mobinou

CERN UPC esade IED

Sponsored by TMB

Final report

Team Nikola **CBI program** **2020 - 2021**

Team Nikola

Camila di Nella

Camila's career starts in Buenos Aires, where she graduated as an Industrial Engineer in University of Buenos Aires. Afterwards, she spent more than 6 years working at Dow, which is one of the biggest chemical producers in the world. In 2019 she moved to Barcelona to enroll in an MBA, where she is the president of Women in Business Club. She leads and manages a club of 90 students in raising awareness on gender gap and also speaks four different languages. In her free time, she was a Hockey Captain!

Hadi Hissi

After starting a Mechatronics, Robotics and Automation engineering degree in Lebanon, Hadi moved to Barcelona to pursue a scholarship in industrial and product design at IED. Within the past years he gained experience working as a junior industrial designer at Mermelada studio to support his studies and furthermore he participated in multiple disciplinary projects such as protopixel hackathon, in which he hacked the Agbar tower!

Manel Gracia

Manel is a student in Telecommunication Engineering at UPC, with a major in Telematics. Nowadays, he is working at the university in the field of telematics, concretely, using Docker to deliver services in containers so they have their own software, libraries and configuration files. In his free time, he is a volunteer at the IT department in Telecogresca, which is an association that organizes university festivals and promotes the music and culture of our country among others.

Marta Rodriguez

Marta is a student in Telecommunications Engineering at UPC. Nowadays, she is doing an internship in Cybersecurity at PriceWaterhouseCoopers, and working in a research project at UPC, which is about interaction with microorganisms. Furthermore, she is interested in infrastructures of the cloud and machine learning, in which she is doing her specialization. In her free time, she is a pianist and also loves chess and cheese!

Team

Saketh Reddy

Saketh grew and studied in India, where he graduated in electrical, electronics and communications engineering at SRM university. He has two main working experiences: the first one was in India, where he worked as an Operations Manager at Xenia Hospital for almost 4 years. The second one took place in Barcelona, where he was the Business development specialist at NuBanca company, giving him a strong knowledge of working in a team and increased his business skills. Ah, he is also a great photographer!

A Communication dossier

We have been introduced with the challenge of Urban Mobility in COVID times in coordination with TMB. COVID has changed the way commuters commute everyday and ridership in public transportation has decreased steeply. Our purpose is to develop an innovative solution that can help enhance the experience of commuters to commute with confidence in public transportation. On an average time spent in public transit by a commuter varies between -105 149 minutes. That is a lot of time for the virus to spread from person to person.

To better understand what has made commuters switch to alternative means of transportation we conducted a survey from people all over the world to better understand their commuting habits before and after COVID. We have observed an increase in usage of personal cars and micro mobility. We have also had multiple interviews with experts from TMB to help us better understand the problem.
Main insights from the survey:

_ Millennials and middle age groups opted for personal means of transportation such as cars and micro mobility

_ Public transportation, which is less ventilated, is considered as hazardous for the spread of the virus

_ Less elderly respondents answered the survey

To better understand about elderly and their problems associated with public transportation, we went to streets and made some friends to get personal insights:

_ They find it very hard to transport using public transportation and has made them dependent on Taxis(costly) and family/friends(dependency) for their commuting needs

_ They are willing to be part of micro mobility revolution which can help them commute hassle free

_ They lost trust in public transportation as they have to encounter with non-elderly, who do not care much about social distancing measures

We had many solutions that can likely help everyone keep social distance but we choose Mobinou depending on the interview insights. Mobinou is a unique personalized transportation designed and operated for elderly to help them commute with trust and safety.

Mobinou seamlessly integrates with 5G and IOT to better navigate inside the urban streets. It understands the movements of obstacles by using 4 powerful sensors to facilitate navigation. Mobinou can also be customized as per the needs of elderly with an option to sit or stand.
As the service is novel, it is hard to estimate the expected budget as a whole. The budget allocation depends on the Phases and the usage patterns of the elderly commuters. We estimate that the price per Mobinou to be XXX Eur and metallic strip to be XX Eur/Meter. Phase0- is estimated to be XXXXXXX Eur and is expected to move to phase1- in 2-1.5 years. Commercial and truck transportation, opening up to non-elderly and expanding it to supermarkets and malls is integrated into Mobinou in Phase3-.
We believe that Mobinou technology and business model to be the future of urban transportation. With growing automation and vehicles on road, Mobinou will solve the basic needs with fast, reliable and personalized transportation.

B From research to a problem statement

We were given the challenge of urban mobility in times of Covid19- and taking care of the Sustainable goals number 3, Good health and wellbeing, and number 11, Sustainable cities and communities [A3.1. The 17 Sustainable goals].
We realized that commuting has always been an important issue to tackle in cities, now with Covid it only urges for earlier solutions. Our main sponsor TMB told us that they were losing lots of money because people were not using public transport anymore since the pandemic. Who were the main people that weren›t using it? Why? Of course we had our hypothesis but we had to check.

B.1 Interviews to experts:

We had the opportunity to meet experts from Repsol and TMB to give answers and questions.

Interviews to TMB. Margarida López & Bernat Fernandez:

As TMB has been our main sponsor, we were very interested in understanding their point of view of the challenge. From them we learnt that distributing people has always been a big issue to tackle and they are waiting for more powerful technologies to help them. They provided us with many statistics and data that would help us decide what we wanted to target. The main people who had lost complete interest in public transport are retired people as well as people with health vulnerabilities. Unfortunately, this data is confidential and we can not share it in this final report.
In a second interview, we had a deep conversation with Marta about their sanitation protocols, integration of micromobilities with public transport, crowd control and digital ticketing among other topics. We also talked about the future of their mobile application.

Interview to Repsol. Claudia Esarte & Juan Nicolás Aguado:

From them we learnt how important it is to be green not only for the sake of the environment but also for efficiency and economy. They talked to us about Scutum, the new electric scooter they were proposing in collaboration with Caixabank which was inspiring at later points of the project.

From research to problem statement

(Part 2)

B.2 Massive survey:

Being at a point where Covid had created many different behaviours in relation to the way of commuting, we wanted to do a massive survey to understand which had been the impact of the pandemic. We prepared it in Catalan, Spanish and English and we tried to be as less biased as possible. We got more than 250 responses within the three languages. In [A3.2. Some statistics from the massive survey] you can see some of the answers we got. To conclude, people are using much less public transport and most people have changed to individual means of transport. In particular, young people have moved to micro mobility.

B.3 Making new friends:

However, on those surveys we weren't targeting people beyond 40 years old so we went to the streets and made new friends.

Marta and Maria were a couple we found in the streets that as most of the people we interviewed, they used to take public transportation but they don't trust it anymore since the pandemic. For them the lack of social distancing is a key factor.

"Now with Covid it is impossible to respect social distancing both in metro and bus so they are not options. We try to reduce our mobility as much as possible"
"Children tend to touch everything and especially the buttons"

Marta (34 y.o) and Maria (39 y.o)
Women couple with children

Jordi and Anna complain that the estimated data about crowds provided is so inaccurate that most of the time their predictions on how it will be are better. They like the real data that Google Maps provide but they think the mobile application should give this data as well. We told that to Bernat and Margarida from TMB and they told us this

"Why do I want the estimated crowd in my usual commutes when I know by hand because I see it everyday. If only there was a real time status to check"
"When I leave my job, I check when is the bus arriving and if it is late, I am forced to take the metro because I go to the school to take my kids"

Jordi (35 y.o), Anna (35 y.o) and Paula (36)
A married couple with children and a woman with children

From research to problem statement

(Part 3)

Glenda has been taking care of an elderly woman in a wheelchair for 2 years now. She gave us a lot of feedback and complaints they usually find while commuting around Barcelona. For those reasons, they most of the time have to take a taxi as a first and only option.

“Elevators› priority has never been respected. They are small and they always get nervous because they don’t know how to react.”
“Elderly people have to shout to have space or to get in and off at the stops. Also social distancing shines by their absence.

Glenda (39 y.o)
Caregiver of a 82 elderly woman in a wheelchair

With Jorge we spent almost one hour talking about many vehicles that disappeared at some point of the past and he would love to see more (and not only in museums). He was an enthusiast of transportation and he didn’t understand why there wasn’t a micro mobility personalized for elderly people.
Nor him nor us knew that this would be so inspiring in a later point of the project when the first sketches of Mobinou, our proposal, were drawn.
Thanks Jorge.

“Elevators› priority has never been respected. They are small and they always get nervous because they don’t know how to react.”
“Elderly people have to shout to have space or to get in and off at the stops. Also social distancing shines by their absence.

Jorge (78 y.o)
Australian man that has been living all around the

Manuel (31 y.o)
Glovo worker and father of one kid

Manuel has been a Glovo delivery worker for almost one year. He only uses the bicycle because he can reach anywhere with it and he is so used to it. He told us that in the beginning of the new appearing micro mobility vehicles, the bike line was not well regulated but now people are getting used to it and respecting each other more and more.

“I only use bicycles because I don’t really like using the metro nor bus. I don’t like sharing narrowed spaces and now with Covid I feel they are not controlling the occupation of the wagons”

From research to problem statement

(Part 4)

Take-aways and conclusiuons

We learnt a lot talking to people in the streets. We were very lucky to find interesting and predisposed people to talk to. Some other insights:

_ Many elder need to shout to have space to be able to move and the social distancing shine by its absence

_ Many people are always in a hurry, so slower people get constantly pushed

_ There are many people moving around in different directions inside stations which make slower people get confused and not know how to react

B.4 Massive survey:

Another exercise we have been doing is going to the metro stations that we found most interesting and do detailed observations in the behaviours of commuters. Some interesting insights:

At T-junction, everyone clashes because they choose the shortest path.

Most of the people are almost always involved in mobile phones.

At platforms with entrances located at corners, there is a huge free space never used.

When static arrows are used to guide people (to walk on the right side), people just don't care.

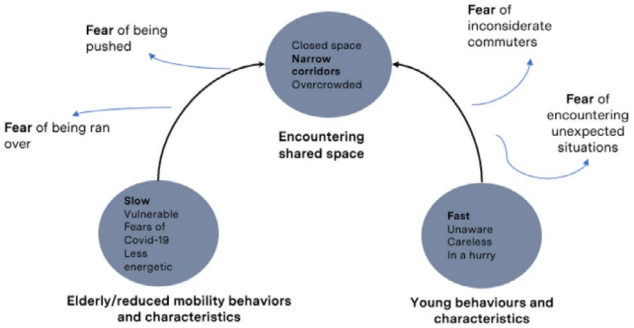
Estimated predictions of occupancy barely ever are accurate enough to trust.

People disconnect from the real world while commuting.

During these observations, we understood that there is more space than what we originally thought in the metro infrastructure (and mostly in the platforms). There is a lack of optimisation of space and also we are trying to fit many different people with different needs and behaviours in the exact same place.

What is happening inside collective means of transport?

We are trying to put people with reduced mobility behaviours (who are slow, vulnerable and less energetic) and people with younger behaviours (who are faster, unaware, careless and most of the time in a hurry) in the same shared space (which is narrowed and sometimes overcrowded). These three combine in a result of lots of fears: Fear of being pushed. Fear of being run over. Fear of unexpected situations. Fear of inconsiderate commuters.



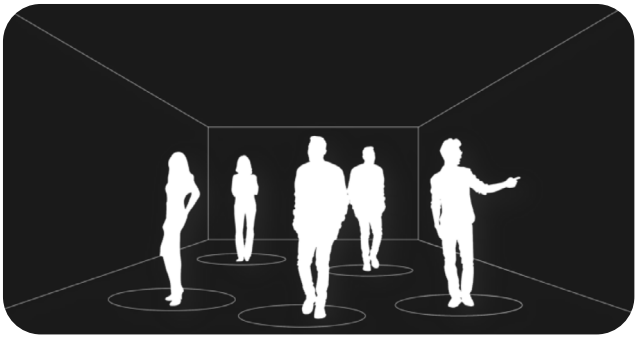
From research to problem statement

(Part 5)

We realized there are many solutions out there in the market which they really like. They have lifts, personalized validation points, ramps that help them go in the trains or bus and reserved sits among others. Their main problem lies in the path between those let's say "safe points".
As a collective means of transport, they are all the time sharing spaces with different speeds and people in a hurry so usually they panic about being pushed and run over.

B.5 First dimension approach - the ring concept experiment:

We had an idea. Proposing a system that would help people respect social distancing as well as realising where there was more space to walk through. How? Projecting lights around people would help them realise where their space ended and where the space of other people began.



We wanted to check why social distancing was not being respected within crowds? For lack of space, lack of respect? Our hypothesis: Unconsciousness. We had detected a lack of optimisation of space.
We developed the ring concept experiment that would help us identify behaviours and answer the worries we had about that topic.

Experiment plan

_ Emulate a corridor similar to metro stations with mannequin
_ Give users the 3 cardboard rings
_ Explain them not to cross the lines. Now tape lines are walls.
_ Ask them to carry the rings and walk in the space provided
_ Whenever they come close to others flash red light
_ Observe unconscious behaviors and ask some questions
_ Learnings and reflections

We booked a studio at IED and prepared the scenario using tape to emulate the walls and also mannequins to emulate people standing waiting or talking. We could film the whole experiment which lasted a bit more than an hour to do further observations at home.
With the use of an arduino and some switches we programmed a light strip. More details in [3.3 The ring experiment, light strip and Arduino].

From research to problem statement

(Part 6)

Conclusions

We learnt that helping people visualize their own space makes them care and remind of the social distancing. However the experiment had had some weak points which made the results awkward at some points.

_ Difficulties to materialize social distancing. Cardboard rings are only 1.2m instead of 1.5m. It was still difficult to avoid clashes between rings

_ Although people might want to respect social distance, there is not enough space to do so in the current layout of metro stations

_ We should organize people's flows and their paths in order to truly achieve social distancing

_ Take into consideration human errors that lead to possible accidents

We kept developing the ring idea to more realistic approaches [A3.4 Further development on the first dimension approach], helping people distribute along empty spaces and doing recommendations so they could be aware of people with reduced mobility and anticipation.

B.6 Are we really solving the problem?

At this point we realised that we needed to be more critics with our proposal. We weren't really solving the problem.

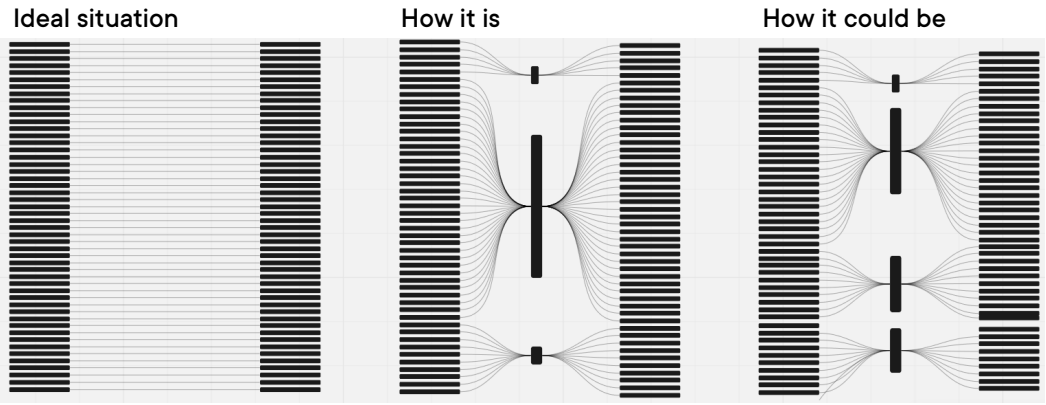
_ Collective skepticism: most of the time recommendation systems are used, there are many people who don't really care. This creates some skepticism on them to know if it is trustworthy enough.

_ Emerging solutions for the same issue: TMB is doing such a great job and every time we go to the metro to observe we find new solutions.

At this point we sat down, thought about all the research we had previously done and brainstormed again. Some of the ideas we came out can be found in [A3.5 Brainstorming again]
However we realized that by now, we had been trying to improve the quality of service inside collective means of transport. Maybe the solution could be in the streets. This is how we came to what we call the second dimension approach.

C From ideation to a solution

Commuting means going from one part of the city to another part of the city. The best way we could achieve this would be teleporting. No one would have any trouble during the commute but it is as ridiculous as it sounds. The current system is structured in a way where we are trying to fit many people with different characteristics and behaviours together. This could be improved by providing a personalized experience.

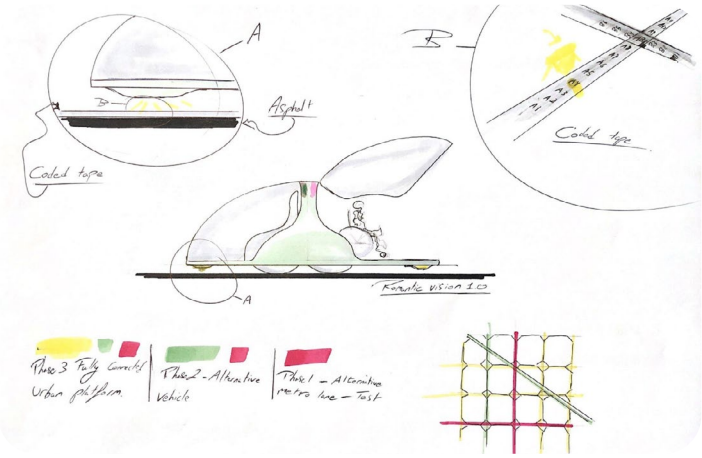


We wanted to approach the challenge of urban mobility helping elderly and reduced mobility people because they are the most vulnerable and also the less focused. In the world we live in today, younger generations have many options for affordable transport. During the pandemic, everybody has had the choice to turn their back on public transport and use micro mobility or bicycles.

C.1 Romantic vision

The birth of the current concept was the result of this romantic vision. We imagined a micro mobility solution that would be able to house two users back to back and transport them on a predefined path that the vehicle would scan.

However, we realized that not only was a very futuristic and expensive solution but it didn't have enough basis towards a personalized alternative for elderly people.

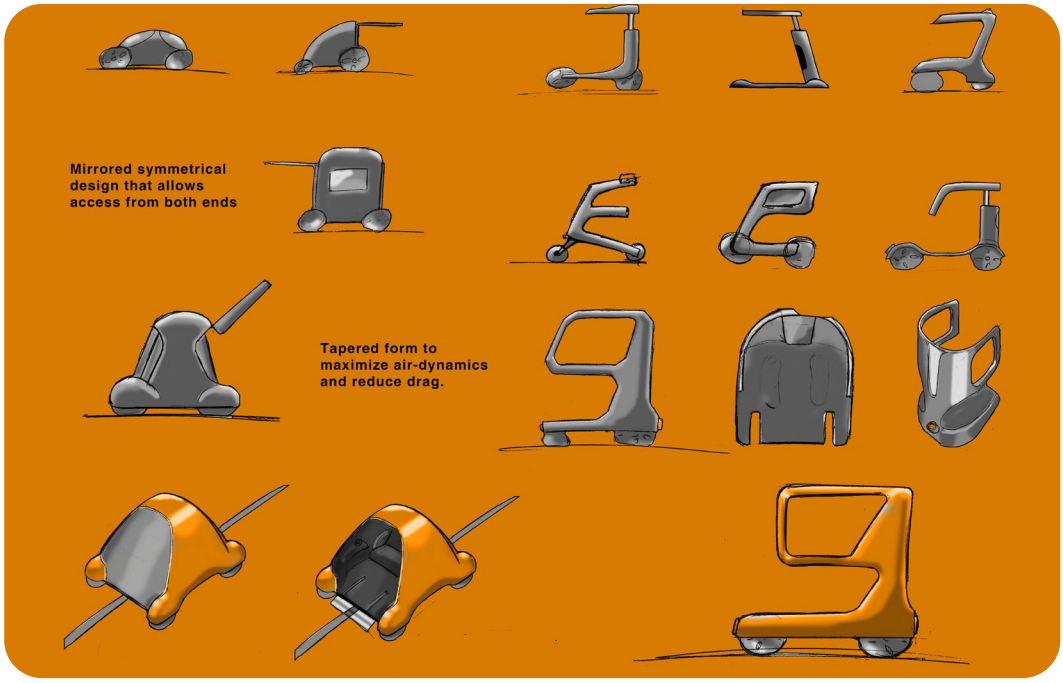


From ideation to a solution

(Part 2)

C.2 Ideation and iteration

We went through an elaborate process of ideation to imagine different ways to make this concept a reality. With every small sketch we imagined the future potential in terms of user experience, function, cost effectiveness and realistic proportion. At this point, we decided to get feedback from our target user at the same time we were changing the design.



The ideation process was more of an irregular loop rather than a messy process. We had a clear direction in mind at this point, not knowing what our final solution is, but confident that the iterations would lead us there. This process was a mix of artistic and practical exploartions. With every redesign, we were examining the viability of the resulting product in terms of form, function, sustainability, manufacturing costs, engineering technologies, user experience and safety. For a product that will live in the streets, any failure or oversight in one of these categories would be deemed catasrtophic.

In the last phase of iterations before visiting the streets and talking to people for the second time, we had the following: A vehicle specifically tailored for the elderly, that would be offered as a public or private service (like city-bikes) to offer them a fair, reliable and affordable transport option around the city. The vehicle would have semi-autonmous capabilites using proven and simple technologies. Meaning that the user who might struggle with multitasking, balancing, exerting physical effort and/or wants to be isolated from others (for health reasons) can so do so by utilizing the features of this transport solution

In terms of multi-tasking, we would narrow down all the tasks associated with driving a random street vehicle (from bicycles to scooters and cars), such as steering, navigation, being alert for stopping, emergency braking and so forth, to one task which would be using the emergency brakes. All the rest would be hypothetically handled by the vehicle itself, icluding the emergency brakes by the function is still offered for extra safety.

Our next step was to ask more elder and reduced mobility people and see how they would respond to these features and what their overall insights and concerns are.

From ideation to a solution

(Part 3)

C.3 Ideation interviews

We went through an elaborate process of ideation to imagine different ways to make this concept a reality. With every small sketch we imagined the future potential in terms of user experience, function, cost effectiveness and realistic proportion. At this point, we decided to get feedback from our target user at the same time we were changing the design.

Remedios, Carmen and José Antonio have always loved going together to different neighbourhoods of Barcelona by metro or bus and then spending the evening there, discovering new places. But nowadays, with covid situation, they don't feel safe commuting anymore, and they don't even think about commuting in micro mobility services, because they said that the ones that exists now, doesn't fit with elder people.

"I would love to have a vehicle where you could commute alone like in a bike or scooter but at the same time you don't have to drive and have almost no control of it, as in the metro or the bus."

Remedios, Carmen y José Antonio (,83 ,81 60 y.o)

Elder locals of Gracia, Barcelona.

Maria del Carmen and Milagros, as you can see in the photograph, need to walk with an orthopedic walker, because if they don't use it, they will fall... Moreover, as almost all older interviewed people agree that with covid, they definitely will not use any kind of public transportation. So, mixing these two insights, they said that if there exists a micro mobility vehicle that ensures them stability, they will use it for commuting across Barcelona.

"I will say it briefly and clear: The most important thing for us is stability."

Milagros and Maria del Carmen(85 and 86 y.o):

Elder locals of Sants district, Barcelona

Other insights

Estefanía is an elder woman who has mobility problems that make her have slow reactions. So, if a micro mobility vehicle for older people exists, for her it would be imprescindible to have some sensor that detects the obstacle alone, so she could not take the control in unexpected situations. Furthermore, she said that she can accept that nowadays there are more screen than buttons, but in case our vehicle has one screen, it would be great if we make as understandable and easy as we can.

"The fact that worries me the most is that everything in the world is being digitized so rapidly"

From ideation to a solution

(Part 4)

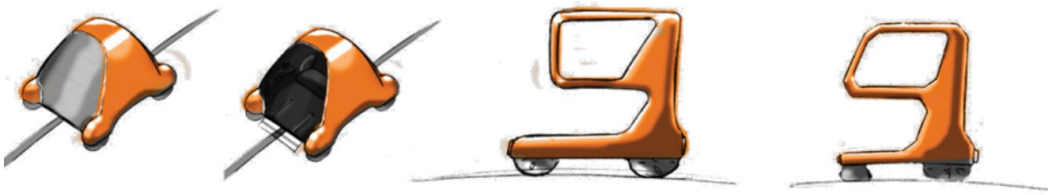
Our solution could help them go to some places in Barcelona they used to go but they cannot now because they are far away and they prefer staying around in their neighborhood. It also could be used to go to parks like the Ciutadella where they would love to go but they don›t because they are very far and always full of people.
For very long commutes it would look difficult, although they said they don›t usually do that long and in those cases they always ask their sons for recommendation (and they always say to use taxi).

Conclusions

When we talk about elderly people, at a first glance you would see they are tired, irritable, innocent and sometimes hostile but their true personalities are way beyond that. They are warm, full of life, active and even stylish. We believe it is important to take those into consideration. Everyone thinks of them as people who do not know how to use technologies and are not interested in being part of the society. We have encountered that this could be true 10 year ago, but from now, the arriving ageing generations will already be tech savvy.

In general, we all have many different alternatives rather than public transport when we want to commute. We asked the users again what kind of alternatives they had available. We saw that there are some in the market, but they are not being used.

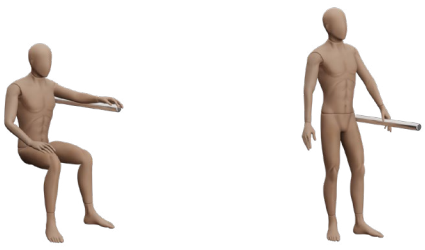
There are the electric bikes, the electric wheelchairs, the mobility scooter and of course taxi, the kind of mobility they need but the one they cannot afford. Most of them have free taxis calling their sons but they feel they are disturbing them.
We researched all of them and we found two main problems. They are expensive (few people get a subsidy to use a taxi but in general it is impossible to give it to all of them) and they must own it. We also understood that taxi would be perfect if it was free because they don't have to care about the control of it. So, we stopped and found a perfect spot to work and provide a proposal that could help them with their needs.



At this point, we had two main ideas, positive to with or without capsule. Although during not weather friendly days it is not convenient to use such an alternative without the roof, we found that those days people with reduced mobility wouldn't use it anyway because of the path between the origin and the vehicle.

C.3 Unlocking opportunities behind human proprtions

We also explored the human body and the possibilities we could open by investigating proportions. We found that if we have something to hold on to on shoulder height when sitting would be in the radius of the arms when standing. This allowed us to evolve our product into one that can allow users to sit for comfort or stand for better health.

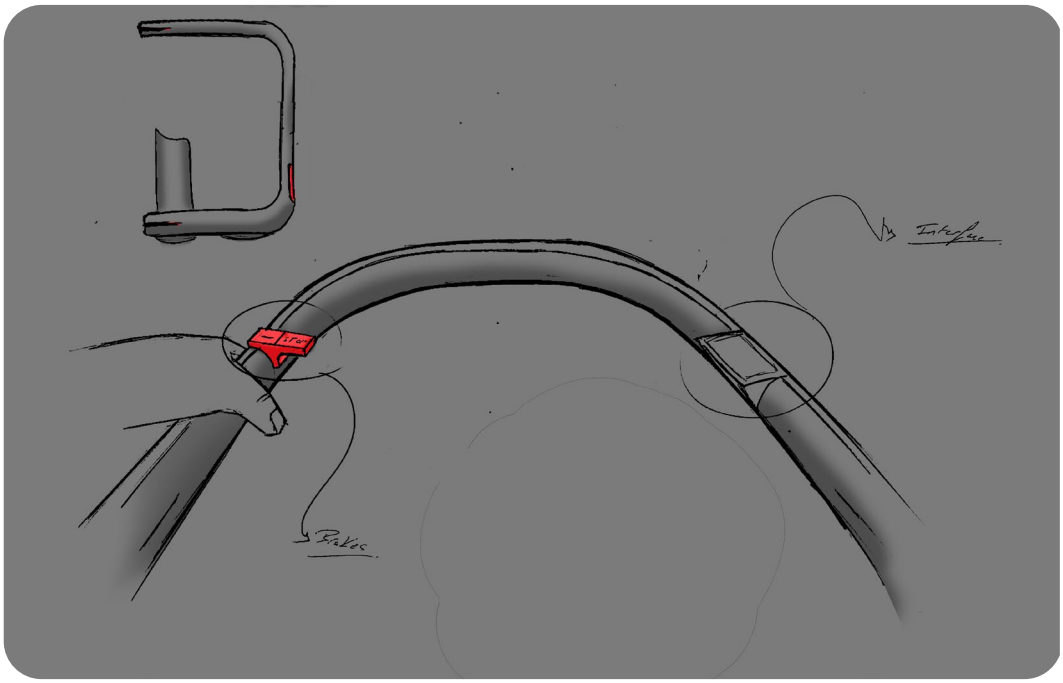


From ideation to a solution

(Part 5)

C.4 Final ideation and industrial design plan

At this point, we were gathering every piece of data, research, exploration and experimentation that we gathered from the original concept of creating isolated and categorized metro pods during the first sprint week to arriving onto our final concept which is drastically diffrent (yet related). We were trying what piece of data fits in this concept to enhance it further and what needs to go.



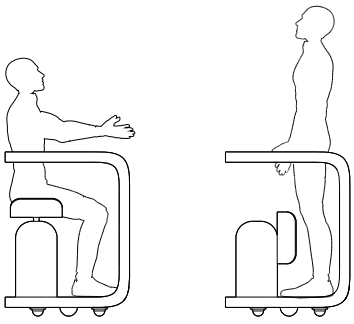
The sketch shown above was the blue-print upon which our final design, engineering and business models were built. The plan was layed out as follows:

Function

As stated earlier with our intentions and after recieving feedback from the users, we would like to take away all control from the uer and give them one task only which was to look out for emergency situations and be able to brake, in normal situation the vehicle would be able to brake by itself and detet obstacle. (More details on the technology in the following chapter). The user would only need to chose their destination, and they are off. They can make use of the streets like everybody, chosing to either sit or stand, making use of the vast urban infrustructure they were once indirectly **excluded** from.

Form

The vehicle would feature an aluminium frame in this U-form which creates a visual, economical and enviromental balance. Due to this, we can reduce our reliance on plastics and use standard 5 mm (aprox.) sheets of aluminiums that are bent and laser cut or cnc milled to form the shape. The form was also intnded to use only as much material as possible to support the user and withstand impact. For a low to medium production, the process is more justifiable than traditional methods or using molds.



D Final solution

Birth of Mobinou

D.1 Final design

The final design builds upon the sketches and plans from the previous chapter. Here you can see Mobino proudly presented in it final form, layed on top of the mangetic strip which holds the secret behind the semi-autonmous capabilities we introduced.

Seated perspective

Standing perspective

Final solution

(Part 2)

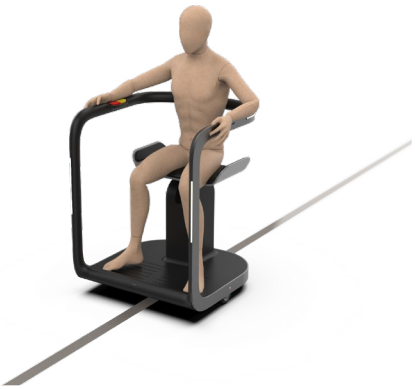
Brake and horn

On the left panel, Mobinou features the brake and horn, it is stratigically placed to be equally accesible while sitting or standing. the bottom part of the handle is designed with a curviture which compliments the palm, in a way that it is easy to make a grip for an enhanced and subtle stability. The user would only interact with these two elements while Mobinou is in transit.

Destination display

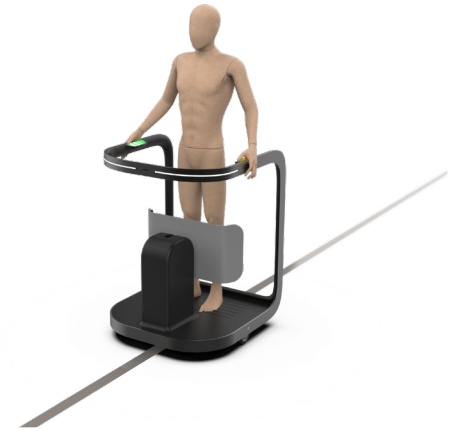
The right panel of Mobinou features a touch e-ink display that is specifically used for inputing the desired destination, using a very simple and easy-to-understand UI. These stops are subject to changes, as the system expands, this is why a display is mroe sustainable and logical than buttons.

User seated



When seated, the enclosure on the back astcs as a back rest, the side rails of mobinou are a comforable position to grab on-to. Mobinou offers enough leg-room to be comfortable and also place an object (carry-ons) between the user´s legs.

User standing



When standing mode is enable, the seat rotates 90 ° and acts as a knees rest. Slight bends on the side of the seat help the users legs stay in place as is the case with their thighs when seated. An extra benifit of the seat rotation, is the it situates the user right in the middle of the center of gravity, ensuring that the vehicle is well balanced at all times.

Final solution

(Part 3)

Potential branding

LED light indicators and illuminator

Final solution

(Part 4)

D.2 Stability through battery location

One of the main challenges which an electric vehicle with these characteristics has is stability and electric range through batteries Riders of standing e-scooters largely injure themselves in falls. For this reason, vehicle stability is a design priority. The stability of a micro-vehicle is influenced by a number of design factors including frame geometry and weight distribution" (*).

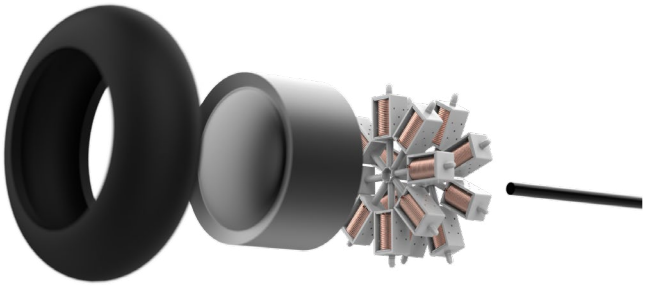
With Mobinou we are joining both as a positive feature. We need high capacity batteries which are heavier and by locating them in the lowest part of the vehicle we are lowering the point of gravity, thus gaining stability. In the picture it can be seen in blue the location of the batteries inside Mobinou. The battery capacity was calculated taking into consideration other micro mobility vehicles such as the electric scooters.

(*) https://www.itf-oecd.org/sites/default/files/docs/safe-micromobility_1.pdf

D.3 Driver motor

Many micromobility vehicles have adopted the solution of embedding the engine inside the wheels which saves a lot of much needed space and provides various other benifits (**).

After, concluding that we needed more battery space, we decided that using this techonlogy would be very benificial for Mobinou and its use is justified.



(**) https://electric-scooter.guide/guides/electric-scooter-motors/

Final solution

(Part 5)

D.4 Guiding line- magnetic strip

As previously mentioned, one of the main characteristics of Mobinou is using a guideline to provide semi autonomous capabilities. We did deep research in all the many alternatives in the market. To make our decision, we took into consideration costs of infrastructure and maintenance, the environment and how proven the technology is.

We encountered two main similar usages of guidelines. The trams: “The latest iteration of guided bus systems that have an optical guidance system and sensors to follow line markings along the road are still in test mode and have not been widely implemented, except in China.” (*) and AGV (Automated Guided Vehicles) (**), “AGV magnetic tapes guarantee safe and precise operation. The process flow is logistically designed with a defined path”

The more interesting where the optical guidance and the magnetic tape:

Optical guidance

PROS

+ Inexpensive site preparation. It only needs painting a line.

+ Ease of reconfiguration. If the route needs to be changed, you can simply paint a new line and clean the old one.

CONS

- Difficulties to anticipate situations. There is no way we could tell the vehicle where there is a turn or a slope to help with anticipation.

- Usage in a dirty environment has its challenges. Water, leaves or other obstacles could make the vehicle lose the track.

Magnetic tape

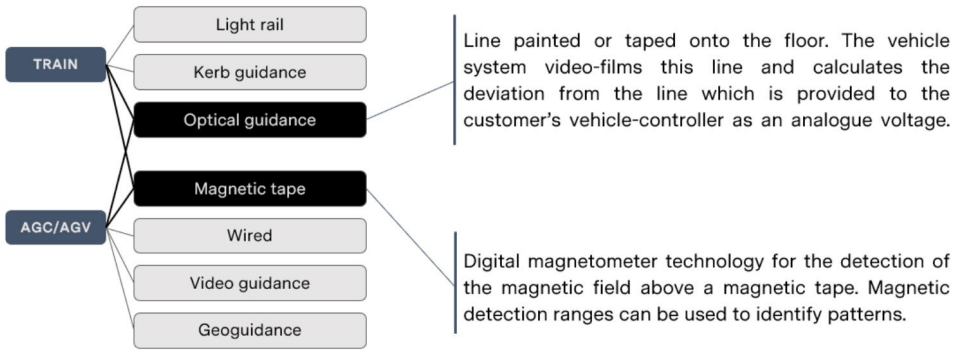
The sensor is based on digital magnetometer technology for the detection of the magnetic field above the magnetic tape.

+ Inexpensive site preparation. Although it is a little bit more expensive than the optical, it is still cheap.

+ Not much maintenance needed. The life of the tape line is higher than any other alternative.

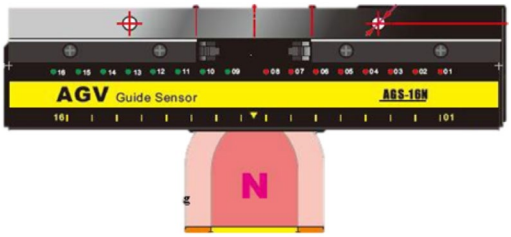
+ Capability to anticipate incoming environments.Using detection ranges, it can detect junctions and follow turnoffs.

+ Not affected by dirt nor weather.



Final solution

(Part 6)



We finally chose to use the magnetic tape because it wouldn't need extra technologies to gain a robust semi autonomous guided system.

D.5 Vehicle to anything communications with 5G:

So far safety measures have been done to minimize the effect on the car drivers and passengers (such seat belts or Airbags). However, safety can be improved avoiding accidents. How?

_ Cooperative awareness: Provide information about: presence, location, direction and status to the neighbouring vehicles.

_ Cooperative sensing: Exchange sensor data from one vehicle to others such image cameras, LIDAR or objects detected.

_ Cooperative manoeuvres: Exchange of information to coordinate movement.

_ Teleoperated driving: Possibility to control vehicles remotely. Used in situations that can only be solved by another human. For example, when a user panics and does not know how to react.

There are two already paths to a solution like this: IEEE802.11 and cellular based technologies (LTE-V2X, 4G and NR CV2X, 5G).

Technology operation	802.11p	C-V2X Rel-14/15	C-V2X Rel-16 (expected design)
Specification completed	Completed	Rel-14 completed in 2016. Rel-15 to be completed in 2018	2019
Support for low latency direct communications	✓	✓ (Rel-14 – 4ms)	✓ (≤ 1ms)
Support for network communications	Limited (via APs only)	✓	✓
Can operate without network assistance	✓	✓	✓
Can operate in ITS 5.9 GHz spectrum	✓	✓	✓
SIM-less operation	✓	✓	✓
Security and privacy on V2V/V2I/V2P	✓ (as per IEEE WAVE and ETSI-ITS security services)	✓ (as per IEEE WAVE and ETSI-ITS security services)	✓ (as per IEEE WAVE and ETSI-ITS security services)
Security/Privacy on V2N	N/A	✓	✓
Coexistence in 5.9GHz	✓ (Adjacent channel with 3GPP tech)	✓ (Adjacent channel with 11p; co-channel coexistence from R14 onwards)	✓ (Adjacent channel with 11p; co-channel coexistence from R14 onwards & WiFi)
Evolution path	✗	✓	✓ Compatible with Rel-14/15

We chose a combination of LTE-V2X and NR CV2X because can be used with the same antena and both are in the same evolution path. What is more, 802.11p has proved to have no evolutionary path. 5G is great news for IoT projects like Mobinou.
The current Barcelona free WIFI system can be used with 5G so that the system can be integrated to achieve seamless integrated communication between the pods. Location, speed and battery level can be continuously monitored to have a greater idea of what is happening with them and what can be done to avoid breakdowns

Final solution

(Part 7)

(*) https://www.imamagnets.com/en/blog/agv-magnetic-tape-and-its-advantages/.
(**) https://gtaconsultants.worldsecuresystems.com/ThoughtLeadership/GTA_Insights_Trackless20%Trams.pdf
(***) https://www.investopedia.com/terms/v/v2x-vehicletovehicle-or-vehicletoinfrastructure.asp#:~:text=Vehicle2%Dto2%Deverything20%(V2X)20%is20%a20%technology20%that,communication2%C20%it20%has20%several20%components
https://en.wikipedia.org/wiki/Vehicle-to-everything
https://www.researchgate.net/publication/3_323843658GPP_C-V2X_and_IEEE_80211p_for_Vehicle-to-Vehicle_communications_in_highway_platooning_scenarios

D.6 Obstacle detection

The detection of an obstacle in a traffic environment situation is not an easy thing because of so many different things which we are going to explain hereunder.

_ Not always the obstacle movement or the interactions in traffic scenes can be predicted.

_ Really cluttered background and enormous range of different visibilities under various lighting and weather conditions. Also objects to be detected in this environment have a huge variety of appearances owing to different shapes, sizes, orientation with respect to the camera›s position.

_ Host vehicle is moving, so the algorithm for this detection application must be able to cope with the obstacles and background›s moving aspects.

_ Have to work (as fast as possible) in real time and this could be such a strong limitation in terms of the computational cost.

_ Priceless enough to be affordable.

Types of sensors

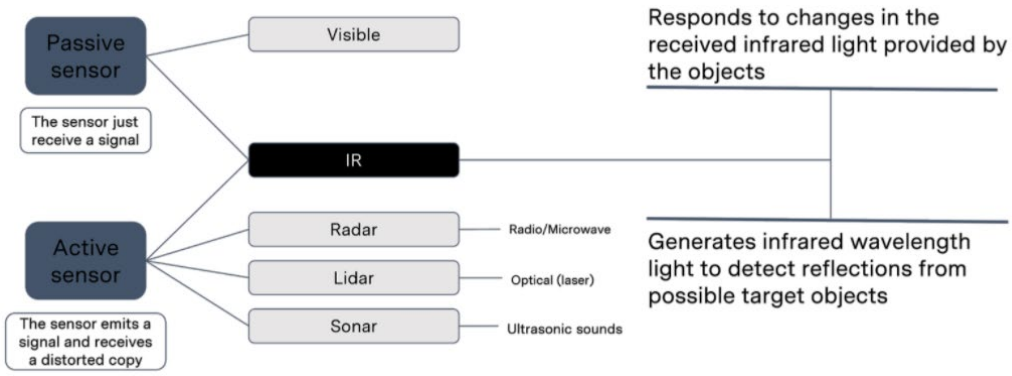
We made a research of all the sensors that exist, to end up finding the one that fits the most with our vehicle. Firstly, we noticed that there are two main sensors groups: Passives and Actives. The main difference between them is the way they works. The passive sensors just receive a signal: It detects the reflected, emitted or transmitted electromagnetic radiation provided by natural energy sources. Conversely, the active sensors emit a signal and receive a distorted copy of the respective signal: It detects reflected responses from objects irradiated with artificially generated energy sources. So, once we got deeper knowledge about its working method, we did a simple pros and contras table.

	Pros	Contras
Passive	- Cheap - Lightweight - Lifetime - Low Noise	- Limited Storage - Shorter Range than active
Active	- Long Range (more than 100m)	- Expensive - Large and Heavy - Noisy - Limited lifetime (3-5 years of battery life)

Final solution

(Part 8)

After doing this, we also made a research about the types of sensors that conform passive and active types. Hereunder we leave a scheme about those ones, with a brief definition of each one.



Analyzing the pros and contras table, we decided that the best option for our case was Passive sensors. In concrete, for the hardware part, our obstacle detection system will have:

_ 4x monocular visual cameras (each in one side of the vehicle)

_ IR light

Visible cameras, as a passive sensor, don't emit any signals. So this is, as we saw before, an important advantage because there aren't interference problems with the environment. Their major issue that we were to fight was that these cameras are not well-suited for darkness conditions. At that point we realized that, if we want our vehicle to work fine and be safe at night, or in the early evening dark hours in winter, we need to add to the cameras something else: the IR light. Knowing that all objects emit infrared radiation, and that it is used in a lot of applications for night vision, with those IR lights the cameras will be able to detect obstacles even in dark scenarios. Hereunder, the left photograph is how the monocular cameras will see the traffic scenario without an IR light, and in the right how they will correctly detect the pedestrian with intelligent night vision system.

In the previous images we can see where the cameras will be fixed, and how they look.
The software part consists in Image processing tools.

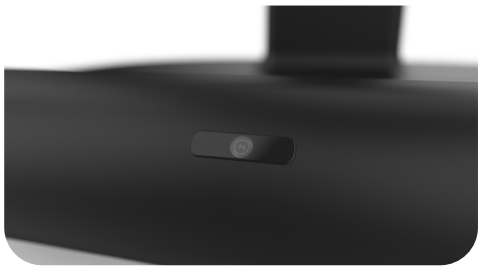
Final solution

(Part 9)

Monicular cameras location on Mobinou

Left

Right

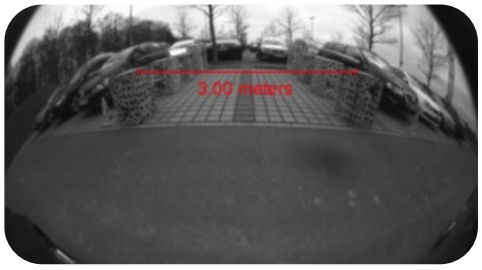


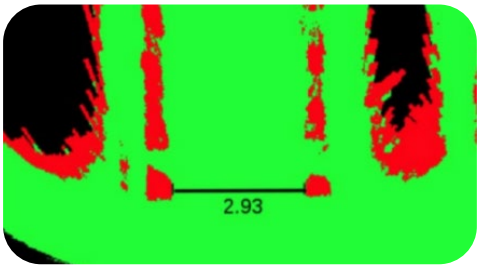
Bottom front (45 degree angle)

Top back

How it works

With this monocular camera and the led night vision, we can build a well-designed and (most important part) safe method to detect obstacles. With image processing tools we can determine which is the distance between objects, as we can see in the following image.

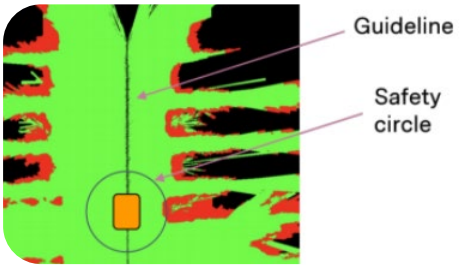




Furthermore, using this tool, we can build an “imaginary” circle around MobiNou, and with image processing software we can divide the environment inside and outside of it in two visual parts:

_ Green: means free space

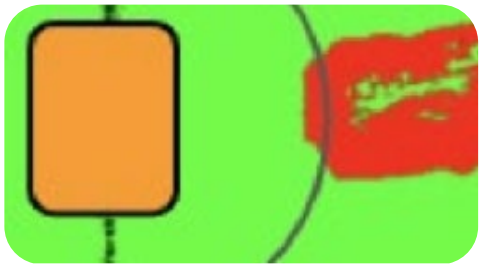
_ Red: obstacle detected, which could be a pedestrian, another vehicle, something throwed in the road.



Final solution

(Part 8)

If inside the imaginary circle we detect any pixel in red, then the vehicle will assume that there is an obstacle nearly and will stop immediately.



E Business model

E.1 Introduction

Following the business canvas model developed during the CBI course, we identified as a problem the before mentioned accessibility to micromobility for reduced mobility users. Our solution – MobiNou – will provide users with a unique value proposition, by providing them a convenient, safe and affordable means of transport. As mentioned before, our customer segment is elder people, aged above 60, which represents %21,6 citizens of Barcelona (*) and disabled people, which represent the represent %8,5 citizens of Barcelona (**).
Therefore, we have defined our business model as follows: we have defined a subscription model, where users pay monthly or yearly fees for using the service.

Revenues

The main revenue stream will be the fee charged to the subscribers for the service. In addition, we will have additional income from advertising

Initial investment

We will also consider what would be the initial investment in infrastructure and the vehicle. We will have the following initial investments: the stations where users pick up and drop the vehicle, the manufacturing of the vehicles and the colored coded tapes on the street.
In addition, we will consider a marketing campaign at the launch of the project tougher with an educational campaign

Cost

As we consider this of public interest, we believe that part of it could be subsidized by the government or sponsors such as TMB.
The main cost elements we have identified are the following:
Fixed cost: will be all the fixed that we will incur regardless of the utilization rate. We will consider maintenance, salaries and overhead.
On the variable cost side, we will consider the energy used per trip and the sanitization per vehicle and any repair that would need to be done, as well as the membership card.

(*) https://ajuntament.barcelona.cat/personesgrans/es/canal/la-gent-gran-de-barcelona#:~:text=Las20%personas20%mayores20%de20%Barcelona2%C20%es20%decir2%C20%las20%personas20%de,2%60C20%25%20%1del20%total

(**) https://www.observatoridiscapacitat.org/es/poblacion-con-discapacidad-en-el-area-metropolitana-de-barcelona-la-realidad-de-barcelona#:~:text=En20%Barcelona20%hay20%20%137.832personas,población20%total20%de20%la20%ciudad

Business model

(Part 2)

E.2 Implementation through phases

We have developed three different stages for the implementation of MobiNou, and identified six key drivers that can be found in the table below: routes, level of autonomy, vehicle screen, tech usage, adaptability and users. In short, the three different phases can be explained as follows:

_ Phase 0, Mobinou will be offered free of cost for a month as a trial to provide confidence to the users. The service will be available in certain streets of Barcelona and the functionality of Mobinou allows users to choose destination, stop and honk.

_ Phase 1, After completion of Phase 0, the magnetic strip would be extended to other streets in Barcelona to expand the network of Mobinou and also will have additional features such as street selection. Also, the magnetic strip will be licensed to allow other vehicle manufacturers to use the technology.

_ Phase 2, Magnetic strip is expanded to supermarkets and malls such as Ikea, giving them more freedom to move around outside and inside.

Characteristics	Phase-0/Trial	Phase-1	Phase-2
Routes	One-month free for elderly to use it Routes will connect to parks/nature and squares where elderly would like to spend their evening walks in nature for pleasure purposes Max speed: 10-12 kmph Time to travel one-way whole length <45 min	**Extension of routes** where there is no Metro/Bus reachability to accommodate more people to use it	Extension of strip to commercial supermarkets/Ikea/ Shopping malls and licensing the technology
Level of Autonomy	1.It follows a strip 2.Has stop and honk buttons 3.Stations	1.Adding decision-making features 2.Giving autonomy to choose route	1.Fully Autonomous 2.Park it anywhere
Vehicle Screen	A screen to choose destination	live tracking, expected time to destination, battery level, air pollution levels etc.	Input destination either manually or through app, Integration of other vehicles trajectory to better understand location and avoid collision on strip
Tech usage	IOT of things and 5G	Introduction to smou (micro mobility integration)	Upgrading with destinations as per routes
Adaptability	Our vehicle	Wheelchairs	Other manufacturers vehicles
Who will use it?	Elderly – 60+	Other reduced mobility users	Commuters/ Shoppers

Business model

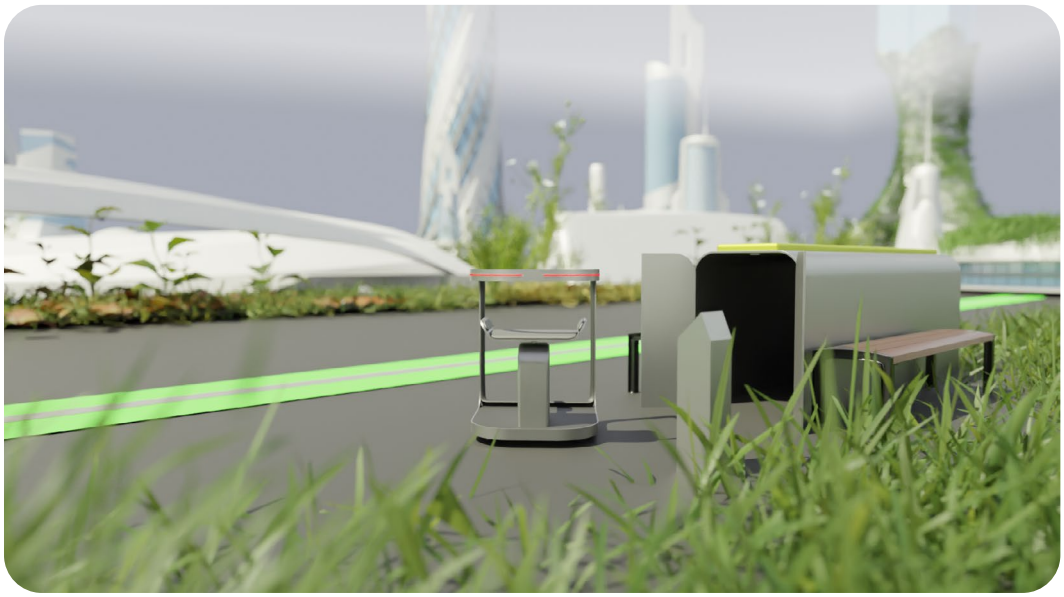
(Part 3)

E.2 Risk and mitigation

_ Competitors such as bicing coming up with similar BM for bikes with elderly - opening up to people with reduced mobility and common people.
_ Political - Vandalism of the vehicles at times - Station is vandalism free and the service in case of strikes and movements, Alarms/Cameras.
_ economic - flu/ pandemic - increase in spending on other resources such as medicines/food - Changing pricing and target group models

Risk	Mitigation
Competitors: Bicing could come up with similar Business model for Bikes with Elderly and reduced mobility	TMB: Taking Mobinou to Phase X by adding electric charging stations for e-mobility to docking stations
Vandalism of the vehicles (Situations such as strikes and movements)	We have the safest stations can also be upgraded with alarms and cameras
Future Epidemics	Expanding Mobinou to Phase X to allow commercial trucks to use the magnetic strips inside the city- Traffic controlling
Increase in spending on other resources	Adapting the pricing model to help everyone commute

Conclusion



We believe in a future that is open, connected, sustainable and humane. With every part of Mobinou we are trying to bring ourselves a step closer to that reality. The journey to arrive here was scattered with multiple obstacles. But the result is something that the entire Nikola team is proud of.

During the final showcase, we recieved many useful insights and numerous expressions of interest. Our next steps will be to take all these insights into consideration and to build upon the interest we recieved to make Mobinou one day a reality.

Appendix

B.1

The 17 Sustainable goals.

"The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice."

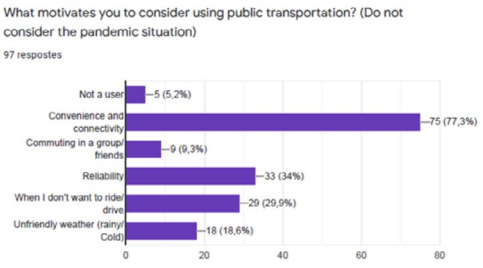
In our project, we are targeting goals number 3, Good health and wellbeing, and number 11, Sustainable cities and communities.

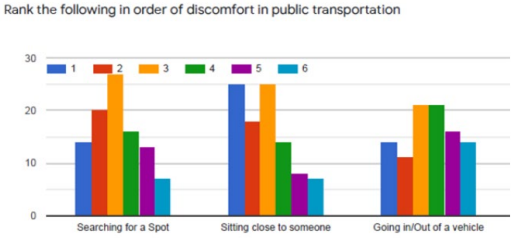
https://www.un.org/sustainabledevelopment/sustainable-development-goals/#:~:text=The20%Sustainable20%Development20%Goals20%are,environmental20%degradation2%C20%peace20%and20%justice.

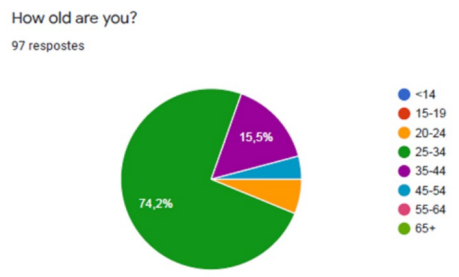
B.2

Some statistics from the massive survey

With the massive survey in catalan, spanish and english we reached almost to 250 people. We asked questions to understand how they changed their behaviors towards commuting within the pandemic. How many times did they use to take public transportation before? How many now? What made them feel discomfort inside public transportation?







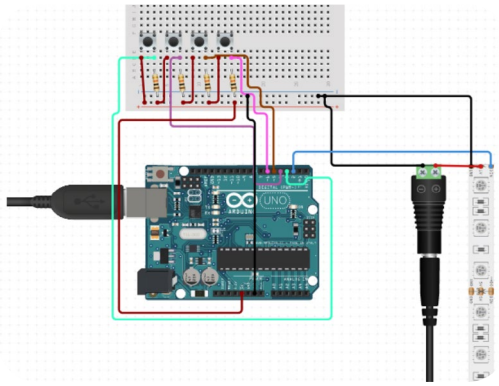
Appendix

(Part 2)

B.3

The ring experiment, light strip and Arduino

To prepare the ring experiment, we would need to develop a program that would help us decide with 4 buttons (protected with resistors) the state of the light strip. With help of Fritzing we could create our own electronic schematics.



The program code was developed with help of the AdaFruit Neopixel library Here you can find the code:

```
#include <Adafruit_NeoPixel.h>
#ifdef __AVR__
#include <avr/power.h>
#endif
#define PIN      2
#define NUM_LEDS 70
#define DELAYVAL 500
Adafruit_NeoPixel strip(NUM_LEDS, PIN, NEO_GRB + NEO_KHZ800);

long val;
long val2;
int pos;
int threshold = 100;
int initial = 0; //checks if it the first loop

int buttonY = 3;
int buttonR = 4;
int buttonR_flash = 5;
int buttonOff = 6;

int buttonY_state = 0;
int buttonR_state = 0;
int buttonR_flash_state = 0;
int buttonOff_state = 0;

void setup(){
  Serial.begin(9600);
  #if defined(__AVR_ATtiny85__) && (F_CPU == 16000000)
  clock_prescale_set(clock_div_1);
#endif
   strip.begin();
   strip.clear();
   pinMode (buttonY , INPUT);
   pinMode (buttonR ,INPUT);
   pinMode (buttonR_flash , INPUT);
   pinMode (buttonOff , INPUT);
}


void loop(){
  buttonY_state = digitalRead(buttonY);
  buttonR_state = digitalRead(buttonR);
  buttonR_flash_state = digitalRead (buttonR_flash);
  buttonOff_state = digitalRead (buttonOff);
  Serial.println("Nada");
  if( buttonY_state == HIGH && buttonR_state == LOW && buttonR_flash_state == LOW && buttonOff_state == LOW ){ // yellow button
    fadeStripIn(0xff, 0xff, 0x3d, 0);
    Serial.println("Yellow");
    delay(1);
  } else if (buttonY_state == LOW && buttonR_state == HIGH && buttonR_flash_state == LOW && buttonOff_state == LOW){ // Red button
    fadeStripIn(0xff, 0x00, 0x00, 0);
    Serial.println("RED");
    delay(1);
  } else if(buttonY_state == LOW && buttonR_state == LOW && buttonR_flash_state == HIGH && buttonOff_state == LOW){ // Red flashing
    Strobe(0xff, 0x00, 0x00, 15, 50, 1000);
    Serial.println("FLASH");
    delay(1);
  } else if (buttonY_state == LOW && buttonR_state == LOW && buttonR_flash_state == LOW && buttonOff_state == HIGH) {
    fadeStripIn(0x00, 0x00, 0x00, 0);;
    Serial.println("BYE");
  }
  delay(5);
}
```

Appendix

(Part 3)

C.1

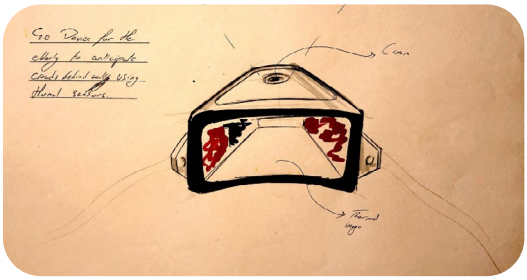
Brainstorming and ideation

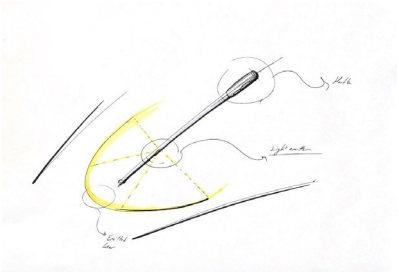
We went through multiple phases of brainstorming ideation, the first of which was during the first intensive week (lightning demos). Our proposal was to take metros wagons that are identical (left) and tranform them into isolated pods (right). These isolated pods would be accomodate people of specific needs, where we would have an intensive care pod that would prioritize people with weaker immune systems, another could be made just for people with children, pods for people with micromobility and so on...

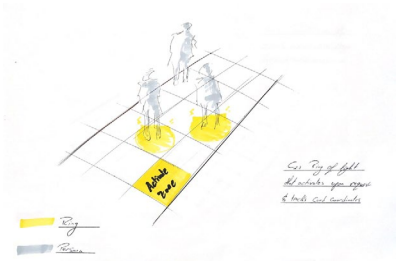
Crtl C Crtl V

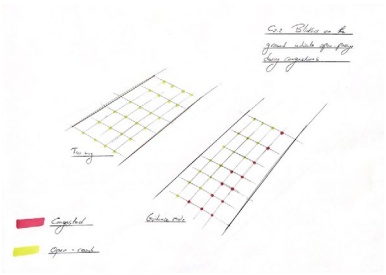
Amount of carry-on
Length of journey
Vulnerability to viruses
Pods rearrange according to line

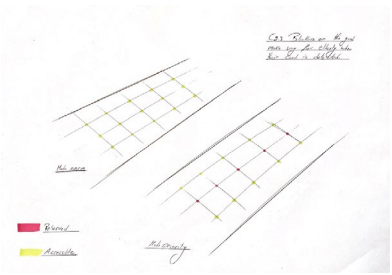
Based on the light projection, we tried to apply it as a feature into blind sticks. However we encountered many alternatives that would solve a similar problem.
A thermal detection device that could be attached to mobile phones and tell you where there were more people to virtually create your path.





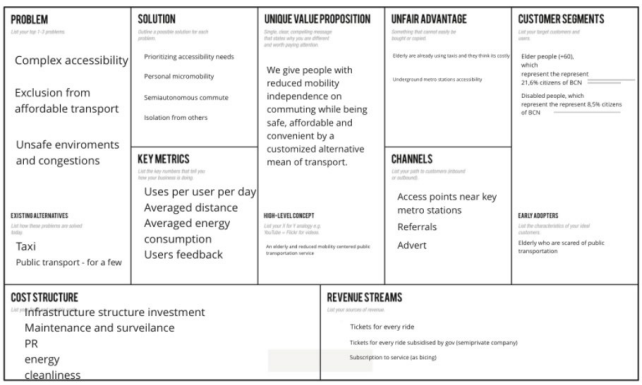






E.1

Business Model Canvas

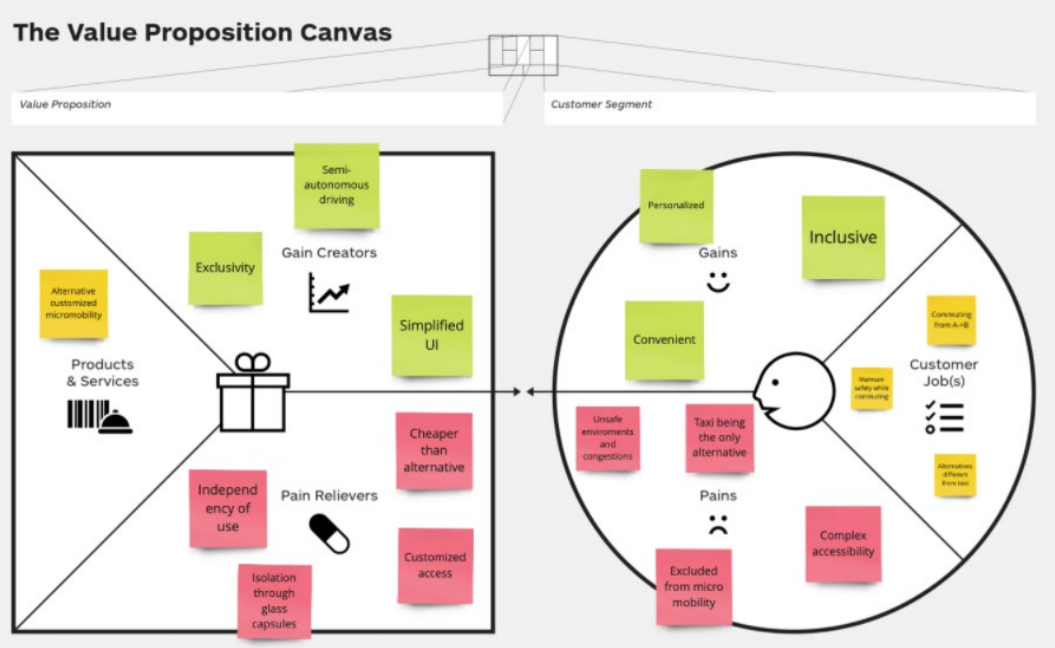


Appendix

(Part 4)

E.2

Value proposition canvas



Mobinou introductory video

https://www.youtube.com/watch?v=rJmse7tA7CU

Mobinou webpage

https://www.hadihissi.com/work/mobinou

Final report

Team Nikola **CBI program** **2020 - 2021**