BITS
Bicycles and Intelligent Transport Systems

Evaluation report

Traffic measurements with 3D camera
Province of Antwerp

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Project coordinated by: Province of Overijssel

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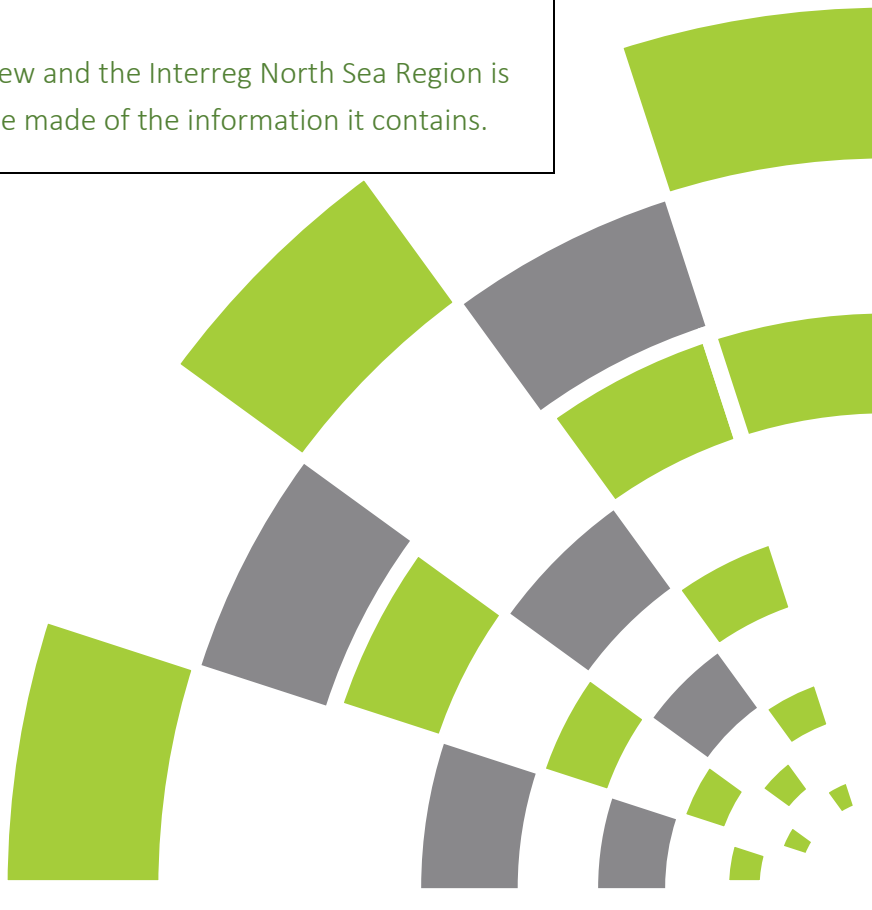

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Short description

Several serious accidents 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 accidents were recorded and 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 accidents and to evaluate the adaptations.

Type of ITS

3D camera and data analysis through Artificial Intelligence

The responsible company for this study is SIGNCO, working with Viscando in subcontracting. Viscando developed the camera technology and made the analyses on the data. In the second round, Viscando also worked with a subcontractor, i.e. NDC. The first study in 2019 had a cost of €18 300; the second study in 2021 had a cost of €12 600. Due to technological innovations, the price lowered between 2019 and 2021.

Timeline

In September 2019, the camera made recordings of the junction for two half days and three full days. In November 2019 a report with the analyses was received and after several meetings and discussions, in Spring 2020 optimisations at the junction were executed. In September 2021, a second round of camera recordings took place. During three full days all traffic flow was measured at the junction. The evaluation report, which made a comparison with the first measurements, was received a few months later. In September 2022, a recommendation workshop with external stakeholders was held to collect their feedback and recommendations.

Hypothesis

By gaining insight with the 3D camera in current behaviour of the traffic and near accidents on the junction, we will be able to make objective, documented recommendations for improving the design of the intersection in order to make it safer and, as a consequence, increase the number of cyclists in the long term.

Data sources

- Reports from Viscando with analyses of 3D camera recordings, made in September 2019 and September 2021
- Report and input of COVEMO (Commission traffic and mobility) from November 2019
- Reports of internal meetings with team cycle policy of the province of Antwerp from September 2019 and January 2020
- PowerPoint with suggestions for optimisations on the intersection, from January 2020

- Data of the BITS survey, collected in Spring 2020
- Input from recommendation workshop with external stakeholders, from September 2022
- Reports of meeting with project managers about the evaluation of the pilot, one from January 2021 and one from August 2022

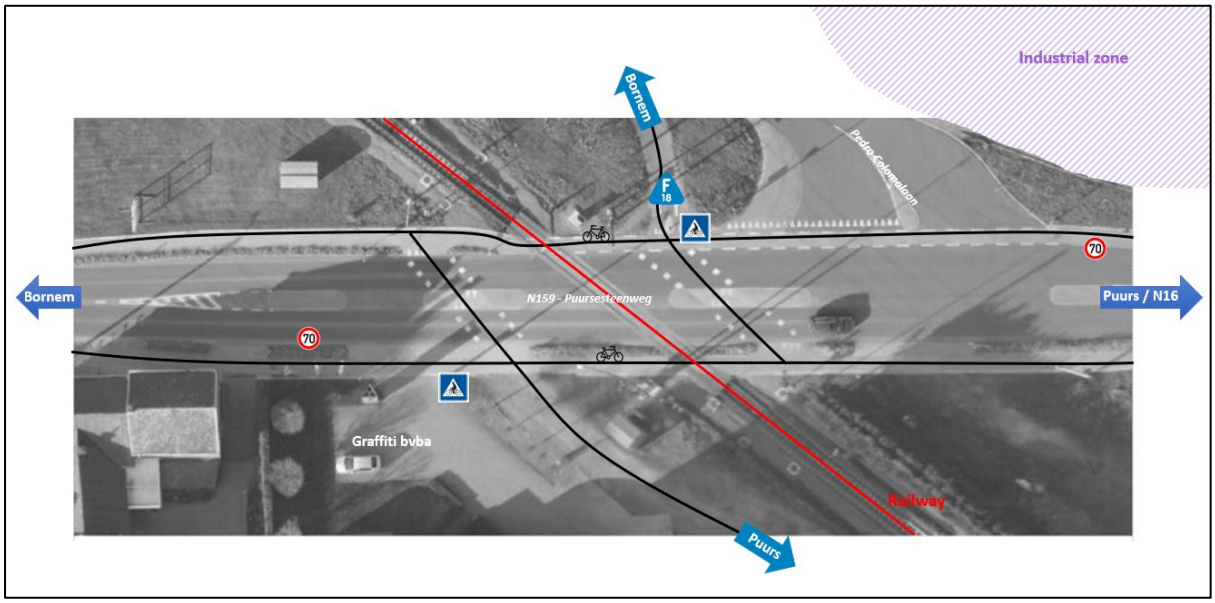
Analysis

Report of the pilot

Before the first camera recordings started, the team cycle policy of the Province had an internal meeting in the beginning of September 2019 to analyse the junction and the traffic flow and to discuss where possible problematic spots would be. This meeting was held as a baseline measure, in order to be able to compare their input with the results of the 3D camera.

During three full days, 4 3D cameras made recordings of the traffic at the intersection of the Puursesteenweg in Bornem, Province of Antwerp. The recordings started on Monday September 23rd 2019 at noon and ended on Friday September 27th at noon. In the beginning of November 2019 an analysis report was received from Viscando.

The picture below shows the junction. The road for cars (horizontally) has a speed limit of 70 km/h. It is crossed by a railway and a crossing for cyclists. Cyclists on the cycle highway (F18) between Sint-Niklaas and Mechelen (vertically) need to cross the road and change to the other side of the railway to continue their ride. The junction is close to an industrial zone and also attracts a lot of heavy vehicles.



The main observations from the 3D camera are the following:

- Daily on average 100 pedestrians are passing by. This is a surprisingly high number for a junction without safe crossing for pedestrians.
- Daily on average 911 cyclists pass the cross road. The camera could not make a distinction between bicycles, speed pedelecs, scooters and motorcycles in this category.
- Cyclists not only cross on the foreseen cycle crossing, but they also cross between the foreseen, cycle crossings in the middle of the road which is the shortest option to cross (i.e. diagonal).
- Although cycle paths are one directional, cyclists are often driving against the allowed driving direction on this junction, particularly on the northern side.
- On average 7250 light vehicles and 642 heavy vehicles are passing by daily.
- The average speed of light vehicles is, given the circumstances, rather high. Light vehicles often don't slow down when approaching the intersection.
- Heavy vehicles slow down more when coming from west compared to coming from east.
- The number of near accidents is higher during peak hours, but there is also more traffic during these hours. The risk on an accident is highest during the night (3 am – 4 am) and in the morning peak (7 am – 9 am).
- Most near accidents are bicycle to bicycle.

It was clear, when receiving the report with the analyses of Viscando, that next to the problems already signalled by the team of cycle policy in the province of Antwerp, also other problematic spots were discovered by the 3D camera. The camera recordings brought interesting new insights of the traffic situation on the junction.

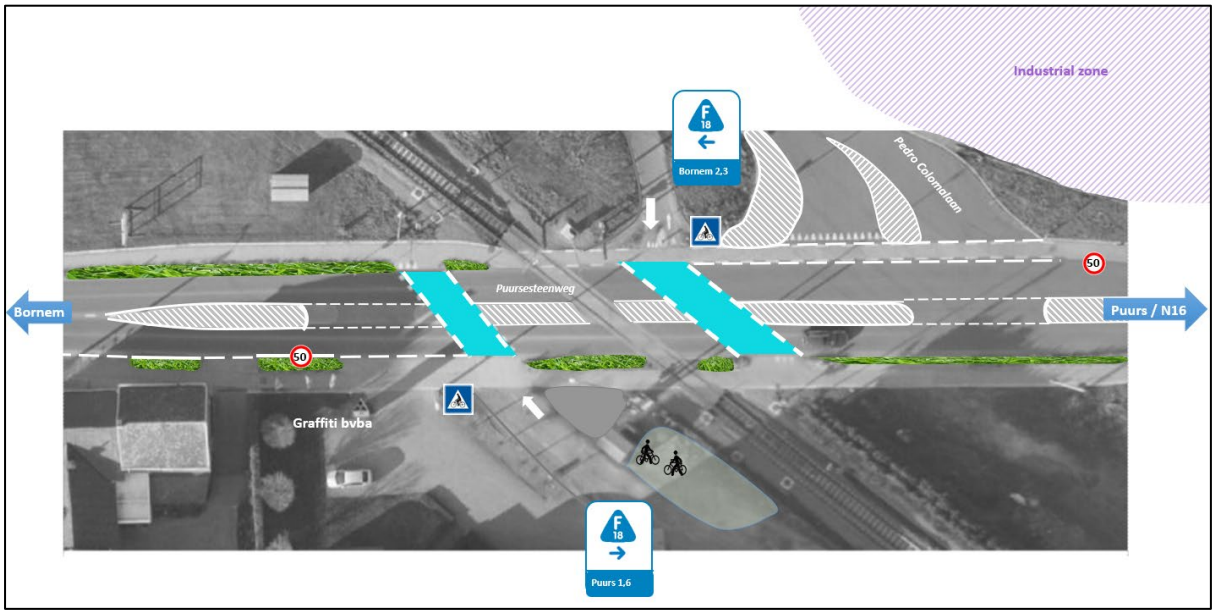
On November 27th 2019, the commission traffic and mobility (COVEMO) of the municipality Bornem came together to discuss the results of the 3D camera. Next to politicians and the local police, also representatives of the schools, companies, associations of seniors and neighbours were represented. During this meeting, the participants were first asked to think about the main traffic flows and potential problems on this junction. Afterwards, the results of the camera recordings were presented and were compared with the input given before. Attendees were surprised about several findings of the 3D camera: the number of pedestrians, cyclists and heavy vehicles, the dangerous situations created on some spots due to the combination of traffic users, the speeds of cars etc. They also gave suggestions for optimisations of the junction and of the technology used. Several reactions and other perspectives were taken into account during this meeting.

In the beginning of 2020 several meetings were organised, first internally within the province of Antwerp cycle policy team, afterwards with politicians of the municipality. During these meetings different options on making the junction safer were positioned against each other. The options went from easy and cheap (clearer markings, speed reduction etc.) to more far-reaching (split off of Pedro Colomalaan, replacing of cycle path to widen the angle, narrowing the road and broaden the cycle paths etc.).

After getting the approval of the alderman of mobility of the municipality, a number of rather small interventions were made at the junction in Spring 2020 (see image below). These interventions are quick-wins with an immediate impact on safety focusing on making potential cyclists more visible and speed reduction of motorized vehicles.

The interventions made are:

(1) Markings on the road were made to emphasise the presence of the cycle crossings using a blue High Friction Surfacing (HFS).
(2) The sign informing motorized vehicles that cyclists can cross the road starts flashing when a cyclist is approaching.
(3) With white markings connecting the different islands in the middle, the illusion of a more narrow road was created.
(4) The maximum allowed speed of traffic was reduced from 70 km/h to 50 km/h on the cross road.



In September 2021 a new round of camera recordings followed in order to evaluate the interventions. From Tuesday afternoon 21 September until Friday afternoon 24 September recordings were made, covering the same area as two years before. It took several months before the evaluation reports were received. For both measured periods the data were processed for exactly the same hours and same days of the week, so that an accurate comparison could be made. Although some innovations and changes in technology took place between 2019 and 2021, all data were adapted after the second measurement so a fair comparison between both measurements could be made.

- On average 7988 light vehicles are passing by daily. This is an increase of 10,2% compared to the measurement in 2019. On the other hand, 524 heavy vehicles passed by on average daily, which is a decrease of 18,5%. This last finding can partly be explained by the closing of several companies in the industrial zone close by.
- On average 809 cyclists are passing by daily, which is a decrease of 11,2% compared to 2019. However, focusing only on the cycle highway, the amount of cycle traffic increased. On the northern path an increase of 78% was observed and on the southern path an increase of 25% was observed. The decrease in total amount of cyclists is thus a consequence of a lot less cyclists on the Puursesteenweg.

- The amount of pedestrians decreased with 17% (although the absolute numbers are rather low compared with the other modalities).
- All motorized traffic increased with 8,2% and all traffic increased with 5,9%.

Average total traffic per day	2019	2021	Difference (in %)
Light vehicles	7 250	7 988	+10,2%
Heavy vehicles	642	524	-18,5%
Bicycles	911	809	-11,2%
Pedestrians	100	83	-17,0%
Motorcycles	30	60	+98,8%
Sum of motorized traffic	**7 922**	**8 572**	**+8,2%**
Sum of all traffic	**8 933**	**9 464**	**+5,9%**

- The overall risk on a near accident increased in the post measurement, from 1,93 on average per hour in 2019 to 2,32 in 2021 (see table). The risk on a near accident between two bicycles nearly halved, while the risk on a bicycle-vehicle near accident doubled and the risk on a vehicle-vehicle near accident multiplied with a factor of 2,5. The category with the highest risk on a near accident moved from bicycle-bicycle to bicycle-vehicle. Important to note here is that the traffic intensity also increased in the second measurement. However, also important to note is that these near accidents are not yet classified in risk levels. When considering the post encroachment time (PET) and the speed of both vehicles involved in a near accident, one can classify all near accidents in a low risk, medium risk, high risk and critical risk category. More research is needed to compare the near accidents and their risk category in both measurement periods.

Amount of near accidents per hour	2019	2021
Bicycle-bicycle	1,13	0,60
Bicycle-vehicle	0,47	0,90
Vehicle-vehicle	0,24	0,60
Pedestrian-bicycle	0,07	0,13
Pedestrian-vehicle	0,01	0,09
All (sum)	**1,93**	**2,32**

- The velocity of bicycles increased between 2019 and 2021, from 15 to 21 km/h on percentile 85, which means that in 2019 85% of the cyclists drove 15 km/h or less and in 2021 85% of the cyclists drove 21 km/h or less. This is probably a consequence of the increase of electric bikes and speedpedelecs.

- On the other hand, the velocity of vehicles decreased, which is logically due to the decreased speed limit from 70 km/h to 50 km/h. While vehicles were often not slowing down when approaching the junction in 2019, we do observe that vehicles slowdown in 2021 when approaching the junction from both sides.
- An increase in the amount of crossing cyclists was observed as well. While in 2019 819 cyclists were crossing on average daily, now 1014 cyclists crossed, which is an increase of 24%. This can be a consequence of an increase of cyclists on the cycle highway.
- Although still a lot of cyclists use the diagonal cross, the shortcut outside the designated passages, the amount of cyclists doing this decreased significantly with 14,3%, to now still 10% of the total crossings. Cyclists prefer the western crossing (which was the same in 2019), and those that cross on the eastern crossing also do this more clearly than in 2019. This can be attributed to a direct influence of the blue coating.

We can conclude that overall traffic on the junction increased with almost 6%, where mainly among light vehicles an increase can be observed. The total amount of cyclists decreased with 11%. The risk on a near accident increased, mainly between bicycles and vehicles and between vehicles. This cannot be explained by velocity of vehicles, since this decreased. Potentially the increased risk on a near accident can be explained by the increased amount of crossing cyclists and by the total increase of traffic. Traffic flows changed considerably between 2019 and 2021. Giving an explanation for this is not easy, since it can be due to the interventions made, but also to the consequences of the COVID-19 pandemic, to the weather, to other factors or to a combination of several factors. Although some interventions were made to improve safety, it is hard to conclude whether safety did improve or not. Although the amount of near accidents increased, they are not necessarily all high risk near accidents. More research is needed to investigate whether the amount of high risk near accidents increased or decreased between both measurements. Nevertheless, we can conclude that the interventions made weren't a total solution on this junction.

Impact

Technology of the 3D camera

Before investigating the impact of the camera recordings and the executed adaptations on the junction, it is necessary to question the usefulness and added value of this type of research. Today the input for traffic safety policy is often statistics and information on traffic accidents in the past, next to subjective interpretations and experiences of users and governmental organizations. The 3D camera technology has the potential to detect where accidents almost happen and this can lead to an adaptation of the junction which can make junctions and roads safer without the need for accidents to actually happen. The 3D camera gives information on the behaviour of road users, their tracks, speed, origin and destination and on near accidents, a new type of data, all extracted automatically from the camera. Since near accidents happen roughly a thousand times more than real accidents, it is a very valuable technology. When striving for zero accidents as a policy, this is a useful tool.

A first advantage of this tool is that it is objective. It doesn't start from a subjective interpretation of one type of road user, but it gives unbiased information of the junction or roads it screens. As mentioned before, a second advantage is the fact that it can identify dangerous roads or junctions before accidents need to happen. All the information collected on near accidents is more objective and precise than one

chance accident. And moreover, statistics on accidents are often incomplete, since not all accidents are taken into account or registered. Thirdly, besides information on near accidents, this tool also gives information on behaviour of road users: how many, which mode, where, how fast, which direction etc. This technology gives a complete overview of the analysed junction. Fourth, the objective data collected is a supportive tool to motivate decisions, for example when priority of infrastructure interventions needs to be decided. Finally, most of this analysis is automated with artificial intelligence and since the tool is still quite new now, further innovation will optimize the technology and will lower the price in the future.

The tool also has some disadvantages. First, the smart camera will only observe what you program it to observe. How users experience the cross road or how the cross road is designed isn't taken into account. Second, it cannot take into account weather circumstances, the broader mobility network or unforeseen circumstances. Thirdly, a lot of data needs to be processed once the recordings were made and this needs a certain type of expertise and knowledge. Not all requesting organisations are able to make time and have the expertise to analyse the raw data. It would be helpful if next to receiving the raw data, a full report with interpretation of the results, adapted to the needs of the requesting organisation, were received as well. Fourthly and additional to the previous remark, the camera only measures and collects data. It doesn't make interpretations, nor does it adapt the junction itself. This still has to be done by the delivering and/or requesting organisation.

BITS survey

After the first measurement in 2019, an exercise was made to hypothesize the potential increase of cyclists due to increased safety on the junction. Using the BITS survey data of all Antwerp respondents, we can make some statements concerning the potential impact of increased safety.

We assume that the interventions made at the intersection would significantly increase safety, since the speed of vehicles was reduced (Isaksson-Hellman & Töreki, 2019, Raihan, Alluri, Wu & Gan, 2019) and since markings were made more visible. In the BITS survey, one out of three Antwerp respondents indicated that they would cycle more if cycle routes would be safer. For 50% of the respondents the absence of a safe cycle route was a barrier to cycle and respectively 47 and 46% was (rather) unsatisfied with the safety of bicycle paths and bicycle crossings. When making a distinction between types of cyclists, we see that more than 50% of the procrastinators, the happy cyclists and the car fanatics (respectively 53%, 57% and 58%) indicate that lack of a safe route is a barrier to cycle more. This is a large difference with only 22% of the die hard cyclists indicating that no safe cycle route is a barrier to cycle for them.

Based on our survey data, we can conclude that for many people lack of a safe route prevents them to cycle (more). When taking a look at the people who would like to cycle a lot more to go shopping or to see family or friends[1], we see that for 33% of them no safe route is to a large extent a barrier to cycle (more). Additionally, for another 30% this is to some extent a barrier, which means that for 63% of the respondents with a high willingness to cycle, lack of a safe route prevents them from cycling (more). In the table below, comparisons with the willingness to cycle more to commute or as a leisure activity in itself can be found.

[1] Full item: to go shopping, or to travel to leisure activities, day care centre or to see family or friends

For more than 30% of the people willing to cycle a lot more, a lack of safety is to a large extent a barrier to cycle, regardless the motive.

	Motive	Lack of safety is a barrier to a large extent	Lack of safety is a barrier to some extent
I would like to cycle a lot more for …	Shopping, see family or friends etc.	33%	30%
	Commute	33%	31%
	Leisure	31%	26%
I would like to cycle more for …	Shopping, see family or friends etc.	25%	31%
	Commute	27%	32%
	Leisure	20%	31%

When comparing the demographic characteristics of the respondents experiencing **a lack of safety as a barrier to a large extent** to cycle (more), with the total group of respondents, some interesting findings appear. People experiencing unsafe routes as a strong barrier are a bit younger, more often female, and more often living together with their children compared to the total population.

If we assume that all people willing to cycle more, also would transform their willingness into action, we can make the following assumptions. When we only take the people with a **high willingness to cycle** (more) into consideration, we can expect 4 to 8% more cyclists if safety would be increased, since 4 to 8% (n=133 and n=120) of the total group of respondents indicated that they would like to cycle a lot more but experience safety as a barrier respectively to a large and to some extent. When also taking the people into account who would like to cycle more, we could expect an increase of 13 to 27% (n=267 and n=331) if safety would be improved. In other words, 27% of the respondents of our survey indicated that they would like to cycle (a lot) more in the future and that they experience a lack of safe routes as a barrier (to a large or to some extent) to cycle.

An immediate increase of 4 to 27% cyclists should not be expected. These numbers are hypothetical, since these people indicate their willingness to cycle; they will not always transform this into action on the bicycle immediately. However, it gives some indications on the impact of increased safety. Moreover, this pilot had the intention to increase safety on one intersection in Bornem and did not increase safety in the entire province. Still, we can hypothetically conclude that improved safety in the wider area in the long term can eventually lead to an increase in cyclists.

Results of the second measurement

Due to the availability of a pre and a post measurement, we can make comparisons between the amount of cyclists before and after the intervention. In the post measurement in 2021, we notice a decrease of 11,2% among cyclists, an increase of 10,2% among light vehicles and a decrease of 18,5% among heavy vehicles. This is an overall increase of 5,9%. The overall traffic thus increased, although the total amount of cyclists decreased. This is not in line with our hypothesis based on the BITS survey that with increased

safety an increase of 4 to 27% cyclists could be expected. However, we can also not conclude that safety did increase on the junction, since the near accidents increased from 1,93 per hour to 2,32 per hour. And especially near accidents between bicycles and vehicles and between two vehicles increased.

Since the overall traffic has increased between the baseline measurement and the post measurement, an increase in risk on an accident could have been expected. To make a fair comparison between the pre and post measurement, a measurement with the same amount of traffic should be needed. However, other circumstances changed as well the past two years: we had the COVID-19 pandemic with its consequences, weather can have an impact, some companies in the industrial zones closed down etc.

We cannot conclude that the 3D camera contributed with a positive impact on the BITS objectives. The first objective is an increase of 10% in uptake of cycling. We did not observe this increase. On the contrary, we saw a decrease of 11,2% in cyclists. The second objective is a decrease of 9% of CO2 emissions. We saw an increase of light vehicles of 10,2%, a decrease of heavy vehicles of 18,5% and an increase of motorcycles of 98,8%. We've used the average CO2 emission of an average passenger car, truck and motorcycle to calculate the CO2 emissions approximately in 2019 and 2021. The average CO2 emission of a new car in 2019 is 122,3g CO2/km (European Environment Agency, 2021). The average CO2 emission of the most represented truck in the market segment is 783,5g CO2/km (Ragon & Rodriguez, 2021). Finally, the average CO2 emission of a motorcycle is 113g CO2/km (Brannon, 2021). When we multiply this by the amount of light vehicles, heavy vehicles and motorcycles in 2019 and 2021 and calculate the difference, we notice an increase of 1 176g CO2/kg, which is 0,08% of the total emission, so in fact negligible. Although we didn't have information on the exact CO2 emissions during the days of measurement, we can make some approximations using reliable averages. Using these, we can conclude that no significant change in CO2 emission can be found between 2019 and 2021.

Experiences project managers

Within the scope of the evaluation of this pilot, we also asked the project managers in the province of Antwerp how they experienced this pilot. When looking back to the intervention and the results, they react mainly positive and satisfied. The added value of this pilot is for them on the one hand the new observation that perception of people is rarely in line with reality. During the process of this pilot, they asked several people, both users and experts, how traffic flows would be and where problematic spots could be situated. The results of these interrogations contradict sometimes with the findings of the camera. On the other hand, the forces of the user (in this case the province), business (Viscando company) and research (University of Oldenburg) are bundled and made each other stronger. Due to analyses of the University and discussions with the province, the technology of Viscando could be optimized, for example with regard to near accidents, the risk level of these near accidents and orientation and speed of involved vehicles.

The project managers in Antwerp also faced some challenges. First, they experienced some problems with the technology. The AI technology faces some problems in distinguishing motorcycles with speed pedelecs. The difference between both is often determined based on speed and location on the road, rather than on a correct estimation of the volume by the AI. This can be improved in the future, since in this analysis it also has an impact on the counting and near accident results. Secondly, due to some post COVID struggles at the providing company, the Province had to wait for a longer time before they received the results and the reporting. Thirdly, the corona pandemic and its consequences also had an impact on this pilot. The

cooperation with the municipality and the execution of the improvements on the intersection were more complex, since the municipality had other priorities to handle.

Overall, the project managers are satisfied with this pilot and its results. The technology offers a ton of data collected on a relatively short period of time. These data can be used to make objective decisions on necessary action on the road. They will definitely recommend the technology of 3D recordings to others and they believe in the potential of the technology.

Conclusions

We can conclude that the main goals of this pilot were achieved, although the BITS objectives weren't met. The evaluation of this ITS implementation had two focuses: evaluating the added value of the technology of the smart camera and analysing whether the BITS objectives were achieved. The 3D camera showed its added value in this pilot. It is useful tool which gives a full image of the junction or road it is analysing and it delivers objective data, which enables to implement a preventive traffic safety policy instead of a curative policy. However, the system doesn't interpret the results and the camera in itself doesn't make the analysed cross road safer. Taking a look at the BITS objectives, we have to conclude that they weren't achieved. Rather than an increase in cyclists due to the ITS implementation, we observed a decrease on the Puursesteenweg (potentially to be explained by different route choices from the cyclists). Next to that, we assumed that CO2 emissions didn't decrease, but remained stable. Unfortunately, we cannot conclude that the ITS implementation increased safety on the junction, since the risk on a near accident increased and mainly the potential risk between cyclist and vehicle increased. All in all, we can conclude this ITS implementation is a complex and nuanced pilot and although not all objectives are reached, this technology does have a lot of potential for the future.

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