Cyclist Safety in Urban Areas

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Cyclist Safety in Urban Areas

by Limin He

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of MFA Industrial Design
School of Design
College of Imaging Arts and Sciences
Rochester Institute of Technology

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Bicycle Safety in the Urban Areas

Limin He

Dr. Mindy Magyar, Thesis Supervisor

ABSTRACT

Cycling as an alternative means of transport is encouraged in urban areas because of the societal and environmental benefits it brings to most cities. However, the conflicts between cyclists and motorists become more obvious in complex urban areas, which places cyclists in a dangerous situation- a higher chance to get involved in serious injuries. To analyze how the problem happens, this paper talks about the user research, environment and collisions analysis. Then, this paper presents survey procedure and results related to user demands for cycling safety. The visibility limitation was found to be the main reason for the conflicts. In terms of solutions, this paper introduces theoretical methods and existing products suggested to enhance cyclists’ visibility, and it proposes a visibility system which is designed with the consideration of Maslow's hierarchy of needs. The whole system makes cyclists conspicuous so as to reduce the collisions between cyclists and motorists.

Key Words:

Bicycle safety, Urban areas, Collisions on the road, Visibility system, Cyclists, Motorists
1. Introduction

Public transportation arises with the change and development of society. Cycling as an alternative mode of transport is encouraged in urban areas because of its society health and environment benefits, although cars are dominating in most cities. But the safety and efficiency are reduced because of the motor vehicle–bicycle conflicts under mixed traffic condition that motor vehicles and bicycles use the same road simultaneously \(^1\). In additional, cyclists, as the most vulnerable of all road users, face more serious injuries than motorists. In 2015 in the United States, over 1,000 bicyclists died and there were almost 467,000 bicycle-related injuries \(^2\). With these conflicts between cyclists and motor-vehicle drivers come property damage and disease burden, even death. Data from 2010 shows fatal and non-fatal crash-related injuries to bicyclists resulted in lifetime medical costs and productivity losses of $10 billion \(^2\). Therefore, bicycle safety in urban areas is an urgent issue to be addressed.

This paper analyzes the reasons behind the conflicts between cyclists and motorists. It starts from road environment research to collisions analysis. First of all, it describes the potential risks for the motor vehicle–bicycle conflicts. Then it shows the most common types of collisions. Some researches were conducted to explore the main risk factors in the following paragraph.

To understand these problems, this paper describes a survey I conducted, shown in Figure 6, in which cyclists and drivers were interviewed about their behaviors and opinions of road safety. Then it introduces the researches, which talks about collisions between bicycle and motor-vehicles. It demonstrates that the main reason for these accidents is that vehicles failed to yield at the intersections. By researching how to help drivers stop their motor-vehicles before they hit
bicycles, the design solution was gained into how to design the product relating to conspicuous of cyclists that help motorists notice them especially under the dark environment. To improve the cyclists’ visibility, a lot of factors attributing to the bicyclers’ visibility were tested and compared.

Based on the tests and research, the solution is a visibility system, which is a product that can be installed on a bike to highlight the main frame of the bike.

1.1 Cyclists and motorists in urban areas
Researching the target groups is the first step to understand why the issue happens. Both cyclists group and motorists group need to be researched as both are contributing factors in the collision. The two groups do not only behave differently on the road, but also they could not share the road cultures. The divergence makes them difficult to understand each other. In the later chapter, this paper describes details about behaviors of cyclists and motorists on the road.

During the crash, different behaviors, interaction ways and road law between motorists’ and cyclists cause many collisions in some specific locations. But according to Kwan, Mapstone, Räsänen and Summala, the most frequently accident is that drivers failed to yield without noticing bicyclers. Therefore, to predict cyclists’ behavior on the road is vital for drivers to avoid the collisions with cyclists. Among the factors to make cyclers’ behaviors predictable, visibility plays an important role in helping bicyclers and motorists communicate well. Meanwhile, an effective approach to reduce the knowledge difference on the visibility of cyclists can help to avoid collisions between cyclists and motorists.
1.2 Problem and Context
On the road, cyclers are neither pedestrians nor motor-vehicles, but somehow between in. They would take up the pedestrians’ space or cars’ space. Therefore, under the complex urban traffic conditions, collisions between cyclists and motorists are obvious. Bicyclist casualties caused millions of deaths and disabilities every year. What contributed to the danger of bicycling in urban areas. And how to provide a safer environment for people riding a bike in this setting?

2. Design Research
As bicycling, representing freedom, health and stress relief, embraced by more and more individuals in cities nowadays, the conflicts between cyclists and motorists become more obvious. To address the conflicts, the process involves researching user scenarios (environment, users’ behaviors and feelings) and products research for analyzing the reasons behind the conflicts. It starts with identifying existing transport planning or urban environment, and then continues to explore cycling safety factors and users research.

2.1 Environment background
As the increasing number of population in urban areas, the demands of transportation infrastructures are rising as well. However, according to the Urban Transportation Modeling System (UTMS), transportation plan was built based on the characteristics of the buildings and road layout, as depicted in Figure 1, while the road space for a bicycle or walking is generally narrow. Pedestrians and cyclists are assumed to stay in those narrow spaces which make them
have less right on the road. Moreover, in the car-dominating United States, most infrastructures are designed for cars, for example, parking areas and driving areas take up the most space of road, which cause conflicts between cyclists and motorists in urban areas. According to Dianhai Wang, Tianjun Feng and Chunyan Liang [3], the road safety reduced due to the motor vehicle–bicycle conflicts under mixed traffic conditions, conditions where that motor vehicles and bicycles use the same road simultaneously resulting in more crashes happen between cyclists and motorists. At the same time, more potential collisions could be caused by more traffic lights and intersections due to the increasing demands of drivers and infrastructures. To alleviate these conflicts, many roads and streets have added more cycling infrastructures (Figure 2. Nonetheless, these infrastructures only covered some places with minor effects on reducing collisions. It still needs to find a more effective way for cyclists and motorists to communicate to solve the complex road situations in the urban areas.

![Figure 1 Road situation in some urban areas](image)
2.2 Cyclists’ and motorists’ behaviors

Prior to the cars were invented, cyclists and pedestrians communicated with each other using bike bells or signs or yelling. But for drivers, there are limited to the options of traffic lights, cars’ lights or car horns to interact with other drivers. These options are not available for cyclists. Thus, the behaviors of cyclists on the road are often demonized by the driving public. The gulf between cyclists’ and drivers’ opinions is demonstrated in public forums in response to news reports \[4\]. The opinion frequently held is that car drivers are the victims of cyclists, blaming cyclists for putting themselves and other road users at risk. Cyclists are usually perceived as irresponsible and not understanding road law. Many believe that cyclists should not be allowed on roads due to the risks they pose to themselves and others. Therefore, motorists may not think cyclists as a part of road users. The different behaviors and road cultures between cyclists and
motorists make drivers difficult to predict cyclists’ actions. So, an effective approach for motorists predicting cyclists’ behaviors can help them to improve this situation.

2.3 Cycling safety analysis

Road traffic crashes account for over a million deaths and some 10 million permanent disabilities a year worldwide (Murray and Lopez, 1996)[5]. Cyclists have the largest proportion of self-reported near-miss crashes, significantly higher than that of motorists and comparable to that of pedestrians[5]. Cyclists visibility is a vital factor for exploring solutions to reduce the collisions between cyclists and motorists.

2.3.1 The cycling crashes in the urban environment

Cyclists are considered as to be among the most vulnerable of all road users. Moreover, the jury consequences of a crash are also more severe for cyclists, where the probability of a cyclist being seriously injured following involvement in a crash was found to be almost 27% in Australian data collected over a four-year period[3]. In additional to the urban areas, research suggests that bicyclist deaths occur because of the complex road environment and traffic congestion, which all make cyclists give up cycling in great numbers.

According to a research, the crossing crashes comprise about 5/6 of the total number of crashes[7]. Amy J. Schramm, A. Rakotonirainy and Narelle L. Haworth said the single most frequent crash type was vehicle failing to yield in crossing path crashes, at 21.7%. Yinhai Wang and Nancy L.Nihan category accidents involving bikes and motor-vehicle into three types: head-on motor vehicle related collisions, left-turn motor vehicle related collisions, and right-turn motor vehicle related collisions. The first type normally occurs when a motorist leaves a driver or turn
right at an intersection and approaches a cyclist from the right side, which resulting in the hit on the side of a bike (Figure 3). It is very hard for drivers to detect cyclists with peripheral vision. In the left-turn condition, drivers have a difficult time seeing bicyclists using edge (Figure 4). The sight obstacle makes drivers difficult to see cyclists under this situation. And the right- turn crash scenarios, a bicyclist can be hit by a motorist turning right in front of them (Figure 5). Because cyclists next to them in the same direction cannot be noticed easily. Additionally, cyclists riding against traffic are particularly vulnerable to collisions at intersections, especially for vehicles turning from a street perpendicular to the cyclists’ path (Summala et al., 1996).

![Figure 3 Right Hook](image-url)
Figure 4 Left Cross/Hook

Figure 5 Pullout turn right
2.3.2 The Bicycle Visibility factor for bicycles and motor-vehicles’ collisions

During the crash, complex road situations, users’ behaviors, interaction ways and road law all attributed to motorist- cyclist collisions. However, late detection of cyclists suggests that their visibility on the road may be an important contributing factor for their crash involvement.

A consistent finding is that drivers do not detect cyclists until it is too late to avoid a collision (Kwan and Mapstone, 2004; Räsänen and Summala, 1998)\(^9\)\(^{10}\). In particular, according to Herslund and Jorgensen, a proportion of crashes between vehicles and cyclists have been identified as “Looked-but-failed-to-see” crashes, which suggests shortcomings in driver attention processes\(^11\) (as proposed by Brown, 2005). Cyclists as a group may thus underestimate the importance of attracting other road users’ attention when visibility is limited, such as under night time conditions\(^12\). In the test conducted by Lacherez, Wood, Marszalek and King, 19% of 184 bicyclists reported not using bicycle lights at the time of the crash, and only 34% were wearing reflective clothing. Only two participants (of 184) nominated bicyclist visibility as the cause of the crash: 61% attributed the crash to driver inattention\(^13\). Motorists cannot always pay enough attention to the surrounding environment resulting in failing to notice cyclists.

Cyclists visibility can help motorists to notice and predict cyclists’ actions. The visibility was degraded further by low-light conditions according to the test by Owens and Sivak\(^14\), who found that 78.8% of all fatal collisions involving vulnerable road users occurred during low-light conditions. Night-time cycling has been shown to be more dangerous than cycling in daylight,
with 40% of cyclist fatalities occurring at night despite much lower exposure rates than in the
daytime [15]. Aside from the potential risks of cyclists’ invisibility, the number of days off work
following a bicycle crash injury was found to be substantially lower among cyclists who reported
that they always wore high visibility clothing [16] (Thornley et al.). Therefore, increasing
visibility of cyclists is especially important under low-light conditions.

2.3.3 Users survey
In order to study how the collisions between cyclists and motorists happen and the demands of
cyclists and drivers to avoid collisions, a survey was performed, as depicted in figure 6. In the
survey, the sample of 16 participants included 10 cyclists (age range 18–60 years), and 6 drivers
(age range 18–60 years). All cyclists have rich cycling experience and they ride the bike
regularly except for the winter while drivers all have at least 2 years’ driver experience. A series
of questions for cyclists were asked about how they would behave on the road, what they would
wear for safety, how they avoid the potential risks on the road, any crashes they met and the
feelings about riding a bike in urban areas. For drivers, they were asked about any accident or
near accident they met and how to avoid or solve the collisions between them and cyclists.
The interview

For cyclists:

1. How long have you been for riding a bike?
2. What are the reasons for riding a bicycle?
3. Have you had an accident or near accident when you ride a bike? If yes, could you describe the details?
4. What kind of equipment do you prepare for riding a bike?
5. What are the potential risks do you think on the road?
6. What do you usually do to avoid the potential risks on the road?
7. Will you follow the road rules?
8. Do you feel safe when you ride a bike in downtown? Why?

For drivers:

1. Have you had been involved in an motor-vehicle and bicycle accident or near accident when you drive a car? If yes, could you describe the details?
2. How do you think the cyclists on the road?
3. How do you usually solve the collisions between motor-vehicles and bicycle?

Figure 6 A survey for the user research

Results

As cyclists are not motor-vehicles or pedestrians, they behave in a more flexible way. 5 out of 10 cyclists do not follow the road rules. Cyclists will try to avoid riding on the road and they cannot recognize some road surface markings, like the symbol that means bicycles must share the road with motor vehicles (Figure 7). Meanwhile, cyclists cannot understand the drivers’ behaviors and
vice versa. All drivers hope cyclists can behave like a car and be more visible. Therefore, there is a need of better communication between cyclists and motorists. Then collisions can be avoided or reduced between bicycles and motor-vehicles.

Figure 7 The signals on the road means motorists share the road with cyclists

3. Solutions for reducing bicycle-vehicle crashes

To establish the initial concepts of the solution, some directions were explored. One is that how to make cyclists more visible for motorists and help them to reduce understanding differences about regarding cyclist visibility. Another focuses on the road plan, which is to ensure cyclists to have enough space to turn at the sections when needed. Compared with redesigning the current road situation in urban areas, improving the cyclist visibility is an economic cost solution. In terms of cyclists’ visibility, there are many factors affecting the feasibility of the solution. A cyclists’ conspicuity would be effected by the object contrast, size, movement, illumination, background ‘clutter’ and road condition, also the cognitive process of the driver and his/her
responses in detection and recognition\textsuperscript{[17]}. A lot of tests were conducted to assess the solutions of improving the cyclists’ visibility and help drivers detect and recognize cyclists.

3.1 Theoretical approaches for addressing the visibility of cyclists on the road
There are researches focusing on reducing bicycle-vehicle crashes from different perspectives. J.P.Schepers and J.C.Wüst did research the road factors and they found the accident probability is decreased at intersections where the cycle track approaches are deflected between 2 and 5m away from the main carriageway\textsuperscript{[18]}. Yen-Bor Lin, Chung-Ping Young proposed a bicycle detection algorithm and a geometric model of bicycle for single side-view image to help indicate the bike movement\textsuperscript{[19]} (Figure 8). They hoped to detect cyclists to improve the safety of transportation systems. Furthermore, research has shown that increasing use of visibility aids may improve the ability of drivers to recognize cyclists and that the ability of drivers to respond in time is greater when cyclists or pedestrians use visibility aids.

![Figure 8 The detected bicycle model on the single side view image](image)
As regards solutions, many researches pay attention to catch motorists’ visual attention through improving the cyclists’ conspicuity. Visual attention is thought to operate as a two-stage process. In general, visual attention can process information around in parallel and then concentrate on the specific area[10]. Human visual attention first responds to contrasts in color and light, then to the emotional and cultural value of a specific color according to a research paper researchers from the University of Barcelona on the saliency (or visual pop-out effect) of color. The most common products are reflective materials, fluorescent clothing, static and flashing lights.

3.2 Visible products

*The reflective materials and Fluorescent*

To make cyclists more conspicuous, a bunch of different items of clothing or equipment are available on the market. Among these products, fluorescent clothing as more visible than reflective clothing during the day, and the reverse at night, those were still quite similar[20]. And due to the different lights of a day, different visibility aids have also different effects. Fluorescent clothing is a useful visibility aid in the daytime as it converts the wavelength of light in the ultraviolet range (which is in high saturation in sunlight) to longer, visible wavelengths, thus leading to an overall increase in reflected visible light[21] (Joint Technical Committee SF/4, 1999). At the same time, biological motion was explored to make cyclists more visible for motorists. Based on the test performed by Stacy A Balk, Richard A Tyrrellô, conspicuity is maximal when people are both moving and wearing retroreflective treatments that highlight the form of their body and Participants' response distances were maximal for the full biological-motion configuration and
remained surprisingly long when convenient subsets of reflective markers were positioned on the pedestrian's ankles and wrists (Figure 9) [22].

![Figure 9 The five clothing configurations](image)

(a) black; (b) vest; (c) ankles; (d) ankles+wrists, A + W; (e) full biological motion.

*The lights*

Lights are playing an important role in our daily life. When we mention the emergence lights, stop signs and error reminders, we all associate those things with red. And many researches all show red is the most effective at attracting our attentions.

Usually, motor-vehicles drivers used to interact with cyclists using lights on the road. Every light on the car has several modes which can help others to notice them and predict their movements. For cyclists, the visibility aids used most often were front and rear bicycle lights, with 83% and 90% of respondents indicating that they always use these. Although it is common for cyclists to carry front and rear lights in the low-light environment, it is still hard to share the same perception of the meaning of lights for motorists and cyclists. Based on visibility aids test
by Joanne M. Wood, Philippe F. Lacherez, Ralph P. Marszalek, Mark J. King, cyclists rated themselves as significantly more visible when using bicycle lights than did the drivers.

Currently, more new researches are exploring how to make a cyclist more conspicuous for drivers. Many new products are installed on a pedal, handlebars and wheels, which can catch people’s attentions easily through making the bike look bigger visually (Figure 10) [23].

![Figure 10 Led lights on wheel, via Amazon](https://www.amazon.com/Waterproof-Bicycle-Accessories-Decoration-bicyclers/dp/B01CDTT5G0/ref=dp_8084_468_3? encoding=UTF8&pd_rd_i=B01CDTT5G0&pd_rd_r=9X3MKAP5TFB93YXAB69V&pd_rd_w=T59xB&pd_rd_wg=SiMaW&refRID=9X3MKAP5TFB93YXAB69V)

### 3.3 The direction of the solution

While many of the products focus on making cyclists more visible and using signaling easily, others help improve the road situation. According to the research, making cyclists conspicuous is a more effective approach for addressing the collisions. However, most of the products about visible symbol cannot be easily recognized to be a bike’s symbol and fail to show the distance
between bikes and vehicles. Cyclists do not use visibility aids on a regular basis (Hagel et al., 2007) [24].

Based on these researches, I proposed the solution (Figure 11), which can be installed on a bike easily and help others notice and recognize cyclists. Due to the different situations of visible limitations, I chose the main frame of a bike: the Fork and Seat Stay. It can be easily notice from different perspectives.

![Figure 11 The design concept](image)

4. Visibility testing

In this case, I compared several different visibility aids including: fluorescent, lights in different colors. Different installation positions of visibility aids with users participating in the tests were also included. Based on the data collected from these tests, I came up with the prototype to test
the feasibility of the solution. Every test examined three factors of the solution: Feasibility, Appearance and Materials.

4.1 Test for the visibility of the initial concept

The first test was to study the effects of two main popular visible aids. Two different items chosen were reflective materials and lights, and both items were tested in four different user scenarios (figure 12&13).

User Scenario 1: At intersection, when a car turns left, a cyclist crosses the street. The driver cannot notice a bike until it lights on it.

User Scenario 2: A car drives behind a bike. The drive cannot see the reflective material on the sides but red reflective lights on the rear.

User Scenario 3: At the section, a car goes straight and the bike turns left. The driver cannot notice a bike until the bike appear in his sight.

User Scenario 4: At the T intersection, when a car comes out, a bike goes straight. The driver cannot notice a bike until the bike appears in his sight.
Light were chosen because they worked better than reflective materials. The second test was to understand how to make the bike conspicuous with lights. Different shapes of lights were designed, different colors were chosen and different heights were set according to different heights of main parts of a bike. Then one user was asked about the visibility of lights involved in the test in the simulated scenarios. The outcome showed that Triangular, Rectangular and Line is
better, Combined heights is better, as shown in the table 1&2. Therefore, this visible system would be installed on the Seat Stay and Fork.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Visibility (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>4</td>
</tr>
<tr>
<td>Circle</td>
<td>3</td>
</tr>
<tr>
<td>Rectangular</td>
<td>4</td>
</tr>
<tr>
<td>triangular</td>
<td>5</td>
</tr>
<tr>
<td>Dot</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 1 Outcomes of different shapes of lights' test*

<table>
<thead>
<tr>
<th>Height(m)</th>
<th>Visibility (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>0.9</td>
<td>4</td>
</tr>
<tr>
<td>0.8</td>
<td>4</td>
</tr>
<tr>
<td>0.4</td>
<td>3</td>
</tr>
<tr>
<td>0.26</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 2 Outcomes of different heights of lights' test*

After the shapes and installation positions of the lights were decided, different types of lights (LED and Fiber Optic hair lights) were installed on a bike to test the visibility and appearance in real environment, as shown in figure 14&15. It is easier for a drive to notice and recognize the bike installed with the LED lights.
Figure 14 Led lights on the fork and seat stay

Figure 15 Fiber optic hair lights on the fork and seat stay
4.2 Visibility decisions

These tests show different visibility effects. The blue LED lights installed on the fork and seat stay of a bike is feasible and visible. The form of the visibility system is rectangular or triangular, which can attract drivers’ attentions best (Figure 16). According to the Law of Closure of Gestalt theory, individuals can perceive objects as being whole when they are not completed. So, the open rectangular can be seen as a closure shape.

![Figure 16 The form of light](image)

5. Factors for refining the solution to consider

In this product design, improving visibility is considered as the main function given that visibility plays a vital role for reducing the collisions between cyclists and motorists based on the
researches. Therefore, this product should help to avoid collisions. Besides, there are other design elements needed to be incorporated into the development process: Usability, Aesthetic and Consistency.

5.1 The visibility in product design
In terms of visible concepts, object contrast, size, movement, illumination, background ‘clutter’ and road condition are all important factors. As the main users, drivers get used to use car lights which highlight the frame of the back of a car (Figure 17) to interact with other drivers. And the common feature of all car lights is that the lights can be visible from different directions, and usually lights are long and disperse in the back. The heights of car lights are also similar as the best practice. These lights have become a kind symbol for drivers to recognize a car. Therefore, lights on a bike should follow the similar pattern to tell drivers: this is a bike!

![Figure 17 Car's back light](image)

Meanwhile, the biological motion test did by Stacy A Balk, Richard A Tyrrell proved that biological-motion configuration can make conspicuity best. However, because the shape of a bike is very narrow to the viewers behind it, so it limits the lights from spreading out. It is the key to make the lights as large as possible by taking advantage of the structure of a bike.
As for the lights color, it is better to combine blue and red than other color designs because most street lights are warm orange. The contrast between the design and environment lights can attract peoples’ attentions better according to the test (Thomson Higher Education @2007).

5.2 Other design elements

Usability, user-oriented factor, can help users achieve their objectives effectively. It usually requires a simple structure so users can learn how to use the product easier. Sometimes, some necessary symbols can offer users guidelines for them to figure out product operation. The main concerns for the physical product include: how to install, how to carry, how to pick up and other possible interactions between users and goods. In this case, it was a visible system installed on bikes.

Therefore, the product needs to acquire features like easy to install on a bike, easy to turn on and etc. Then, pleasant appearance is a bonus to satisfy users’ psychology demands. A nice-looking form of a product can help users to enjoy it while using it, and it can be achieved with a nice design plus as little decoration as possible maintain minimum product weight. Matching the product with product context is able to maintain its style consistency, which can contribute to the integrity of the product. For this solution, since it would go on a bike, the form of product should follow the design language of a bike.

Base on the factors discussed above, elements for designing the final product using Maslow's Hierarchy of Needs which includes basic needs, psychological needs and self-fulfillment, and
they are transformed into three elements: Function, Economy and Aesthetic, as shown in Figure 18.

![Diagram showing the transformation of elements into Function, Economy, and Aesthetic]

6. Final Design

The objective of this design is achieved via a visibility system gets installed on a bike. After the analysis of all elements, the visibility aids on the fork and seat stay can be the same, which helps reduce the cost of production. The final product, as depicted in Figure 19&20, shows the main frame of a bike, of which the lights can be perceived as rectangular. It can be adjustable in order to match the different frames of different bikes. The whole system also can be seen from different directions, which helps the bike to be noticed in different environment settings.
Figure 19 The structure of the final product

Figure 20 The product on a bike
7. Discussion for the further design

Bicycle crash is a very urgent topic to address as the increasing number of cyclists in urban areas. It can cause a huge loss to people’s life and economy. The factors causing these crashes include many different aspects: complex urban environments, dimmer lights, various transportations with different road cultures, different recognitions of visibility of cyclists and so on. Among these factors, the visibility of cyclists play a vital role for causing collisions between cyclists and motorists. A good visibility of cyclists can help drivers recognize cyclists in time. Therefore, there are lot of research and products are about how to make cyclists conspicuous. In addition, sharing the road culture, improving the street environment and speed limits all can contribute to alleviate the collisions between cyclists and motorists. In terms of public acceptability of these solutions, it mainly relies on the ease of application, maintenance, life-time and cost. The aesthetic of product is another significant factor to be considered. In this case, drivers’ reactions to the installed visibility system were studied in different environment settings. The solution was designed based on a series of researches and tests, which highlighted the frame of a bike and could be used on different styles of bikes with an adjustable feature. For production, the shape of the fork and seat stay is to be combined to one uniform design language, in which case only one kind of design is needed to meet the users’ demands on both fork and seat stay, so it will cause less confusion for users and improve the product feasibility, meanwhile, the production cost can be significantly reduced. Although the solution was proved to be feasible, there are more improvements can be done. So, more conducted research and tests based on the solution should be explored.
References:


