Luminate

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Problem/Opportunity

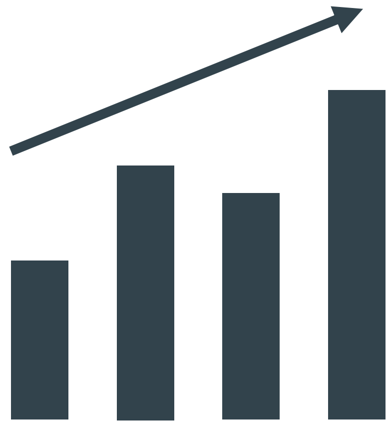
The problem

In 2020, cyclist fatalities rose by a staggering 41%, highlighting the massive safety risk many take when out on their bikes. A trend has been identified on where these accidents take place, 38.1% of all cyclists killed or seriously injured are at a junction and a further 11.8% occur at a roundabout. This highlights how dangerous these sections of road can be.

The typical accident unfolds when a vehicle emerges from a junction or entrance to a roundabout as a cyclist is passing, resulting in either the cyclist being thrown over the bonnet or wiped out from the side. In almost all cases the more vulnerable road user comes off worst.

Standard bike lights don't account for side visibility, making it difficult for some drivers to spot the cyclist before it's too late.

The Market



The UK cycling market is expected to be worth £2.2 billion by the end of 2020. The pandemic has renewed the joy of cycling for many around the world. E-bike sales have also doubled since the start of 2020.

The sudden new boom within the industry means a lot more people will be out on the road, presenting a massive opportunity to influence the current market. Millions of pounds have been spent developing bike lights for the front and back of the bike but, very few side lights have been brought to market. Products which help cyclists improve their side visibility are typically a hassle to set up and inconvenient to transfer to other bikes. On top of this, many commuting cyclists feel they need to remove all the lights from their bike at the risk of them being stolen.

Intended User

Commuting cyclists are disproportionally the worst affected when it comes to accidents reported on UK roads. They are 45% more likely to be admitted to hospital for an injury compared to other commuting methods.

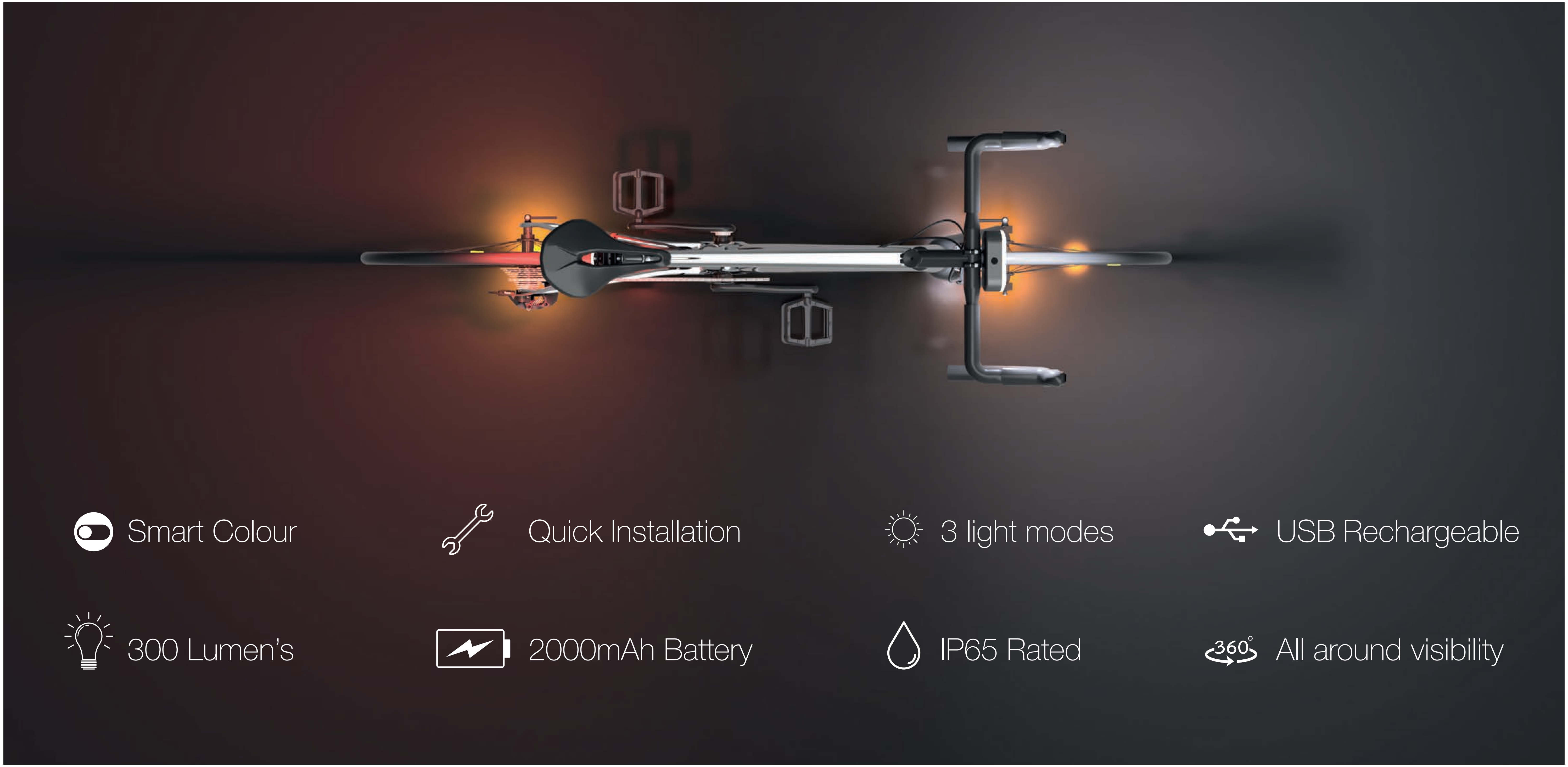
Consequently, the product was designed with the commuting cyclist in mind. Therefore the product had to be eye catching so road users could easily identify the more vulnerable cyclist amidst busy traffic.

Thieves are also a common foe cyclists face when they leave their bike unattended. Therefore, ensuring that the product could be easily removed from the bike and taken with the user was key.

The Brief

'Design a convenient and relatively low cost product which improves side visibility of commuting cyclist.'

Product Overview



WHO:

Commuting cyclist who wants to be visible from all angles, whilst navigating busy urban environments.

WHAT:

A bike light which can be used on the front or rear of the bike, as well as two removable lights that effectively highlight the motion of the bicycle's tyres. The light can be easily attached and detached for safe keeping.

WHERE:

Urban environments will be the primary area of use, however, Luminate can be used anywhere a bike can be cycled.

WHEN:

On the daily commute to work, a friends house or the shops. Luminate can be used for any scenario at any time of day.

WHY:

Side visibility is an aspect of cyclist safety which has been massively neglected by the market. There is a great opportunity to create a 360° lighting system which has high performance as well as style.

Research

Academic Papers

Various academic papers were read in order to understand the psychology behind what factors effected how cyclists were treated on the road.

Interestingly, cyclists were given much less room on the road when they were wearing safety equipment such as a helmet.

Empathic Modelling

Empathic modelling was employed so I could appreciate what both cyclists and road users experienced.

Various tests were conducted so I could understand how motorist could potentially miss a cyclist when navigating a junction or roundabout

Market Research

Extensive market research was undertaken to appreciate what existing products were available. This was essential to ensure that a unique selling point could be identified within a very competitive market.

Interviews

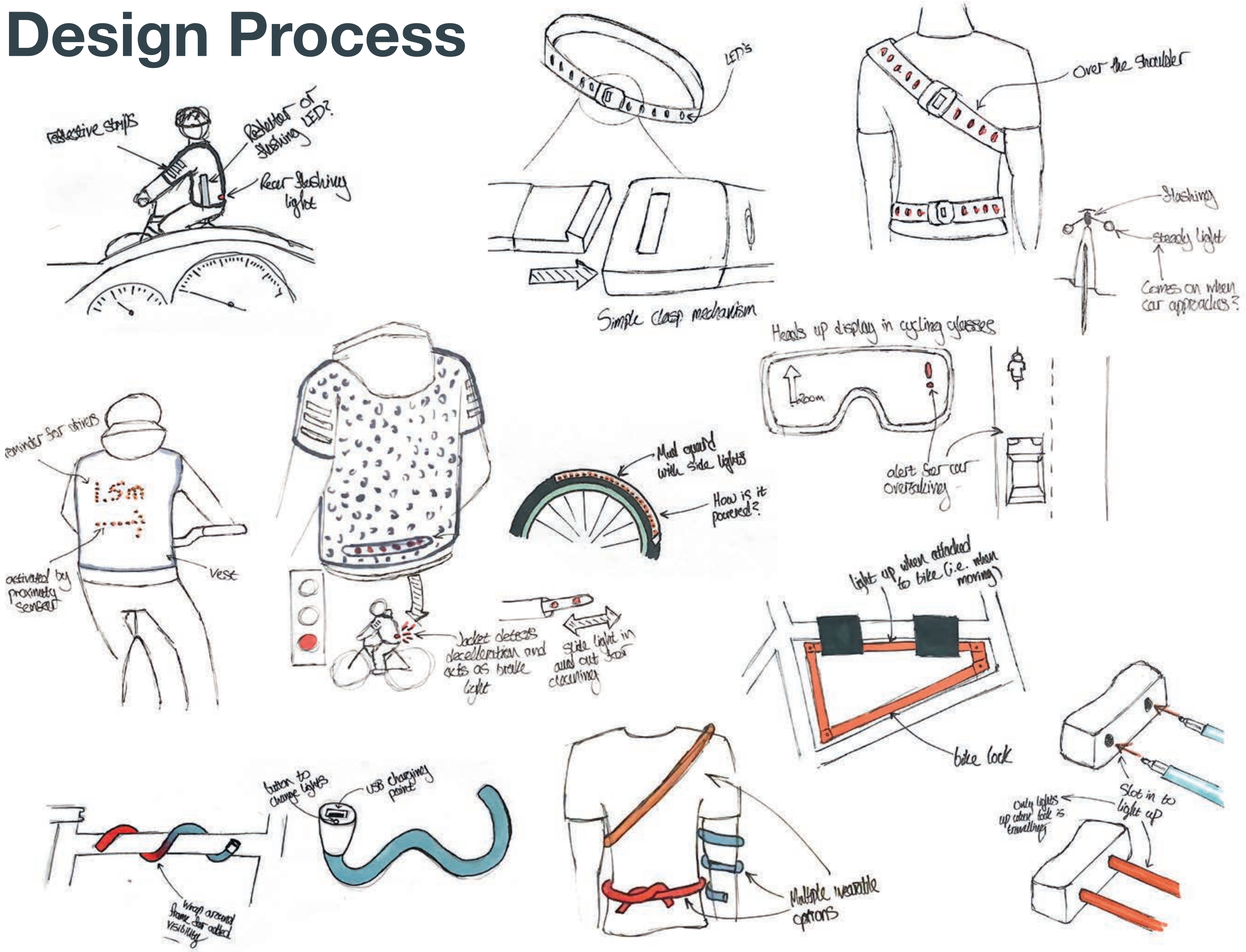
Several interviews were planned over the course of the project with a wide range of users. The interviews were conducted with: commuters, ex-road police officers, charities, hobby cyclists and victims of cycling incidents. This allowed me to build a comprehensive understanding of cyclist safety issues.

Survey and Data Analysis

A survey was conducted to better understand what kind of accidents cyclists are involved in and how they occur. Over 97 responses were recorded, enabling me to identify patterns within the data. This highlighted that junctions and roundabouts were a serious problem for many cyclists.

Another survey was later conducted to understand when buying a new safety product what cyclists looked for the most. High performance was the top ranked answer closely followed by good durability. Showing that most users would rather pay the extra money for a product that works well as opposed to a cheap alternative.

Design Process



Initially a wide range of problems relating to cyclist safety were considered, however, after comprehensive research three focus areas were established: roundabouts, overtakes and cyclist apparel.

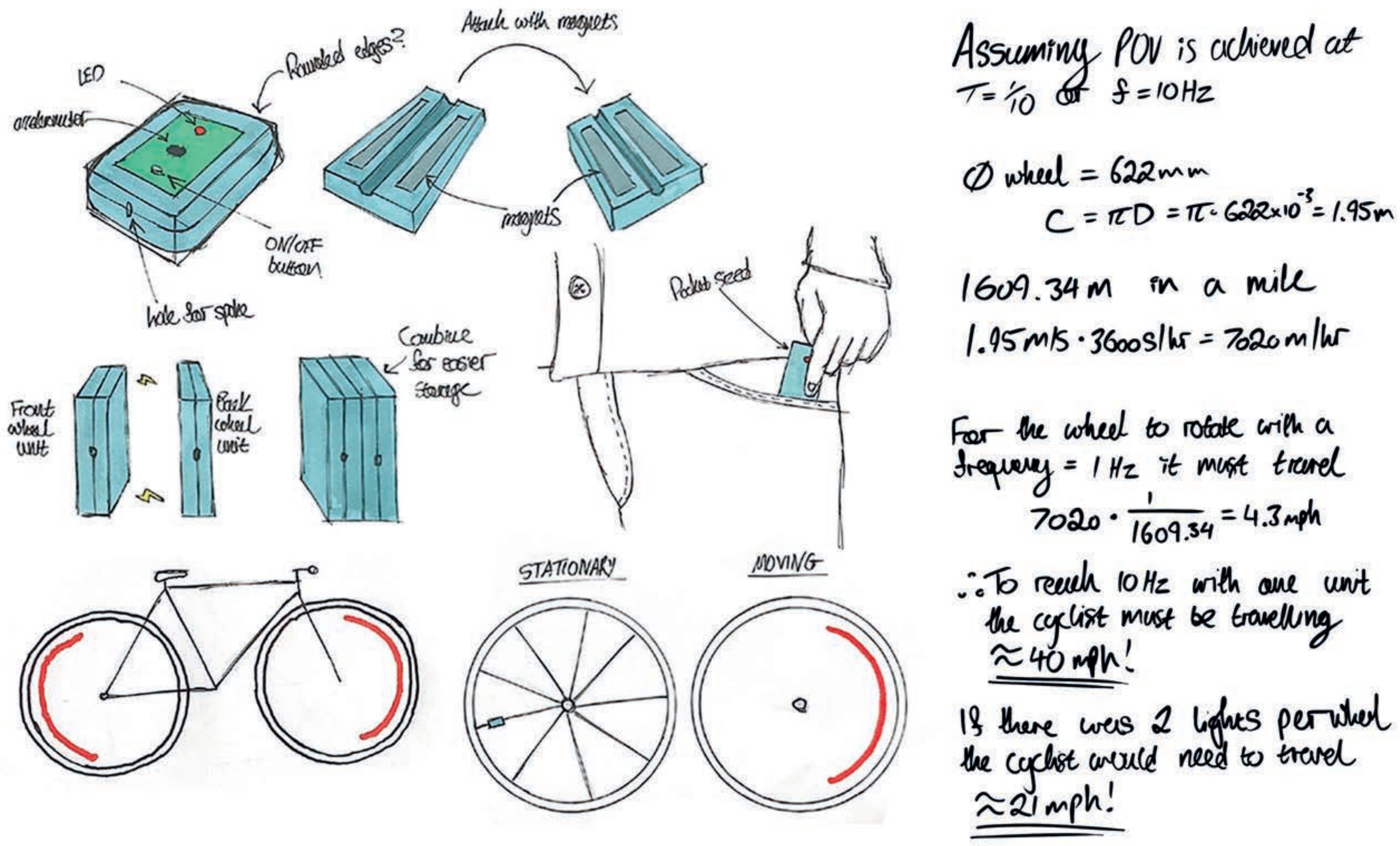
Initial concepts were developed and shown at the interim presentations. After the interims, I began to look into how accidents happen at junctions and roundabouts. Leading me to conduct some empathic modelling to better understand what both cyclist and drivers see whilst navigating these sections of road.

The process highlighted a neglected area of cyclist safety which is side visibility. It was clear after reviewing the footage captured from the session that despite the cyclist having front and back lights they were very difficult to spot. This insight dictated the direction my project would ultimately take.

With the focus of the project clearly set on improving side visibility of cyclists, some initial concepts were explored through sketching and prototyping.

The prototypes were tested in pitch black conditions as well as urban environments to see how they would perform in both scenarios. The main priority at this point was discovering what visuals caught the eye of other road users. Compilation videos for each prototype were made and shown to tutorial groups where feedback was provided on the most noticeable visuals.

After numerous tests I decided that highlighting the wheels was the best option as opposed to the frame. The wheels are much more noticeable due to the rotational motion. This brought on further concept generation but with a more refined set of user/product requirements. Creating more solutions focused on the end-user, commuters.



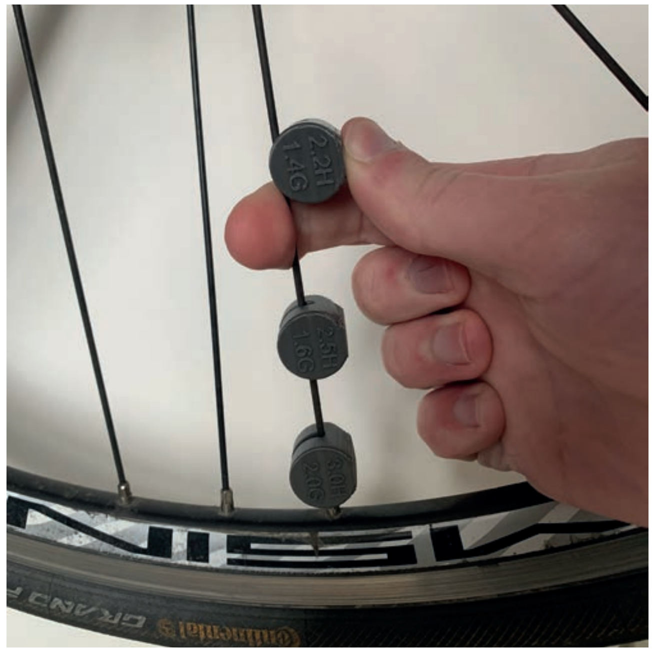
Design Process

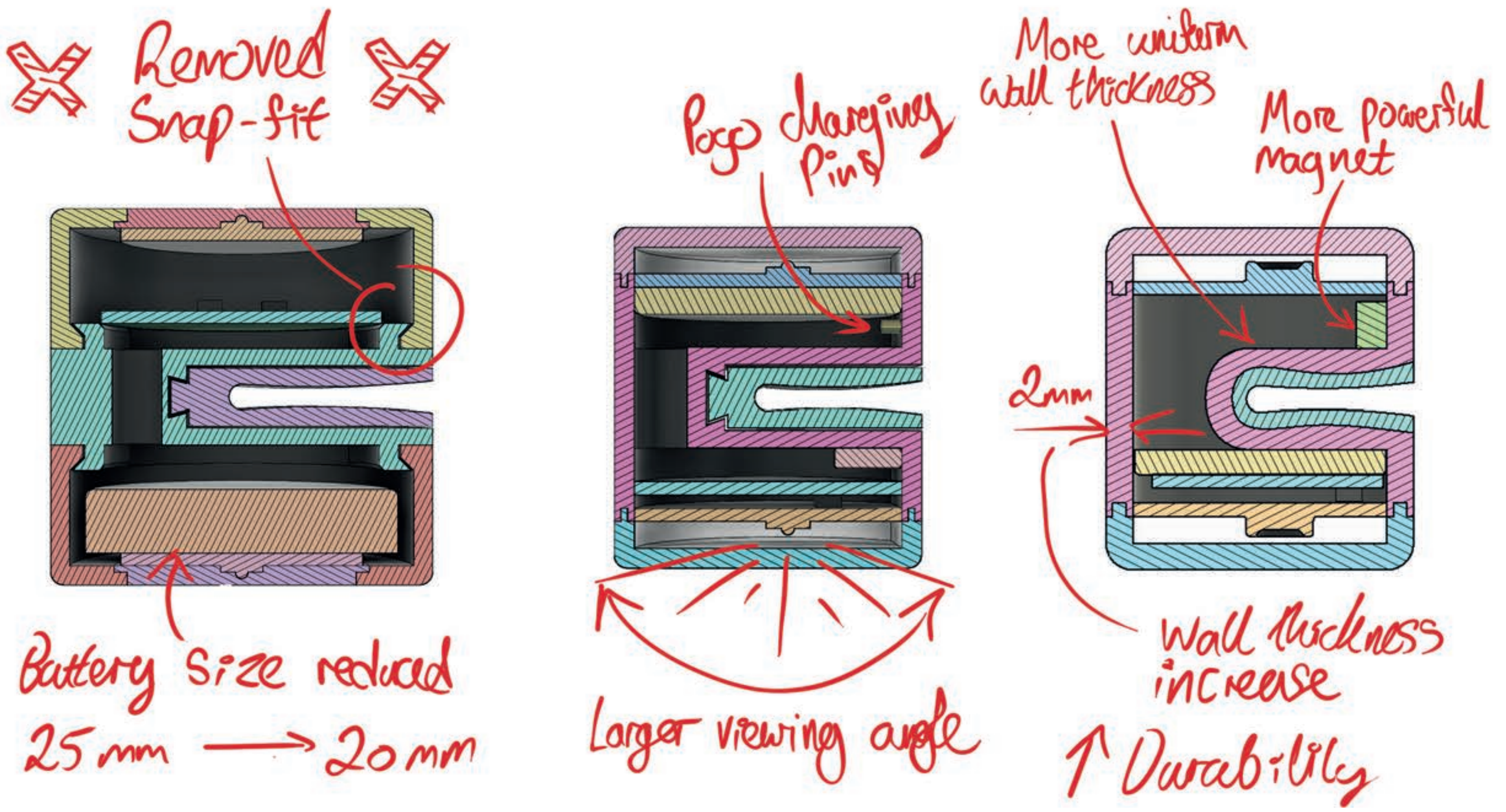
Further tests on different light arrangements were conducted to understand how they performed at various speeds and distances away from the observer. The results concluded that 2 or 3 lights per wheel provided the best visual, 1 light also worked but didn't give off quite the same visual impact. The more lights attached to the wheel the more set up and hassle it was for the user. Therefore, the right balance between performance and ease of use had to met.

A survey was conducted to understand cyclists buying habits when purchasing new safety equipment. When buying a new product the two main criteria people looked for were high performance and good durability. Utilising this data a concept evaluation matrix was created to asses all the current ideas.

The concept that came out on top was a persistence of vision (POV) device. Persistence of visions is an optical illusion that occurs when an image is in motion but it appears to be still. I wanted to achieve the same effect with a bike light that was simple to take on and off. Many existing bike lights which use this optical illusion are bulky and take a substantial amount time to set up.

After some quick calculations shown in the top right corner, I realised this concept would not be feasible. This being said I did think the idea of bike lights which could be easily taken on and off the spoke was a good one. This prompted me to develop a new concept which is where the first iteration of Luminate was conceived.





Design Process

I understood that the spoke light had to be designed first as its shape and size would dictate how big the main light was going to be. It was also acknowledged that the method of attaching the light to the spokes was going to be the most important part of the design.

3D printed prototypes of the spoke lights were made, experimenting different tolerances on the snap-fit joints. One issue that I encountered here was keeping the lights still as the wheel rotated.

This led me to consider a permanent attachment on the spoke which the lights would snap onto whenever required. However, this added more parts to the assembly, required extra time to set-up and meant the product couldn't be transferred easily to another bike.

To prevent the light from rotating and sliding up and down the spoke, a rubber lining was added to the snap-fit. Friction and compressional forces of an elastic material like rubber would provide enough grip to hold it in place.

Experimenting with this idea a TPU insert was 3D printed and slotted into a PLA mock up of the spoke light. The model was then attached to the spokes and I cycled up and down a cobbled street to see if the lights would move when exposed to repetitive forces. The lights did not move, marking the test as a success and proving this was a feasible method of attachment.

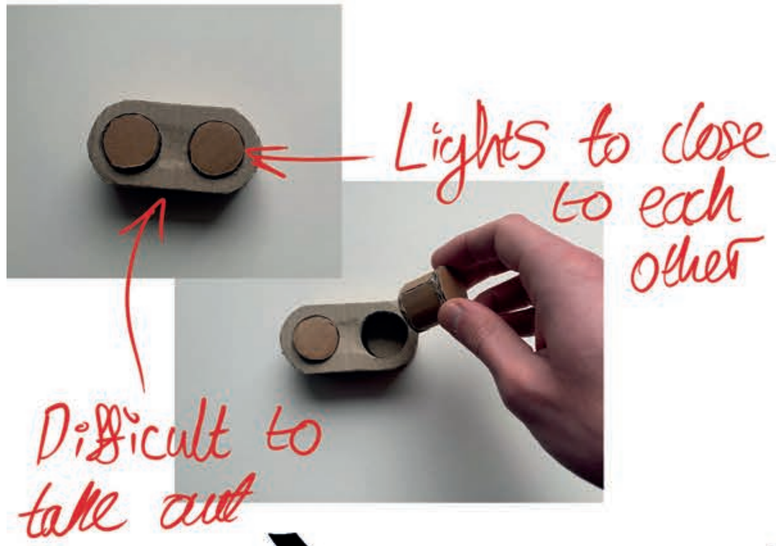
After the joining mechanism had been finalised, the focus switched to component selection. Chip on board (COB) LEDs were chosen for their high production efficiency over surface mounted (SMD) LEDs. Furthermore, COB LEDs produce no glare and typically have a beam angle of 180° which enables the user to be seen a lot easier.

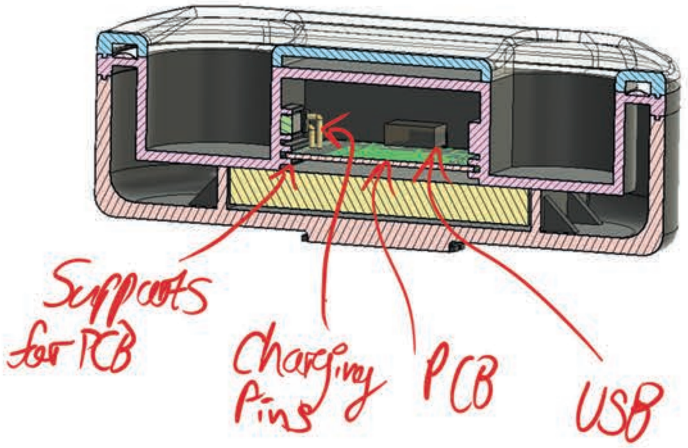
Power requirements were then calculated based on estimated times of operation, modelled off data released by Strava. Revealing the average commuter cycles 15.8km a day and has an average speed of 19.3km/hr.

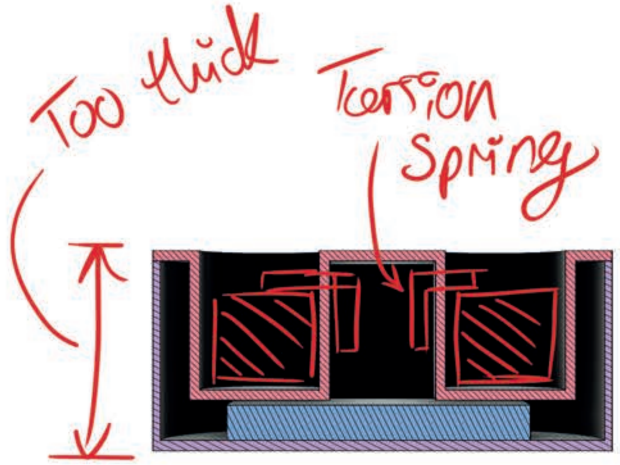
A 120mAh li-ion battery was selected for the spoke lights and a 2000mAh li-ion for the main light. Providing enough charge to last the user a weeks worth of commuting.

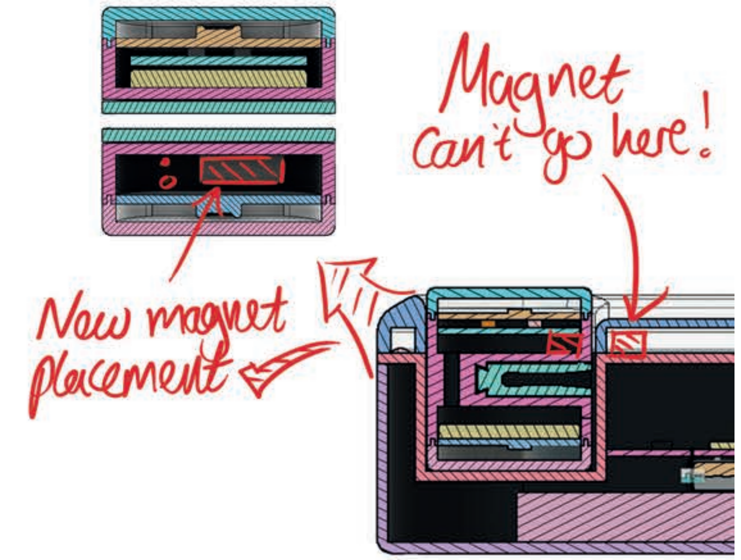
Lastly the CAD model was tweaked ensuring the product could be assembled in a logical manner and so the weight distribution within the part was even, mitigating any unwanted rotational movement.

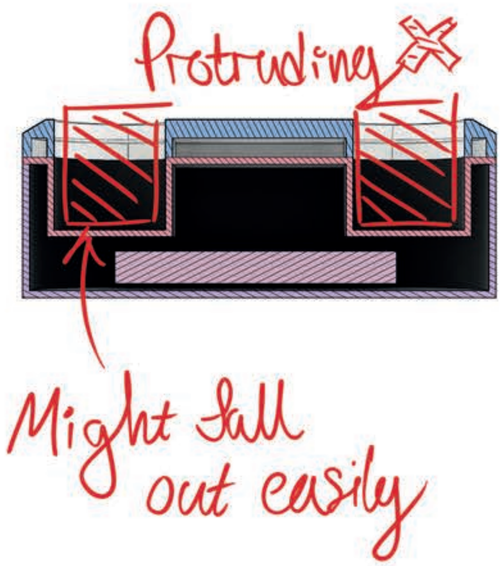
Design Process

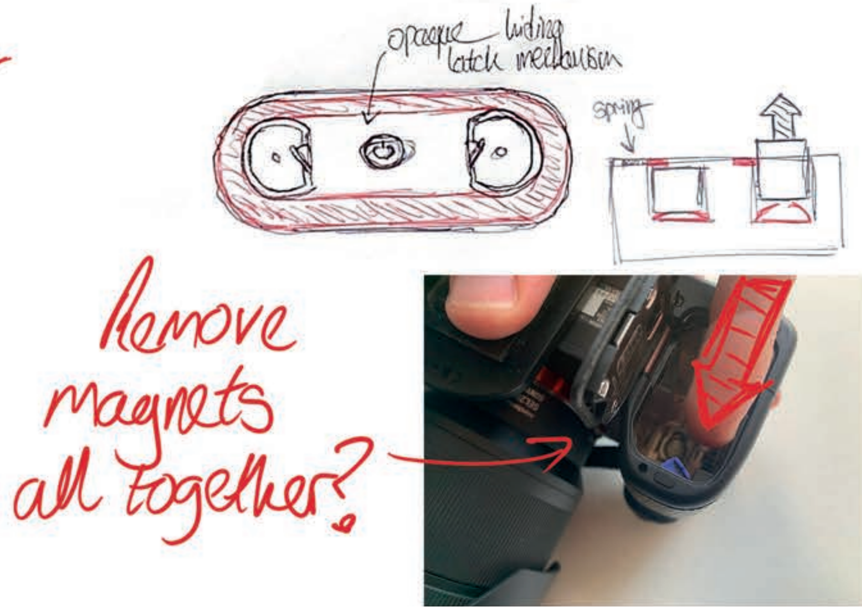












After the design of the spoke light had been finalised, a cardboard prototype was created to get a sense of the overall scale of the product. This highlighted an issue with taking the spoke lights out of the case. I hadn't considered that they would be sitting flush with the main light so there was no where to grab onto.

I considered two options one was having the lights protrude slightly from the main light and the other was to implement a groove into the top face of the main light. I decided to go with the latter as this allowed the user to pinch the lights and pull them out. Furthermore, I thought it looked better and reduced the chance of the lights falling out accidentally.

One of the biggest challenges with the development of the main light was figuring out how all the sub components would be arranged inside the product.

The final placement of the PCB would ultimately decide where external features would be located such as the button and micro-USB charging port. In the end it was decided that the PCB should be hidden inside the casing about half way up, meaning the charging point and button placement were in suitable locations.

Following a tutorial session a few concerns were raised about the spoke lights being held in the case with magnets, I began to explore other alternatives options. Multiple solutions were considered but mimicking the mechanism used to hold a camera battery in place was the most promising.

The idea was to use a torsional spring, so the latch would remain over the spoke light restricting its movement. A conical spring would then be used to push the light out once the latch had been pulled back.

I explored this option further in CAD but soon realised it was making the part a lot thicker. The spoke lights had to be sunk deeper into the base for the spring loaded claps to keep them secure. Testing the magnet solution, a couple of prototypes were printed off and magnets of different strengths ordered. The first set used had a 0.9kg pull and worked reasonably well but could easily dislodge on a bumpy road. The second set had a 2.2kg pull requiring a lot more force to remove the lights but not too much that it was a struggle.

Another issue these prototypes highlighted was when the spoke lights sat in the case they would be sitting in line with the clear PC cover. This meant the magnet would be visible through the plastic which I didn't want. To avoid this the magnets were placed along side the charging pins so they were both hidden away in the base.

Main Body: PA66

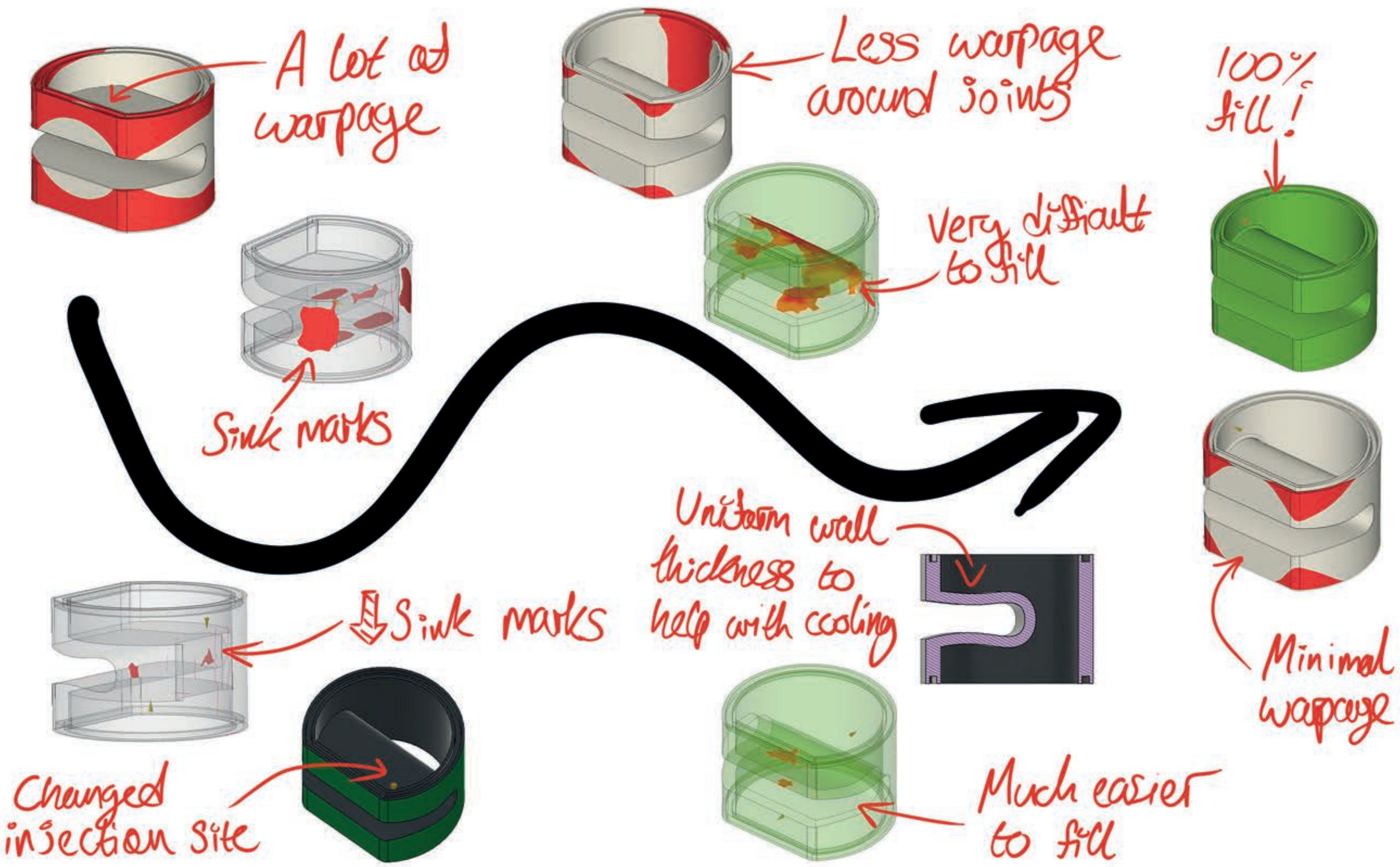
- Very high stiffness
- Very high strength
- Excellent chemical resistance

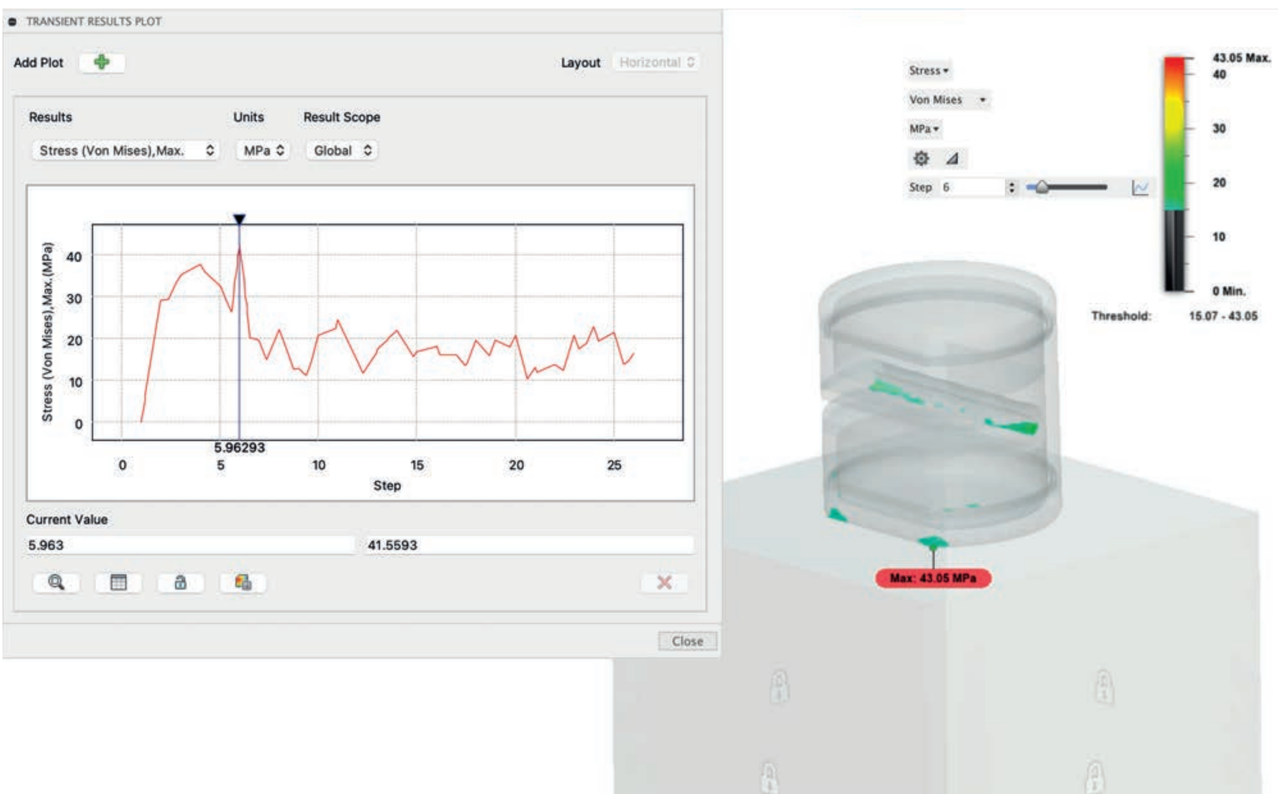
Lens: Polycarbonate

- Excellent optical clarity
- Outstanding strength, stiffness and impact resistance
- Good dimensional stability

Snap-fit Lining: TPO (Shore A55)

- Exceptional impact resistance
- Easily moulded
- Great dimensional stability





Materials & Manufacturing

Material indices for the specific problem were calculated and employed to aid with the selection process. GRANTA Edupak was used to ensure a wide range of materials were considered for the product. Several requirements were applied to the material selection process such as: excellent injection moulding capabilities, suitable for recycling, and excellent resistance to fresh and salt water.

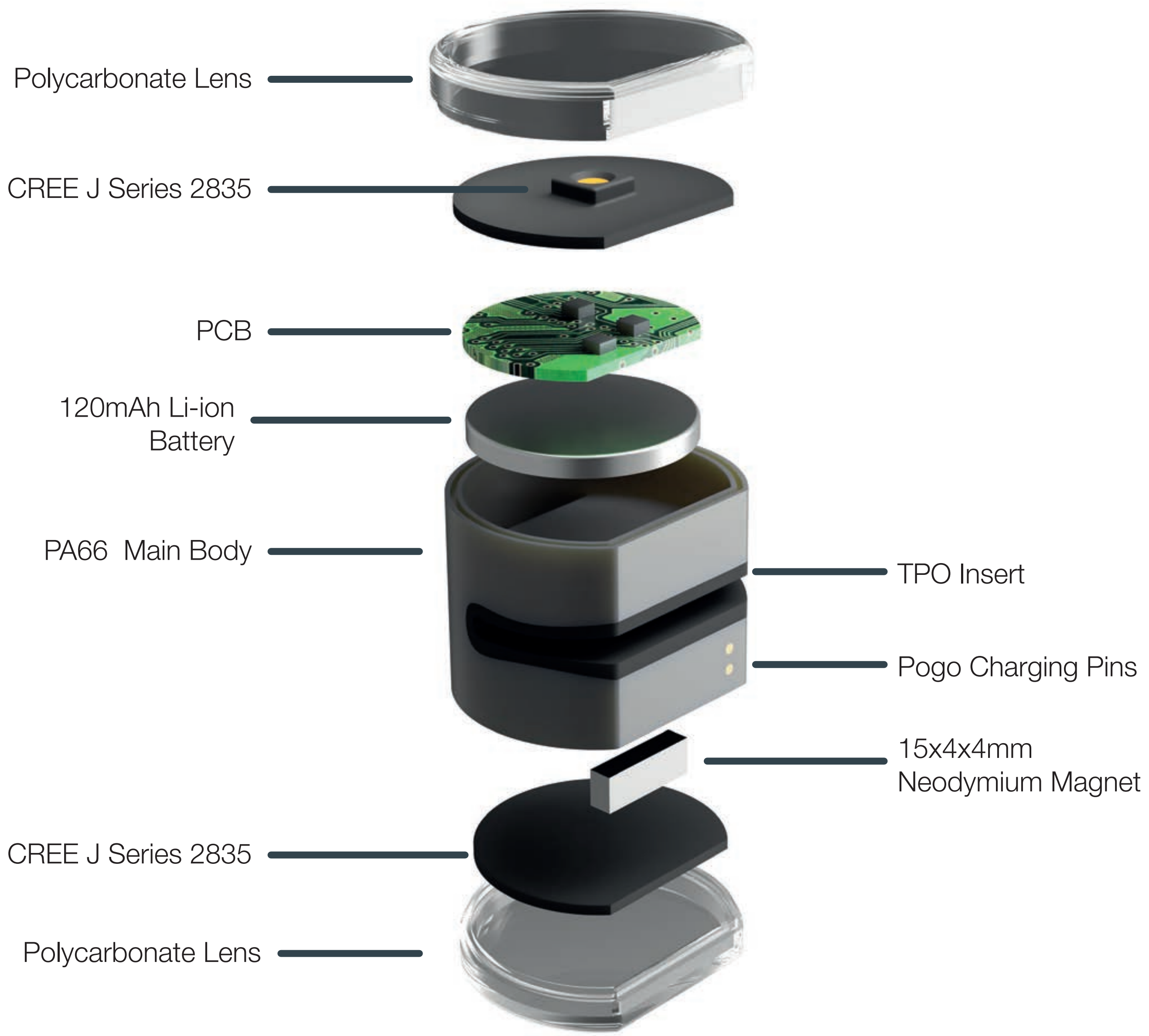
PA66 was chosen for the main body of the lights due to great impact resistance properties as well as good flow for easy processing.

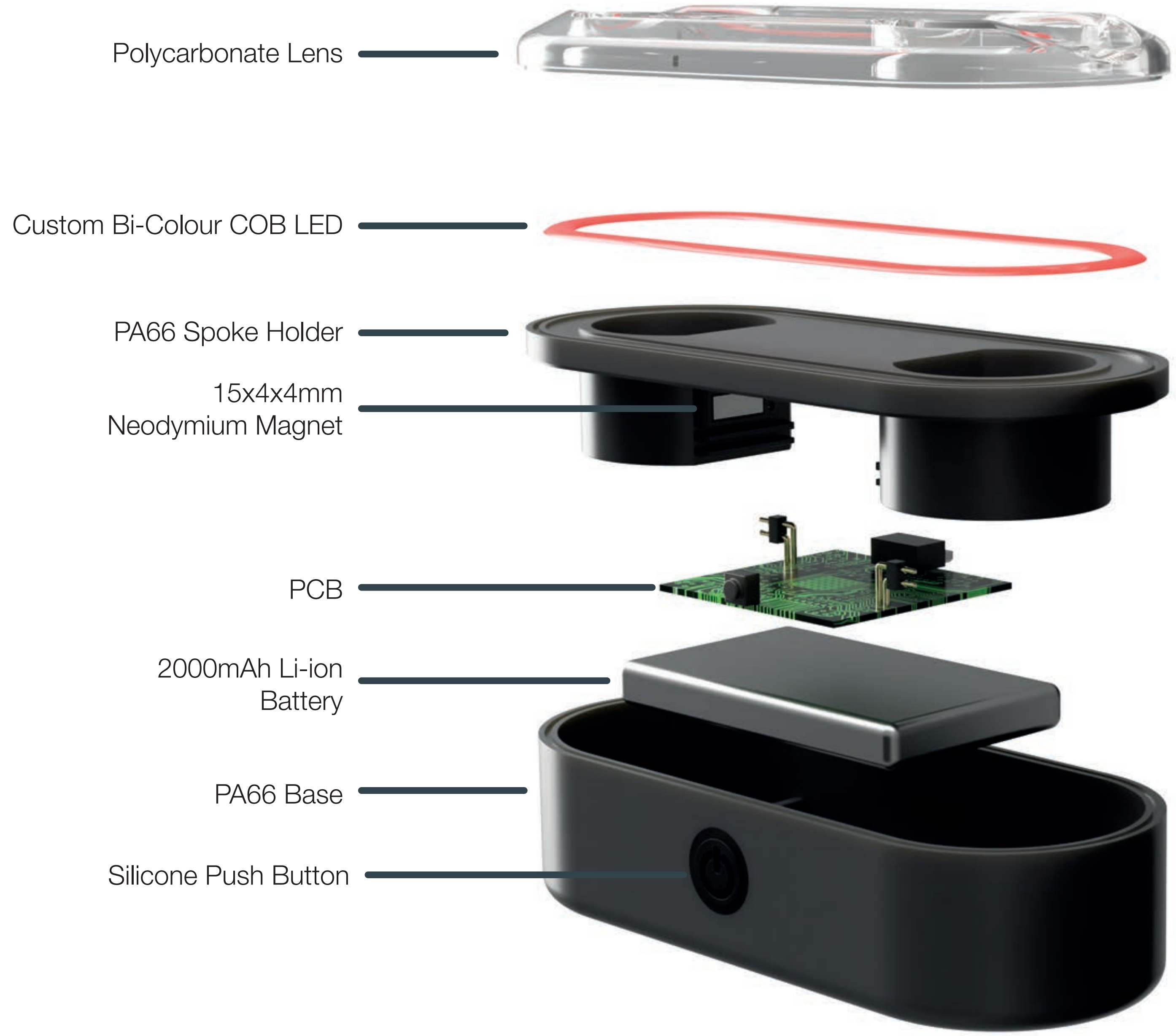
Polystyrene (general purpose, crystal) was initially chosen as the material which would house the LEDs. However, after running some impact tests on Fusion 360 and comparing how it performed against polycarbonate (PC) which was a close second, PC was chosen.

TPO was carefully selected as the material which would line the inside of the snap-fit joint on the spoke light. It is chemically compatible with ABS meaning no mechanical support had to be incorporated into the design, keeping tooling costs low.

The product is intended for mass manufacture, therefore injection moulding was the ideal process to manufacture the product. The main challenge was tweaking the design so it was suitable for the chosen process. Injection moulding simulations were run in Fusion 360 to analyse where potential defects would arise. Subsequently, design changes such as including draft angles and applying a uniform wall thickness were made to mitigate these effects.

Two-shot injection moulding will be employed for the surface of the spoke light snap-fit. The process was chosen instead of overmoulding as it is more suitable for large production runs. This method enables the elastomer TPO to be moulded over the hard surface of the ABS, which has a much greater coefficient of friction. Providing a much more secure fit, reducing the chances of the spoke light dislodging whilst cycling.

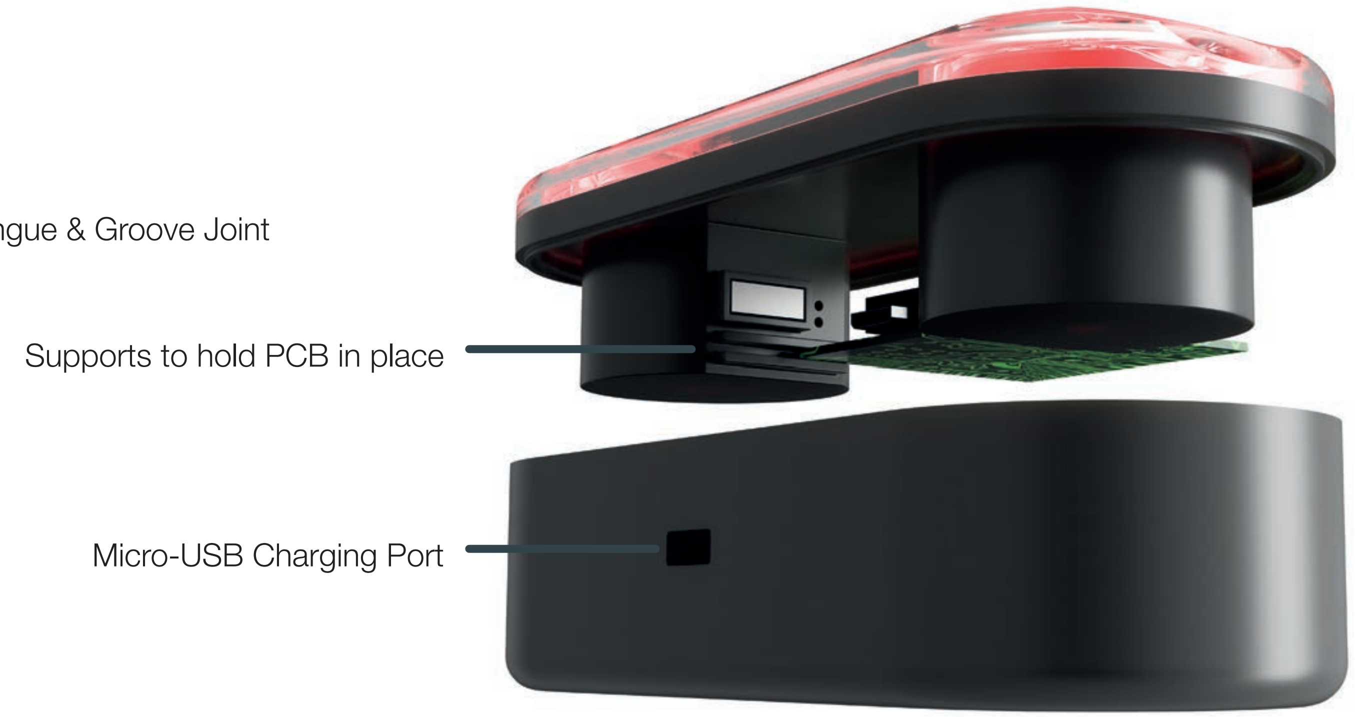




Assembly

Due to the products environment of use, ensuring the vulnerable internal components are protected from foreign bodies such as dust, dirt and moisture is key. With this in mind, it was decided that the product would be assembled via tongue and groove joints and sealed shut with waterproof sealant.

Snap-fits or screws in conjunction with rubber gaskets were considered, however this introduces potential failure points within the design. When the product is dropped, when the temperature is too hot or cold, or when the seal is not properly placed during assembly, water ingress can occur. Furthermore, keeping the product compact was key, so introducing bulky gaskets wasn't desirable.



User Journey

1. User picks up their fully charged Luminate light.

2. They make their way downstairs ready for the commute.

3. The front light is attached to the handle bars and it recognises the polarity in the front mount, automatically turning the light white.

4. The spoke lights are removed from their case and pressed firmly onto spokes.

5. If the user has a 2nd unit the same process is followed with the back light.

6. Upon removal from case the spoke lights automatically turn orange indicating side visibility mode has been activated.

7. Once all the lights are secure the user sets of on their commute.

8. The user arrives at their destination locking up their bike.

9. The spoke lights are quickly and easily removed.

10. They are then placed back in the main light where they begin to charge ready for the trip home.

11. The main lights are simply removed from the handle bars and seat post.

12. The products compact design allows the user to take the lights with them mitigating the chance of theft.