Final Evaluation Report

BITS PROJECT

Authors:Griet Vanwynsberghe, Hans Vermeersch, Rebecca Thys

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1. INTRODUCTION

The three main overall objectives of the Bicycles and Intelligent Transport Systems project are:

- Implementing ITS solutions that directly increase the take-up of cycling (+10%) and reduce CO_2 emission (-9%)
- Sharing cycling data and building a Cycle Data Hub to share, analyse and visualize the data (>100 data sets)
- Using collected data to get a better insight in the needs of cyclists to drastically improve cycling policies. By integrating ITS methodologies and datasets we aim to strengthen a shift towards multimodality and will anchor cycling into broader mobility policies.

In this 'final report' we focus on the general conclusions of the BITS project. Firstly, we discuss the evaluation methodology that lays at the base of these conclusions. Secondly, we will discuss the conclusions with respect to the different types of BITS-implementations:

- Addressing and motivating the individual cyclist
- Data collection and increasing data access in function of policy
- Infrastructure-oriented implementations

Thirdly we will formulate general conclusions. It is advised to read this 'evaluation report' simultaneously with the 'recommendations report' as both are highly intertwined and follow largely the same structure.

2. EVALUATION METHODOLOGY

The evaluation procedure consisted of three key elements:

- The BITS survey that was enrolled in the areas of the project partners
- A procedure to evaluate each of the specific implementations
- A procedure to reach to ‘general conclusions’ for each type of BITS implementation

Each of these key elements will be described in this chapter.

2.1. The BITS Survey

2.1.1. Scope and goal of the survey

Within the scope of the BITS project, a large-scale survey on cycling and ITS was rolled out in the different participating regions and cities. Over 7000 respondents completed our survey and shared their cycling experiences and their interest on ITS in cycling.

The main goal of the survey was to get insight into people’s cycling behaviour as well as their perceived motivations and barriers for cycling. Why do people use their bicycle and what prevents them from cycling or from cycling more? Moreover, their interest in ITS technologies in cycling was questioned. It has been investigated whether respondents would be encouraged to cycle more if ITS would be present and what type of ITS interests them most.

2.1.2. Methodology

The BITS survey was developed during the first year of the BITS project. The content of the survey was discussed with the project partners and feedback was given during the process of developing the survey. In the spring of 2020, the survey was rolled out. The survey has been rolled out in the cities and regions of the six project partners implementing ITS implementations.

To ensure a certain number of responses, coherent for all six project partners, it has been chosen to work together with a market research agency collecting a certain amount of completed surveys. For five of the six participating partners (Zwolle, Bruges, East Riding of Yorkshire, Aarhus and Oldenburg) 300 completed surveys for each partner were delivered. On request of the Province of Antwerp 1000 completed surveys were collected in their region. In total, the market research agency collected 2500 completed questionnaires. These completed surveys were collected in April and May 2020.

Next to the data collection by a market research agency, partners were given the option to share an online link of the survey among their inhabitants via SurveyMonkey, to increase the amount of completed surveys. Four partners (Zwolle, Bruges, Antwerp and Oldenburg) chose to use the online link to have more respondents. In total 4583 people completed the online survey, which brings the total of completed BITS surveys to 7083. In Table 1, the exact amount of respondents per region and per type of data collection can be found. The SurveyMonkey data was collected in May and June 2020.

Table 1 – Total amount of respondents BITS survey

Project partner	Market research agency	SurveyMonkey	Total
Province of Antwerp (BE)	1000	2459	3459
City of Bruges (BE)	300	646	946
City of Oldenburg (DE)	300	1203	1503
City of Zwolle (NL)	300	275	575
City of Aarhus (DK)	300	0	300
East Riding of Yorkshire Council (UK)	300	0	300
Total	2500	4583	7083

The survey consisted of different parts:

(1) socio-demographic information such as year of birth, gender, and living environment;
(2) modes of transport used at the moment;
(3) current bicycle use and willingness to cycle in the future;
(4) motivations for cycling (health, pleasure, environment etc.);
(5) barriers to cycle and elements preventing and promoting cycling;
(6) perception on cycling infrastructure in their local area;
(7) interest for ITS in cycling.

Finally, to each regional survey, some specific questions were added. The project partners were given the option to add questions to their interest to the survey that was rolled out in their city or region. In a general way the questions asked in the survey allow us to address research questions on motivations and attitudes associated with the building blocks of the BITS pyramid.

For more information on the BITS survey (including questionnaire), we refer to the evaluation methodology on the BITS project website 20191211-report-evaluation-methodology-wp5.pdf (northsearegion.eu)

2.1.3. Important caveats regarding the BITS Survey and its results

The data was collected via two different ways. On the one hand, results were collected by a market research agency. On the other hand, partners in the different cities and regions could share an online link to the survey among their inhabitants as much as they wanted.

This resulted in differences between the two groups of respondents. The respondents who completed the survey via SurveyMonkey were more often 'bike lovers'. These people had a more frequent use of their bicycle and showed a higher motivation to cycle. It is likely the 'bike lovers' more often take the time to complete a bicycle survey compared to car enthusiasts.

In addition, we saw a lot more people that completed the survey from the Province of Antwerp compared to the other regions and cities. This was the case because they asked the market research agency to have more respondents and because they recruited more respondents by actively using the SurveyMonkey link.

Although it was not our intention to strive for a representative sample, it is important to take these remarks into account when interpreting the survey results. Even though we didn't have a representative sample, the high number of respondents allows us still to make several conclusions.

2.2. Evaluation of the individual implementations

For the evaluation of the implementations, a common procedure was developed to ensure comparability of implementation results (were possible) through a series of cocreation sessions.

In a first step, we organized co-creation sessions that involved the important stakeholders of the different partners and the partner responsible for the evaluation of the implementation (VIVES University of Applied Sciences). During these sessions the participants formulated clear goals for each implementation as well as clearly defined hypotheses on how the implementation would contribute to the overall BITS goals: an uptake in cycling and a decrease in CO2 emissions.

In a second step, for each implementation a method of evaluation was developed by the evaluation partner in close cooperation with the implementation partners to ensure validity and feasibility. Implementation partners were responsible for the necessary data collection.
In a third step a common evaluation template was developed to streamline the evaluation process.

After the implementations were finished, for each partner a recommendation workshop was held in which the partner's stakeholders reflected more deeply on the strengths, weaknesses, opportunities and challenges of the implementation.

In total 26 BITS implementations have been evaluated. These detailed evaluations can be found on the BITS website under '[project deliverables]'.

2.3. General conclusions & recommendations

2.3.1. Clustering of the implementations

Evaluating the overall impact of the various implementations is not an easy task. The different implementations are hardly comparable. The differences in design across implementations exceed the similarities. Nevertheless, in this report we aim to discuss some conclusions based on comparisons across implementations. We observe three major categories of implementations:

(1) A first category regroups implementations that aim at directly informing or motivating individuals. These are for example the implementations using motivational or informative signs next to the road, implementations that created apps to motivate people to cycle and implementations that focus on giving access to bikes trough a renting or library system.
(2) A second category concerns implementations that aim at improving infrastructure to increase safety, speed or comfort for cyclists and by doing so indirectly hope to add to the motivation of individual cyclists. It involves for example implementations exploring the use of smart lighting for supporting the safety and comfort of cyclists while also taking into account the ecosystems and the animals living in the area. It equally involves the implementations trying to make intersections safer by using camera's to evaluate the risk for crashes or near crashes or by placing signs and by installing smart traffic lights that interact with cyclists. The BITS project equally includes implementations that aim at increasing the

speed for cyclists by shortening the waiting time at traffic lights and to add to the comfort of cycling by installing digital signs to inform about the available parking facilities in the city.

(3) A third type of implementations focusses on data collection to inform and influence cycling policies that should facilitate and motivate people to use their bikes. Data are collected in different manners, by way of various types of sensors: counting sensors, light and temperature sensors, sensors that detect movement or still particular matter sensors to measure air quality. Data are equally collected by GPS and by camera's and 3D camera's. Some implementations aim at aggregating different types of data and others to visualise data.

Most implementations are layered, they are partially aimed at directly influencing the individual cyclist or at improving infrastructure and at investing in data collection to influence cycling policy. Some are involved on two or all of the three dimensions. Where relevant we will discuss multiple dimensions per implementation.

2.3.2. Recommendations workshops

During the evaluation process, it became clear that measuring impacts – in particular with respect to the global goals of the BITS-project, cycling uptake and CO2 emissions reduction, but as well with respect to some specific implementations – did not always deliver sufficient information to draw nuanced conclusions for the implementations and to formulate recommendations for stakeholders in policy & industry to learn from them.

For this reason, we organized a series of recommendation workshops. Each partner assembled the stakeholders involved in their implementations together with policy makers and experts to critically discuss the gained experiences and lessons learned. These workshops gave us valuable information on qualitative information that can inform others involved in future cycling ITS projects.

The 'lessons learned' that accompany the general conclusions described in this report are reported in the Recommendation Report of the BITS project.

3. ADRESSING AND MOTIVATING THE INDIVIDUAL CYCLIST

3.1. Introduction

In this section we discuss the implementations of the BITS projects in which ITS is applied to directly impact the individual cyclist. The most basic way to increase the number of cyclists is to facilitate access to bikes. ITS can be used to make a bike sharing system more efficient and to collect data. In the BITS project we find three implementations that developed a bike sharing system.

In Overijssel in the Netherlands it concerns a more ‘classic’ bike sharing system, just like in the city of Oldenburg. In Withernsea in the United Kingdom they developed a bike library for people that are less customed with cycling and do not have a bike of their own. As compared to the implementation in Overijssel they focus on a particular and less privileged population and thereby they are the only implementation in the BITS project to explicitly have included a social objective.

Another way to directly address the individual cyclist is to develop implementations using ITS to increase people’s motivation to use their bike and start cycling instead of using their car or public transport. In the BITS project we find several implementations that developed an app to motivate people to cycle. In the city of Oldenburg, the project partners developed two types of apps to support people’s motivation: an app for businesses, one for citizens and the CO2 fit app. They included gamification to support the motivation of cyclists. In Overijssel, two apps have been developed. A first one called ‘bike buddies’ to support employees of particular companies to commute by bike to work and an app specifically developed for bike couriers in the city of Zwolle. This app communicates with traffic lights and makes them turn green when a bike courier is approaching. This allows these bikers to move faster through the city.

Besides apps, there are two other methods used in the BITS project to affect cyclists motivation. Firstly by installing motivational or informational signs next to the cycling path. We find three examples in the BITS project: (1) the implementation “a referral system for parking spaces” in Zwolle, (2) the implementation “more cyclists, more trees” developed by Cycledata and (3) the implementation “high speed and motivational signs” of Cycledata. Secondly, you can give people a meaningful role in improving the air quality or the nature in their environment, as for example has been done in the implementation “snifferbike” in Zwolle. Because implementations in the BITS project often combine various objectives and address both the individual cyclist as the infrastructure and are designed to collect data, some of the above-mentioned implementations will equally return in the next chapters. However, they will then be discussed from a different perspective.

In what follows we first investigate the BITS survey. We discuss the part of the survey that gives us insight in both the incentives and obstacles to cycle. We will use this information to discuss the choices that were made by the project partners of BITS to directly address the individual cyclist. We will also discuss some elements of the individual implementations that allow us to better understand what worked and what did not work in trying to increase the motivation of individuals to use their bikes more often. We thereby focus on the efficiency of the ITS that has been developed in these implementations.

3.2. BITS Survey: what do we learn about the intrinsic motivation for people to cycle?

3.2.1. Incentives and obstacles to cycle

The survey has been administered among around 7000 people in the different regions of the BITS project. The survey consists of different parts:

(1) socio-demographic information such as year of birth, gender, and living environment
(2) modes of transport used at the moment
(3) current bicycle use and willingness to cycle in the future
(4) motivations for cycling (health, pleasure, environment etc.)
(5) barriers to cycle and elements preventing and promoting cycling
(6) perception on cycling infrastructure in their local area
(7) interest for ITS in cycling

Respondents were given 25 motivations to cycle or not cycle and were asked to which extent they agreed with the statements. The results can be found in Table 2. A large majority of the respondents (88%) indicates that they like cycling. Respondents are also convinced of the health advantages of cycling: 88% indicate that cycling is good for their health and for 68% it reduces stress. Next to the health benefits, respondents are well aware of the environmental benefits of cycling. More than 95% of the respondents is convinced that cycling is good for our environment and 89% indicate that cycling instead of using motorized transport helps against climate change. More than two third of the respondents say that cycling allows them to discover new places. Finally, more than 75% indicate that cycling is a cheap mode of transport.

Using the answers on the 25 motivations to cycle, clusters of motivations have been constructed. The 25 motivation items (such as I like cycling, cycling is safe, cycling is good for my health etc.) were grouped into seven subdimensions: fun, safety, health, environment, practical, financial and social reasons. In the table below the clusters have been indicated with alternating green colours. Rows with 'negative' motivations are marked in red text.

Table 2 – Motivations to cycle

Motivation statement	Somewhat agree	Strongly agree
I like cycling	**32%**	**56%**
I like cycling to be alone	**29%**	**18%**
Cycling allows me to discover new places	**17%**	**35%**
I think cycling is boring	3%	2%
I like cycling with others	**37%**	**20%**
Cycling helps me to reduce stress	**41%**	**27%**
I think cycling is relaxing	**40%**	**41%**
Cycling helps me sleep better	**36%**	**20%**
Cycling is good for my health	**29%**	**59%**
I think cycling is exhausting	6%	2%
I think cycling is safe	**33%**	**11%**
I think cycling is dangerous and/or scary	14%	4%

Cycling helps me arrive at my destination faster compared to other modes of transportation	**32%**	**22%**
Cycling is a fast and efficient way to reach my workplace	**32%**	**22%**
I think cycling is complicated (organisation etc)	**14%**	**6%**
I think cycling is a waste of time	**2%**	**1%**
Cycling is not possible for me practically	**7%**	**7%**
As a cyclist, you are too much dependent of the weather and other environmental factors	**29%**	**11%**
Cycling is good for the environment	**16%**	**79%**
Cycling reduces CO2 emissions	**15%**	**77%**
Cycling instead of using motorized transport helps against climate change	**22%**	**67%**
I think cycling is a cheap mode of transport	**36%**	**40%**
Cycling is too expensive	3%	3%

The most important incentive for cycling is first and foremost its impact on the environment, CO2 emissions and climate change. The positive answers for the three items of this cluster exceed 90%. The positive role cyclists have in fighting climate change is of main concern to people. The second most important motivation is the fun factor. People choose to cycle just because they like it. The third and fourth concern the benefits cycling holds respectively for physical and mental health (relaxing). The fifth most underscored incentive refers to the low cost of riding a bike. Cycling is much cheaper compared to other modes of transport. If we look at the obstacles (see table 2 text in red), we notice that the dependency on weather conditions is at the very top. 40% indicated that they agree with the statement that cycling is too dependent on weather conditions. That is double of the second most underscored obstacle: 20% agrees that cycling can be complicated. Thirdly, the lack of safety prevents people from cycling (18%), its lack of practicality (14%) and finally because it can be exhausting (8%).

3.2.2. Types of cyclists: diversity in cycling profiles

Using the answers on the 25 motivations to cycle, clusters of types of cyclists were constructed. Firstly, the 25 motivation items (such as I like cycling, cycling is safe, cycling is good for my health etc.) were grouped into seven subdimensions (fun, safety, health, environment, practical, financial and social reasons). In table 2 we indicated these clusters by using various shades of green. In the cluster analysis, respondents scoring the same on a combination of the subdimensions were grouped together. This resulted in four groups of respondents. The respondents within one group were more similar to each other concerning the cycle motivations compared to the respondents in other groups.

In a second step, we tried to find out what characterized the four clusters and what made each cluster different from the other clusters. How do the clusters score on cycle use, willingness to cycle, barriers to cycle etc. and what differentiates the clusters? This analysis resulted in the following four types of cyclists: Happy cyclists (n = 1428), Diehards (n = 1085), Procrastinators (n = 1035), and Car fanatics (n = 323). Below, the cycling behaviour of the different clusters will be described. Afterwards, we will describe the opinions of the different types of cyclists on cycling infrastructure and ITS in cycling.

The **Happy cyclists** are people who regularly use their bike; 79% is a frequent cycler, which means they cycle at least once a week. In the whole sample, 75% is frequent cycler. Three out of four uses their bike more than once a week for shopping, while six out of ten uses the bike more than once a week for commuting. More than half of the Happy cyclists would like to cycle more as a leisure activity.

Although Happy cyclists are regularly using their bicycle, **Diehards** are cycling even more. 95% of them are frequent cyclers and thus cycle more than once a week. They use their bike very often for shopping, commuting and for sport. And these people score very high on all cycling motivations.

The third cluster are the **Procrastinators**. These people use their bike often; more than one out of two is a frequent cycler. However, more than other clusters, these people have high aspirations to cycle more in the future. 40% want to cycle (a lot) more for commuting, 54% want to cycle (a lot) more for shopping and travel to family and friends and 62% would like to cycle (a lot) more as a leisure activity in itself. In the total sample, 29% would like to cycle (a lot) more for commuting, 41% would like to cycle (a lot) more for shopping and travel to family and friends, and 54% would like to cycle (a lot) more as a leisure activity in itself.

Finally, we have the Car fanatics. Among these people only a small number is frequent cyclist and they use their car very often. Three out of four car fanatics use their car daily or several times a week, compared to 46% of the total sample. These people also show low aspirations to cycle more in the future, except for sport. They also score least positive on the cycling motivations.

Within the clusters a mix of personal characteristics is found. No clustering on personal characteristics was made, so we often found similarities between clusters. However, also some interesting differences between the clusters appeared. The Procrastinators and Car fanatics are on average younger (respectively age 36.9 and 38.1) compared to the Happy cyclists and Diehards (respectively age 40.7 and 43.3). Car fanatics more often live in the centre of a city compared to the other clusters (68% compared to 53 to 59%). Happy cyclists and Diehards are on average higher educated compared to Procrastinators and especially Car fanatics. In proportion, more people running a household full-time and unemployed people can be found among the Car fanatics and more retired people can be found among the Diehards. In Table 3, an overview can be found of the proportion of each type of cyclists within the demographic characteristics. All described associations between the types of cyclists and a demographic variable are significant at $p < 0.05$.

Table 3 – Proportion types of cyclists within demographic characteristics

	Happy cyclists	Diehards	Procrastinators	Car fanatics	Total
Gender					
Male	37%	30%	26%	7%	50%
Female	37%	27%	26%	10%	50%
Age (mean)	40.7	43.3	36.9	38.1	40.2
Living environment					
City centre	36%	29%	25%	10%	57%
Suburbs	39%	28%	27%	6%	37%
Countryside	32%	21%	37%	10%	5%
Family situation					
I live alone	30%	27%	31%	12%	18%
I live without partner, with children	35%	18%	37%	10%	5%
I live with my partner	40%	26%	25%	9%	34%
I live with my partner and children	41%	30%	23%	6%	32%
I share a house with friends	26%	50%	21%	3%	4%
I live with my parents	35%	17%	43%	5%	5%
Other	14%	29%	22%	35%	1%

Education					
Primary education	30%	10%	52%	8%	2%
Lower secondary educ. (age 12-15)	39%	13%	35%	13%	10%
Upper secondary educ. (age 15-18)	34%	21%	32%	13%	37%
Bachelor's degree or similar	40%	31%	22%	7%	27%
Master's degree or higher	36%	43%	19%	2%	24%
Professional situation					
I am a pupil or student	29%	29%	37%	5%	11%
I work full-time	38%	28%	25%	9%	56%
I work part-time	43%	32%	23%	2%	16%
I am temporarily not working	34%	19%	39%	8%	6%
I run a household full-time	20%	17%	30%	33%	3%
I am in retirement	33%	42%	22%	3%	4%
I am unemployed	35%	12%	25%	28%	3%
Total	27%	37%	28%	8%	100%

3.2.3. How to use the Survey-results for discussing implementations

The results of the BITS-survey came two years into the BITS-project. They arrived at a moment the implementations already are designed. For designing the implementations the partners used the framework beneath. The overall aim of the BITS-project is to increase cycling with 10% and to reduce CO2 emission with 9%. The intermediary variables that have been identified by the project partners to reach these objectives are threefold: by improving safety & reliability, speed & convenience and finally comfort & experience. This is shown in figure 1.

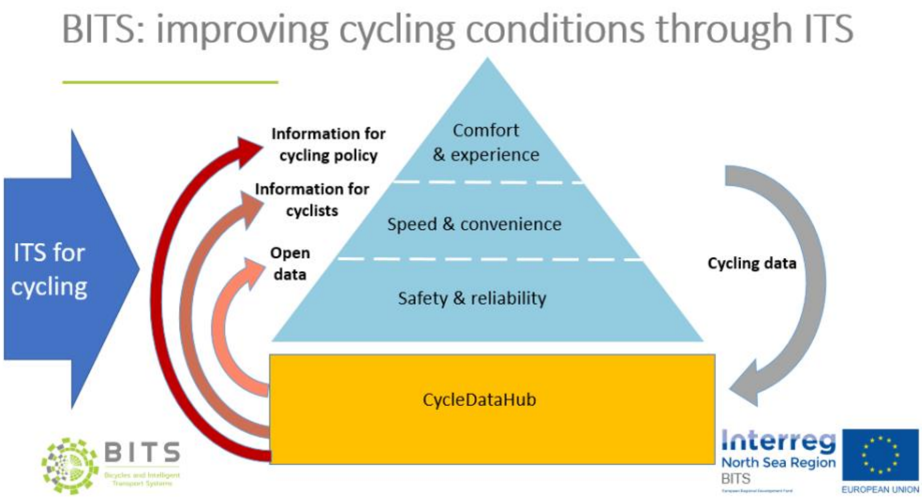

Figure 1 - framework for designing BITS project

The pyramid presented above is a clear framework and makes a lot of sense. However, the results of the BITS-survey suggest other intermediary variables that could be important to increase the number of cyclists and thereby reduce CO2 emissions. We suggest to expand the pyramid with 'incentives'. If we would strictly apply the priorities given by people participating to the BITS-survey, we believe that a very successful way to motivate people to cycle would be valorising the role they have in fighting climate change or still, emphasizing the fun factor or the benefits cycling has for physical and mental health. We do not find these intermediary factors in the above pyramid. The variables that figure in the pyramid seem less to address incentives. They are more about the obstacles to overcome.

3.2.4. ITS to support incentives and mitigate obstacles?

Understanding incentives and obstacles to cycling is one thing, the question however remains whether people are accepting towards innovative ITS for further supporting these incentives or mitigating the obstacles. Therefore, a further part of the BITS survey questioned people's interest in ITS for cycling. We investigated whether ITS within the field of cycling has a possibility to make cycling safer and more efficient and could be a means for attracting more cyclists. A large interest in ITS was found. Different types of people, both concerning socio-demographic characteristics and cycling habits (see above: the typology of cyclists), show different interest in varying types of ITS, but overall, we can conclude that the survey shows a large growth potential for ITS in cycling. ITS in cycling shows many opportunities to make cycling safer, more attractive and more efficient, which will lead eventually to more people cycling and will be a large step forward in the strive to more liveable urban areas and a modal shift to green transport.

Table 4 – Proportion of respondents that would be encouraged to cycle (more often) per ITS solution

	Total
Theft prevention app or bike locator after theft	74%
Traffic light sensors prompting green light	72%
App giving the fastest route	64%
App giving the most scenic route	61%
App or signs giving the real cycle time	59%
Informative LED lights on bicycle paths	50%
Sensor showing free parking space	48%
App giving the safest route	43%
App giving health info while cycling	40%
App showing your saved emissions	39%
Nudging app giving rewards	38%
App for finding cycle buddy	18%

In the above table in can be noted that respondents give priority to applying ITS to prevent losing a bike because of theft. Next, they are highly interested in light sensors prompting green light and apps that monitor faster and more scenic routes or giving the real cycle time. Remarkably, although the impact on climate change and on health is highly ranked among the most important incentives to cycle, ITS for supporting this motivation is not so largely identified as being interesting. Only 39% of the respondents are interested in an app that would measure the number of emissions saved by cycling. An app for finding a cycle buddy is found important for only 18% of the respondents. The information in the table above shows that respondents are less hoping for ITS to support social or societal motivations, but rather expect ITS to help them with practical issues linked to cycling: making them find their bike when stolen, allowing to go faster or to choose the fasted route. To end with, we note that the enumerated list is still rather limited. In the table we observe many wishes for ITS implementations that take the form of an app. Moreover, no ITS is mentioned to give feedback on health indicators. As we will discover in one of the implementations, giving feedback on health appears to be a good motivator. We will look at success and failure in implementations directly addressing individual cyclist and confront these successes and failures with the outcomes of the BITS survey. The result of this discussion could inspire further ITS projects for bicycles to use scientific based insights on incentives and obstacles to design their implementations for having a maximal impact.

3.3. Individual implementations: Success and failure in addressing motivational needs

The BITS project contained many projects that address and motivate individual cyclists. In this section we categorize them in four types:

(I) implementation increasing access to bikes (libraries and shared bike systems)
(II) implementations informing and motivating cyclists by placing digital signs next to the road,
(III) apps created to motivate cyclists
(IV) implementations that give cyclists a meaningful role in improving air quality or other environmental challenges

3.3.1. Increasing access to bikes: libraries and shared bike systems

Introduction

Prior to supporting people's motivation to cycle, people need to have a bike or at least have access to one. The BITS survey learned us that only a small minority of the respondents does not own a bike. Across the participating regions the percentage of people not owing a bike varies between 3,9% (Oldenburg) and 15,3% (Aarhus). In East Riding the percentage equals 12,3%. However, we note that these percentages may increase for particular sub-populations. When we calculate for example the relationship (correlation) between owning a bike on the one hand and level of education on the other, we notice a significant positive relationship meaning that the higher the level of education the higher the chance of owning a bicycle.

The BITS partners of East Riding of Yorkshire Council (ERYC) identified the need in Withernsea for increasing the access to bikes in particular neighbourhoods. They designed a bike library implementation. People can rent a bike for a longer period of time. They included ITS in the project to collect data on the bicycle infrastructure in Withernsea. A different way to give access to a bike is a shared bike system that allows people to better combine various modes of transport. The project partners in Overijssel designed a bike sharing system at different strategic locations in the province. A shared bike system allows to rent a bike for a limited time mostly to do one trajectory, for example from the railway station to the office. Deelfiets Nederland used ITS to make these sharing systems more efficient and to collect data for further cycling policy.

East Riding of Yorkshire Council: the bike library implementation in Withernsea

The bicycle library was launched with 50 bikes in Withernsea in July 2021, giving residents the opportunity to borrow a brand-new bicycle for free. The scheme had embedded within it a cycle buddy, whose role was to offer support with maintenance and advice on safe cycling, and to help to improve health and wellbeing in the participants.

The bicycles were all fitted with state-of-the-art trackers, which gathered rider statistics and data on road condition, crashes blackspots and cycle use, as well as lights, which provided access to a personal app featuring rider insights (e.g., calories expended, distance travelled). The data collected included popular routes, speed, dwell times, plus data on swerving, braking and collisions as well as in-app user reports. The implementation succeeded in meeting the targets linked to increasing the number of km cycled, replacing motor transport, generating new datasets for use by council colleagues and the Cycle Data Hub; and improving the health and wellbeing.

This project has not (yet) resulted in a significant CO2 reduction, but this implementation was more oriented to an initial behavioural change towards healthier living, which in the long run also might have a positive impact with respect to CO2 reduction. In summary, the project is leaving a legacy as the partners in Withernsea will continue to promote sustainable forms of transport and cycling as a means of improving health and wellbeing after the project has ended.

The Province of Overijssel: Bike sharing

The main objective of the bike sharing project in Overijssel has been providing (electric) share bikes on strategic locations in the province and give the different target groups a sustainable alternative for transportation by car and/or public transport. The key parts of the unique proposition of provider *Deelfiets Nederland* are station-based shared bikes, own developed portal/app and the intention of collaboration with local partners. In consultation with every city Deelfiets Nederland picked the best locations for the share bike stations. In the end, Deelfiets Nederland has placed over 120 shared bikes on 13 locations in the Province of Overijssel. In almost all cases, these shared bikes can be used by anyone with a Deelfiets Nederland account. In the specific case of the Deltion College, a closed user group of 100 student users has been made. In the area of Steenwijkerland 42 shared bikes have been equipped with air quality measurement sensors, providing useful data during every ride. The data is used by the city of Steenwijk for getting insights of air quality in the area.

Deelfiets Nederland used three different ITS systems to support their implementation. Firstly, Deelfiets Nederland decided in 2019 to start developing its own platform/app. This has been a huge challenge, but currently they are enjoying the benefits of this IT journey. The set-up of the platform is quite flexible, so if Deelfiets Nederland is facing a new opportunity with additional requirements, a rather small adjustment in back/front office set-up will be enough to match these additional requirements. This provides a huge Unique Selling Point in the shared mobility market. Secondly, another feature of the Deelfiets Nederland platform is the option to provide a real-time dashboard to the share bike partners. In case partners are involved, a real-time dashboard has huge benefits in the daily operation. Based on the dashboard, a party is able to plan its operation efficiently and is always in control regarding the status of the shared bike fleet. Thirdly, in the Steenwijkerland region Deelfiets Nederland has equipped all the electric share bikes with Sodaq air quality measuring sensors connected to the battery of the share bikes. These sensors are providing air quality data during every ride which can be used for different goals.

Deelfiets Nederland is still facing the impact of COVID-19, looking at the challenges of getting share bikes and parts. The intention of Deelfiets Nederland is that the implemented project will be profitable after the subsidy period has ended. Therefore, Deelfiets Nederland will only take part in new bike sharing projects if every project partner is committed to make this project a success.

Conclusion: success and failure

A bike library is a good way to address less privileged groups that do not own a bike. It is a very direct and straightforward way to encourage cycling among certain populations. As the partners discussed in the recommendation workshop it increases cycling with 100% for those concerned. Indeed, the people never owned a bike before. The qualitative interviews they administered among users showed a great positive impact of having a bike on various aspects of their lives. It not only facilitated finding a job or being involved in volunteering, but it also impacted their physical and mental health. They sometimes lost weight or felt more relaxed now that they can make use of a bike. The trackers installed on the bikes showed their added value, they produced good information on local cycle infrastructure that could be used in future cycling policy.

Moreover, the ITS included in the implementation, added a socially valued role to the bike library project. The people using a bike with trackers probably felt socially valued because of the role they have in improving future cycling policy. This could be an extra motivational factor, especially for underprivileged populations. One of the major challenges in the processes to a green transition is to include all layers of the population. A big threat to the green transition is the narrative that it is too expensive and only for those citizens that can afford it. If society wants to succeed the green transition by increasing for example cycling and thereby reducing CO2 emissions, the green transition should become a narrative to which all citizens can relate to. It therefore is remarkable that the Withernsea project is the only BITS implementation having a social objective, emphasizing with their library implementation that cycling should be more accessible for underprivileged groups. From this perspective we suggest that future implementations more frequently include such a social perspective.

Many European cities nowadays have one or more bike sharing systems. As a library project, they aim at facilitating cycling even when people cannot make use of their own bike. The main objective however is to support the motivation of citizens to combine different more modes of more sustainable transport options as compared to car driving. A shared bike system located at a railway station is a good example. However, there are more options for locating bike drop points. The interviews that have been conducted to evaluate the implementation, show very positive reactions for the location near the Deltion college. In this case the location does respond to a strong need. Respondents find it an excellent initiative and express their intention to make use of the system.

The results of the survey among a broader population of both users and non-users of Deelfiets Nederland, are on the contrary not as positive. Respondents do not indicate that they are motivated to make use of the system. Only a very tiny minority (some respondents only) answered that a shared bike systems is indispensable to organise his or her mobility. The contrast between the survey among Deltion students and that among a broader less specific population suggests the importance of well choosing the location and the population. We suggest that further research on the criteria for selecting locations and population is needed, especially when aiming beyond the 'classic' locations such as railway stations.

The added value of the ITS developed for this implementation was not clear for the users of Deelfiets Nederland. 100% of the respondents of the survey indicated not being aware that the bikes contain a sensor that measures air quality. Most of them indicate that they are not interested in this type of data. Notwithstanding, the overall BITS survey shows that people are strongly motivated to cycle because of the reduced impact cycling has on climate change. We therefore think that this ITS option has more potential than shown in this implementation. Further research is needed to better understand how to fully mobilise people's motivation to cycle because of its positive impact on the environment. Most probably, the implementation lacked a well-designed communication campaign to make people aware of the sensors and thereby of the role they can play in measuring air quality by simply renting a bike.

3.3.2. Implementations Informing and motivating cyclists by placing signs next to the road

In some BITS projects the individual cyclist is addressed by digital signs placed next to the road. We find three implementations in which signs are used to speak to the motivation of cyclists. Firstly, Cycledata installed a sign in the city of Bunnik in the Netherlands that respond to people's motivation to reduce their impact on climate change. In this implementation a digital message encourages people to cycle more often by stating that for every 100 cyclists that passes the sign, a tree will be planted in the near environment. Secondly, Cycledata equally designed an implementation in which motivational signs were installed to lower the speed for cyclist at a dangerous intersection in Utrecht. They tried different motivational speeches to find out what type of message works best. Thirdly, in Zwolle a parking referral system for bicycles has been tested on its impact. Informational signs indicate where to find free parking spaces and by doing so they try to speak to cyclists' motivation to cycle by lowering practical obstacles (not finding any parking space).

The signs in these implementations try to directly address the cyclists motivation. They do that each in a very distinct way responding to various intrinsic motivations people have to use their bike. In this sense we can discuss the three implementations under this section. However, placing signs equally means an adaptation to the infrastructure. We therefore will come back to some of these implementations in the next section. We will discuss the implementations from a different perspective.

Implementation from Cycledata: more cyclists, more trees

In the province of Utrecht, in Bunnik alongside the Koningslaan, a rewarding system had been installed to encourage people to cycle more. A digital counting system was installed near the cycling path which indicated how many cyclists already passed by and how this corresponded with the planting of trees in the area. The main message at the digital sign was: 'for every 100 cyclists, we will plant a tree in this area'. In this way, the implementation aimed to evaluate the impact of a collective rewarding system on the increase of cycling. The implementation was run by the company Cycledata in cooperation with the Province of Utrecht. In September 2021, the implementation started running. During a period of two weeks (13/9/22 – 26/9/22), the digital sign 'for every 100 cyclists, we will plant a tree in this area' was operational and the number of cyclists was measured daily. The actual number of cyclists was shown on the digital sign. To evaluate whether the motivational sign can be linked to an increase in cyclists, the number of cyclists was equally measured before and after the trial when no sign was presented. To support the implementation, the municipality strongly invested in a good communication strategy, before, during and after the implementation.

The implementation ran smoothly mainly because the commune was in favour to try out this implementation using the motivational sign "more cyclists, more trees". The commune strongly supported the implementation with a performant communication strategy, before, during and after the implementation. The collective rewarding system of planting trees in exchange for cyclists passing by leads to an increase in cycling use among residents with approximately 34%. However, once the implementation was finished, the impact disappeared rather quickly: the number of cyclists returned to the situation measured before the signs "more cyclists, more trees" were placed. The BITS-target of an increase of 10% cyclists, has been reached.

Cycledata: Implementation from cycle data: speed measurement & motivational signs

In Utrecht, there is a dangerous intersection for cyclists in the Biltstraat. It is a busy cycling path and when cyclists approach the traffic light, they do not have a clear view on the intersection mainly due to the curve in the cycle path and the surrounding buildings. Previous research has also shown that cyclists feel unsafe when approaching this intersection, especially due to the high intensity of bicycle traffic during the rush hours.

By means of installing measuring equipment and different types of dynamic signs with motivational feedback for cyclists, the implementation aims to reduce speed and experienced traffic intensity and thus to improve safety feelings among cyclists. The implementation was run by the company Cycledata in cooperation with the City of Utrecht. In autumn 2021, the implementation started running. Between September 2021 and the end of November 2021, there were three separate measurements of speed and traffic intensity.

Firstly, a baseline measurement with no motivational feedback. Secondly, a measurement with three regular signs including positive messages such as 'relax', 'take it easy'. Thirdly, a measurement with two digital signs including different types of messages ranging from neutral messages (e.g. 'Good travel', 'Welcome'), over messages with smileys, positive messages (see measurement with regular signs) to negative messages or warnings.

Each type of measurement was tested for about two weeks. Five sensors continuously measured the speed and the cycling intensity of the cyclists passing by. Depending on the numbers of cyclists and their speeds, the messages were adjusted accordingly. The implementations that give cyclists a meaningful role in improving air quality or other environmental challenges he goal of the ITS was to detect if and which type of motivational message may have an impact on the speed of cyclists and, secondly on the feelings of unsafety caused by high speed and high cycling intensity.

In the light of the BITS-project goals, we may conclude that the main goals of this implementation are only very partially reached. While, objectively, no impact on cycling speed was measured due to the digital signs, 22% of the survey participants notwithstanding reported to have adjusted their speed and 5% experienced less crowdedness on the cycle lane due to the signs. Accordingly, this type of ITS, installed at a busy and complex traffic situation, may have a small but nevertheless relevant impact on the feelings of unsafety caused by high speed and high cycling intensity. Eventually, in the long run, increasing feelings of safety at this intersection may help to motivate more people to cycle there and thereby decrease the level of CO2 emission.

Conclusion: success factors across the implementations

The results of the three implementations are not conclusive. The implementations show that the use of signs to speak to the motivation of cyclists is not easy. One of the most successful implementations is the implementation 'more cyclist, more trees'. We see three reasons why. Firstly, the implementation responds to an intrinsic motivation. The BITS survey learned that a concern with the ecological issues is a strong motivation to cycle. Moreover, this sign addresses a positive motivation, while in both other implementations, the signs try to help to overcome an obstacle to cycle, respectively the lack of safety and the practical issue of finding parking space. In the survey we read that while more than 90% is motivated to cycle for reducing his or her impact on the climate change, only less than 18% of the respondents says that safety and practical issues prevents them from cycling. We suggest that this could be a reason for the difference in impact we find across the three implementations. We believe that responding to positive motivations could be more efficient as compared to addressing overcoming obstacles. Other important positive motivations are the fun factor and health benefits. The implementation in Aarhus that builds a rope led light on a cycle path in a forested area, is instructive in this regard. Although designed to make the cycle path safer, it has been the ‘fun factor’ that has been mentioned in interviews as a successful aspect of the implementation. An interesting experiment could be an implementation that explicitly addresses the fun factor of cycling to increase the number of cyclists and thereby reduce CO2 emissions.

Secondly, the message in the first implementation is very concrete and the impact is fast and made visible in the near environment of the sign. The lack of success that we find for the parking referral system in Zwolle, is not only a consequence of not speaking to a major concern of cyclists. Respondents also indicated they simply did not notice the sign. The signs in Zwolle are placed at locations where the cyclists are not looking for information about free parking spaces. Moreover, the signs were not visible enough. A large majority indicated that they did not even notice the signs. Moreover, most people that noticed the signs, did not react to the information. The project managers suggest that an app could be a more effective tool to set up a parking referral system. An app indeed allows for the information to reach the individual cyclists when he or she is in need of it. The implementation of Cycledata at the dangerous intersection in Utrecht is better designed in this regard. The messages on the digital signs reach the cyclists at the needed location and around a quarter of the users indicated in a survey that they lowered their speed after having seen the sign. However, also in this case the location of the signs is not ideal. Project managers believe that there are too many signs, causing confusion or at least too many stimuli. They think that other than visual signs are increasingly in vogue to alert cyclists or to speak to the motivation of cyclists. It could be interesting to experiment with these in the future.

Thirdly, a communication campaign has been associated to the sign ‘more cyclists, more trees’. Influencing the motivation is not only dependent of the sign but is supported by various ways of communication. We could imagine that parallel communication campaign could equally have helped both other implementations to be more successful. To end with, we conclude that signs can be used to address motivation of individual cyclists. However, more research is needed to adjust ITS to the associated motivation.

3.3.3. Creating an app to motivate cyclists

In the BITS-project there are five different apps that are built to motivate individuals to cycle more. Three have been bought by Baron Mobility, a bike leasing company from Oldenburg. A first one addresses companies and aims at increasing the number employers that commute to work by bicycle. A second one does not focus on companies, but more general on the citizens of Oldenburg in Germany. A third also focuses on companies but uses slightly different functions. All three apps included gamification and a competitive element has been added to the app. The two other app that are present in the BITS project have been created respectively in Overijssel and in Zwolle. The one in Overijssel equally focusses on companies and encourages people to register with a buddy or with several colleagues. The app equally included some gamification elements, however in contrast to the Oldenburg implementation, it does not concern a competitive game, but an individual return. First financially but later on the return was in form of data on their physical and mental health. The implementation in Zwolle paid for an existing app for bike couriers to make it easier for them to deliver packages within the city centre. The app connect with some traffic lights that consequently turn green when the bike couriers are approaching. This should allow them to move faster and deliver packages more efficiently within Zwolle.

Baron: App for business in Oldenburg

In this implementation, a mobile application was launched in several companies in which commuters were asked to register and to participate in the Company Challenge. In this six-week challenge, employees were motivated to cycle to work using competition between colleagues and the potential to win prizes. Next to the Company Challenge, two companies also launched an additional, internal challenge with an internal dashboard and own prizes in order to motivate their employees to cycle more.

In order to evaluate whether the app improves the motivation of commuters to cycle, the app registered bicycle usage in kilometres (average/ person), average cycling speed, days the bike is used, number of people that installed the application, and the use of a leased bike. In addition, the app questioned its users through pop-up questions when first opening the app and secondly at the end of the implementation. Also, a questionnaire was sent to the participating companies after the closure of the Company challenge and internal challenge. Nine of the 16 participating companies gave additional qualitative feedback.

If we consider the immediate increase of 12% of participants who commute by bike more than once a week as well as a high willingness to cycle more for commuting in the future among 53% of the participants, we can conclude that the main goal of this implementation is reached. We can conclude that a short, well-defined company challenge, such as the Oldenburg Company Challenge or an internal challenge tailored to and managed by the company, may lead to an increase in cycling use among the particular target group of regular commuters by bike, resulting in a higher number of km cycled – due to the longer distances cycled and a higher frequency of commuting - and accordingly a reduction of CO2 emission.

Although it seems that gamification features have less impact on cycling motivation than previously expected, this implementation reported the added value of having the opportunity to network and cycle together with colleagues by the use of ITS technology. Accordingly, we also believe that the increase in cycling use among the commuters by bike may have a stimulating effect on other colleagues in the long term and that this type of ITS, eventually, may lead to an increased uptake of cycling among those who do not commute by bike yet.

Baron: App for citizens in Oldenburg

An interactive mobile application, the smartphone app Ciclogreen, was used in order to collect data about the cycling behaviour of citizens in the city of Oldenburg and to measure to what extent an app with gamification features could encourage citizens to cycle more often. On the one hand, the app registered bicycle usage and other statistics (e.g. average cycling speed, days the bike is used, etc.), while on the other hand, the app questioned its users through pop-up questions starting when first opening the app, continuing after three, six and nine months and closing at the end of the implementation.

This way, the app provides information about the total bike use of the app-users as well as changes in behaviour due to the use of the app. App users were activated by means of challenges of 1-2 months duration each. During these challenges the users could collect points (''Ciclos'') for every kilometre, track their own progress such as the (increasing) kilometres they cycle, check their position in the ranking with other participants and earn discounts and exclusive gifts.

The Oldenburg Bicycle Challenge pursued a gamification approach and measured its impact through pre and post counting of the total bike use of the app-users and five short surveys (at the start, after three months, after six months, after nine months and at the end) in order to evaluate changes in cycling behaviour due to the use of the app.

If we look at the overall objectives of the implementation, we may conclude that the Oldenburg Citizens Challenge resulted in a higher usage of bikes. Overall, about 20% of the participants reported that they were using the bike more often since using the app. This also corresponds with a reported increase of actual cycling: we found an immediate increase of 7% of participants who commute by bike (almost) daily as well as an immediate increase of 4% of participants who use the bike for shopping or leisure activities at least once a week. Likewise, the data – both registered data as well as survey results – clearly showed an increase in the number of kms, and thus longer distances, travelled among the active participants in the challenge.

When considering the impact of the Challenge on the cycling behaviour and motivations, it is also important to take into account the most effective app functionalities. The implementation revealed which app functionalities motivated the recurrent app users the most to cycle more. Being able to record their routes via the app as well as being able to see their own statistics in the app such as distance, CO2 savings and calorie consumption have the most impact on the motivation to continue using the app, and indirectly to cycle more. Overall, it was clear that the app users were far less motivated by earning discounts and winning prizes, which was of course one of the main features of the Oldenburg Bicycle Challenge. The impact of this type of ITS technology has been realised due to the app functionalities such as tracking routes and displaying own statistics. Recurrent challenges, including earnings discounts or winning prizes, seemed to be less effective and maybe even discouraging if we consider the very low number of active users. This can be considered as a contraindication of the uptake of cycling.

Baron: CO2 Fit Challenge

Baron mobility service GmbH (with its brand mein-dienstrad.de) organized a CO2 Fit Challenge by which Baron wanted to investigate the impact of a gamification-based app on cycling behaviour. The app Changers Fit has more extensive tracking and gamification options than apps used in earlier implementations and allows, for example, automatic tracking and linking with various smartwatches such as Garmin, Fitbit and Misfit. The app is oriented at motivating users by the elements of competition, rewarding, info on CO2 savings and emissions as well as statistics on the cycling and mobility behaviour and bringing people together (in a community).

In the CO2 Fit Challenge, Baron wanted to test the research question to which extent an app with gamification functions contributes to an increase in bicycle use and achieves the BITS goal of a 10% increase in bicycle use. This implementation with a different gamification app of Baron Mobility Services also wanted to investigate which app-functions play a crucial role for motivating to cycle. It is hypothesized that competition, CO2 emission reduction and community-building are important motivators.

At the start, in September 2022, a first survey was held as a baseline measure, in order to be able to track subsequent changes and compare results. A final survey was conducted at the end of the implementation, in October 2022. The surveys allowed for a pre- and post-test to assess to what degree there was an uptake in cycling during the challenge and a decrease in motorised forms of mobility.

The app delivered data on the number of km's cycled, and the total CO2 reduction as a result of the challenge. These data indicate in general a modest (commuting) to strong (outside work) uptake in cycling that is associated with the implementation. If every participant had been using a car in total 20.294 kg would have been created. The app indicates that 7908 kg of CO2 or 40% of that number has been avoided because participants were walking, cycling or car-pooling/taking public transport. Obviously even before the implementation people were cycling, walking, car-pooling or taking public transport, so the number has to be corrected by the estimate change in car-use as a result of the implementation, based on the reports of the pre- and post-test surveys.

With respect to the uptake in cycling for each of these categories, a respectively 5,9%-points, 6,7%-points and 23.7%-points could be expected. If we follow the same logic as above there would be an average increase in bicycle uptake of 12,1%. Based on these number the implementation achieved its objectives and the overall BITS objectives. It is important to notice that these numbers are theoretical and based on a set of untested assumptions (e.g. importantly the numbers of km for each category, the logic behind the CO2 emission reduction by avoiding a car ride the app uses). In addition, we could not compare the characteristics of the respondents of the pre- and post-test sample (that may or may not tell us something about some forms of bias). However, we can conclude that the numbers show that the app and its gamification aspects can motivate people to cycle more and as such has the potential to contribute to reduced CO2 emissions.

The CO2 Fit app implementation was clearly aligned with the overall BITS goals and successfully reached its goals. The app has the potential, at least in the short term, to change mobility related behaviour, increases the uptake of cycling and decreases the use of cars primarily with respect to commuting and mobility outside of the work context. Follow-up evaluation efforts should focus on its long-term impact on behaviour and its effects in other target groups within the population.

Overijssel: App 'bike buddies'

The goal of the Bike Buddies project is to encourage employees in the province of Overijssel to bike more often to work and by this to improve the accessibility of Overijssel, contribute to a cleaner climate and increase vitality of the employees. Participants - formerly motorists - cycled to work for 5 months using the app Bike buddies. They do this in a team, with a buddy and other colleagues. On the basis of the number of rides recorded and the commuting distance, participants and buddy build up a financial reward.

The hypothesis was that regular cycling to work would improve the health of the participants and as such increase the intrinsic motivation of the participants making the monetary reward over time less important as a motivator.

Cycling to work using the Bike Buddies app has a positive effect on physical health and mental well-being. There is a shift in intrinsic motivation to continue cycling. As participants experience the positive effects of cycling more, the financial incentive (extrinsic motivator) becomes less important. The Bike Buddies app is a successful tool to increase employee health and well-being and initiate lifestyle change. There was definitely an uptake of cycling and a reduction of 30.3 tons of CO2 as participants switched their mode of transport. Their participation in the Bike Buddies program has reduced their commuter car trips and thus their CO2 emission with at least 25% and possibly even 50% or more.

Zwolle: App for bike couriers

The Schwung app was launched in the city of Zwolle. This app interacts with the traffic lights and gives priority to cyclists. In this implementation "The Schwung app for bike couriers", by an extension of the existing app, absolute priority is given to bike couriers with the aim to make them move faster through the city and to allow them to deliver more packages in the same amount of time. In this BITS implementation, the app tracks ones route and interacts with the traffic lights when the cyclist is approaching the traffic lights.

The hypothesis is that the use of the app allows bike couriers to save time when delivering packages and by this the overall hypothesis is that by giving cargo bikes priority, clean city logistics will be promoted and more cargo bikes and less freight vehicles will be entering the (inner) city.

While in itself, the implementation can be evaluated moderately positive based on the effects on speed and flow of the bike couriers during participation in traffic, it was unclear what the effects were on other traffic participants. Also, its potential to increase green/clean bike courier traffic in the city at the expense of more polluting deliveries remains unclear and may depend on the extension of the implementation to other courier companies (currently only one company has access to the system).

No direct effect on cycling uptake or CO2 reduction can be assessed because the app users were already cycling, but eventually bike couriers might get a competitive advantage compared to other couriers with delivery vans, which might lead to a (small) shift from delivery vans to bike couriers. It should be mentioned that, based on the BITS-survey, the majority of the citizens of Zwolle (54.6%) indicate that an app that decreases the waiting time as a result of stop lights would probably or definitely encourage them to cycle more. The introduction of the Schwung app – oriented at the general population – might as such have a more profound effect on some overall BITS goals like uptake on cycling and CO2 reduction, however this observation lies beyond the scope of this specific implementation.

Conclusion: speaking to intrinsic motivation is more encouraging than gamification or competitive elements

An app is a good tool to address cyclists directly and to support the motivation to cycle more. The five implementations that are part of the BITS projects teach us some do's and don'ts when designing an app with the objective to increase cycling. A first series of don'ts concerns the gamification. A competitive game can increase the motivation to cycle. However, the implementations show that this only concerns those that are already cycling. It did not convince those that not yet make use of their bikes. Moreover, the impact of a competitive game seem to be temporary and endures as long as the game is on. Furthermore, while users of the App for businesses still react positively to the competitive element, this seems not to be the case for the App for citizens. Registration to be eligible to win prizes are very low, leading project partners to think that this type of gamification even can be a contraindication to cycle. The implementation in Overijssel 'bike buddies" showed that results of gamification are better when they consider internal motivations to cycle. Giving cyclists a return on various physical or mental health indicators appeared to be a better motivator. The BITS-survey indeed showed that next to fun and ecological principles, a concern with health was a major incentive to cycling. Building further on this insight, we recommend partners, to consider the internal motivations that drive people to cycle. Based on the results of the BITS survey we suggest that feedback on the ecological footprint could be a good motivational tool to include in an app. The same is true for feedback on healthy, safe or scenic routes, on weather conditions and on the saved travel time. These are the major incentives or obstacles as indicated by the respondents of the BITS-survey.

The app for bike couriers in Zwolle can be improved in this regard. Many of the users of the app, said that feedback on the saved travel time could be an added value. This implementation suffered another don't. The app only connected to four traffic lights in the city of Zwolle. The scale of the implementation was not large enough for the bike couriers to experience the saved travel time. Most bike couriers say to be in favour of the app and the idea behind the app, however under the conditions that more traffic lights are connected. Most bike couriers indicated that they did not notice any difference.

To sum up, in designing an app to address the motivation to cycle, it is important to understand what drives the intrinsic motivation to cycle. The Bits-survey only give a glimpse of the major incentives and obstacles. Interesting in this regard is the construction of a typology of cyclists we discussed earlier. When designing an app it could be helpful to understand the types of cyclists you want to reach to maximally support their motivation to cycle. Feedback on health indicators appears to be a good way to motivate people to cycle more often. In general, there is still a lot of room for improvement and experiment to design an optimal app to support cycling motivation.

3.3.4. Giving cyclists a meaningful role in improving air quality or other environmental challenges

The results of the BITS-survey were produced two years far in the BITS-project. Remarkably, the concern with climate change is the most shared motivation among respondents in the different regions. We find only one implementation that directly addresses this motivation: the sniffer bike implementation in Zwolle. Citizens of Zwolle have been involved in data collection on air quality. Sensors have been placed on a certain number of bicycles and citizens have been asked to ride their equipped bikes to collect information. This implementation therefore is also discussed in the part on implementations on data collection. However we briefly discuss the implementation equally from this perspective because it is the only implementation that responds to people concern with the environment.

Zwolle: The implementation with a Sniffer Bike

The main objective of this implementation is to collect data on air quality on and along bicycle routes in Zwolle. The city decided to distribute a certain amount of sensors among Zwolle inhabitants. The sensors had to be placed on the bicycles and they collect environmental data when cycling. All collected data together gives insights in more and less clean cycle routes in the city.

In December 2019 ten inhabitants of Zwolle started to cycle with a sensor on their bike, this as a small implementation study. They collected air quality data during several months. In a second phase, the city of Zwolle wanted to upscale the implementation, however due to COVID-19 and shortage of materials to build the sensors the larger roll-out took place on 7 September 2022. On that day over 140 cyclists started using the sensor. The intention is to scale-up to 250 Sniffer bikes.

In Spring 2022, the first ten users of the Sniffer bike were presented a survey with some questions concerning their motivations to participate and their cycling behaviour. Since the large roll-out of the 250 sensors came too late for the evaluation within the BITS project, this was not taken into account anymore.

However, also from this small experiment several interesting lessons could be learned. Users appreciated the fact that they contributed to data collection on air quality on a larger scale. The lack of involvement from the city and several technical issues were barriers for them. No conclusions concerning the BITS objectives could be made due to a lack of data and the goal of the implementation (collecting data and promoting clean cycling routes) was only partly achieved. We can however conclude that an important added value of this ITS implementation is the citizens' participation. Without much effort, citizens are involved in data collection which contributes to policy preparation and policy making.

A good practice and a good opportunity to give back to participants

Given the fact that (reducing) the ecological footprint is a real motivation for people to choose the bike over the car it is remarkable that this motivation is not more largely addressed in the BITS-projects. In future implementations experimenting with ITS to increase cycling in Europe, this intrinsic motivation should in our opinion be more largely addressed. This implementation shows that citizens are motivated to participate in a citizens science project on air quality. At this moment project partners are looking into creating a map that indicates the healthiest routes in Zwolle. This would be a very interesting tool to further motivate people to cycle more.

3.3.5. General conclusions on projects directly addressing the individual cyclist

The BITS-survey generated interesting insights in people's incentives and obstacles to cycle. The results came in after two years into the BITS Survey. At that time the implementations had already been designed. Retrospectively, the results of the survey are a good framework to understand success and failure in the implementations directly addressing individual cyclists. Implementations that address incentives endorsed by a large majority of respondents, seem to be more successful as compared to those implementations that do not.

Implementations that respond to incentives show to be more successful as compared to those aiming at mitigating obstacles. The signs addressing the individual cyclist with information on free parking spaces or with motivational messages to reduce speed to avoid danger, are not as well received compared to a sign promising additional trees in the environment when cycling more. Further research and experiments are needed to decide on the best practices to make people cycle more.

Another example in this regard concerns the differential impact of the various modalities included in the Apps. The feedback on health indicators included in the App 'bike buddies' appears to deliver better results as compared to competitive games, financial incentives or prizes to be won as tested by the Oldenburg university. The survey indeed showed that health benefits are among the most important incentives for people to cycle. The survey results therefore suggests that implementations responding to people's motivation to reduce his or her ecological footprint or implementations strengthening the fun factor could equally be successful.

The survey data allowed to calculate different profiles of cyclists. The BITS-project does not include implementations that addresses simultaneously different types of cyclists. We suggest however that it could be interesting to test how taking into account various profiles could add to the success of an implementation. The implementation in Withernsea is the only one that addresses a very specific sub-population of less privileged groups. We suggest this to be a stronger focus in future BITS projects. For an ecological transition to be a success, it will be primordial to include all layers of society in the narrative.

4. DATA COLLECTION AND INCREASING DATA ACCESS TO IMPROVE CYCLING POLICY

4.1. Introduction

Sharing cycling data and building a platform to share, analyse and visualize the data and allowing for ‘collected data to get better insight in the needs of cyclists to drastically improve cycling policies’ are important goals of the BITS-project. In this section we discuss how and to what extent the BITS project has succeeded in this respect.

All BITS implementations generate data in one way or another – at the minimum they generate data to allow for an evaluation of the implementation. As such they contributed to the BITS goals of stimulating a culture of reflexivity among providers and users, among businesses and policymakers.

This section describes implementations that focus on innovative ways of data collection, on making data more accessible and/or visible in function of policy making in general or on improving safety, comfort and other for cyclists.

The first category consists of implementations that, for example, count cyclists, collect data on air pollution, data on the use of parking facilities or data on crashes and near crashes at specific points of interest in the project partner’s area.

The second category consists of implementations like ‘data cycling hub’ and ‘bicycledata.de’ and the Cycle Barometer Dashboard on visualization of cycling data to inform policy.

It should be clear that the implementations differ substantially in scope, method and (implementation-specific) goals, making a comparison difficult. For this reason, we will discuss the two types separately and address some of their findings and challenges, focusing on how and to what degree they contribute to the overall BITS goals. We will end with a brief overview of what the BITS Survey has learned us on how the general public in the participating areas feels on data-sharing and apps that create data that can be used for policy.

4.2. Implementations focussing on data collection in function of policy

Several implementations in the BITs project were focused on collecting and analysing objective data with the purpose of objectified decision or policy making, often using innovative technologies. We will differentiate here between implementations that focus on (i) collecting basic data on cycling in the implementation area, (ii) collecting data on emissions or emission reduction, (iii) data on safety conditions (often at intersections). We shortly discuss the goal and results and the main finding of the implementations under each category and try to formulate some general conclusions.

4.2.1. Collecting basic data on cycling

Counting implementation at East Riding

Withernsea has been identified as a community where levels of physical activity are low and so East Riding of Yorkshire Council was implementing new and exciting ways of encouraging residents to live healthier and more active lives, including through the BITS project. At the start of the project, the council recognised that it had little data on cycling levels in the town. To address this gap, the council installed temporary static counters at five locations to count cyclists during five week-long surveys through the project at five time periods within a time frame of more than 2.5 years. They gathered information on the number of cyclists, their direction of travel, their speed of travel and the date time and location of the journeys. Based on these data a new repository of cycling data was established that enabled the project team to identify and analyse cycling trends in Withernsea.

East Riding of Yorkshire Council is an area that was at the beginning of the BITS project setting early steps to develop a cycling policy (partially in function of improving the health of its inhabitants). Baseline cycling data were needed to build and evaluate that policy.

The implementation was evaluated positively with respect to its specific goals: counting definitely was considered very valuable for policy preparation in the domain of mobility. With respect to the overall BITS goals we could not conclude that the slight increase in cyclists noted overtime does automatically leads to a decrease of CO2 emissions - we have no information on the use of the bicycles that replaced motorised vehicles. However, we can assume that a more cycling-supporting policy based on data is an import condition to work towards an increase in cyclists and over time to a reduction in CO2 emissions in the future.

The implementation-owners learnt that it is important to put these numbers into perspective: the counting is just one snapshot and are determined by the circumstances, such as the weather, COVID-19 restrictions, organised events etc. Therefore, we also need to be careful making conclusions and collecting base-line measures on which policies can be developed take a substantial time amount to increase accuracy.

Counting Kiosk (Bruges)

A similar implementation as the one in East-Riding was the installation of a counting kiosk along a new partly realised cycling highway connecting the city centre and the north of Bruges (beach and harbour). The counting kiosk shows the amount of cyclists that passed that day and that year. The kiosk also shows a text explaining what the cycle highway is for.

The City of Bruges wanted to know if the mere fact of having a counting kiosk would attract more people to use this route for recreational and functional movements, but especially monitor the use of the cycling highway for policy reasons.

Installation of the kiosk hasn’t been realised yet because alignment issues between the power company and the company installing the kiosk. In that company there was a lot of change in the personnel so the following-up wasn’t up to speed. While not have succeeded on its own terms (and unable to have had an impact on the overall BITS goals), the implementation was exemplary for many implementations in the sense that cooperation between public and/or private instances take often much more time than initially anticipated even for relatively small projects.

4.2.2. Collecting data for the purpose of safety improvements

Two implementations used innovative methods for near-crash analysis to address safety issues on intersections.

3D camera Antwerp

Several serious crashes have happened on the junction Puursesteenweg in Bornem (Province of Antwerp, Belgium) in the past. The junction combines a railway crossing, an industrial zone, a primary road and a cycle highway. During three full days, all traffic behaviour and all near crashes were recorded by a 3D camera and analysed by using Artificial Intelligence. The results were used for recommendations on improving the design and safety of the intersection.

After some small changes to the junction, a post measurement of three full days took place to remeasure traffic behaviour and near crashes and to evaluate the adaptations. Although a small increase in crashes was noticed – and no real improvement of safety could be concluded - the implementation was partially successful as it helped to understand how innovative ways of data collection and analysis can go beyond more classic methods of evaluating the safety situation at intersections.

The implementation also highlighted the complexities of evaluating impact even based on 'objective data' as a general increase in traffic at the intersection had been noted in the time interval between pre- and post-test (what could obviously increase the probability of (near)crashes) due to unknown reasons.

4.2.3. Implementations on improving bicycle path surface quality analysis

Cycling infrastructure and, in particular well maintained and constructed bicycle lane surfaces, may have a substantial contribution to the cyclists' experience of a safe and comfortable ride.

Vibration is not a desirable feature for cyclists. Therefore, vibration due to the infrastructure that is not properly built, designed or maintained, is perceived as discomfort during the ride (Gogola, 2020). Also, defective pavement surfaces and insufficient maintenance can expose cyclists to health risks through crashes or injuries such as excessive hand arm vibration, problems with the back or other parts of the body (e.g. saddle pains) and even stress (Bayram et al., 2018; Gadsby et al., 2021).

In general, bicycles are mostly designed for urban environments (e.g. city and urban bicycles) and are often not equipped with sufficient suspensions, systems of springs and shock absorbers, to reduce the vibration. While wearing gloves, adjusting tyre pressure (or tyre type) or avoiding specific routes which require riding over defective pavement surfaces all seems to be used by regular cyclists to improve the comfort, the importance of the pavement surface design and maintenance condition is still paramount in influencing the overall extent of cycling in cities (Bayram et al., 2018).

Two implementations focused on measuring the quality of bicycle path surfaces: one implementation in Bruges using the Fietsersbond Measuring Bike, and one in the province of Antwerp comparing three different systems to allow for a better comparison between the systems used internationally. The implementations aimed at setting steps towards regular monitoring of the cycle path surfaces to objectify the need with respect to maintenance.

Bicycle Path Surface Quality Bruges

In the implementation of the city of Bruges, a measuring bike ('meetfiets'), a bicycle equipped with different sensors able to detect imperfections on the cycling paths, cycled on the roads in the city centre of Bruges in 2020 and 2021 while measuring the quality and comfort of the infrastructure. The Fietsersbond's measuring bike evaluated the strengths and weaknesses of the selected cycling routes. These measurements were intended to give the city of Bruges a clear view of the status of its bike paths and can use the findings to make appropriate decisions and to improve the bike network in the future.

The implementation succeeded in its specific goals, showing that by using the measuring bike, it is possible to process relevant data, to evaluate old and new infrastructure quality regularly and to enhance the level of road network maintenance for cyclists. As such, we can conclude that the main goals of this implementation are reached. However, to keep in mind, still different measuring systems exist and are often not comparable. While the implementation helped validating a way to collect data on infrastructure objectively and systematically (which according to the BITS Survey is not satisfactory for a substantial group of citizens), it has not contributed to the overall BITS-goals. Over the long term however it may help to increase the comfort and safety of cyclists.

Bicycle Path Surface Quality, Province of Antwerp and University of Oldenburg

The implementation of the province of Antwerp aimed to make the measurement of the surface quality more efficient by evaluating three systems: Comfortbike (meetfiets), FPP (Bike Path Profilometer) and Drivenby. This implementation may lead to an international standard for cycle path surface quality measurements.

The implementation succeeded in its implementation specific goals as it may help to create an international standard for cycle path surface quality measurements that will allow (local, regional and international) comparisons helping policy makers to formulate more objective targets. It did not directly contribute to the overall goals of the BITS-project, but definitely contributed to increased opportunities for data comparisons for the purpose of policy-making.

4.2.4. Collecting data on emissions

Snifferbike Zwolle

The main objective of the Snifferbike implementation was to collect data on air quality on and along bicycle routes in Zwolle. The city decided to divide a certain amount of sensors among Zwolle inhabitants that had to be placed on bicycles. The sensors collected environmental data when the inhabitant was cycling. All collected data together allow to assess air quality alongst the cycle routes in the city. The objective at the start was to inform citizens afterwards about more and less clean cycle routes and to adapt cycling policy to the result, e.g. by giving more attention to management and maintenance of this route or by removing motorized vehicles from certain roads or during certain hours of the day.

Particle Matter Sensor Measurement , Cycledata

In Kampen on the city bridge, the Signum bicycle counter was installed together with the first prototype particulate matter meter. After the installation, Cycledata analysed the particulate matter measurement daily between 21/03/2022 and 27/03/2022. In addition, they looked at the rush hours in the morning, afternoon and evening and the amount of particulate matter at those times in relation to the other times on the cycle path. The aim of the implementation was to investigate how much particulate matter is present at this location and the amount of particulate matter during a day with a view to healthy air quality. By measuring particulate matter on location, Cycledata wants to make a combination between the number of vehicles that are counted on the cycle path and what content of particulate matter is measured. The goal was to realize clean cycling routes so that cycling can be promoted on these routes.

Currently the promotion of clean cycling routes has had no impact on cycling behaviour and or CO2 emissions. It is probable that it takes more time to inform citizens and create behavioural change before impact can be noticed. However, the positive impact lays primarily in gaining more insight on the air quality in the area and especially more experience in how to interpret the data. While data may appear objective, still many interpretative decisions have to be made (e.g. what's the cutting point between a 'clean route' and a 'non clean route').

4.2.5. General conclusions on generating data to inform policy

Most implementations described above did achieve their implementation-specific goals to a certain extent. They support the fact that that collecting and analysing objective data using innovative technologies can have substantial value with respect to informing policy or contributing to more objective decision making. Each of the implementations showed, however, the strengths and weaknesses of the collection and analysis of data.

Firstly, most implementations show some of the limitations that data collection and analysis may encounter. Relatively simple forms of data collection like bike counting do not necessarily lead to simple conclusions and/or clear and unambiguous policy recommendations. While over time an increase in cyclists was noted in East-riding, the counting are a snapshot and numbers may be strongly affected by circumstances, such as the weather, COVID-19 restrictions, organised events etc. The presence of absence of these circumstances may strongly affect the degree of certainty of policy recommendations.

The 3D camera in the province of Antwerp showed to be a useful tool in collecting objective data that allowed to implement a preventive traffic safety policy instead of a curative policy. However, analysing and interpreting these data may be complicated and changes in traffic flows independent of the implementation driven interventions at the intersection limit strong conclusions: an increase in overall traffic between baseline measurement and the post measurement complicated the interpretation of the increase in the number of crashes between the pre and post measurement.

Changes in cycling behaviour due to the COVID-19 pandemic, weather-related changes in traffic or even an issue like the closure of one or a few companies in the industrial zones near the intersection, add to uncertainty about the interpretation of the implementation results.

The implementation in Zwolle on analysing safety on intersections indicated however that Microtraffic analysis had a great added value compared to traditional accident analysis and checking basic characteristics alone. Whereas the accident analysis and the checking of the Sustainable Safety basic characteristics only give an indication of the problem and the possible cause, the Microtraffic analysis indicated more exactly the problems at hand. With that information, targeted measures could be taken with more confidence than if one were to rely on the more classical tools to develop measures that reduce the likelihood of crashes. It should be noted, however, that changes on the intersection will only be implemented in 2023 and it will take time to evaluate whether these changes are effective in enhancing safety.

With respect to the implementations on bicycle path surface quality, the goals of the implementation in Bruges were reached. In particular, due to the measuring bike, it is possible (1) to have insights into the comfort of specific cycling infrastructure by analysing the surface quality very thoroughly, (2) to evaluate new construction projects upon delivery, and (3) to decide upon new projects or policy priorities in the future (e.g. information about the bad cycling infrastructure can be placed on the political agenda). It is critical, however, that the way of measuring remains the same over time. If other types of measurement or other forms of technology are used by the measuring bike in the future, it will downsize the added value of the ITS intervention in observing objective trends in surface quality of cycling infrastructure. In this respect it is important to note that currently there exist no standardized way of measuring exist, limiting comparability between the situation in different cities. The implementation of the province of Antwerp and the university of Oldenburg succeeded in taking steps towards such a standard by comparing three different systems concluded that the preferred technology (taking budget into account) depends on the goals to be achieved. To join datasets of different technologies into one uniform dataset, more work is needed. This would require a proper conversion algorithm of one dataset to another or to a common standard.

The large-scall roll-out of the Snifferbike implementation took place in September 2022 in Zwolle. Within the scope of the BITS project only the results of the implementation roll-out in December 2019 could be taken into account for evaluation purposes. No conclusions concerning the BITS objectives could be made due to a lack of data and the goal of the implementation (collecting data and promoting clean cycling routes) was only partly achieved. Citizen participation was of important added value for this implementation. Without much effort, citizens were involved in data collection that will contribute to policy preparation and policy making. This implementation also learned it is important to consciously consider the aims of the data collection on beforehand. Data collection can be very useful, but it needs to have a purpose. However, the potential of this type of data collection in the future is very high, since the more data that is collected, the more valuable the collected data becomes.

Secondly, one of the most important outcomes of all three implementations was the element of ‘learning’ and ‘building expertise’ for the stakeholders involved. In East-riding, for example, there was few expertise on bike counting tools. The implementation showed that a ‘learning process’ cannot be avoided when implementing new forms of technology: some experience is needed to learn how to interpret the data and/or to develop methodologies that can improve future counting projects. Similarly, for the province of Antwerp, the use of 3D cameras for analysing traffic flows on intersections was new and the implementation coordinators stressed the importance of lessons learned during the project. That experience is shared by the implementation coordinators in Zwolle. The technology was new and based on their experience the technology is currently more often used when analysing dangerous situations at traffic points.

Thirdly, a self-evident however important caveat is that collecting data on a policy related issues, in itself does not solve the issues at hand. Few of the implementations described above could be expected to have a fast and clear impact on the overall BITS goals. An uptake in cycling and a decrease in CO2 emissions often requires huge investments in infrastructure, difficult political decisions and campaigns to change the hearts and minds of citizens. Even if objective data are available that clearly hint at a solution for a specific problem, any of these issues may be and often are an obstacle or challenge for policy makers or data analysts trying to evaluate the added value of decision making based on objective data.

Summarising, collecting and especially interpreting ‘objective data’ is not without its problems and challenges. It often requires several forms of expertise from experienced professionals who need to build experience through a learning process. It should be noted that many of the technologies used change rapidly and progress in data analysis techniques or improved knowledge – based on the learning process mentioned above - on the conditions in which the use of specific technologies may deliver the greatest added value, may contribute to strengthening ‘the practice of data-driven policy making’ in the near future. As such, the difficulties regarding the interpretation of data should, not be used as an argument to defend a ‘relying on gut-feelings' approach.

4.3. Implementations focused on making data more accessible, comparable and visual

Next to implementations that focus on data-driven decision-making, the BITS project included 3 implementations on making data more accessible and stimulating data sharing: the Data Cycling Hub and Bicycledata.de and the Cycling Barometer Dashboard.

4.3.1. Cycle Data Hub

The Cycle Data Hub (CDH) was developed and launched by the Province of Antwerp, within the scope of the BITS project. The Cycle Data Hub serves as an international platform to share and find bicycle data. The aim is to provide a central hub where a wide range of diverse cycle data collectors at a local, national and international level can collaborate to collect, test, share and compare cycle data sets.

The CDH contains data on bicycle use, infrastructure, health, safety, climate impact and bicycle business performance. These data are essential to give the cyclist more visibility in statistics, analyses and policy, with the ultimate goal to increase the take-up of cycling and reduce CO2 emission. What the platform is and looks like today is the result of a long and thorough learning and research process with several partners and experts.

As a result of the CDH, increased possibilities of comparing data on a specific policy question with data collected elsewhere on related questions may help with overcoming some of the problems regarding the interpretation as described above.

Statistics on the use of the CDH show a considerable increase in activity, indicating its relevance and showing its potential to have an impact on the practice of the open data approach.

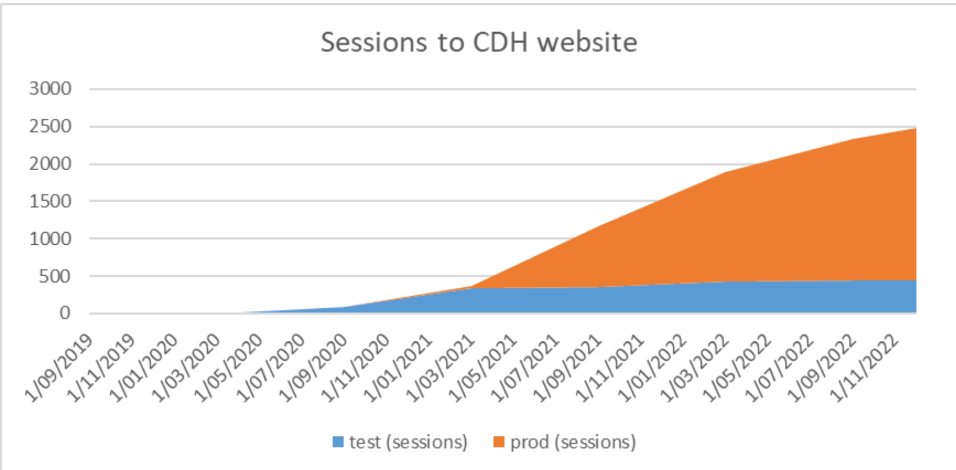

Figure 2 - Evolution of the Number of sessions on the Cycle Data Hub website (Source: Province of Antwerp)

Again, due to the innovative nature of the project one of its important contributions to the cycling policy world is the documentation of 'the learning process' that the implementation went through. Lessons learned are situated at different aspects of the implementations: the development of the platform, the data level (ownership, availability, use of data, awareness, detail, quality), cooperation between partners (within and beyond the project), impact on policy and businesses.

These lessons learned – more in detail discussed in the 'recommendations report' - have a huge potential for strengthening future projects and in stimulating discussions at policy level.

4.3.2. Bicycledata.de

Bicycledata.de is an interactive website on which cycling data gathered within the scope of the BITS project as well as other cycling data can be found. Users can compile and download the processed raw data and they can display analyses and visualizations. The data was enriched by geo coordinates and weather data. Data structures of similar types of data were harmonized (e.g. counting, near crashes) to make the database more valuable.

As a result of this implementation, the tool developed contains many valuable, often enriched data sets and thanks to e.g. the KPI's, comparisons of cycling data are more straightforward. In total, five types of cycling data are made available: (1) bicycle counting, (2) bike sensors, (3) near crashes, (4) bicycle parking, and (5) bicycle. The bicycledata.de clearly met its implementation specific goals. Like the Data Cycling Hub implementation, this implementation met similar problems and challenges and resulted in a great 'learning opportunity' and similar 'lessons learned'.

4.3.3. Cycle Barometer Dashboard

The Cycle Barometer Dashboard is an online dashboard for the evaluation of trends in quality measurements of cycle infrastructure. It allows for a comparison between historical and recent measurements and how these have improved or lost in quality. The dashboard allows for filtering of municipalities/streets, it visualises length of cycle paths, mixed traffic, single and bi-directional, quality scores, number of obstacles. Other tabs in the dashboard allow for a cartographic comparison of before and after maps displaying final score, width, buffer zone from cycle path to road, of cycle paths, the surface quality, mixed traffic and speed of motorized traffic in mixed traffic.

The implementation encountered a number of issues, that can be attributed to the data structure, data quality and technology. Historical data, for example, were never synchronised to the more recent agreed upon data structure making the comparison between historical and recent data flawed and in need of time-consuming manual corrections. In addition, street names were inconsequently registered between historical and recent measurements which makes correlating historical to recent datasets is not always as accurate as hoped. Moreover, try-outs indicated that the (at the start of the implementation) planned comparisons between historical and recent data possible, based on arcade expressions on the fly in the ArcGIS dashboard, caused many delays and crashes for a fluently functioning dashboard. Also, it was learnt that by re-editing the basic data structure behind the dashboard, the datalinks behind the entire dashboard needed to be rebuilt each time.

Summarising although the Cycle Barometer Dashboard did not yet result in a functioning deliverable, many lessens have been learned during the process.

4.3.4. General conclusions on data sharing projects

Taking into account the Cycling Data Hub and bicycledata.de met their own BITS objectives – and de Cycle Barometer Dashboard still has the potential to do so - the implementations definitely reached their goals by contributing to the BITS goal of 'open data' (basic layer of the BITS pyramid).

Although both projects do not immediately lead to the uptake in cycling and the reduction of CO_2 emissions, they have the potential to contribute to more objectified policy making and stimulate innovations that affect the other layers of the BITS-pyramid: make cycling more safe, reliable, convenient, comfortable and increase ease of use and experience.

The tree implementations shared some common pitfalls and challenges. One challenge for the development of data sharing platforms is that their impact is at its highest when they are sustainable over time, which requires resources for maintenance and further development. In addition, building and maintaining a strong partnership around these platforms will be necessary for (but will also depend on) evolving towards long term common standards for data structures, data quality and technology to allow more efficient means of data visualisation a comparison.

An additional challenge regarding data collection and sharing are the issues surrounding willingness to share data (by citizens), privacy and GDPR. With respect to the last issue, some recommendations based on the implementations above will be discussed in the recommendations report. When it comes to the way citizens look at the use of apps (that collect data) and their concerns about this, the BITS survey allows us to formulate some interesting findings.

The BITS survey contained only few items on the BITS-project goal of 'sharing cycling data and building a Cycling Datahub to share, analyse and visualize the data as this goal is primarily oriented towards researchers, policy makers and cycling industry stakeholders. The respondents, however, were asked to what degree they would be willing to share data with policy makers and what barriers they would experience.

76.6% of the respondents was willing 'to contribute to optimisation of cycling infrastructure or policy by connection a sensor to his/her bicycle that 'collects road information and send it to the public authorities' and 74% would be willing to do so with respect to 'environmental data'.

While knowledge on the working of apps – 8% (somewhat) agrees that he/she doesn't know how apps work – seems not to be a huge barrier for the of BITS application that allow for interaction between cyclists and their environment, both 'privacy-issues' (37.3% indicates being worried about this) and the possibility of 'distraction' (32.1%) that apps may cause (leading to unsafe traffic) are greater concerns.

Table 4 - % of respondents agreeing with statements of app use

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
I am worried about my privacy when using apps	9,3%	26,6%	26,8%	29,3%	8,0%
I think using apps is time consuming	15,3%	28,1%	30,7%	23,3%	2,6%
I don't know how these apps work	35,8%	33,9%	22,4%	6,5%	1,5%
I think using apps is complicated	23,3%	31,6%	30,9%	12,6%	1,6%
Apps can give me a lot of useful information	1,4%	5,7%	22,9%	51,9%	18,2%
An app can distract me when cycling and can cause unsafe traffic situations	8,0%	24,2%	35,8%	24,6%	7,5%

Concerns on privacy that a substantial number of respondents has regarding the use of data generated by bicycle-related apps, suggests that policy makers and companies should explain carefully what kind of data these apps generate and how data are collected in line with existing GDPR rules. This holds equally for all stakeholders in the BITS project.

In conclusion, both projects have potential to contribute to a culture of decision-making based on objective data as they make more sources of data available to a broader public as such increasing the possibilities regarding interpretating and comparing data. One of the challenges for both platforms is to secure their sustainability over time as hosting and maintenance require continued resources.

4.4. Final conclusions

Sharing cycling data and building a platform to share, analyse and visualize the data and allowing for 'collected data to get better insight in the needs of cyclists to drastically improve cycling policies' were important goals of the BITS-project. We can conclude that most implementations that focused on these goals were successful. The implementations within this category, did not unexpectedly, contribute little to the overall goal of the uptake in cycling and the reduction of CO_2 emissions within the timeframe of the project. However, the implementations discussed have contributed to a 'culture of objectifying cycle policy' and such a culture - despite the shortcomings objective data have – may help policy makers to advance beyond instead of 'gut-feeling' or 'educated guess-work'. Over the long run better cycling policies may increase safety, comfort, speed, ease of use for cyclists.

5. INFRASTRUCTURE ORIENTED IMPLEMENTATIONS

In this section we will discuss the implementations that focus on the cycling environment and infrastructure in the broad sense as purely infrastructural interventions without an ITS component fall outside the scope of the BITS project. Firstly we will discuss some findings from the BITS survey on how citizens of the project partners evaluate the cycling infrastructure in their area, secondly we will discuss the implementations to assess the potential ITS applications can have for improving the infrastructure by making it safer, easier to use and more comfortable.

5.1. BITS survey: how do people in evaluate existing cycling infrastructure in their region

In the BITS survey, we asked the respondents to evaluate their satisfaction with the cycling infrastructure in their region.

Respondents appear in general quite critical with respect to the cycling infrastructure. For example, 51% is not (at all) satisfied with the condition of the cycle paths and 50% with cycle path width in their region. Only with regard to 'bicycle sharing systems' is the dissatisfaction relatively low (22%).

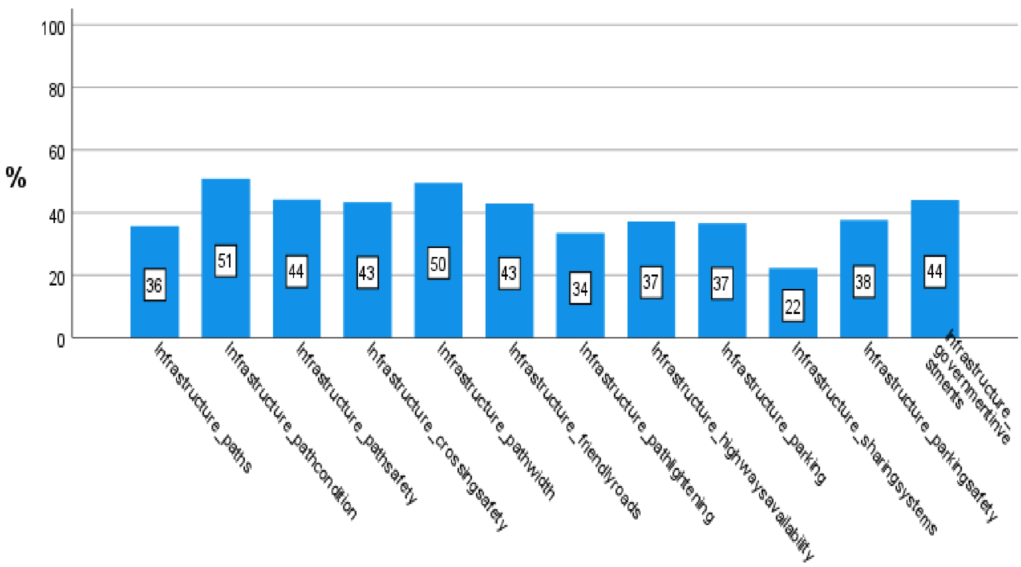

Figure 3 - % of respondents not (at all) satisfied with different elements of the cycling infrastructure (compared to 'neutral' and (very) satisfied).

This general trend is confirmed by the finding that 44.3% of the respondents is dissatisfied with 'the investments and initiatives of the government concerning bicycle policy' in their region. Respondents of Zwolle, Aarhus and East Riding are more satisfied than respondents from Bruges and the province of Antwerp and dissatisfaction is highest in Oldenburg. These differences are significant ($F=68.88$; $p<0.001$).

To a certain extent the fact that the respondents of East Riding appear relatively more satisfied than respondents in some other regions may be surprising. The project administrators of East Riding had after all clearly indicated that the area was low in cycling infrastructure and that cycling was not an established mode of transport yet. However, it could be reasoned that relative satisfaction may come from the fact that fewer people are cycling or interested in cycling, making them unaware or not interested in the current state of the infrastructure.

5.2. What type of interventions have been done in BITS?

Several implementations in the BITS-project have focused on improving different parts of the cycling infrastructure with support of ITS applications. In the following sections, we discuss the implementations that have mostly contributed to the safety, comfort, experience, speed and ease of use of cyclists.

Meetfiets Bruges

In this implementation, a measuring bike ('meetfiets'), a bicycle equipped with different sensors able to detect imperfections on the cycling paths, cycled on the roads in the city centre of Bruges in 2020 and 2021 while measuring the quality and comfort of the infrastructure. The Fietsersbond's Measuring Bike evaluated the strengths and weaknesses of the selected cycling routes. With the results of the implementation, the city of Bruges is provided with information about the current state of bicycle path surface quality.

The implementation indicated that by using the 'measuring bike', it is possible to process relevant data, to evaluate old and new infrastructure quality regularly and to enhance the level of road network maintenance for cyclists. As such, we can conclude that the main goals of this implementation are reached.

Given the objectives of the BITS project of increasing the uptake of cycling and reducing CO2 emissions, may only be realized indirectly by this type of ITS. More specifically, as supported by the literature (e.g. Foster et al., 2011; Gogola, 2020), an improved quality of the cycling paths may generate improved comfort and less health risks which may stimulate cyclists to cycle more. Hölzel et al. (2012) even concluded that improving the bikers' comfort, for instance through cycling pavement surfaces constructed from asphalt, may encourage a greater uptake of cycling by new cyclists.

Accordingly, we conclude that an increase in cycling use may be expected and realized in the long run – under the condition that 'measuring' will also result in systematic policies and investments to improve bicycle path surface quality - not at least because this type of ITS helps to ameliorate some of the risks of cycling as well as to develop reasoned cycling policies in municipalities.

Meetfiets Antwerpen in cooperation with the University of Oldenburg

While the province of Antwerp measures the quality of cycle path surfaces with a measuring bicycle, the Flemish government however uses a profilometer and still other systems exist greatly complicating the comparability of the results and more coordinated efforts towards improvement. This evaluation of cycle path quality may lead to the construction of higher quality cycle paths, which then attract more cyclists. Both the surface quality and sufficient width increase the comfort of cycling and the safety for cyclists. The present implementation aims to make the measurement of the surface quality more efficiently by evaluating three systems in comparison: Comfortbike, FPP (Bike Path Profilometer) and Drivenby. Over time this implementation may lead towards an international standard for cycle path surface quality measurements.

The implementation met its own objectives by increasing knowledge on three forms of technology that measure bicycle path surface analysis. Based on the comparison of the technologies It may be concluded that the technology that is preferred (taking into account the budget) really depends on what goals one wants to achieve with the quality measurement. To compare different techniques, the 'conversion' of one dataset to another or to a common standard, more work is needed.

The implementation in itself did not directly contribute to some of the overall goals of the BITS project as it could not have been expected to contribute in a short term to increasing numbers of cyclists or a reduction in CO2. However, analysis of the BITS survey indicates that at least in theory a better cycling infrastructure of which a high-quality bicycle paths are important to a large majority of cyclists, has the potential in the long run to increase the uptake of cycling.

General conclusions with respect to measuring cycling path surface quality

The BITS survey indicated that in the participating areas a large number of respondents is dissatisfied with cycle infrastructure including the safety of cycling paths and the condition of the cycling paths (51%). Measuring surface quality however will, in itself, not affect the uptake of cycling in the short term but it may help to objectify the problem and may form the basis for a long-term policy towards improving bicycle path surface quality. An important condition however is that these implementations are scaled up and integrated and a structural and systematic program of improving cycling path surface quality is established. A European standard of quality allowing local and international comparisons may increase pressure on authorities to work towards progress. The implementation of the province of Antwerp and the University of Oldenburg has taken important steps in that direction, however, it is clear that more work needs to be done to achieve this goal. More concrete recommendations will be discussed in the 'recommendations report'.

5.2.1. Safe and fast crossings

Several implementations focused on making intersections safer and/or giving cyclists priority above motorized vehicles: safety by Radar, Bike Chain and the Schwung-app. Two other implementations – 3D-camera (Province of Antwerp) and Camera (Zwolle) are discussed in the section on data-collection.

Safe Bike Crossing Zwolle

The intersection Assendorperstraat - Luttenbergstraat - Bartjensstraat in Zwolle is known as a traffic unsafe intersection. The municipality of Zwolle (with help of Mobycon) has therefore decided to investigate this intersection as an implementation project to see whether and to what extent Microtraffic's new conflict analysis technique offers added value compared to existing research methods. Existing research methods were analysing the registered data of actual crashes and testing the intersection design against the Sustainable Safety design characteristics.

The use of the technique clearly showed added value and has contributed to the understanding on how safety on the intersection could be improved. As such, the implementation specific goals were achieved. As the intersection still has to be adapted (at least partially by the results of the implementation), there could not be an effect on the overall BITS goals be expected but numbers indicate than an improved safety in traffic could at least in theory lead to an uptake in cycling.

Safety by Radar, Aarhus

The Aarhus' implementation 'Safety by Radar' consists of sensors placed at traffic lights that are able to register cyclists who are approaching the traffic lights. The traffic light is positioned downhill so cyclist approached them with high speed. The sensors can regulate the traffic lights in such a way that they increase the timing of the green lights. In this way cyclists can reach the other side of the intersection safely and it is avoided that they have to slow down suddenly in case the lights jump on red.

Based on the survey of cyclists at the specific intersection, we may conclude that this intervention increased cyclists' experience of comfort and safety (although comfort was not always recognized as safety). For further evaluation, objective statistics on crashes, conflicts and near-conflicts will be needed. However, the BITS survey indicated that there is a high willingness to cycle more amongst citizens of Aarhus, and that increased safety would contribute to transform intentions into behaviour and that systems that increase the flow of cyclists in traffic (city-wide) could increase the uptake of cycling and has the potential of reducing CO2 emissions.

Bike Chain (0verijssel)

The bike chain ITS implementation stimulated cyclists to cycle in a group and to reduce speed differences when approaching traffic lights. When three or more cyclists form a group when approaching the traffic light, they get priority green. This should increase speed and convenience of cycling.

Based on the analyses made above, we can conclude that the total cycle time (the time between the start of a green light and the start of the following green light for one direction) increased slightly for vehicles, but decreased more significantly for cyclists. We can conclude that this is a win-win situation, since the system of the bike chain works for cyclists and gives them priority on the one hand and on the other, the overall impact on vehicles is limited.

Looking at the subjective experience of cyclists, the majority did not have the feeling that they travelled faster and the bike chain wouldn't motivate them to cycle more often or to choose the bike instead of a motorized vehicle. However, two third of the respondents think it is a good idea to roll out the system on a larger scale.

Taking a look at the BITS objectives, no conclusions can be made concerning the target of 10% increase in take-up of cycling among target groups. Since no data is available on the total amount of cyclists before and after installation, we cannot make conclusions on this objective. Using the survey data, however, 12% of the respondents indicated to use their bicycle more often due to this ITS implementation, so a potential increase in cyclists could be expected based on this survey. The second objective, concerning a decrease of 9% of CO2 emission, is also hard to check.

It was unfortunate that no counting data on the amount of cyclists before and after installation of the bike chain was available. Moreover, exact numbers on the amount of times the bike chain started working due to a group of three or more cyclists and gave priority to cyclists is also not known. An estimation can be made, but in the case of two groups riding closely behind each other, the traffic lights remained green and this was counted as one action, while, in reality, two groups passed by. Moreover, due to external factors, the systems was a few times not working. What the potential impact was on the loss of credibility among users was not measured and is hard to measure as well. However, it would have been interesting to be able to take this into account as well.

Schwung-app: traffic flow for courier, Zwolle

The Schwung-app was launched in the city of Zwolle. This app interacts with the traffic lights and gives priority to cyclists. In this implementation "The Schwung-app for bike couriers", by an extension of the existing app, absolute priority is given to bike couriers with the aim to make them move faster through the city and to allow them to deliver more packages in the same amount of time. In this BITS implementation, the app tracks ones route and interacts with the traffic lights when the cyclist is approaching the traffic lights. The app extension for couriers allows couriers to apply for priority at 60 meters when approaching the traffic light. The app for regular cyclist allows to apply for priority at 20 meters. The light automatically turns green when the bike courier arrives which is not necessarily the case for regular cyclists. By giving absolute priority to the couriers, the aim is to attract more cargo bikes to the inner city and less delivery vans.

The Schwung-app implementation can be considered a successful experiment and this for at least three reasons. The statistics collected by the app show that the implementation strongly coincides with an increased use of the Schwung app. The number of passages registered by the apps more than doubled.

Secondly, the different analyses of the waiting time at the seven intersections during the implementation phase, shows that the bike couriers objectively gain time using the Schwung-app. Other traffic users have to wait longer which possibly can lead to congestion problems and possibly an increase of CO2. However, the scale of the intervention was too small to make conclusions about the impact on the overall traffic flow in Zwolle.

Thirdly, looking at the survey administered among the bike couriers we notice that a large majority of all couriers would recommend the use of the app. Notwithstanding, they also say that there is still a lot of room for improvement. More traffic lights should be connected to the app to make a real difference. The motivation to make use of cargo bikes could further be supported by integrating more feedback in the app as for example an overview of the time saved due to the app. Especially in busy and complex traffic environments the Schwung-app for bike couriers could give a competitive advantage to bike couriers compared to motorized vehicles and thereby in the end reduce CO2 emissions.

General conclusions regarding ITS that help passing intersections more safe and faster

One general conclusion about the implementations above is that while – objectively – the intervention probably shortens the travel time for cyclists and in certain cases increases the safety and/or comfort, this is not always felt by individual cyclists as the area in which the implementations are installed is too small to make a substantial difference regarding the full trajectory of the cyclist. If however this ITS implementation would be rolled out on a longer route with several traffic lights following each other, the effect for the cyclists would be potentially much larger and cyclists would actually experience a difference. This also creates complexities for the evaluation of these implementations (see recommendations paper).

5.2.2. Bicycle parking systems: comfort

Two implementations of the BITS-project focussed on ITS interventions for improving bicycle parkings.

Parking referral system

In the city of Bruges a parking referral system for bikes (PRSB) was installed in two underground parking facilities in the centre of Bruges, i.e. at ‘t Zand and Concertgebouw. In the parking, the amount of parked vehicles are monitored continuously by optical sensors. Above the ground, LED screens are installed, which gives the people passing by an overview of the available parking spots in the parking facility. Since both parking facilities are close to each other, the LED screens also show the number of available spots of the other parking lot.

Apart from the technical and administrative pitfalls, it is quite clear that the implementation has been successful in several ways. This type of intervention clearly supports the visibility of the two underground parking facilities in the city centre. From the *users' perspective*, the added value of the system in creating more visibility is recognized and an extension to other parking facilities is even recommended.

Also, if we look at the overall objectives of the implementation, we may conclude that the parking referral system for bikes (PRSB) with LED-screens results in a higher usage of the parking facilities. Some observations as well as the average occupancy rate (%) per day showed an increase at both parking facilities. Overall, considering pre- and post-measurements, the number of users increased with about 6.5% which may be an indication of higher cycling use. Also, two of the survey participants indicated that the system actually stimulates them to replace the car by bike. This may be a small but relevant indication of a 'modal shift' meaning that a certain reduction of CO2 emission can be expected.

For *policy-makers*, the parking referral system has an added value in making it easier to detect orphan bikes and to collect permanent information about the occupancy rate of the parking facilities. As such, the collected data may e.g. help to develop targeted actions to the users of the PRSB, as it is known when each parking facility is used the most (e.g. weekdays versus weekend).

To conclude, in the light of the BITS-project goals, we may conclude that the main goals of this implementation are reached partially. While it is clearly more convenient for cyclists to use the parking, the PRSB does not really impact on the take-up of cycling nor on the cycling motivations of the current users of the parking referral system.

Wayfinding

The city centre of Zwolle is becoming increasingly crowded with parked bicycles. The government wants to attract more cyclists to the city centre but they do not want them to park their bicycles in public space. They want them to use the bicycle parking facilities with sufficient free spaces. The Wayfinding implementation aimed at supporting the use of these facilities. On three city entrances of the city, adaptive signs will be place that are controlled by data from the counting sensors in the bike storages. On these signs, cyclists were able to read which parking facilities are suggested for them since they have enough free places.

The results of the Wayfinding implementation, however, have not been convincing. The survey among users of the parking facilities showed that a large majority did not notice the signs. The minority that did notice the signs says that the information did not influence their choice concerning the parking facilities. The analyses made by Royal HaskoningDHV of the data administered by the counting sensors does not allow to support the efficiency of the implementation either. The data do not show a different pattern of inflow at the parking facilities following the information on the digital signs. However, this does not mean that a referral system cannot support an efficient use of parking facilities. The survey administered among the users informed about the changes that could support the added value of a referral system. First and foremost the visibility of the signs should be enhanced. In order to generate an impact on cyclist behaviour, the signs must be noticed. Respondents replied that there should be more signs. They should moreover be better located, closer to the parking facilities, they should be in brighter colours to support their visibility and information on more parking facilities should be included to really make a difference.

A remark by the project managers concerns the integration of this type of information in, for example, the Schwung-app (another implementation in the city of Zwolle). Indeed, merging information on parking facilities in an app addresses various remarks made by the users. It would make the information much more accessible, visible and up to date for cyclists.

Finally, it could be concluded that although there is some room for improvement in finetuning the technology, counting sensors allow to objectively map bicycle flows. Notwithstanding, this type of data collection was not the best way to study the impact of the Wayfinding implementation. The scale of the implementation was too small for the counting sensors to detect changes in bicycle flows following the information on the digital signs. A survey showed to be a better instrument in this case. The implementation still shows the potential of using counting sensors to understand bicycle traffic behaviour also for other objectives than the more efficient use of parking facilities.

General remarks on parking referral systems

While the implementation in Bruges was successful – at least with respect to the implementation's specific goals – the implementation in Zwolle was less convincing. It is important to give sufficient visibility to the parking referral signs. It is also possible that finding a bicycle parking spot is in general less of a problem for citizens (parking is less problematic in cities for cyclists than for car-users). While individual cyclists can park their bike on many places (and want to park as close to their destination), the problem of chaotic parking in public space is primarily a collective problem in the hands of the city. A referral system may not be a sufficient incentive for citizens if not accompanied by other measures, like higher chances of being fined for cyclists parking in public spaces. The parking referral system in Bruges is different in this respect as it focuses on helping cyclists to find a parking spot IN a, often crowded, bicycle parking (which caters to their self-interest).

5.2.3. Smart lighting

Several BITS-implementation experimented with innovative forms of lighting that may increase safety and comfort for cyclists while minimizing the environmental impact.

Rope light (Aarhus)

This ITS intervention concerns the installation of a LED rope light on a big Cycle Super Highway (CSH) in Aarhus. The CSH goes through a green area with forest connecting a big residential area with the Hospital and big business park. The cycle path is mostly used for commuting to and from work and due to regulations on nature area, the city of Aarhus is not allowed to put up continuous lighting on the CSH. The rope light installation winds 400 meters along the cycle path and is adapted to the season. The cycle path lights up in the dark by means of sensors measuring light quality but the sensors also measure temperature. The rope takes the colour Blue in frosty weather, red in autumn, green in spring.

The rope light adds to feelings of safety without disturbing ecosystem and the animals living in the forest. The aesthetic of the intervention was highly appreciated. However, there were some downsides to the intervention. The intervention was costly, and the question is whether this kind of lighting should be a priority within the overall cycling policy in Aarhus. Still, the rope light implementation showed the utility of introducing a rope light in many other situations, mainly to make intersections safer. Because of its safety supporting qualities, in theory this application has the potential to increase cycling and decrease $CO2$ (cfr. BITS-survey).

Smart lighting

At the outskirts of the city of Zwolle, the area Hessenpoort has been under construction during the previous years and still is at the current moment. The Hessenpoort includes a business park and industrial companies. Part of the development of this area concerns the construction of bicycle infrastructure. A new lighting system had to be placed on the cycle paths. However, since the terrain lays within a green zone, the lighting may disturb the animals living there. Lighting is notwithstanding a crucial element to create a safe route for the cyclists. Therefore, smart lighting technology has been installed. The lighting starts when a cyclist arrives and is turned off when nobody is passing.

The hypothesis that people will start to cycle more because of the smart lighting system cannot be confirmed. We do not have data on the number of cyclists before or after the intervention. We therefore cannot confirm whether this implementation reached the BITS-objectives. Data from after the intervention did not show more positive feelings of safety and comfort. The smart lighting infrastructure does not add to feelings of safety and comfort as compared to a situation of continuous lighting. However this equally means that the smart lighting did not contribute to feelings of unsafety and lack of comfort, while it has a clear ecological advantage of not disturbing the animals living at the Hessenpoort. Moreover, smart lighting, although more expensive as compared to continuous lighting, saves energy in the long run and therefore supports an ecological transition and decrease of CO2.

General conclusions on smart lighting

While smart lighting may have a positive impact on the environment, it does little to improve feelings of safety and comfort and an immediate increase in the uptake of cycling should not be expected. Its higher cost price should be weighed against the benefits of a lower energy cost over time (and potential lower CO2 emissions due to lower energy consumption) to see if a more general roll-out should be given a priority status.

5.3. Concluding remarks on BITS & Infrastructure

The BITS interventions described above were not intended to have a direct impact on the individual's motivation to cycle, however, by changing and improving the cycling environment, they are directed at increasing the benefits and lowering the costs of cycling compared to other ways of transportation. If cycling increases in safety, ease of use, speed and comfort compared to other forms of transportation, over time there will be a noticeable uptake in cycling.

Most of the implementations described above were however small in scale and scope and while it is hard to imagine why, objectively, they would not contribute to cyclists' safety, comfort or speed, for this reason we often failed to directly capture a change in the subjective experience of cyclists, although there were hopeful signs in the right direction.

To achieve the goal of transforming the subjective experience of cyclists, a systematic and integrated approach is needed that goes beyond experimenting with implementations. It should be clear that the benefits of intervening at one intersection – like many implementations have done – to make it safer or to decrease waiting time for cyclists is not necessarily noticeable for individuals, however, if the interventions are scaled up over the whole of the city the individual cyclists' experience may change.

As described in the 'recommendation report', this conclusion raises questions regarding evaluating the impact of implementations. Ideally, implementations should be scaled up after a positive effect is noted, however, often a real positive effect will only be detectable after up-scaling.

6. FINAL CONCLUSIONS

One of the strengths of the BITS project is a rich diversity in innovative implementations and new ways of collecting data and/or analysing cycling policy questions.

Although many did, not all implementations fully reached their implementation specific goals. Some implementations suffered delays, setbacks and/or met with restrictions due to the COVID-19 pandemic and the policies to curb it. Measuring impact was complicated due to changes in mobility (or leisure time) related behaviour during and after the lockdowns. Other implementations' ambitions were probably too high compared to the limited scale of the implementation; others were confronted with technical problems that could not be easily surpassed within a limited time-frame and/or long administrative procedures needed before an implementation could be realized. In addition, not all implementations could be expected to have directly and within the time frame of the project an impact on some of the overall goals of BITS.

However, the BITS project can be considered a success overall as it is clear that policy makers, business and other stakeholders that want to contribute to the uptake of cycling and/or want to use the possibilities that cycling offers to generate new and innovative data, can find plenty of inspiration in the BITS project. In addition, even implementations that did not fully reach their goals have proved to be very informative with respect to 'lessons learned' for future projects. Not all implementations of course are directly transferable to other contexts, however most implementations have generated insights that could help with such a transfer (see recommendations report).

Given the challenges the project was confronted with globally and within the European space, it can be hoped for that the results of the BITS project will find their way into new and better forms of policy making that recognize the importance of cycling and cycling-related data collection as part of the solution for mobility and climate related problems.