

LockBar

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64,500 reported bicycle thefts in **2021**

45% of stolen bicycles were **locked** at the time of theft



25% of cyclists gave up on cycling after having a bike stolen

54% of bike thefts were from the place without a monitor



15% of bike thefts were from the public place

Younger adult (16 to 34)



have been more likely to be victims

Where does bicycle theft occur?

The Office of National Statistics data shows that between 2019 and 2020, in Table 1, approximately half of all recorded bike thefts occurred in semi-private locations, areas away from the property, and garages or car parks nearby but unconnected to the home. Nearly 14% of bikes were taken from public places such as local stores, supermarkets, and gyms.

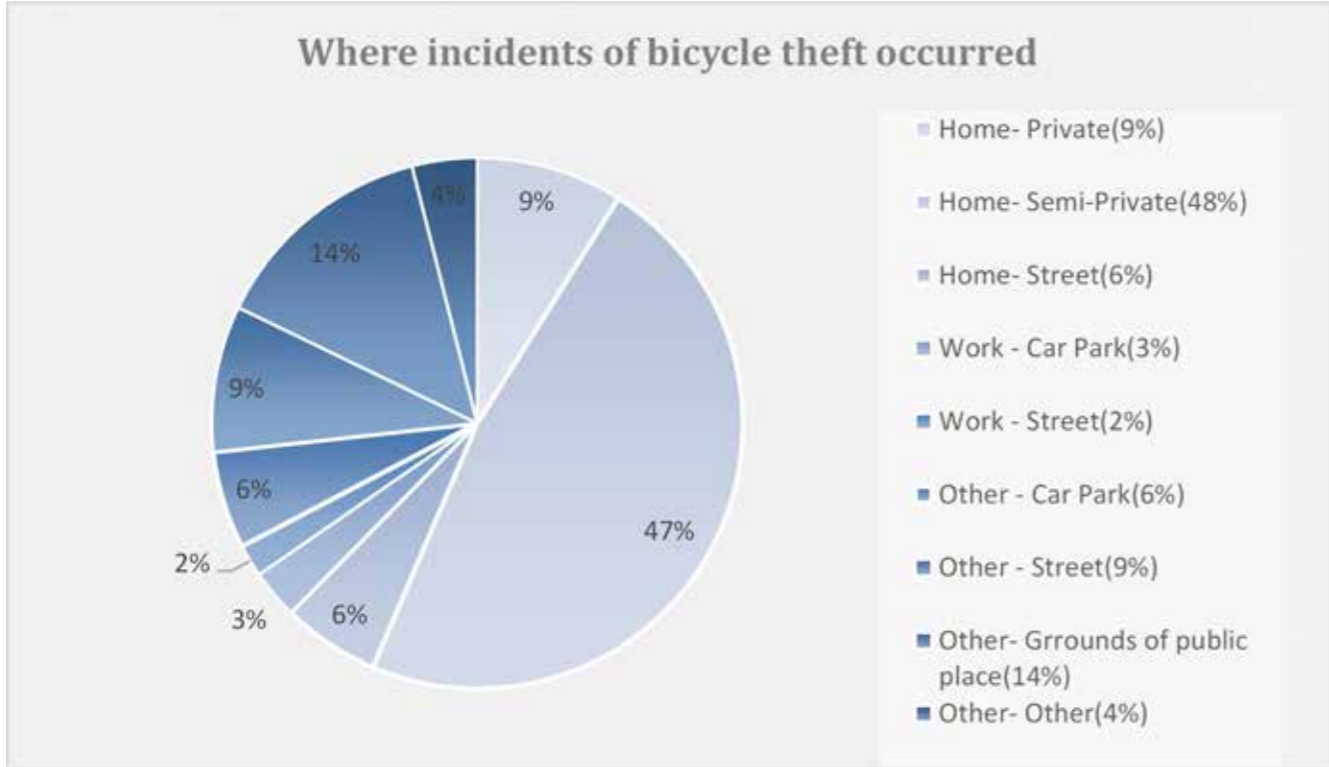


Table 1: Where incidents of bicycle theft occurred in the UK

What contributed bicycle theft factors?

Rise of bicycle demand

Bicycles are gaining popularity as a healthier and more environmentally friendly mode of transportation

Removable

The bike is lightweight, and lots of quick release system



Valuable

Bikes can now cost from £100 to over £1000

Current Products Research

▼ Folding Bike Lock



▼ Bike chain lock



▼ On-street parking



▼ GPS tracker



Primary User Interview

▼ Bicycle Theft Victim One

SUMMARY:
He owned an e-bike and cycled for commuting and fitness. He parked his e-bike in his apartment and it was stolen. There is no security in his apartment, some people will follow the resident to enter.

GOAL:
He wants his bike to be safe so he won't have to worry about it while he is outside or sleeping.

- NEED:**
- Can easy to use in every environment
 - Can safeguard other components
 - The bicycle lock needs to be robust

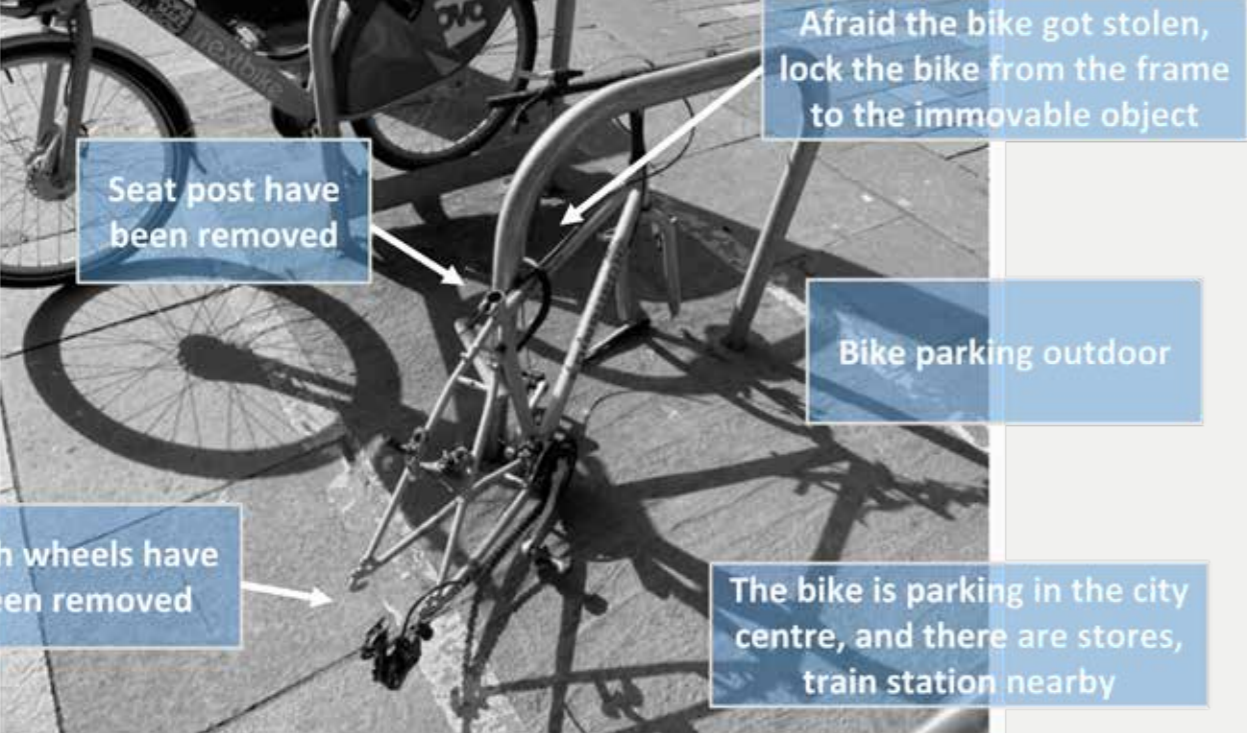
▼ Bicycle Theft Victim Two

SUMMARY:
She had a city bike and rode it to school. She locked her bike by cable lock, and left her bike outside the bar, and it was stolen while she was inside. She purchased a used one because she couldn't afford a new one.

GOAL:
She wants her bike to be safe because she needs bike to commute, and

- NEED:**
- Can easy to use in every environment
 - Can be easy to carry
 - The lock should protect the entire bike

RoadSide Research



Problem Scenario



If use leave their bike outside, they always be concerned that it might be stolen.



While a heavy lock can improve safety, a lighter bag is always preferable when riding.

Following my research, I discovered that bicycle theft is still a major issue in the present era. There are some requirements summarised in insights that can be considered based on the interview and looking for the process of how the thief destroyed the bike and how they left the crime scene.

Reduce the theft's willingness to steal

Thieves prefer bikes that are more valuable and appear to be easier to steal. As a result, there is an opportunity to increase the difficulty of stealing a bicycle while also making the bicycle's value invisible.

Increase the difficulty of stealing the bike

Some tools and techniques for stealing a bike include using sledgehammers, bolt cutters and a multi-tool that allows for quick removal of parts. As a result, there is an opportunity to increase the bicycle's strength or allow the bicycle's defensive effect to block the attack of external forces.

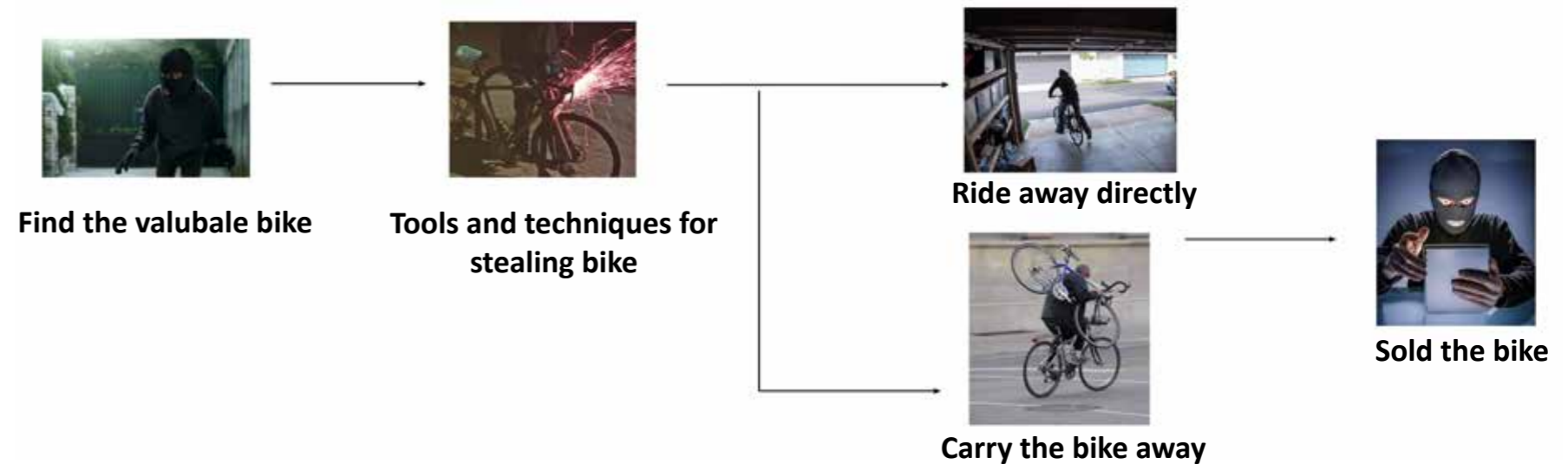
Increase the difficulty of riding the bike away directly

Some of the thieves prefer to ride away with the bike because it will not be noticed by pedestrians. As a result, even if the lock has been broken, the bike may have difficulty riding away from the crime scene.

Increase the difficulty of selling the bike

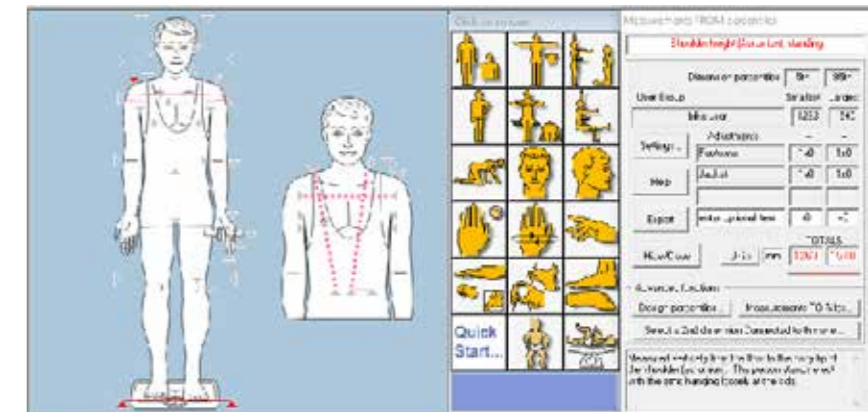
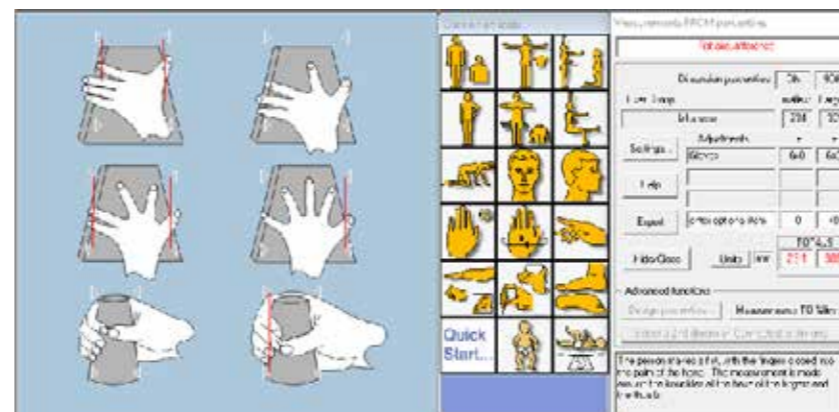
Some of the thieves sold the bike after they take away the bike. As a result, there is an opportunity to keep stolen bicycles from selling. If the bike does not sell, the number of thieves who steal will be reduced.

The process of theft take away the bike



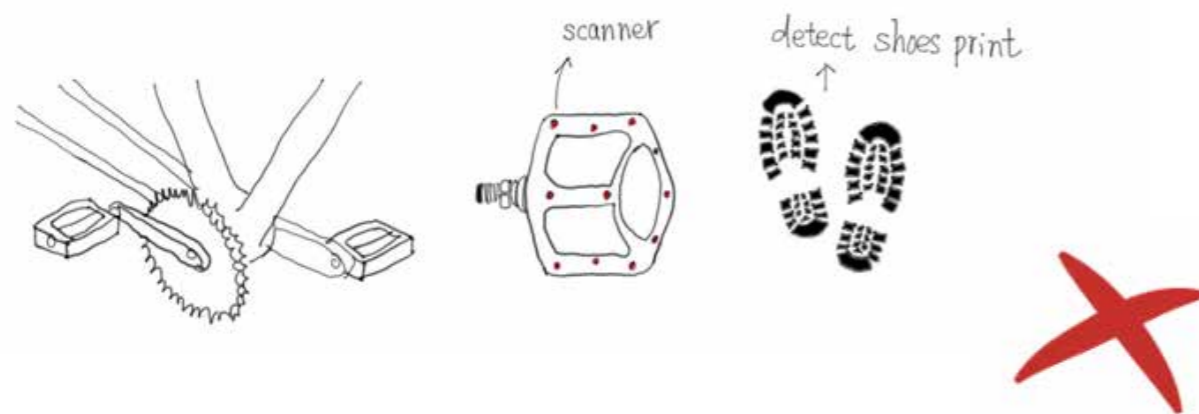
User target and anthropometry

According to the data, the majority of victims of bicycle theft are between the ages of 16 to 34. Because most people cannot afford to replace their stolen bike, and do not have a large enough budget to purchase expensive products. Thus, the project is to improve the anti-theft performance of the user's bicycle and provide it at an affordable price. The user target bicycle will be the city bike and people who frequently park their bikes outdoor. The human factor and ergonomics must be considered when designing the product, finding anthropometric data is a critical step. Define the user group percentages as 50% British men and 50% British women aged 16 to 35. Because the product's goal is for the user to be as efficient as possible, the percentile range accommodates the 5th to 95th percentile, which means that 90% of people can use this design.



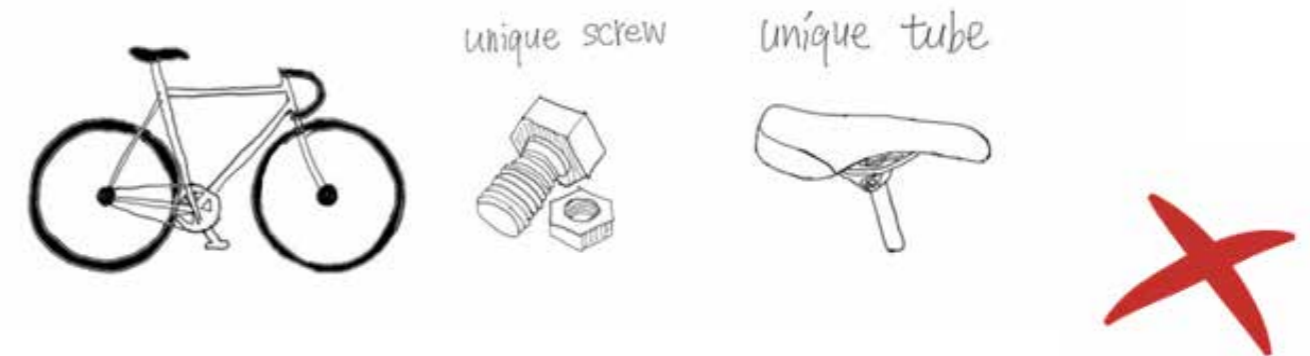
▼ Concept 1

The first idea is a pedal lock with shoe print identification. When parking the bike, it should be locked, and only user-specified shoes can unlock it. This concept's primary technical applications are optical and ultrasonic, and it requires a power supply system.



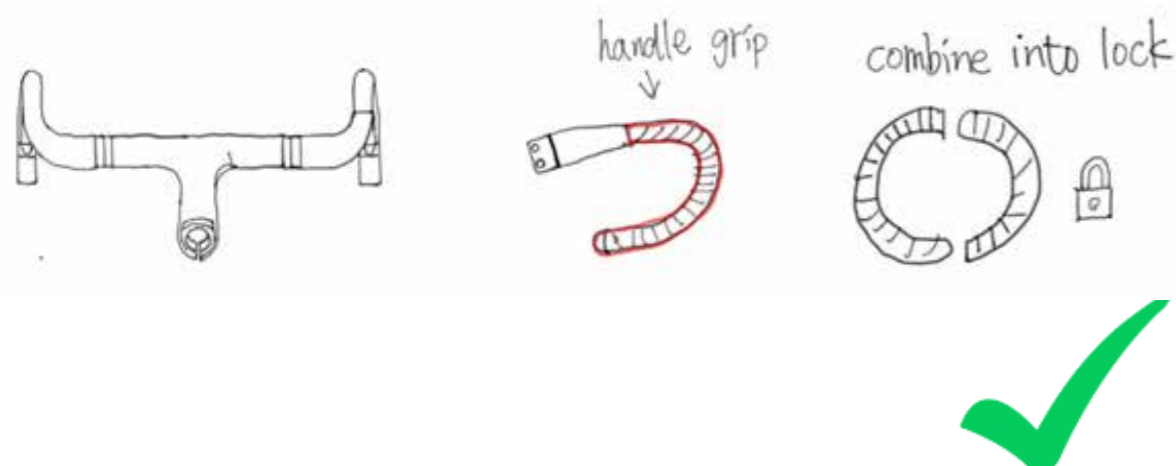
▼ Concept 2

The second concept is the unique bike, which means that each component of the bike can be unique. The user is the only one who has access to the special tools for tightening and loosening the screws and nuts. Manufacturing is the primary technical application for this concept. It must consider how to manufacture a product in mass production.



▼ Concept 3

The third concept is the handlebar lock, which indicates that the handlebar can also function as a lock. When a bike is taken, most thieves ride it right away. In order to reduce the rate, removing the handlebar into a lock makes it impossible for a thief to get off the bike directly. The principal technical application for this concept is the material and the mechanism.



▼ Concept Decision

Use numbers to calculate the importance of several factors to determine which concepts have the most potential for advancement and meet the user target needs. Scores the product criteria on a scale of one to five, with one representing a low score and five representing a high score. The total weight is calculated using the following formula:

$$\text{Total Weight} = \text{Security} * 2 + \text{Lightweight} * 2 + \text{Easy to use} * 2 + \text{Durable} + \text{Affordable cost} + \text{Apperance} + \text{Operating time}$$

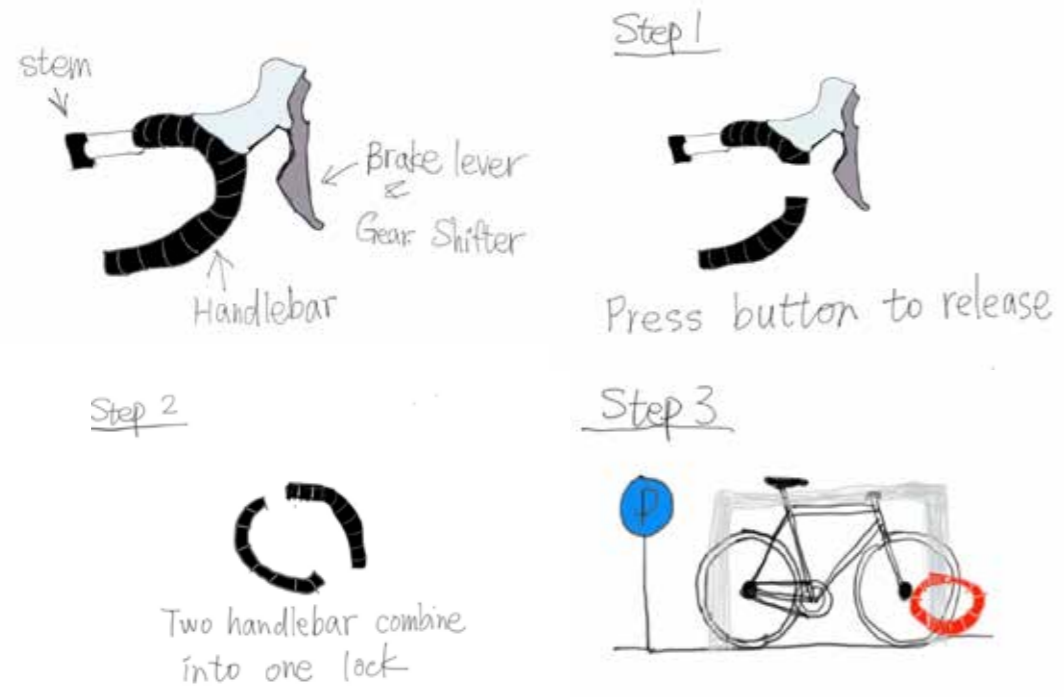
The user's objective needs focus on security, lightweight design, and ease of use, hence weight importance is multiplied by two. When the math is done, the handlebar lock comes out on top.

Criteria \ Concept	Pedal Lock	Unique Bike	Handlebar Lock
Security	3	2.5	4
Lightweight	3.5	5	3.5
Easy to use	5	3.5	4
Durable	3.5	4	3.5
Affordable cost	1	2	5
Apperance	4	2	3
Operating time	4	4	3
Total Weight	35.5	34	37.5

Final Concept Developments

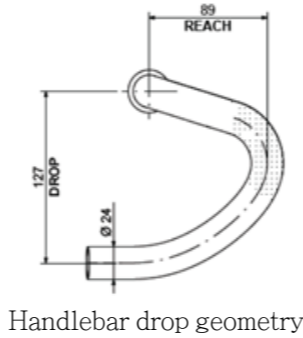
▼ Concept 1

The handlebars are drop bars. Detach the handle grip from the handlebar to begin locking the bike. Fold the two handlebar grips together to form a semicircle. Finally, secure the bicycle lock.



Problem

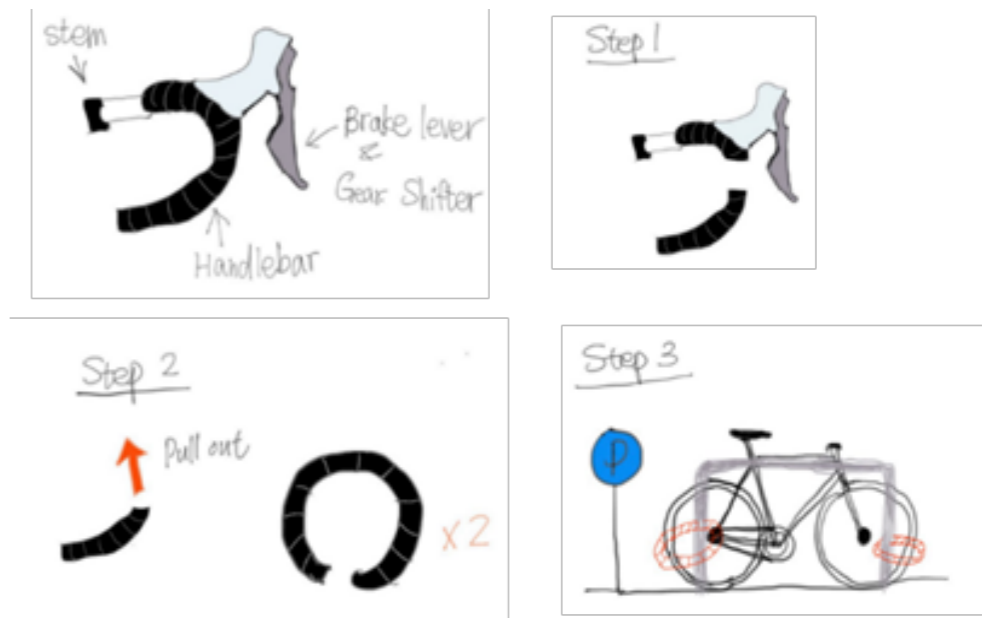
The difference in standard dimensions is approximately 100–130 mm. The actual usable portion, however, is only 70–100 millimetres long. As a result, the lock's diameter is only 45–64 mm, implying that it is not suitable for all environments.



Evolution

To remedy the issue of the first edition concept, the handle grip should be longer.

▼ Concept 2

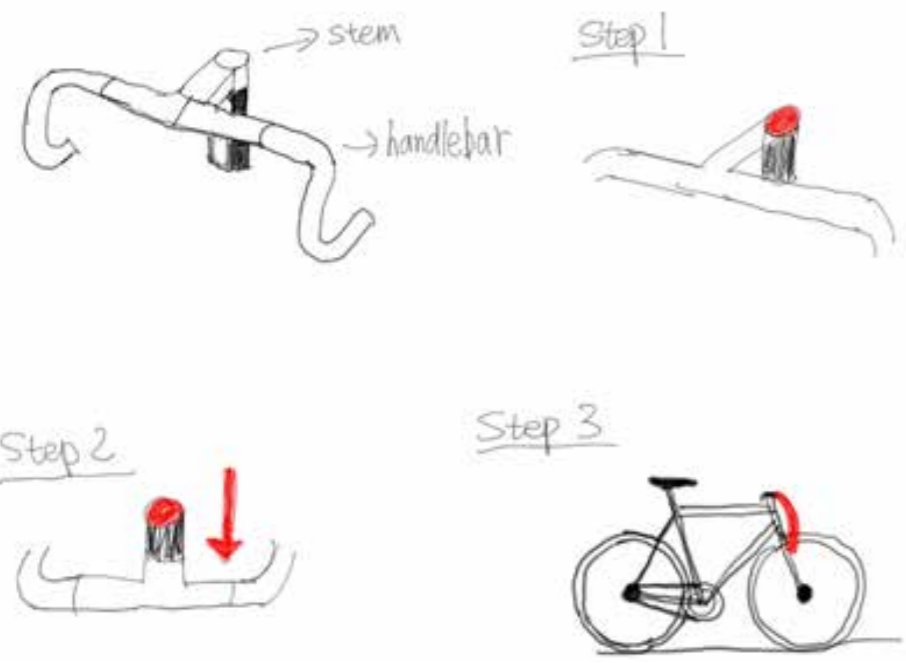


The handlebars are also drop bars. Remove the handlebar grip and extend it to lock the bike. One grip has four sections, each about 70–100 millimetres long, with a total extension length of about 280–400 millimetres. Locking two handlebar grips separately or locking two grips together into a lock is possible.

Problem

However, the ISO 4210 bending test is required for all bicycle handlebars. It maintains a 600 Newton force for one minute at a distance of 50 mm from the handlebar's free end and parallel to the fork steerer's axis. Making the handlebar removable poses the danger of failing the bending test due to the concentration of stress.

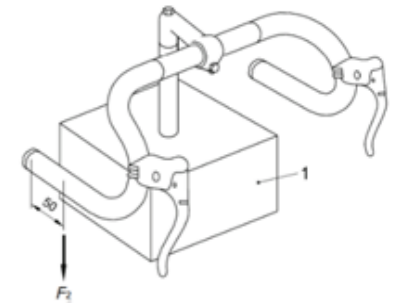
▼ Concept 3



To address the issue of the second edition concept, the handlebar stem is made of one piece moulding to prevent bending. When locked, the stem can be rotated and the handlebar folded. The system can protect the front wheel and keep thieves from stealing the bike. Even if the lock is destroyed, the theft will be hard to ride away the whole bike. The product's name is LockBar.

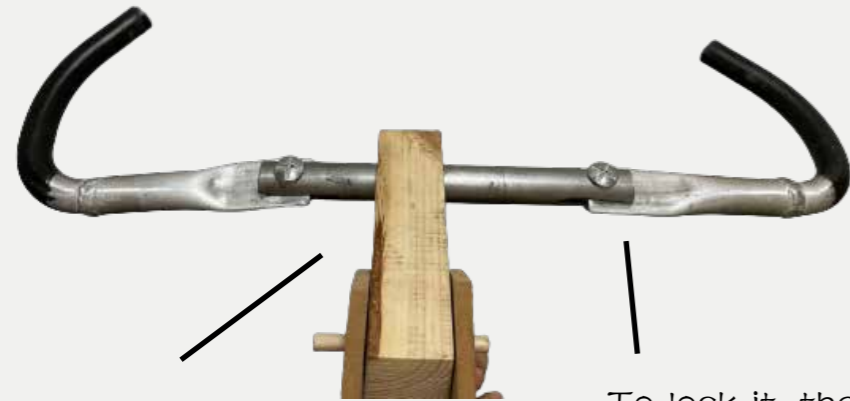
Forces in Newtons

Bicycle type	City and trekking bicycles	Young adult bicycles
Force, F_2	600	600



Forces and Position on handlebar test

Prototype



Can rotate down to let the handlebar attach the front wheel

To lock it, the handlebar can rotate and connect to the other side handlebar

Ride the bike



User Test Problem Feedback

- Because of the two-piece handlebar, the handlebar may shake while riding
- The brake install might have a problem, because the connection place is nearby the place to install the brake
- Not used to the shape of the handlebar
- Don't want to bring key while riding

Lock the bike



▼ Unlock the bike



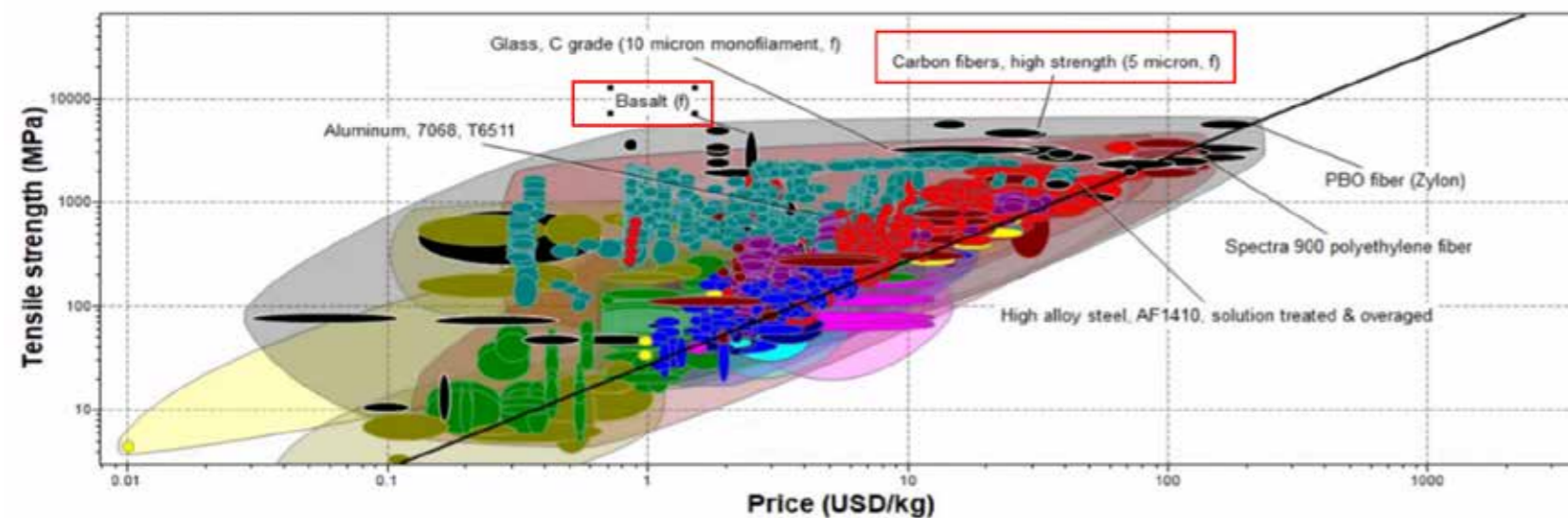
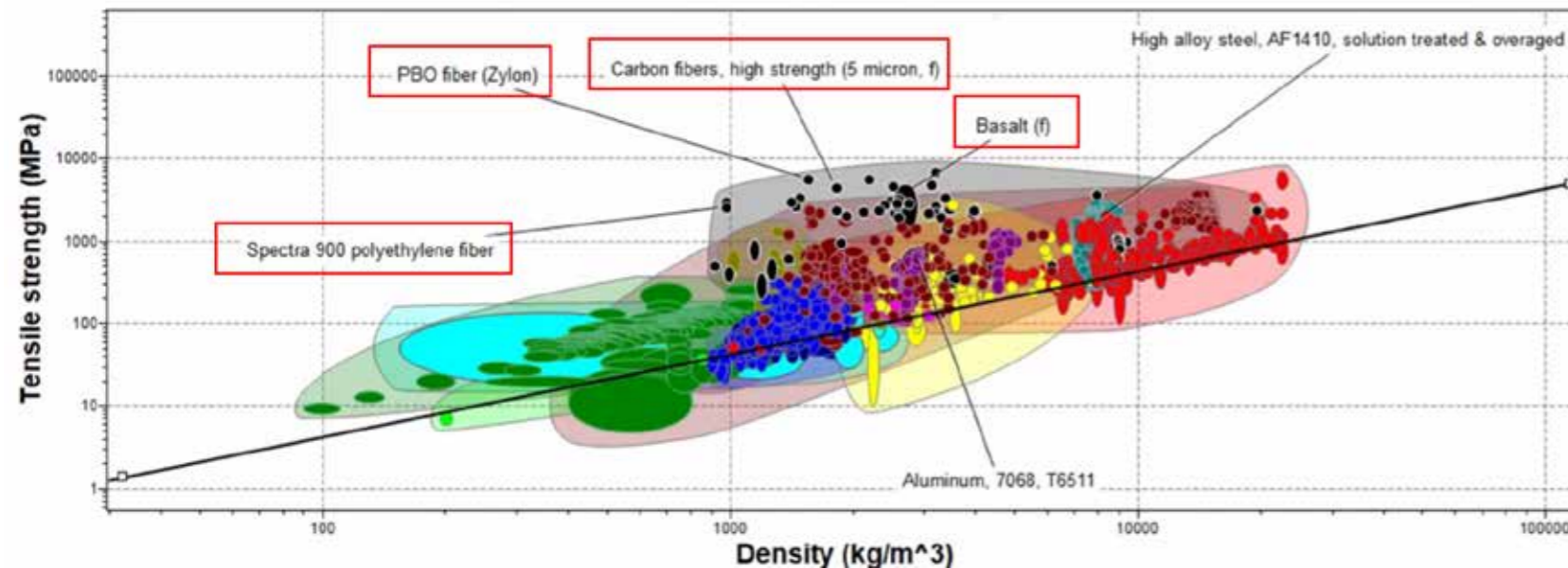
User Test Problem Feedback

- The handlebar fall straight off when released
- Because of the height, cannot be locked in some immovable object
- Hands will come into contact with the wheels and become dirty
- Because of the connection to the wheel, the handlebar may become dirty
- Where should the key be inserted to lock the handlebar?
- Not flexible enough to lock

User Test Problem Feedback

- Do the user have to lift up the handlebar manually?
- Need to bend down to unlock it
- Is the handlebar light enough to control the bike?
- Can the handlebar lock protect the whole bike?

Because handlebars must be lightweight, the majority of them are made of aluminium. To prevent theft, locks must be strong, which is why the majority of locks are made of alloy steel. It is possible to find a material suitable for the Barlock by using Granta EduPack to select more robust and lighter materials. The cost of the material should also be considered and it should be reasonable.

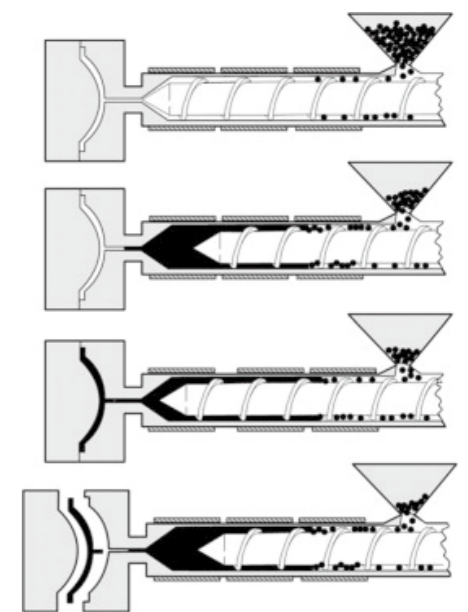


Materials above the index line have a higher performance index and thus perform better when the index lines are set to one. When compared to metal, most composites have high tensile strength and are lightweight, but only basalt fibres and carbon fibres are less expensive. Carbon fibre is the lightest available material with a higher tensile strength than other materials. Basalt fibre is less expensive than other types, has greater toughness, and can withstand higher temperatures. Basalt fibre will be used for the majority of the material in the Barlock because it has a high hardness performance, is inexpensive, and has a wide range of operating temperatures.

Manufacture

Injection Molding

Because the materials are basalt fibre, and the component's shape is more complex and requires high precision. Injection molding can be done with a machine that is relatively simple to acquire, programme, and control, and it is quick. For high-volume production, injection moulding will be the best option. However, the cost of purchasing expensive moulds is a disadvantage of injection moulding.



Injection Molding

Automated Fibre Placement (AFP)

Because the materials are basalt fibre, so using AFP method to manufacture is able to create more intricate shapes. The automated method increases precision, repeatability, and quality while lowering labour expenses. However, the rate of construction is quite slow, and processing equipment is expensive.



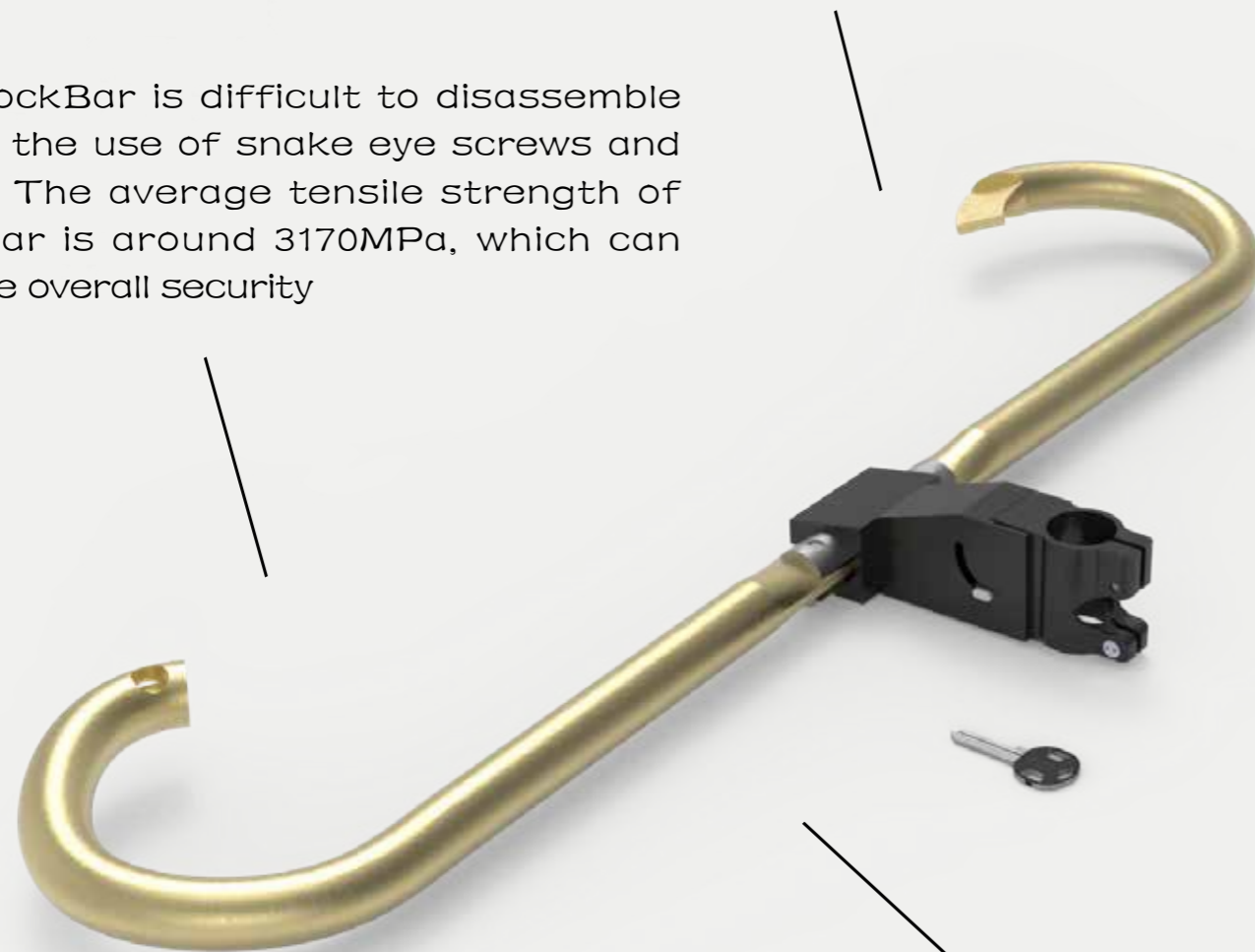
AFP

Criteria	Material	Alloy Steel	Aluminium 6061	Carbon Fibre	Basalt Fibre
Tensile Strength (Mpa)		1.93 ~ 2.13 (e3)	206 ~ 240	4.4 ~ 4.8 (e3)	1.43 ~ 4.9 (e3)
Material Price (USD/kg)		36.7 ~ 44.9	2.25 ~ 2.79	25.1 ~ 33.6	2.38 ~ 2.63
Hardness (Vickers)(HV)		568 ~ 594	74 ~ 87	660 ~ 810	400 ~ 1370
Density (kg/m ³)		7.85 ~ 7.93 (e3)	2.69 ~ 2.73 (e3)	1.8 ~ 1.84 (e3)	2.5 ~ 2.89 (e3)
Service Temperature Range (°C)		-73 ~ 427	-273 ~ 150	-273 ~ 580	-260 ~ 850

LockBar Overview

Both the handlebars and the locks work, so it won't need to ride with a lock and won't forget to bring it. It required a key to lock the whole system

The LockBar is difficult to disassemble due to the use of snake eye screws and rivets. The average tensile strength of LockBar is around 3170MPa, which can improve overall security



The lockbar fits most bicycles, and the size is consistent with current bicycle specifications

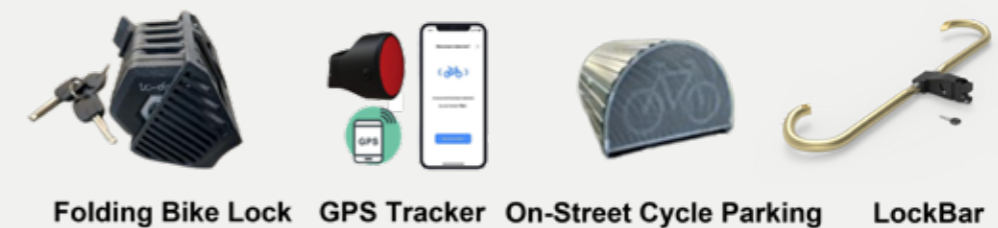
The handlebar's elevation angle can be adjusted to match the user's riding angle and height. The entire system is IP55-rated, which means it is dust and water resistant

Design Solution

Does it meet the user requirements?

- ✓ **Must be highly secure**
 - The entire system has grown in strength, making it difficult to destroy
 - If the lock is broken, the theft will have a more difficult time riding away
 - The bike can be locked to the fixed object
- ✓ **Must be easy to use**
 - The time it takes to lock and unlock the bike is approximately 25 seconds
 - It only needed a key to work
 - It can be used in any environment
- ✓ **Must be easy to carry**
 - Because the lock is also a handlebar, it does not need to be stored elsewhere
- ✓ **Must be durable**
 - The whole system can work in a high range temperature
 - All metals are stainless steel and will be anti-rust paint.

Product Comparison



	Folding Bike Lock	GPS Tracker	On-Street Cycle Parking	LockBar
Locking Speed	30 seconds	X	15 seconds	10 seconds
Unlocking Speed	30 seconds	X	15 seconds	12 seconds
Destroy Difficulty	Easy	Difficulty	Difficulty	Difficulty
Theft escape Difficulty	Easy	Easy	Easy	Difficulty
Cons	Heavy	Need Power	Location restrictions	Need Key

Rotary Shaft

Made of Basalt fibre, the primary function is to connect both the left and right handlebars, and it also serves as a magnet storage area

Stem Case

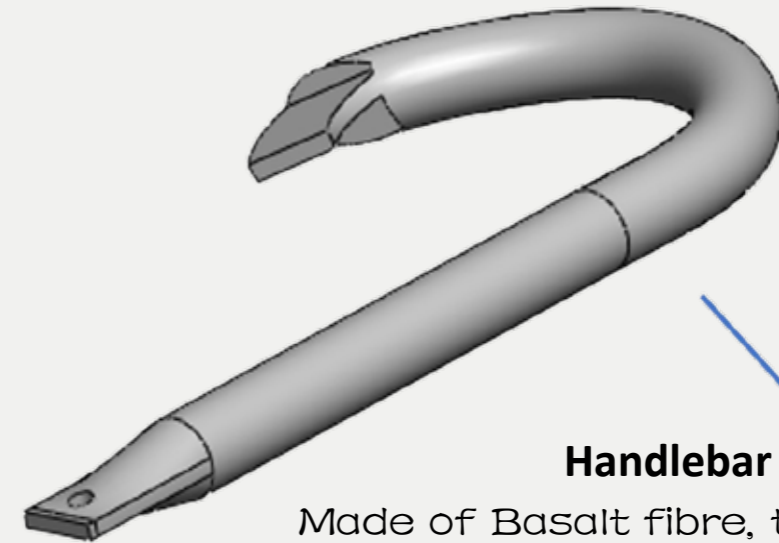
Made of Basalt fibre, the primary function is to connect the Stem and the Rotary Shaft. The stem case can rotate while release the button

Handlebar Left Side

Made of Basalt fibre, the primary function is lock system and control bike movement. It can be connect with right side handlebar, and equipped with a key insert hole

Neodymium Magnet

Made of MnAL Alloys, the primary function is to attract the handlebars, preventing them from moving while riding



Handlebar Left Side

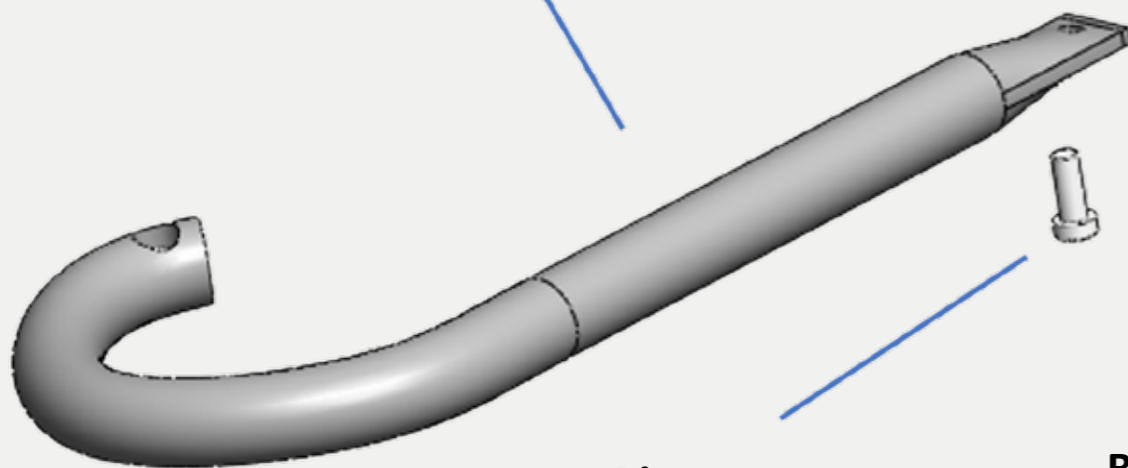
Made of Basalt fibre, the primary function is lock system and control bike movement. It can be connect with left side handlebar

Rivet

Made of 304 Stainless steel, the primary function is to join the right handlebar and the rotary shaft and prevent any vertical removal

Snake Eye Screw

Made of 316 Stainless steel, the primary function is fastening the steerer tube and the stem. The screw is a tamper screw that can be adjusted only with a two-hole drive bit.



Rivet

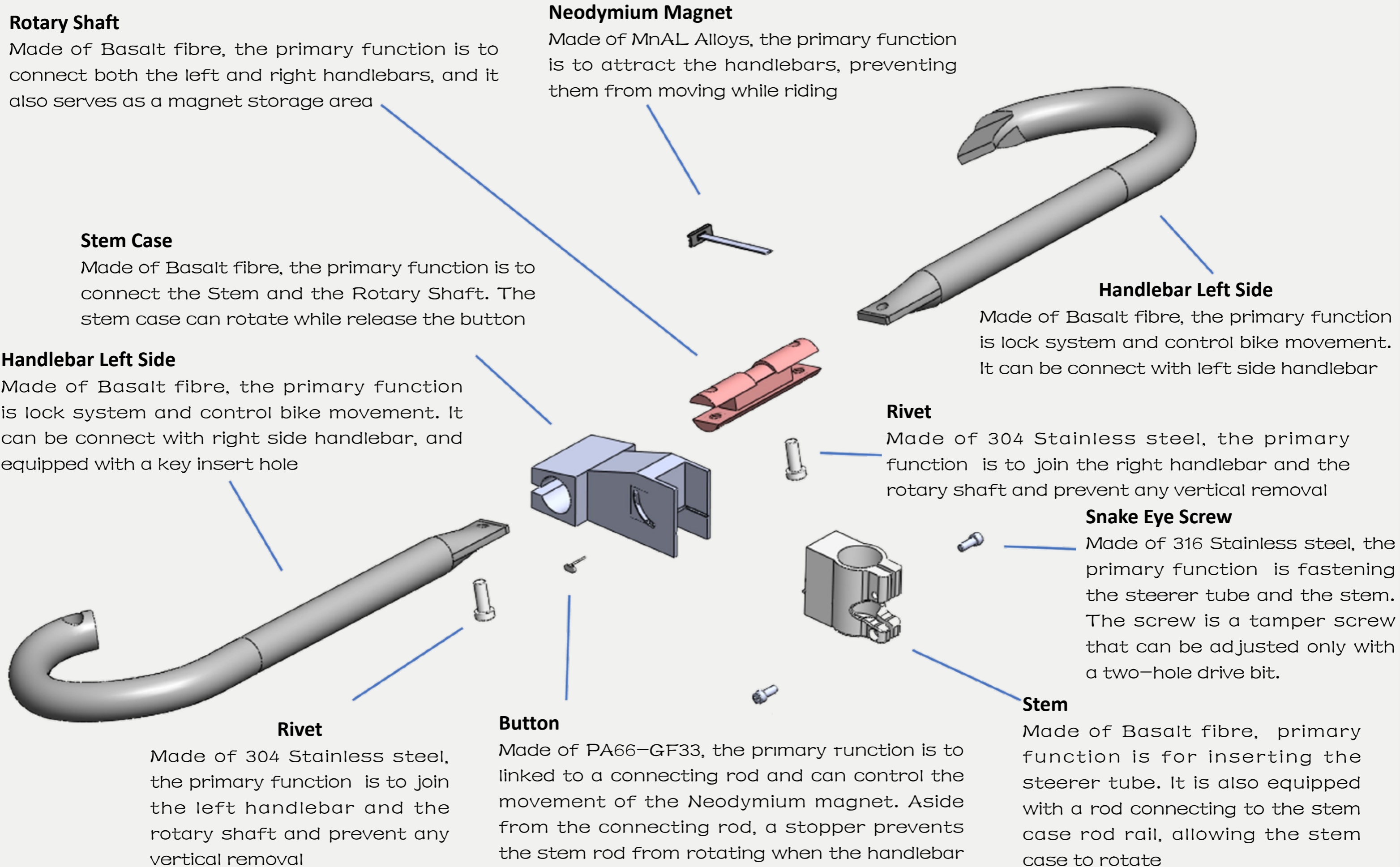
Made of 304 Stainless steel, the primary function is to join the left handlebar and the rotary shaft and prevent any vertical removal

Button

Made of PA66-GF33, the primary function is to linked to a connecting rod and can control the movement of the Neodymium magnet. Aside from the connecting rod, a stopper prevents the stem rod from rotating when the handlebar

Stem

Made of Basalt fibre, primary function is for inserting the steerer tube. It is also equipped with a rod connecting to the stem case rod rail, allowing the stem case to rotate



Lock the bike



Step 1 :

Parking the bike close to an immovable object



Step 2 :

Pull the Button up to manually rotate the bicycle stem



Step 3 :

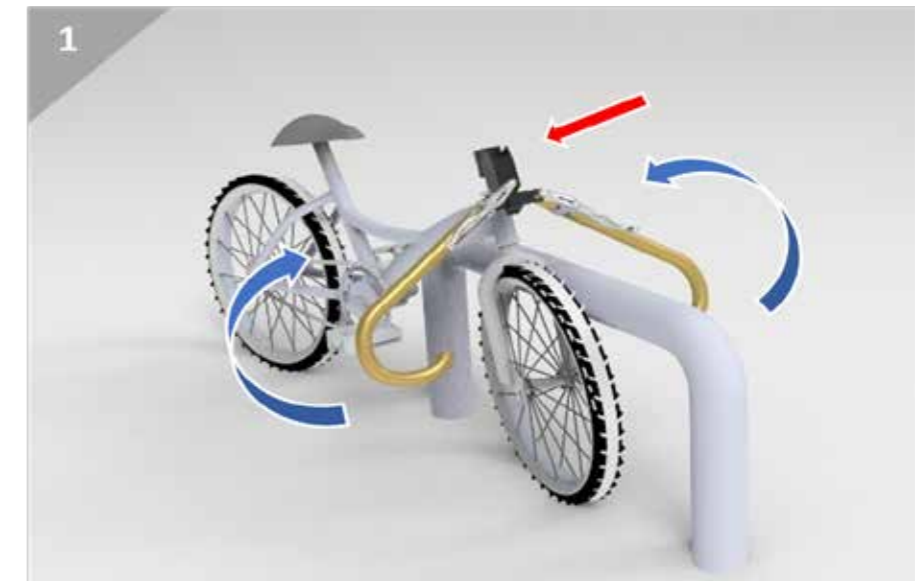
Turn the handlebar manually across the fixed object



Step 4 :

The handlebars are manually linked and locked, and they are locked using the key.

Unlock the bike



Step 1 :

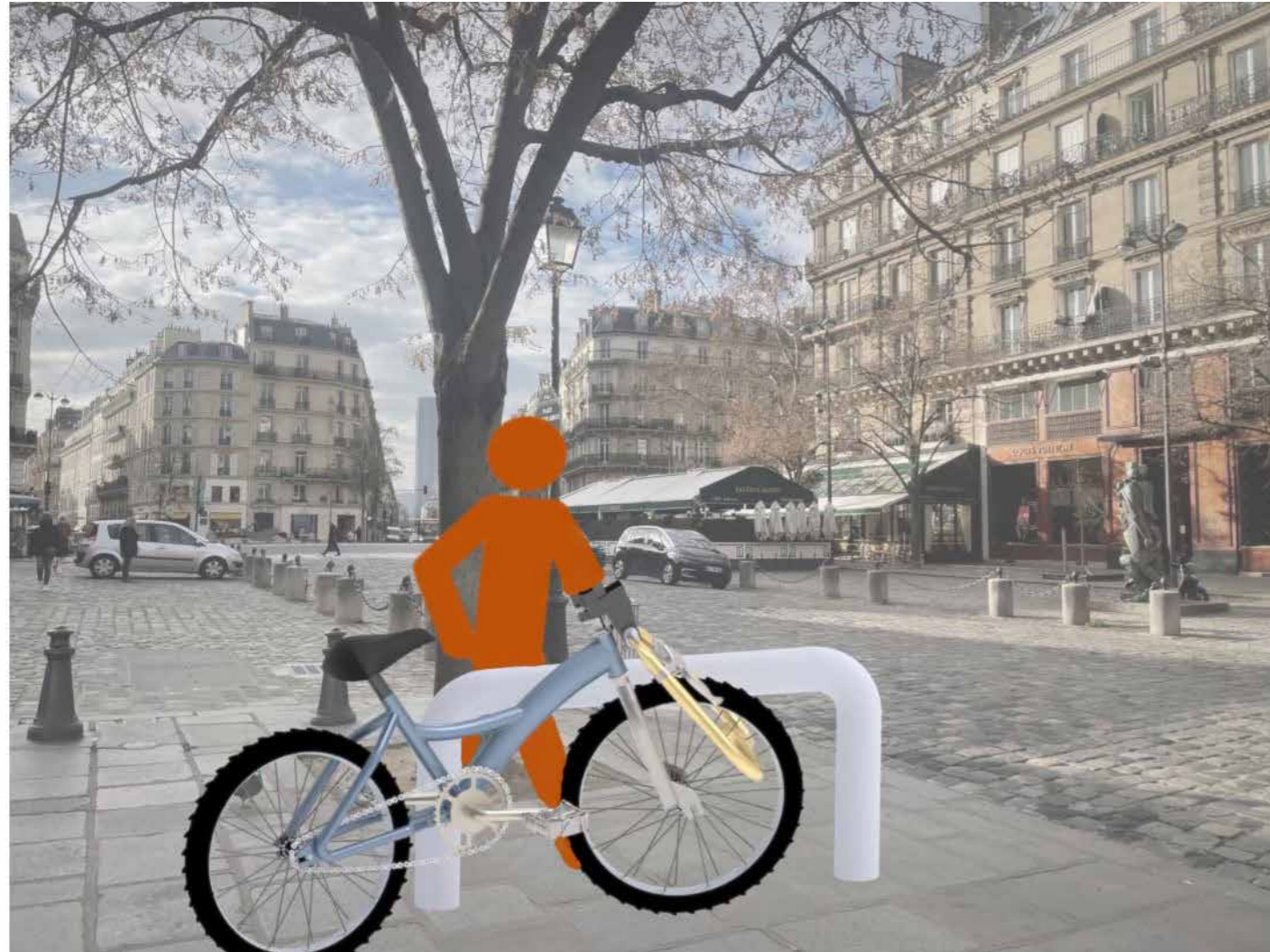
To unlock the handlebar, first unlock it with the key, then press the button and manually rotate it back to its original position,



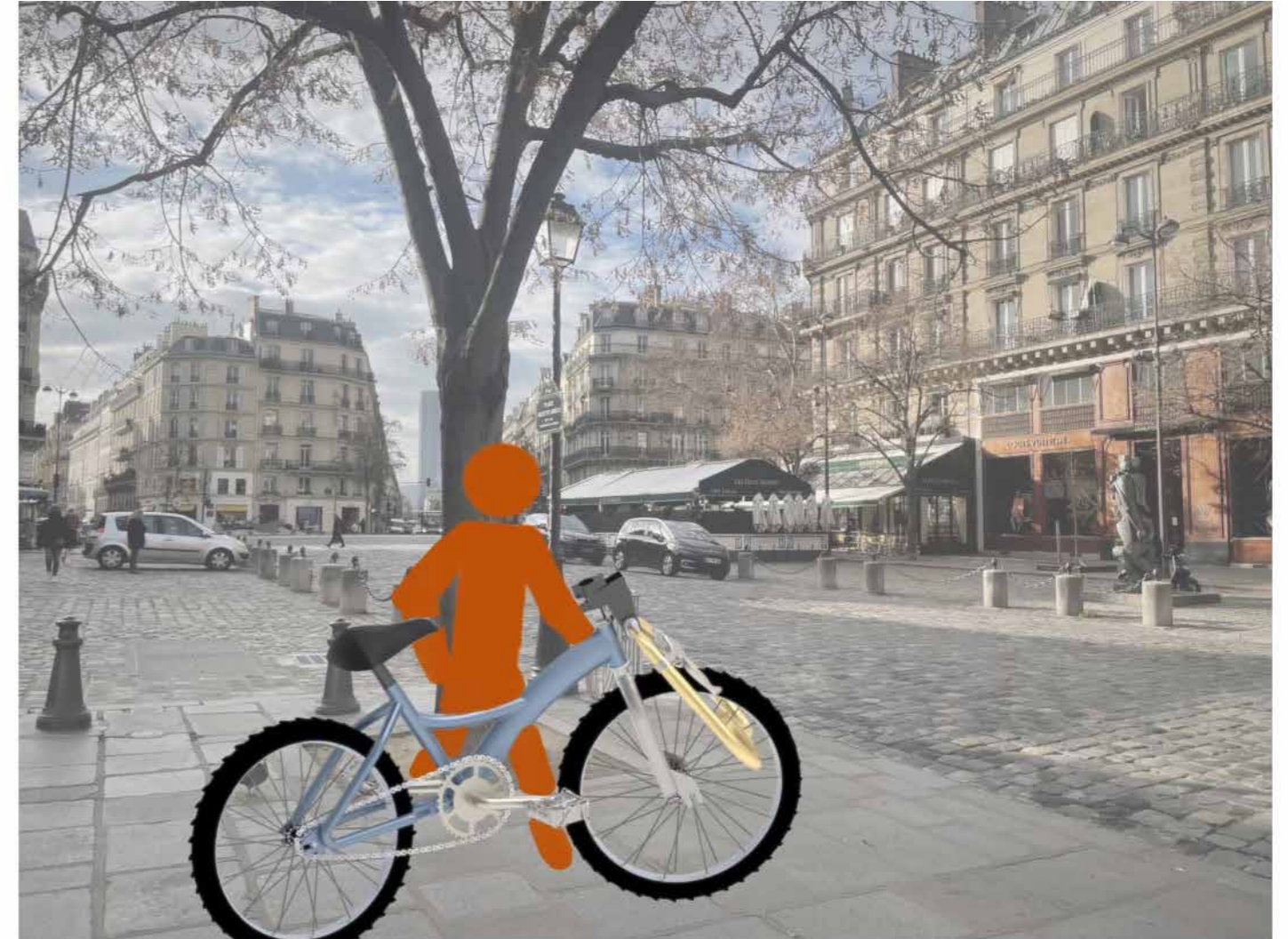
Step 2 :

When the handlebar is unlocked, manually place it in the riding position

Can lock with an immovable object



Can be attached directly to the tire of the bike



Feel safe to park whatever you want

Conclusion

This project's goal is to create a dependable and long-lasting bike lock. The process considered theft prevention, human factors, and dependability. Some requirements have been met during this process, but some issues, such as the mechanism, price, have yet to be resolved. I hope that this product concept will allow cyclists, including myself, to no longer be concerned about bicycle theft outside.

Refelection

In this project, I learned how to quickly verify inferences and apply the various methods and theories learned in the master's programme this year to practise this project. It is the first time I finished a project on my own in three months, and I believe I can make better use of my time in terms of time management in the future.

Future

Due to time constraints, this project was unable to perform relevant stress tests or ISO 4210 tests, and the result only relied on software to simulate the occurrence of actual conditions in order to speculate on the possibility of fracture and fatigue. Because basalt fibre is not commonly used in the bicycle industry, future products will need to produce samples for testing. And some structures need to be continually upgraded since thieves are skilled at picking locks.

Last but not least, the device needs to be tested on the street to see whether it can deter theft. It also needs to be tested on cyclists to obtain additional feedback on how they find the riding and locking systems.

Reference

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