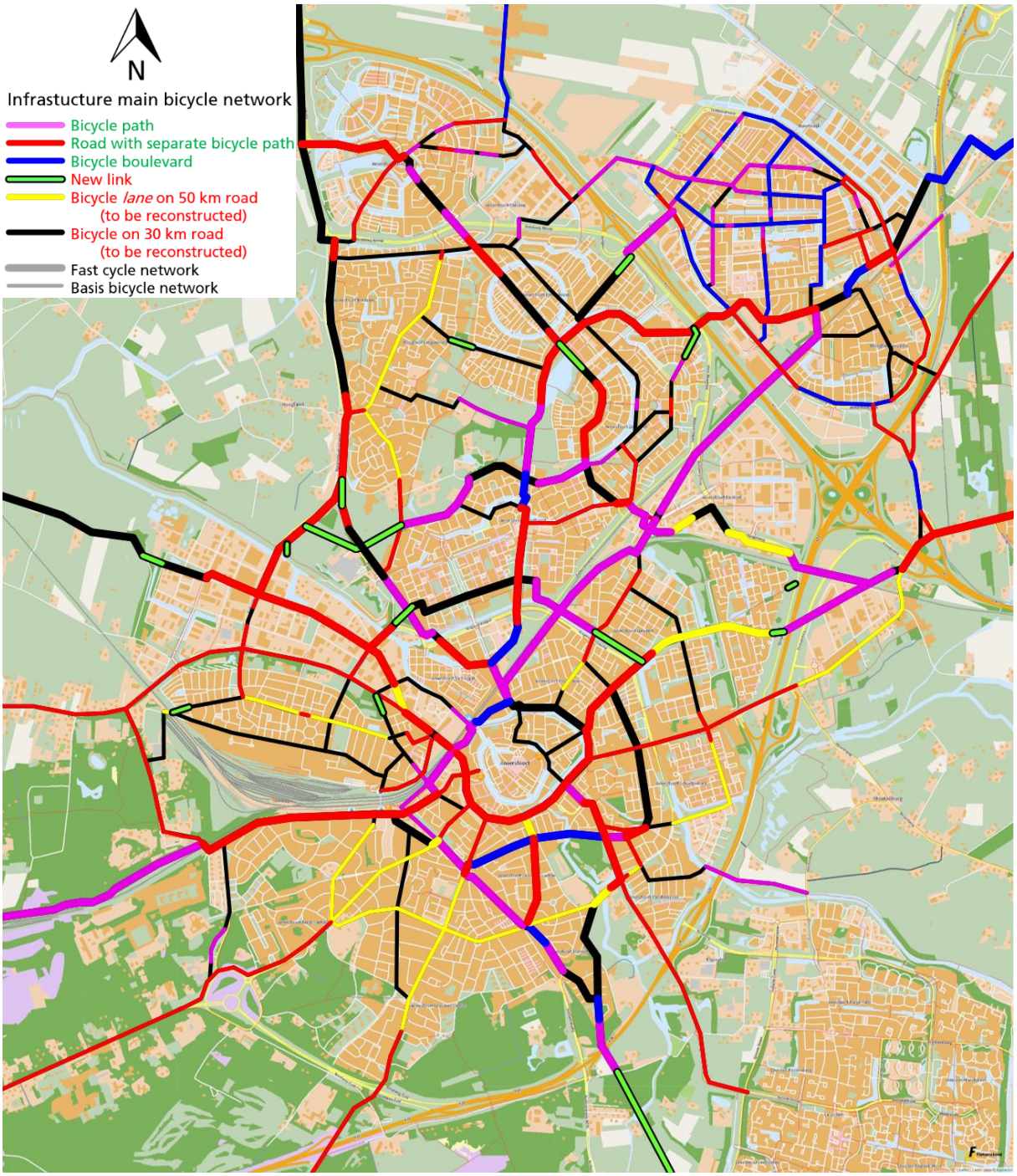


Figure B.6: Infrastructure redesigned main bicycle network Amersfoort

Appendix C: List of measures

This appendix contains all adjustments and measures that have to be made to realize the fast cycle network. This list is a more extensive version of table 5.2 included in chapter 5.4, because in this list the precise location of a measure is displayed. Table C.1, which contains the construction of missing links, refers to appendix E, which contains some maps and explanation about the location of the missing links.

This list is also a supplement to figure B.6, that shows the current bicycle infrastructure, from which it can be deduced at which locations what needs to be done. These lists will indicate what needs to be done per location in the city. Incidentally, in this appendix it is limited to the measures that have to be taken to realize the fast cycle routes. About the basis bicycle network, only the new links are indicated. Other measures regarding the basis bicycle network fall outside the scope of this study.

The announced plans of the municipality are not included in this list. These were considered as already constructed in this study. These plans can be found in chapter 3.5.

Construction of missing links		
Location	**Action**	**Route number**
Bergpas/Het Hallehuis	Construct bicycle path as part of fast cycle route (see figure E.2)	3
Bunschoterstraat/Maatweg(at Meander Hospital)	Construct bicycle path as part of fast cycle route (see figure E.3)	6
Emiclaerseweg/Laan der Hoven	Construct bicycle path as part of fast cycle route (see figure E.4)	7
Meerkoetpad between Liendertseweg en Van Randwijcklaan	Construct bicycle path as part of fast cycle route (see figure E.5)	0
Winkelpad/Maatweg(at Meander Hospital)	Construct bicycle path as part of fast cycle route (see figure E.3)	6
Intersection Bunschoterstraat/Maatweg	Construct direct bicycle path as part of fast cycle route (see figure E.3)	2
Oude Lageweg/Van Randwijcklaan	Construct direct bicycle path as part of fast cycle route (see figure E.6)	5
Ringweg Koppel/Klarissenstraat	Construct direct bicycle path as part of fast cycle route (see figure E.7)	0
Bruggensingel-Zuid/Plataanweg	Construct bicycle path as part of basis bicycle network (see figure E.8)	-
Puntenburgerlaan/Amsterdamseweg	Construct bicycle path as part of basis bicycle network (see figure E.9)	-
Soesterweg/Lijsterbesstraat	Construct bicycle path as part of basis bicycle network (see figure E.10)	-
Zielhorsterlaan/Heideweg	Construct bicycle path as part of basis bicycle network (see figure E.11)	-

Table C.1 List missing links

Transformation of road sections		
Location	**Action**	**Route number**
Berkenweg	Transform to bicycle boulevard with priority	0
Bunschoterstraat (parallel road) north of Rondweg Noord	Transform to bicycle boulevard with priority	2; 7
Bunschoterstraat (parallel road east side) south of Rondweg Noord	Transform to bicycle boulevard with priority	2
Diamantweg	Transform to bicycle boulevard with priority	1
Dorresteinseweg north of Diamanteg	Transform to bicycle boulevard with priority	2
Hardwareweg east of Softwareweg	Transform to bicycle boulevard with priority	6
Heideweg between Oude Veenweg en Willem Thomassenlaan	Transform to bicycle boulevard with priority	4; 8
Het Hallehuis	Transform to bicycle boulevard with priority	3
Het Langhuis	Transform to bicycle boulevard with priority	3
Modemweg	Transform to bicycle boulevard with priority	6
Nijenrode between Emiclaerseweg en Wessel Ilckenstraat	Transform to bicycle boulevard with priority	6; 7
Nijverheidsweg-Noord west of Heliumweg	Transform to bicycle boulevard with priority	1; 6
Patriciërslaan	Transform to bicycle boulevard with priority	7
Randenbroekerweg north of Beethovenweg	Transform to bicycle boulevard with priority	0
Regenboog north of Vuurgloed	Transform to bicycle boulevard with priority	7
Ringweg Dorrestein	Transform to bicycle boulevard with priority	2
Scheltussingel	Transform to bicycle boulevard with priority	2
Schothorsterlaan between Queekhoeven en Winkelpad	Transform to bicycle boulevard with priority	6
Wessel Ilckenstraat	Transform to bicycle boulevard with priority	6; 7
Laan der Hoven between Afrikaring en Aziëring	Transform to bicycle boulevard with priority, introduce speed bumps for cars	7
Magelhaenstraat	Transform to bicycle boulevard with priority, one-way traffic	0
Brouwersstraat	Transform to bicycle path without car traffic	4
Schimmelpennickstraat	Adjust bicycle boulevard to the demands	4
De Oeverweg	Introduce separate bicycle paths	4; 8
Nijverheidsweg-Noord, east of Geldersestraat	Introduce separate bicycle paths	1
Paladijnenweg, west of Meerkoetpad	Introduce separate bicycle paths	0
Ringweg Randenbroek, west of Heiligenbergerweg	Introduce separate bicycle paths	2
Van Randwijkclaan, east of Zangvogelweg	Introduce separate bicycle paths	5
Amsterdamseweg between Nijverheidsweg-Noord en Eemplein	Introduce two-way traffic bicycle path at center side	1
Flierbeeksingel south of Van Randwijcklaan	Introduce two-way traffic bicycle path at center side	2; 5
Stadsring east of Arnhemsweg	Introduce two-way traffic bicycle path at center side	1; 2; 5
Maatweg north of van Hamseweg	Introduce two-way traffic bicycle path at east side	2
Plotterweg	Introduce two-way traffic bicycle path at south side	6
Emiclaerseweg	Replace pavement and widen bicycle path, introduce priority	7

Table C.2: List transformation road sections

Transformation of intersections		
Location	**Action**	**Route number**
Intersection Bunschoterstraat/Boetzelaerlaan	Introduce bicycle tunnel Bunschoterstraat (parallel road, east side)	2
Intersection Laan der Hoven/Jonkvrouw Foeytweg	Adjust bicycle paths to improve flow fast cycle route	7
Intersection Brouwerstraat/Stationsstraat	Redesign intersection, priority at fast cycle route	4

Table C.3: List transformation of intersections

Adjustments of pavement on road sections		
Location	**Action**	**Route number**
Bunschoterstraat between Maatweg en Nijverheidsweg-Noord	Replace pavement and widen bicycle path	6
Heideweg north of Willem Thomassenlaan	Replace pavement and widen bicycle path	8
Laan der Hoven north of Afrikaring	Replace pavement and widen bicycle path	7
Laan der Hoven south of Aziëring	Replace pavement and widen bicycle path	7
Nijverheidsweg-Noord between Heliumweg en Geldersestraat	Replace pavement and widen bicycle path	1; 6
Schothorsterlaan between Emiclaerseweg en Queekhoeven	Replace pavement and widen bicycle path	6
Winkelpad	Replace pavement and widen bicycle path	6
Outputweg between Inputweg en Hardwareweg	Replace pavement bicycle path	6

Table C.4: List adjustments of pavement on road sections

Adjustments of priority schemes at intersections		
Location	**Action**	**Route number**
Intersection Baladelaan/Kanaalweg	Adjust priority scheme for fast cycle route	2
Intersection Brouwerstraat/Smallepad	Adjust priority scheme for fast cycle route	4
Intersection Heideweg/Oude Veenweg	Adjust priority scheme for fast cycle route	4; 8
Intersection Het Langhuis/Het Broek	Adjust priority scheme for fast cycle route	3
Intersection Hoefseweg/Computerweg	Adjust priority scheme for fast cycle route	4
Intersection Nijenrode/Abram Blankaartsingel	Adjust priority scheme for fast cycle route	3
Intersection Nijenrode/Wessel Ilckenstraat	Adjust priority scheme for fast cycle route	6; 7
Intersection Regenboog/Vuurgloed	Adjust priority scheme for fast cycle route	7
Intersection Sara Burgerhartsingel/Wessel Ilckenstraat	Adjust priority scheme for fast cycle route	6; 7
Intersection Emiclaerseweg/Laan naar Emiclaer	Introduce priority at Emiclarseweg	7
Intersection Laan der Hoven/Afrikaring	Introduce priority at Laan der Hoven	7
Intersection Laan der Hoven/Aziëring	Introduce priority at Laan der Hoven	7
Intersection Laan der Hoven/Het Masker	Introduce priority at Laan der Hoven	7
Intersection Liendertseweg/Meerkoetpad	Introduce priority at Meerkoetpad	0
Intersection Paladijnenweg/Meerkoetpad	Introduce priority at Meerkoetpad	0
Intersection Randenbroekerweg/Mozartweg	Introduce priority at Randenbroekerweg	0
Intersection Winkelpad/Elly Takmastraat	Introduce priority at Winkelpad	6

Table C.5: List adjustments of priority schemes at intersections

Appendix D: Details fast cycle route

In this appendix, fast cycle routes from the fast cycle network are designed more into detail, according to the design criteria from appendix A. The fast cycle route Amersfoort Centraal - Euterpeplein - Isselt (see also chapter 5.6) and the fast cycle route Leusden - Centrum - Baarn (see also chapter 5.7) are included.

Fast cycle route Amersfoort Centraal – Euterpeplein – Isselt The next page contains a schematic representation of what has to be done to introduce a fast cycle route between Amersfoort Centraal, Euterpeplein and Isselt. The fast cycle routes are shown in blue in the diagram. Red indicates which adjustments need to be made and green indicates which infrastructure is already available.

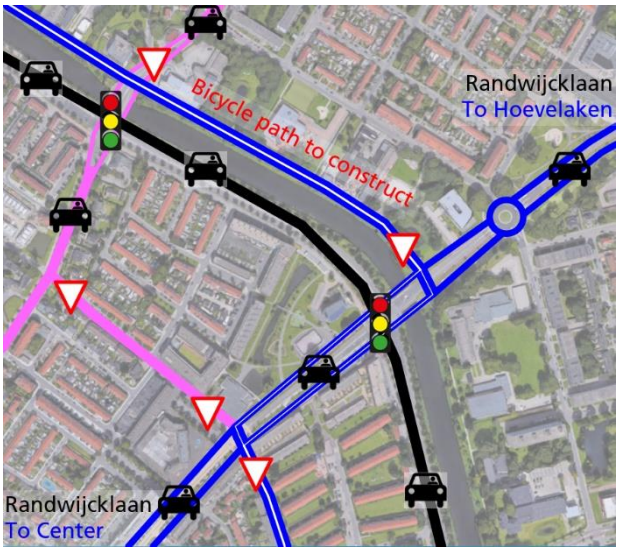


Figure D.1: Detail new bicycle path Meerkoetpad

Two new bicycle paths have to be constructed on this fast cycle route. Figure C.1 shows the new bicycle path between the Van Randwijcklaan and the Liendertseweg. This bicycle path is connected to the fast cycle route Centrum - Hoevelaken and on the other side to an existing bicycle path towards Schothorst, which is part of the same fast cycle route.

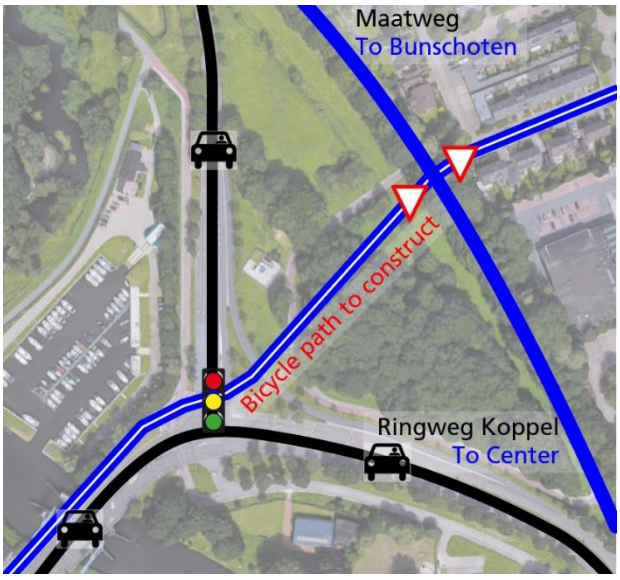
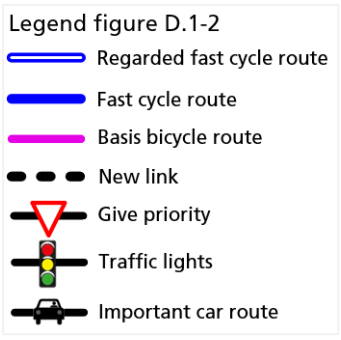
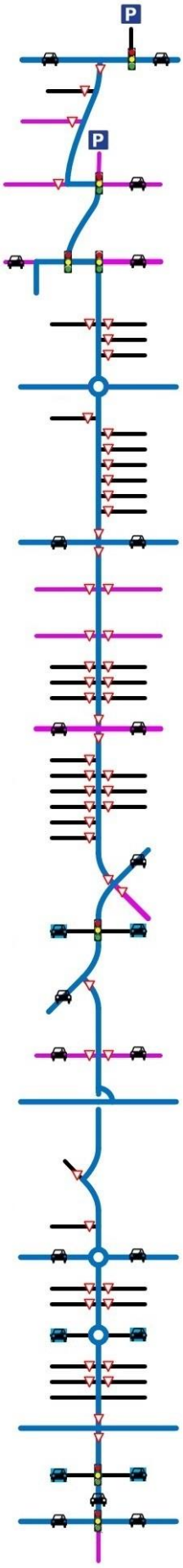


Figure D.2: Detail new bicycle path Ringweg-Koppel - Klarrissengweg

The other new bicycle path will be constructed between the Ringweg Koppel and the Klarrissenweg. This route provides an improved connection to the fast cycle route between Bunschoten and the Center. Due to this improved connection, the fast cycle route between Bunschoten and the Center can be relieved, because this new route offers the possibility of going in an alternative way to the Center and the Station.





Guarded bicycle storage Amersfoort Central station

Stationsplein, fast cycle route ←**Utrecht – Center/Nijkerk**→

Bergweg, to be reconstructed into bicycle boulevard

Guarded bicycle storage Amersfoort Central station

Utrechtseweg, traffic lights

Kersenbaan, bicycle path, pavement has to be replaced

Leusderweg, fast cycle route to **Leusden**, traffic lights

Kroontjesmolen/Bisschopsweg, bicycle boulevard

Vermeerstraat/Hendrik van Viandenstraat, fast cycle route ←**Leusden – Center/Baarn**→, roundabout

Bisschopsweg, bicycle boulevard

Heiligenbergerweg, fast cycle route ←**Leusden – Center/Bunschoten**→

Randenbroekerweg, to be reconstructed into bicycle boulevard, partly one-way road

Hogeweg, due to higher intensity car traffic **no priority**, introduce large refuge islands

Magelhaenstraat, to be reconstructed into bicycle boulevard, one-way road

Van Randwijcklaan, fast cycle route to **Center**

Van Randwijcklaan, separate bicycle paths

Ringweg Randenbroek, traffic lights

Van Randwijcklaan, fast cycle route to **Hoevelaken**

Bicycle path to construct, see figure C.1

Liendertseweg

Bicycle path

Fast cycle route ←**Nijkerk/Vathorst – Center/Utrecht**→, multi-level intersection

Bicycle path

Paladijnenweg, to be reconstructed with separate bicycle paths

Holkerweg, fast cycle route ←**Vathorst – Center**→, roundabout with priority for cyclists

Paladijnenweg, needs to be reconstructed with separate bicycle paths

Kattenbroekerweg, roundabout with priority for cyclists

Paladijnenweg, needs to be reconstructed with separate bicycle paths

Fast cycle route ←**Bunschoten/Hoogland – Center/Leusden**→

Bicycle path to construct, see figure C.2

Maatweg, traffic lights

Ringweg Koppel, separate bicycle paths, pavement has to be replaced

Nijverheidsweg, fast cycle route ←**Baarn – Center/Leusden**→, traffic lights

Fast cycle route Leusden – Center – Baarn - The next page contains a schematic representation of what has to be done to introduce a fast cycle route between Leusden, Amersfoort Center and Baarn. The fast cycle routes are shown in blue in the diagram. Red indicates which adjustments need to be made and green indicates which infrastructure is already available.

An important detail of this route is the course through the quarter Dorrestein. This quarter is shown in figure D.3. In this quarter, two fast cycle routes going into the direction of Leusden meet each other. To connect these routes with the intended fast cycle route to Leusden (see chapter 4.3), the routes come together on the Dorresteinseweg.

The main part of the fast cycle routes going through Dorrestein will consist of bicycle boulevards. However, this district is also used as a shortcut by cars to get from the Arnhemseweg to the Ringweg Randebroek. This is indicated in figure D.3 with an orange arrow. In the current situation, the infrastructure consists of 30 km/h roads with equivalent intersections. By introducing priority schemes (giving priority to the fast cycle routes) and bicycle boulevards, short-cut traffic can be limited and cycling through the district will be made more pleasant.

At the intersection between the Diamantweg and the Kersenbaan, where the bicycle path towards the Johan Karmanhof is separated from the road of the Diamantweg, the car route will exceptionally be given priority. This is due to the presence of the railroad crossing and the traffic lights, which means that cars must be able to enter the Diamantweg unhindered.

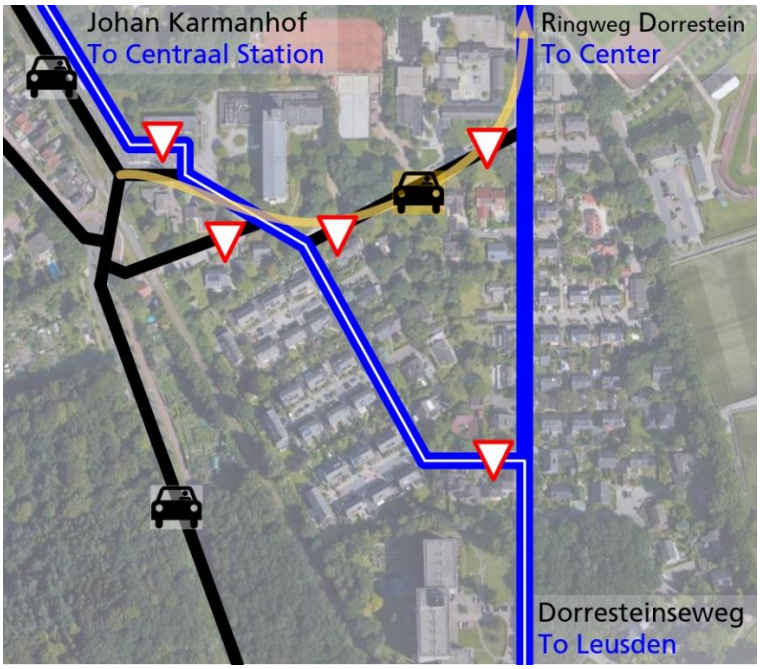
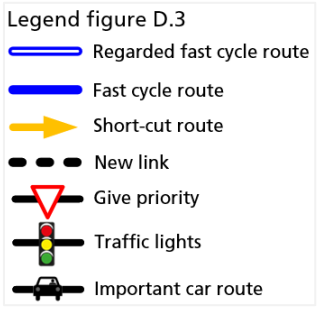
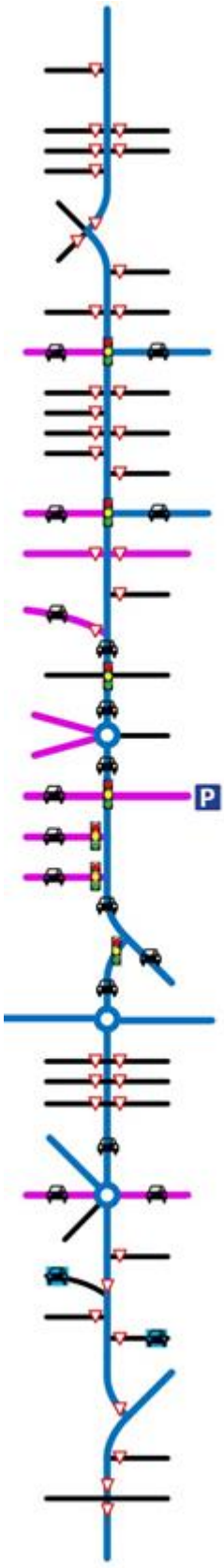


Figure D.3: Detail quarter Dorrestein





A.P. Hilhorstweg, fast cycle route to **Baarn**

A.P. Hilhorstweg
Bicycle path to construct between A.P Hilhorstweg and Radonweg

Radonweg

Nijverheidsweg-Noord, to be reconstructed into bicycle boulevard
Intersection with Heliumweg, because Heliumweg is a distributor road **no priority**

Nijverheidsweg-Noord, separate bicycle paths available, pavement has to be replaced
Bunschoterstraat (N199), fast cycle route to **Bunschoten**, traffic lights

Nijverheidsweg-Noord, separate bicycle paths available, pavement has to be replaced

Industrieweg, fast cycle route to **Schothorst/Euterpeplein**, traffic lights

Nijverheidsweg-Noord, separate bicycle paths available, pavement has to be replaced
Intersection with Amsterdamseweg
Amsterdamseweg, separate bicycle paths available, bicycle path on the north side has to be made suitable for 2 directions

Eemplein, roundabout with priority for cyclists

Stadsring, separate bicycle path available

Stadsring, fast cycle route to **Hoevelaken**
Hendrik van Viandenstraat, separate bicycle parts available
Bisschopsweg, roundabout fast cycle route ←**Centraal Station - Euterpeplein**→

Vermeerstraat, separate bicycle parts available

Roundabout with priority for cyclists

Johan karmhof, bicycle path

Diamantweg, due to higher intensity car traffic **no priority**

Diamantweg, to be reconstructed into bicycle boulevard

Dorresteinseweg, fast cycle route to **Center/Bunschoten**

Dorresteinseweg, bicycle boulevard
Dorresteinseweg, bicycle path
Lockhorsterweg, due to railroad crossing priority to the Lockhorsterweg

Fast cycle route to **Leusden**

Appendix E: Missing links

In this appendix, all missing links in the main bicycle network are elaborated by means of maps. This appendix supplements chapter 5.4.

Figure E.1 provides an overview of the entire main bicycle network. This contains all missing links that are elaborated in a figure further on in this appendix. The fast cycle routes that are eleborated more into detail in chapter 5.6, chapter 5.7 and appendix D are highlighted in this figure.

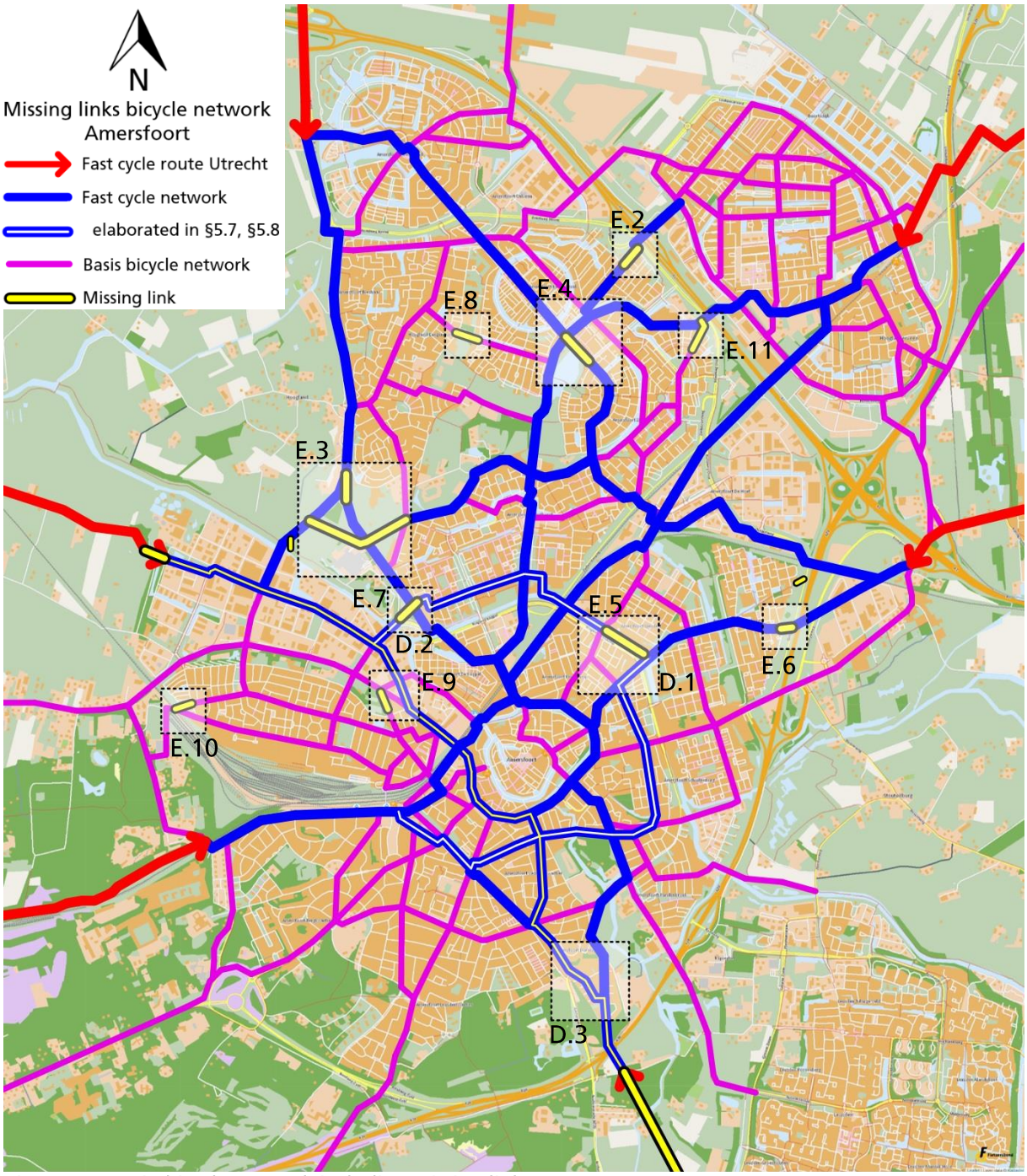


Figure E.1: Main bicycle network including missing links

Legend figure E.2-11

Fast cycle route

Basis bicycle route

New link

Give priority

Traffic lights

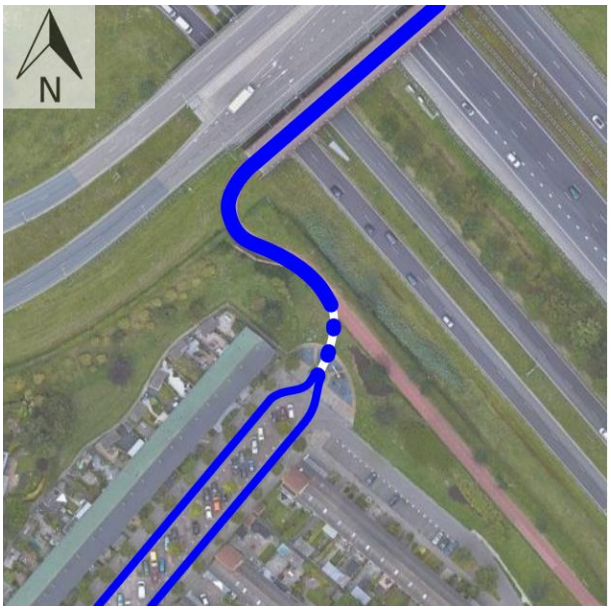


Figure E.2: Connection Bergpas - Het Hallehuis

Connection Bergpas – Het Hallehuis

This new link forms a connection between the bicycle path (passing the motorway) towards Vathorst and the new bicycle boulevard Het Hallehuis towards Schothorst. This connection is part of fast cycle route 3 Vathorst - Center.

For the new bicycle path, the playground on the Hallehuis must be moved. Space is also required for a ramp to pass the highway at a sufficient height.

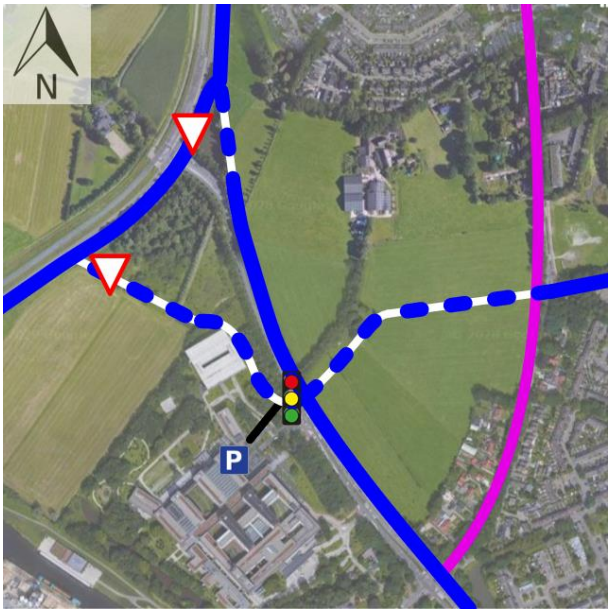


Figure E.3: New connections at the Meander Hospital

New connections at the Meander Hospital

As visible in the figure, two new bicycle connections will have to be constructed. First of all, a new bicycle path (north side in figure E.3) will be built at the intersection Maatweg – Bunschoterstraat. This connection allows cyclists to go straight on the fast cycle route 2 Bunschoten - Leusden.

The other connection (east - west) is part of fast cycle route 6 Hoevelaken - Baarn. The trace of this route follows as much as possible the lines that are already present in the landscape. The bicycle storage of the Meander Hospital is also connected.

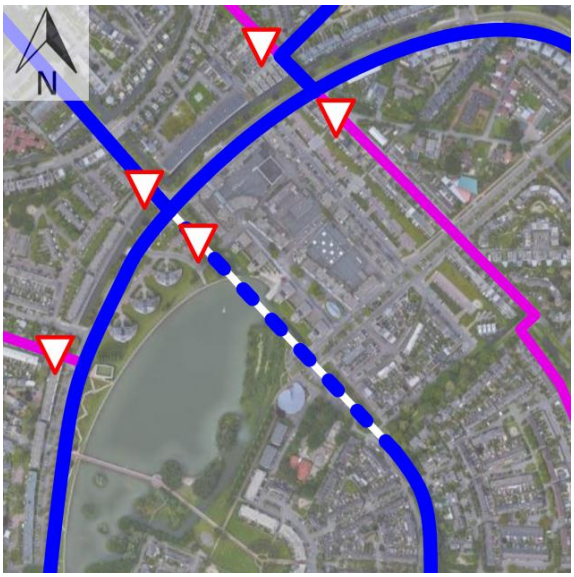


Figure E.4: Connection Emiclaerseweg - Laan der Hoven

Connection Emiclaerseweg – Laan der Hoven

This new link will connect the Emiclaerseweg with the Laan der Hoven and is part of fast cycle route 7 Buschoten - Schothorst. This new bicycle connection goes close to the Emiclaervijver. Pedestrian crossing facilities may have to be made here, so that visitors from the shopping center Emiclaer can go to the Emiclaervijver.

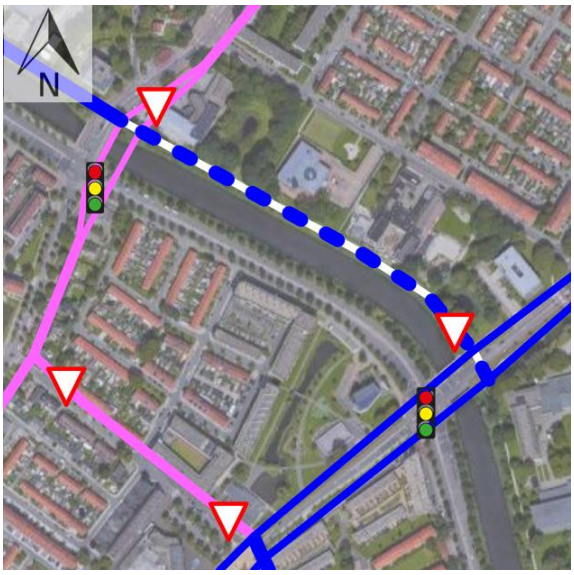


Figure E.5: Meerkoetpad between Liendertseweg en Van Randwijcklaan

Connection Meerkoetpad

This new link will connect the Van Randwijcklaan with the Liendertseweg at the north side of the Valleikanaal. This new connection connects to the existing Meerkoetpad in the direction of Schothorst and will be part of fast cycle route 0. The walking path that is now present at the location will be replaced by a walking and bicycle path. See also the text belonging to figure D.1.

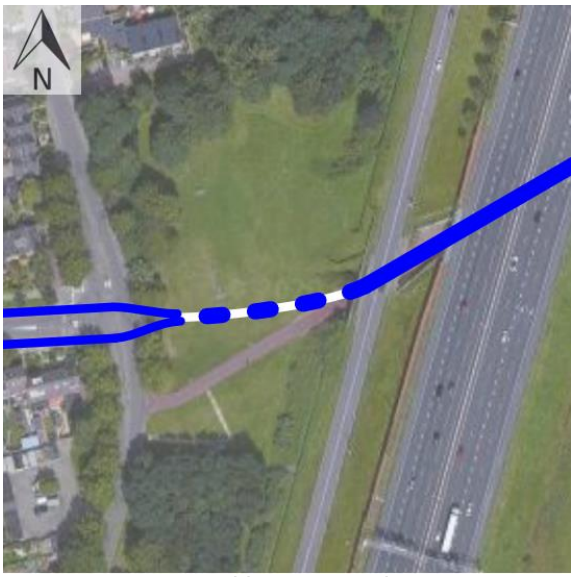


Figure E.6: Improved location Oude Lageweg

Improved location Oude Lageweg

This new link will improve the connection between the Oude Lageweg (the bicycle path under the highway) and the Van Randwijcklaan. Cyclists no longer have to make a zigzag via the Rustenburgerweg. The new fast cycle route (route 5 Hoevelaken - Center) will have priority over the Rustenburgerweg.

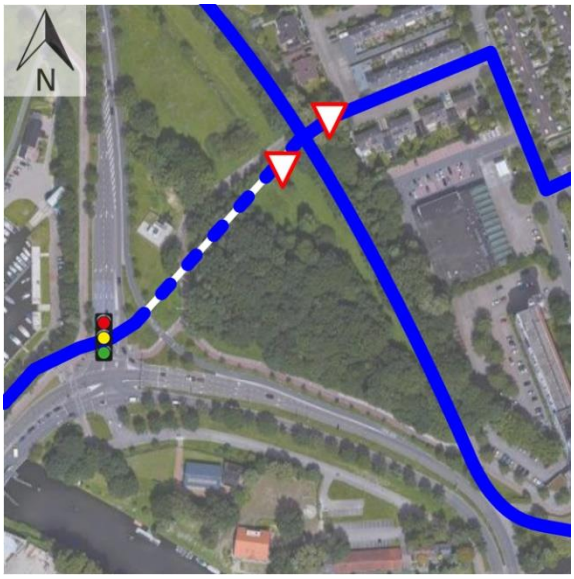


Figure E.7: Connection Ringweg Koppel - Klarissenstraat

Connection Ringweg Koppel – Klarissenstraat

This new link will connect the Ringweg Koppel in a more direct way to the Klarissenstraat and is part of fast cycle route 0. See also the text belonging to figure D.2.

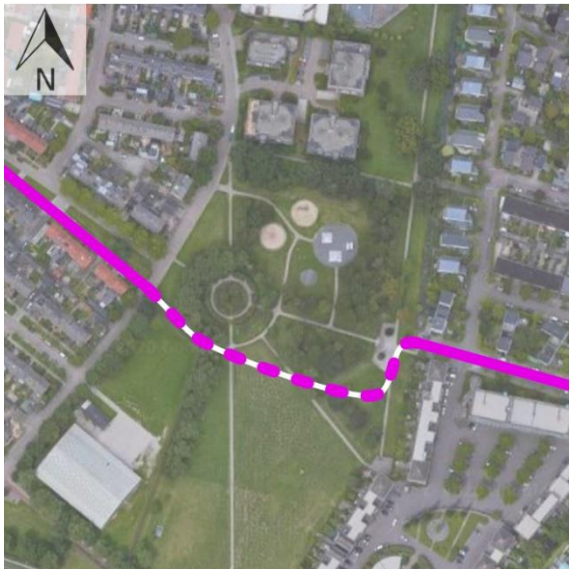


Figure E.8: Connection Bruggensingel -Zuid/Plataanweg

Connection Bruggensingel-Zuid – Plataanweg

This new link is part of the basis bicycle network and is part of a new bicycle route between Hoogland and Schothorst. The bicycle route goes through a park.

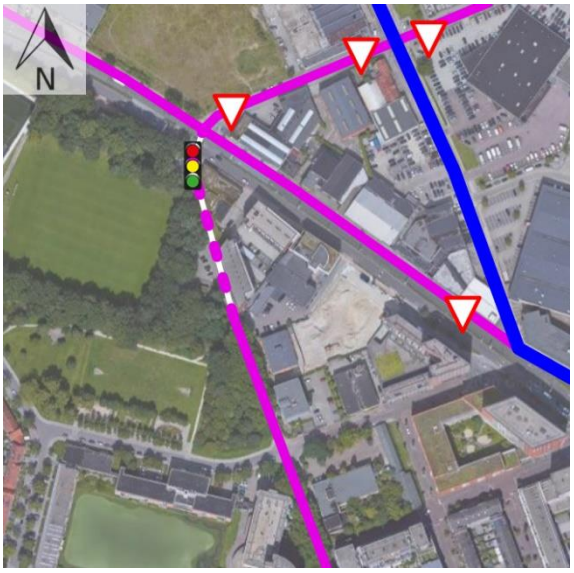


Figure E.9: Connection Puntenburgerlaan - Amsterdamseweg

Connection Puntenburgerlaan – Amsterdamseweg

This new link is part of the basis bicycle network. It improves the accessibility of the Soesterkwartier and the Central Station from Isselt and Baarn (via the fast cycle route).

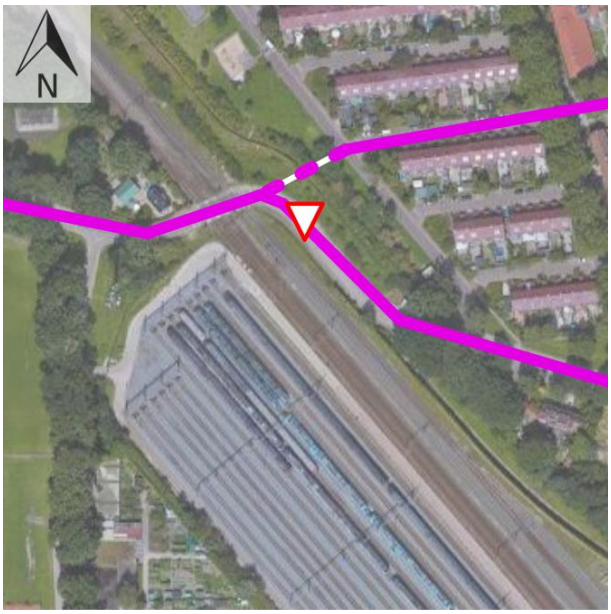


Figure E.10: Connection Soesterweg - Lijsterbesstraat

Connection Soesterweg – Lijsterbesstraat

This new link is part of the basis bicycle network. Due to the construction of this route, it is no longer necessary to detour between Noordewierweg and Soesterweg.

There is now a noise barrier at the location of this route. An opening can be made in the wall as was done at the Gangboord in Noord-Amersfoort

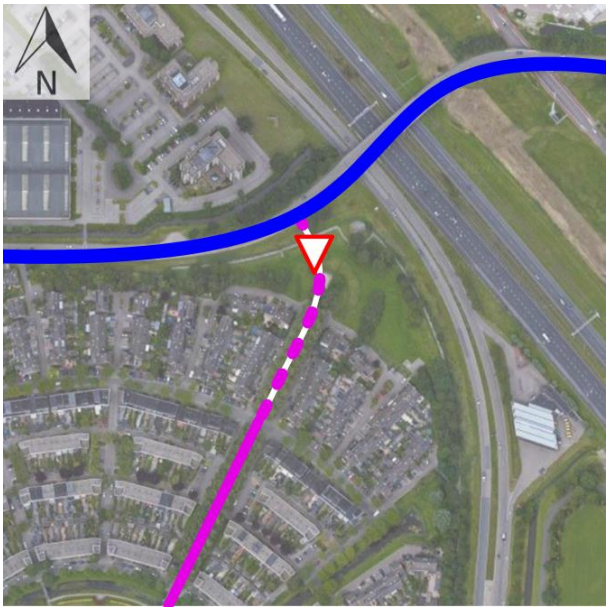


Figure E.11: Connection Zielhorsterlaan - Heideweg

Connection Zielhorsterlaan – Heideweg

This new link is part of the basis bicycle network. By making this connection, it is no longer necessary to detour between the Albert Schweitzersingel and the Heideweg. By constructing this route, Zielhorst will be better connected to fast cycle route 8 towards Nijkerk.