CBI Fusion Point

GOOD WAY

Team 6 (Enrico Fermi) | Challenge 3

Air quality and sustainable mobility

*How can we ensure the **vital flow** of people, goods and services in **clean, equitable and sustainable ways**, and **mitigate the negative effects** of transportation on air quality?*

ENRICO FERMI TEAM
2022

INDEX

RESEARCH

DESK RESEARCH

GLOBAL EMISSIONS

FIRST APPROACHES

At the global scale, the key greenhouses emitted by human activies are Carbon Dioxide (CO2 | 76%), Methane (CH4 | 16%), Nitrous Oxide (N2O | 6%) , and other F-Gases (2%).

Global greenhouse gas emissions can also be broken down by the economic activities that lead to their production. The first one is Electricity and Heat Production (25%), then Agriculture, Forestry and Other Land Use (24%), then Industry (21%), then Transportation (14%), then other energy (10%), and finally Construction and Buildings (6%).

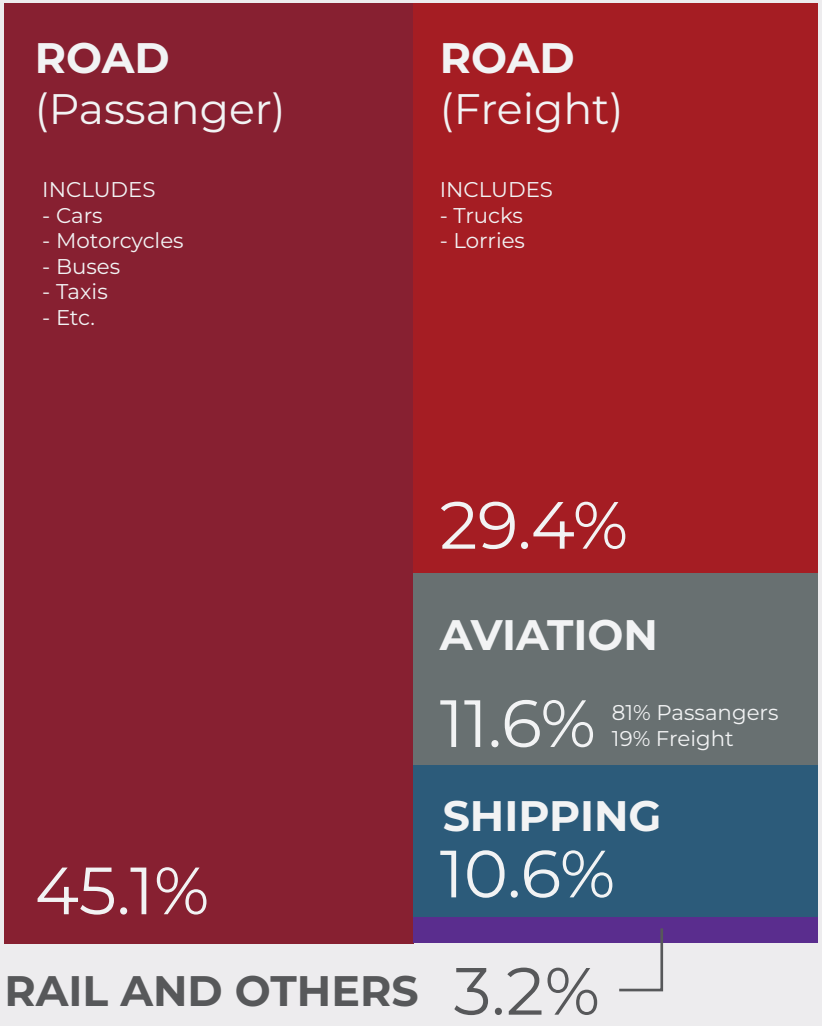
Global Carbon emissions from fossil fuels have significantly increased since 1900. Since 1970, CO2 emissions have increased by about 90% with emissions from fossil fuel combustion and industrial processes contibuting about 78% of the total greenhouse gas emissions increase from 1970 to 2011.

TRANSPORTATION EMISSIONS

Transport accounts for around one-fifth of global carbon dioxide (CO2) emissions: 24% if we only consider CO2 emissions from energy.

In the chart here we see global transport emissions in 2018. This data is sourced from the International Energy Agency (IEA).

GLOBAL CO2 EMISSIONS FROM



https://ourworldindata.org/co2-emissions-from-transport

DESK RESEARCH

VEHICLES POLLUTION

1.1

Currently in Spain there are more than 39 million vehicles, equivalent to 491 per 1000 people.

27.900.000 Cars

494.000 Trucks

6.000.000 Vans

61.000 Buses

Vehicles emit pollutants in three ways

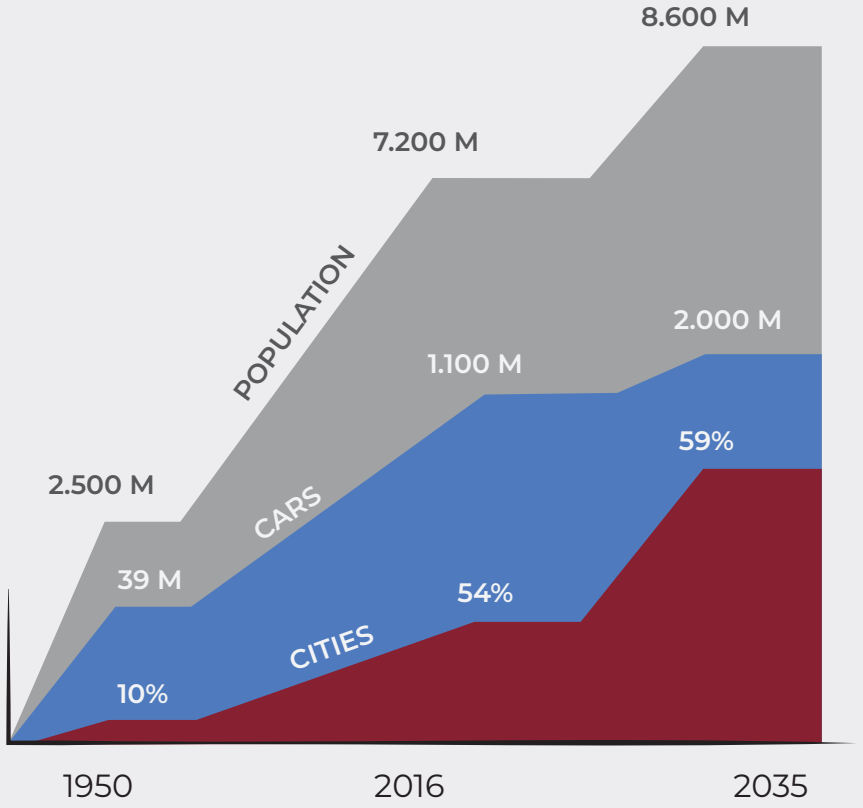
Evaporation of fuel such as gasoline, liquefied petroleum gas (GLP) and alcohols from natural gas (GN).

Substances contained in the exhaust gases such as carbon dioxide (CO2) and water vapor.

Non - exhausted particles from the wear of brake pads, clutch and tires .

The Increase in the urban population has proportionally triggered the increase in vehicles of all kinds.

This generates an increase of emission in a concentrated population ocationating serius health problems to citizents.



DESK RESEARCH

AIR POLLUTANTS

COMMON AIR POLLUTANTS

They are particulate matter (often referred to as particle pollution), ground-level ozone that harm human health, harm the environment, and cause property damage.

CO2 | CARBON DIOXIDE

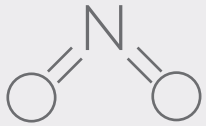
It´s the most significant long-lived greenhouse gas in Earth´s atmosphere. It concentration leads to global warming and also causes ocean acidification dissolving in water forming carbonic acid.

CO | CARBON MONOXIDE

It´s an extremely dangerous odorless and colorless, tasteless and flammable gas that is slightly less dense than air. Moreover, it contibutes to climate change.

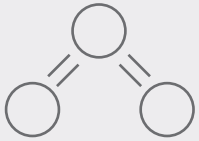
NO2 | NITROGEN DIOXIDE

It´s a chemical compound that cause acid rain, harming sensitive ecosystems such as lakes and forests. Elevated levels of Nitrogen Dioxide can also harm vegetation, decreasing growth, and reduce crop yields.



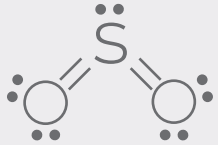
O3 | TROPOSPHERIC OZONE

It is a pollutant and a constituent of smog. It´s high concentrated by emissions from combustion of fossil fuels. Ground level ozone can be harmful to our health in many significative ways.



SO2 | SULFUR DIOXIDE

A chemical compound that is produced of crop extraction and the burning of sulfur-bearing fossil fuels. It´s a major air pollutant and has significant impacts upon human health.

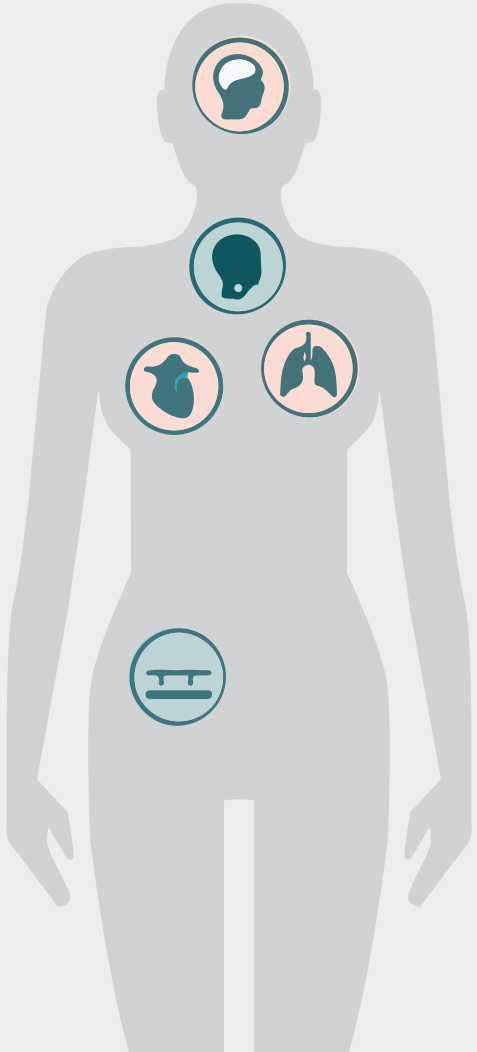


DESK RESEARCH

HEALTH EFFECTS

SHORT TERM EFFECTS

- **HEADACHE**
- **NOSE, THROAT, EYES INFLAMATION**
- **COUGHING, PAINFUL BREATHING**
- **PNEUMONIA, BRONCHITIS**
- **SKIN IRRITATION**



LONG TERM EFFECTS

- **AFFECTS CENTRAL NERVOUS SYSTEM**
  HEADACHE, ANXIETY
- **CARDIOVASCULAR DISEASES**
- **RESPIRATORY DESEASES**
  ASTHMA, CANCER

DESK RESEARCH

CO2 CAPTURE TECHNOLOGIES

CHEMICAL ABSORPTION

A common process operation based on the reaction between CO2 and a chemical solvent. Chemical absorption using amine-based solvents is the most advanced CO2 separation technique.

PHYSICAL SEPARATION

Make use of a solid surface (e.g. activated carbon, alumnia, mettalic oxides or zeolites). CO2 is released by increasing temperature or pressure.

OXY-FUEL SEPARATION

Involves the combustion of a fuel using nearly pure oxygen and the subsequent capture of the CO2 amitted. Because the flue gas is composed almost exlusively of CO2 and water vapour, the latter can be removed easily by means of deshydration to obtain a high purity CO2 steam.

MEMBRANE SEPARATION

Based on polymeric or inorganic devices with high CO2 selectivity, which let CO2 pass through but act as barriers to retain the other gases in the gas stream.

CALCIUM LOOPING

CO2 capture at a high temperature using two main reactors. In the first reactor, lime (CaO) is used as a sorbent to capture CO2 from gas stream to form calcium carbonate (CaCO3). The CaCO3 is subsequently transported to the second reactor where it is regenerated, resulting in lime and tha pure stream of CO2.

CHEMICAL LOOPING

Works similar to calcium looping using small particles of metal creating metal oxide, producing energy and concentrated steam of CO2.

DIRECT SEPARATION

Involves the capture of CO2 process emissions from cement production by inderectly heating the limestone using a special calciner.

DIRECT SEPARATION

Flue gas or steam is used to drive one or multiple turbines, in supercritical CO2 power cycles.

DESK RESEARCH

REDUCING SYSTEMS

1.1

BICYCLES

Bicycles are one of the city´s most sustainable individual means of transport. Barcelona has network of bike lanes and paths that makes it an easy and safe transport.

SERVICE APPS

Some apps as UBER and CABIFY are some examples of how these new transportation systems are becoming popular and a better option for commuters. These apps optimize cars usability and provide a comforatble option to commuters that want to move comfortly without buying a private car.

ELECTRIC SCOOTERS

Electric scooters transport has increased significally for the last five years. More shared systems and lanes adaptation are making this type of transportation the possible answer for the “las mile” solution. The decrease reliability and low speed of public transport makes electric scooters a very tempting option inside the city.

CAR POOLING

Car pool system consist on sharing journeys between citizents to optimize and full seat the capacity of the car. It´s also convinient because reduces each person´s travel costs and reduces pollution, carbon emissions and traffic congestions.

DESK RESEARCH

REDUCING SYSTEMS

1.1

DRONES

In perspective, last-mile delivey by drones could be a good choice both in terms of transport speed and sustainability. Being electrically powered, drones can reduce environmental impact. Moreover, they enable the reduction of road congestion since they don´t interfere with land infraestructure.

AUTONOMOUS TRANSPORTS

Autonomous transportation can not only prevent accidents but also reduce traffic congestion, having a direct consequence in droping down emissions. Futhermore, this technology can reduce “stop-and-go” waves, saving peaoples time and decreasing time cars are on the roads.

CAR SHARING

This trend is a model of car rental system where people rent cars for a very short periods of time. The reservation, pickup, and return is a self-service process and aims that indivuals have access to private cars without having costs and responsabilities associated with car ownerships. Also, car sharing optimize the use of the car reducing car´s parked time.

MOTO SHARING

Moto sharing system works in the same “sharing” direction. It consist on the renting of electric motorcycles for a short period of time. This provides a fast and eco-friendly mobility option to commuters and the optimization of reducing motorcycle´s parking time.

DESK RESEARCH

NORMATIVES

EUROPEAN COMMISSION

The Commission is in the process of reviewing the current F-gas Regulation (see below).

The current Regulation strengthened the previous measures and introduced far-reaching changes by:

Limiting the total amount of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030. This will be the main driver of the move towards more climate-friendly technologies;
Banning the use of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning and foams and aerosols;
Preventing emissions of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life..

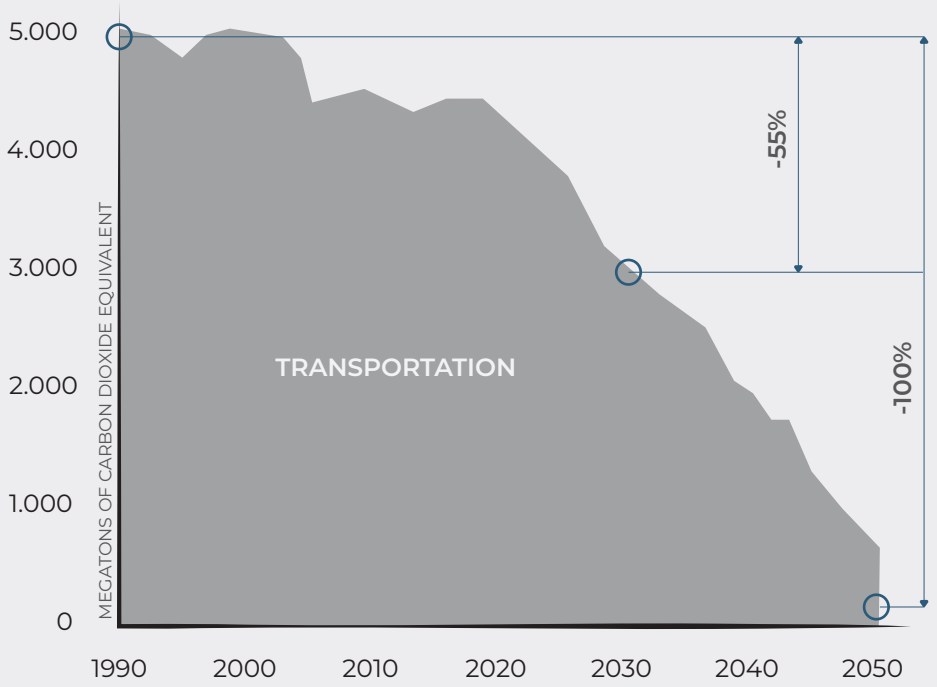
The measures were built on the successful phase-out of ozone-depleting substancesSearch for available translations of the preceding linkEN··· which was achieved in the EU 10 years ahead of the internationally agreed schedule.

Thanks to the F-gas Regulation, the EU's F-gas emissions will be cut by two-thirds by 2030 compared with 2014 levels.

AMBITIOUS PROPOSAL

In December 2019, the European Commission introduced an ambitious proposal to make the bloc climate-neutral by 2050. Although the proposal set specific 2030 and 2050 emission-reduction goals, it did not explain how much each sector and member state should contribute to the desired emissions reductions or what achieving those reductions would cost.

TOTAL TRANSPORTATION EMISSIONS



https://www.mckinsey.com/business-functions/sustainability

DESK RESEARCH

BARCELONA´S CURRENT SITUATION

1.1

IS BARCELONA POLLUTED?

As a regional centre, the daily transit of goods and people cause problems with air quality in Barcelona. In 2015, Barcelona was assigned a D- grade by Friends of the Earth when evaluated against European Commision guidelines for air quality. This score was determined by the levels of air pollutants in Barcelona and measures the city had place to reduce emissions. The pollutants considered most harmful to human health in Barcelona are fine particulate matter (PM2.5 and PM10) and nitrogen dioxide (NO2) pollutants attributed to urban and regional traffic.

High concentrations of NO2 and particulate matter have been an ongoing problem for the capital. In 2019, the European Commision referred Spain for the European Court of Justice to repeated non-compliance with EU air quality standards. One of the city responsible for illegal air pollution levels was Barcelona.

The World Health Organisation (WHO) annual limit values for PM10, PM2.5 and NO2 are set at 20 µg/m3, 10 µg/m3 and 40 µg/m3, respectively. Though the European Union's (EU) air quality standards are less stringent than WHO recommendations for particulate mattter—at 40 µg/m3 for PM10, 25 µg/m3 for PM2.5, and 40 µg/m3 for NO2 —air pollution monitoring stations in Barcelona have also recorded NO2 levels above EU-mandated thresholds as recently as 2019.

WHAT IS THE CAUSE?

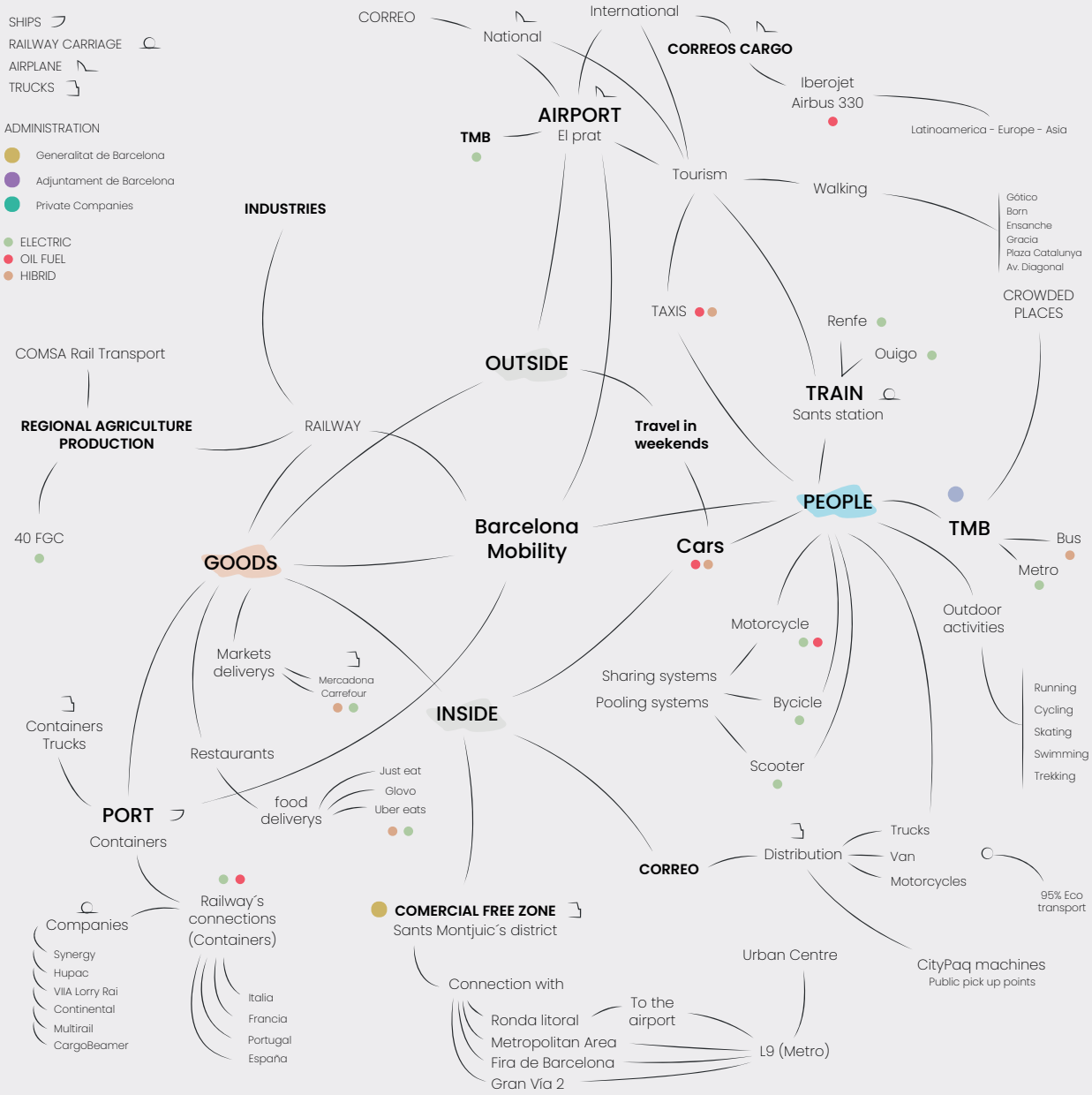
Many cities struggle with air pollution caused by urban transport, and Barcelona is no exception. However, as the largest metropolis on the Mediterranean Sea, Barcelona air pollution also stems from the transit of ships and port activity. In fact, emissions from the nearby port can cause up to 50% of total nitrous oxide levels in Barcelona. Port activity has also been linked to other common air pollutants, a 2016 study determined harbour emissions contribute up to 12% of PM10 and 15% of PM2.5 in urban Barcelona. For this reason, Barcelona City Council subscribed to an initiative that aims to create an Emission Control Area in the Mediterranean Sea (Med-ECA).

In recent years, air pollution in Barcelona has improved in some areas. While in 2010, 80% of air quality monitoring stations in Barcelona exceeded the average annual NO2 limits set by the EU, in 2013 the proportion was down to 29% of stations. Across Barcelona's port and the city, average annual NO2 levels in 2019 stayed below the 40 µg/m3 threshold recommended by the WHO—levels were 32 µg/m3 in the city and 37 µg/m3 at the port. However, average annual PM2.5 levels in 2019 exceeded the 10 µg/m3 limit set by the WHO. In Barcelona's port, average annual PM2.5 concentrations reached 17 µg/m3, while in the city, stations recorded PM2.5 levels above the hourly WHO recommendation of 25 µg/m3 for a total of 26 days during 2019.

MAPPING THE SYSTEM

BARCELONA´S LENS

1.2



CONCLUSIONS

The mobility environment of Barcelona is very complex, but by mapping the mobility system we can have a more conceptual and visual understanding of the main actors involved.

The map can give us a clearer understanding of which mobility stakeholders are most important. Specifically, we can compare the connections between the airport of Barcelona to the ports for example..

Moreover, we can also distinguish the types of transportation that prevail inside and outside the city, their relationships and how citizents and tourists use them.

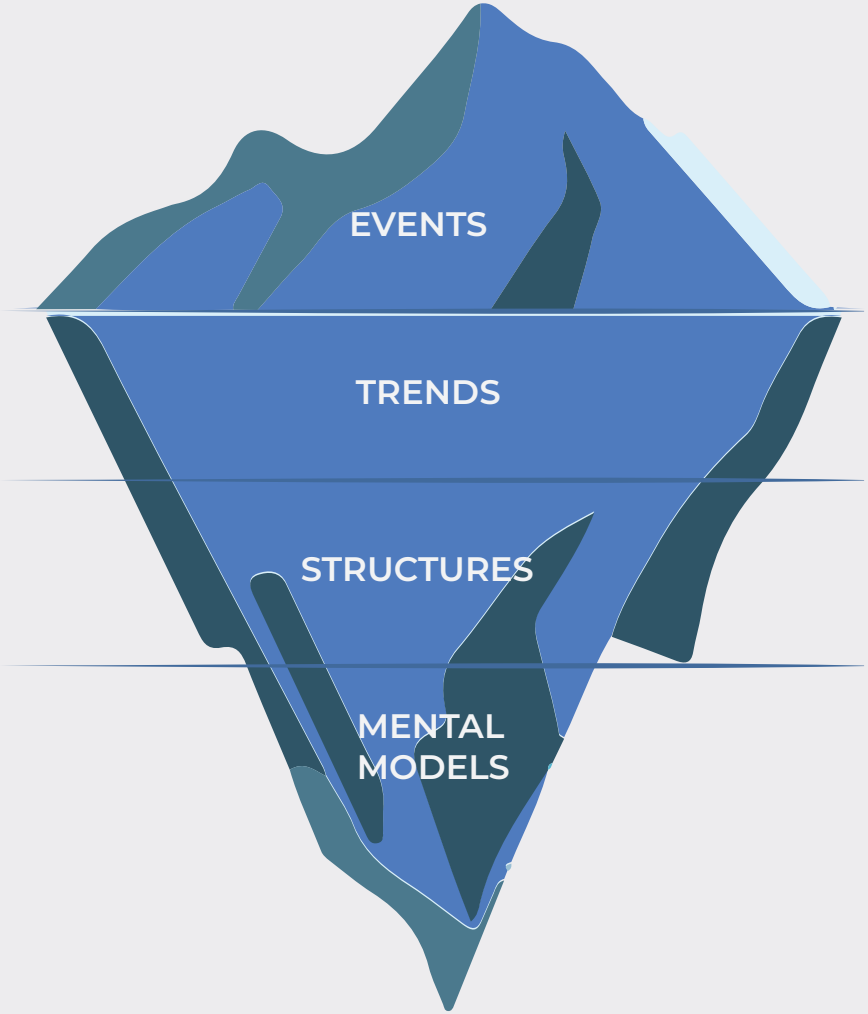
Finally, it´s important to highlight how this map shows us the amount of electric, oil fuel, and hibrid type of transportation is used in each activity, giving us the idea on which sectors could be the most polluting.

https://www.nexotrans.com/noticia/103939/nexolog/correos-
http://arxius.portdebarcelona.cat/tren/o7ES.html
https://www.portdebarcelona.cat/es/web/port-dels-negocis/138
https://www.idescat.cat/pub/?id=aec&n=446&lang=es
https://www.lavanguardia.com/economia/20220206/8037626
https://www.idescat.cat/pub/?id=aec&n=602&lang=es
https://www.fgc.cat/es/quienes-somos/

ICEBERG MODEL

MENTAL VALUES

1.3



React

What just happened?

Resources Crisis Radical changes
Energetic Crisis Air Pollution
Climate change

Anticipate

What trends have there been over time?

Electifying transportation
Autonomy
Faster mobility

Design

What has influenced the patterns?

What are the relationships between the parts?

Technic obsolecense
Economic growth
Phsicologycal obsolecense

Transform

What assumptions, beliefs and values do people hold about the system?

What beliefs keep the system in place?

Success values
Possession
Self demands

The Iceberg model Framework give us a description of system thinking. In addition, it also gives us an idea of which citizens mental models keep the system in place and what assumptions, beliefs and values people have.

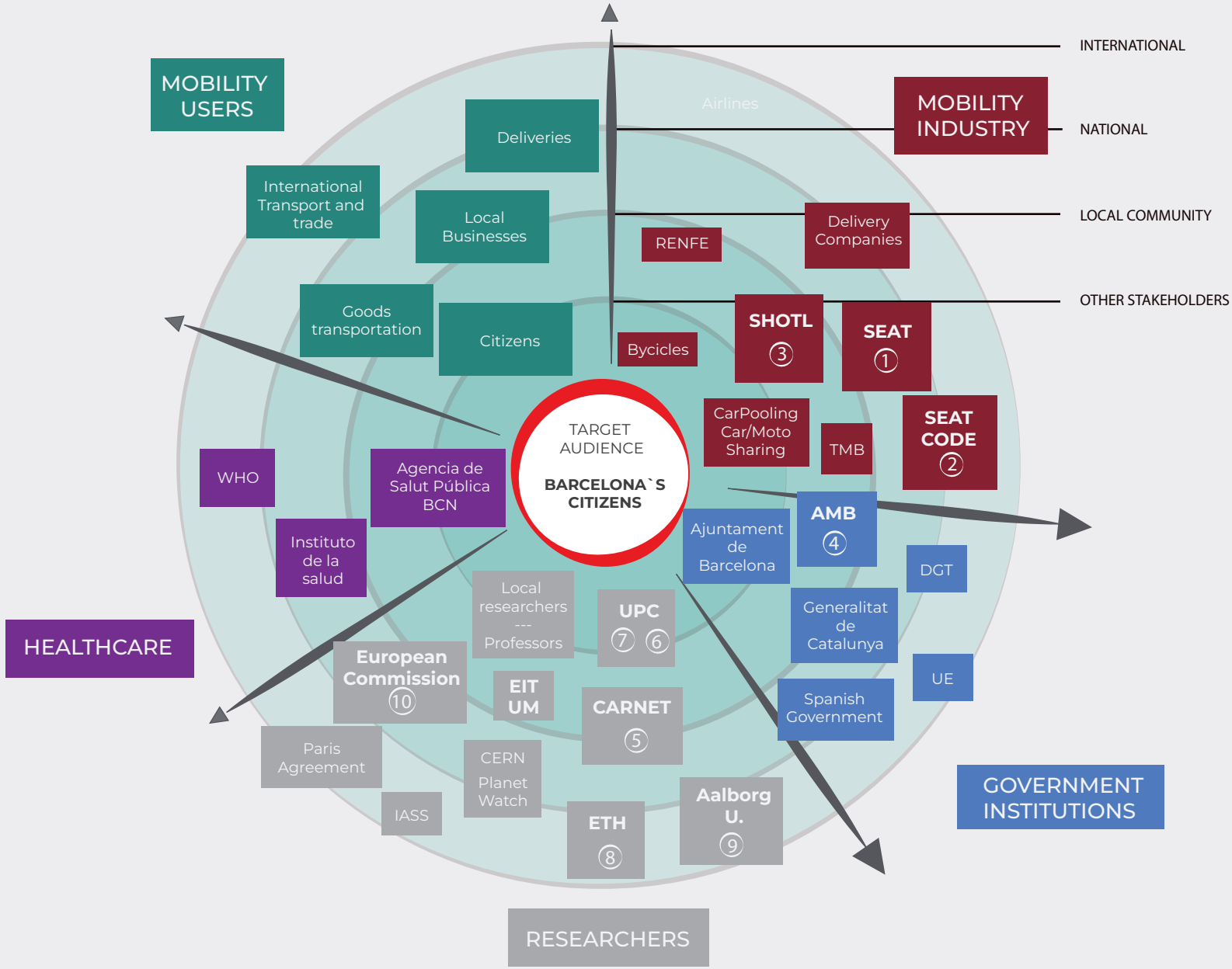
PEOPLE AND CONNECTIONS MAP

STAKEHOLDERS

1.4

CONNECTIONS

1. **VANESSA MARTINEZ**
   SEAT | HR department
2. **SERGI VILA**
   SEAT CODE | Electric Engineer
3. **GERARD MARTRET**
   Shotl´s CEO
4. **MARIONA CONILL DE AZPIAZU**
   AMB | Mobility engineer
5. **ELISA SAYROL**
   EIT | Carnet Projects
6. **PERE LOSANTOS**
   UPC | Researcher
7. **DAVID PINO**
   UPC | Fluid mechanisms
8. **LUKAS AMBÜHL**
   ETH | Traffic modeling
9. **TOKE HAUNSTRUP CHRISTENSEN**
   Aalborg University | Researcher
10. **ENRICO PISIONI**
    European Commision



INTERVIEWS

FINDINGS

INTERVIEWS

VANESSA MARTINEZ SEAT | HR Department	**PERE LOSANTOS** UPC | Researcher
SERGI VILA SEAT | HR Department	**DAVID PINO** UPC | Fluid mechanisms
GERARD MARTRET Shoti's CEO	**LUKAS AMBHÜL** ETH | Traffic modeling
MARIONA CONILL DE AZPIAZU AMB | Mobility engineer	**TOKE HAUNSTRUP CHRISTENSEN** Aaiborg University | Researcher
ELISA SAYROL EIT | Carnet Projectst	**ENRICO PISIONI** European Commision

SERGI VILA

Seat Code is modeling traffic to study the use of ToD. Use ToD vehicles as carsharing when there is no demand *for ToD during certain time periods during the day.*

GERARD MARTRET

Helping elderly people and people who doesn't have access to private vehicles as well as encouraging people to use public *transport to get to the city.*

VANESSA MARTINEZ

Electrification of cars
Moto-sharing
Photocatalytic pavement
Renewable resources to power their factory.

MARIONA CONILL DE AZPIAZU

Expanding bicycle services and infrastructure Working on implement low emission zones (LEZ)
Pollution levels tend to go beyond a WHO recommended threshold in the center of Barcelona.
An app for seeing if loading or unloading zones for cargo is available to reduce trucks driving around, integrating zones.

DAVID PINO

The city of Barcelona was not designed for cars.
There is a lot of information and few solutions. that improve the city exponentially.
He presented the Revolta Escolar program.
Children are the most affected by Air pollution.

INTERVIEWS
FINDINGS

ELISA SAYROL

The ***main obstacle*** *when it comes to sustainable mobility is* ***citizen engagement.***

PERE LOSANTOS

Transportation *accounts for* ***16% of total Greenhouse gas emissions.*** ***Around 75%*** *of this is attributed to the* ***global movement of goods.*** *Sourcing locally would significantly cut down emissions, but the* ***best way to reduce emissions*** *would be to* ***reduce mobility in general.***

ENRICO PISONI

50% of air pollution caused by *transportation comes from non-exhaust pollutant emissions, such as* ***brakes, tires and resuspension of particles*** *that are on the pavement that as vehicles move get in the air.*

TOKE HAUNSTRUP BA CHRISTENSEN

One ***key*** *challenge is to* ***change*** *our overall thinking in policy and urban planning from* ***having the car as the centre of urban and infrastructure development*** *towards supporting more sustainable ways of moving around.*

LUKAS AMBHÜL

Improving public transportation, incentivizing its use and disincentivizing private transportation *is helping Zurich to improve in the field of sustainable mobility.*

OTHER USEFUL INSIGHTS

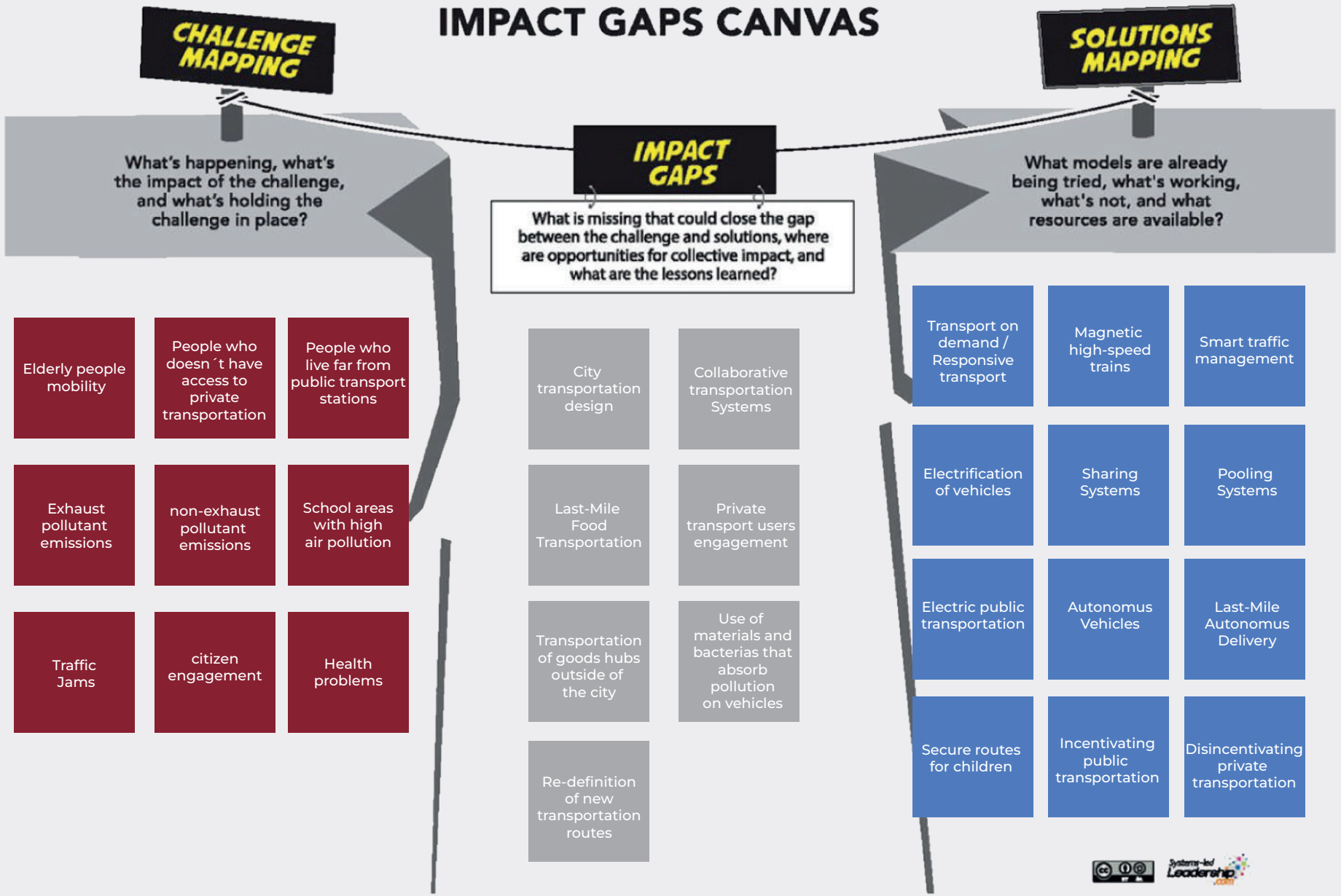
36% of lung cancer is associated with air pollution.
256.000 deaths are attributable to air pollution.
Cars are parked 92% of the time.
On average, one fifth of a car's driving time is wasted looking for parking.

86% of its fuel never reaches the wheels,
& most of the energy that does, moves the car, not people.
Its 5 seats only move 1.5 people.

IMPACT GAP CANVAS

FILLING THE GAPS

1.6



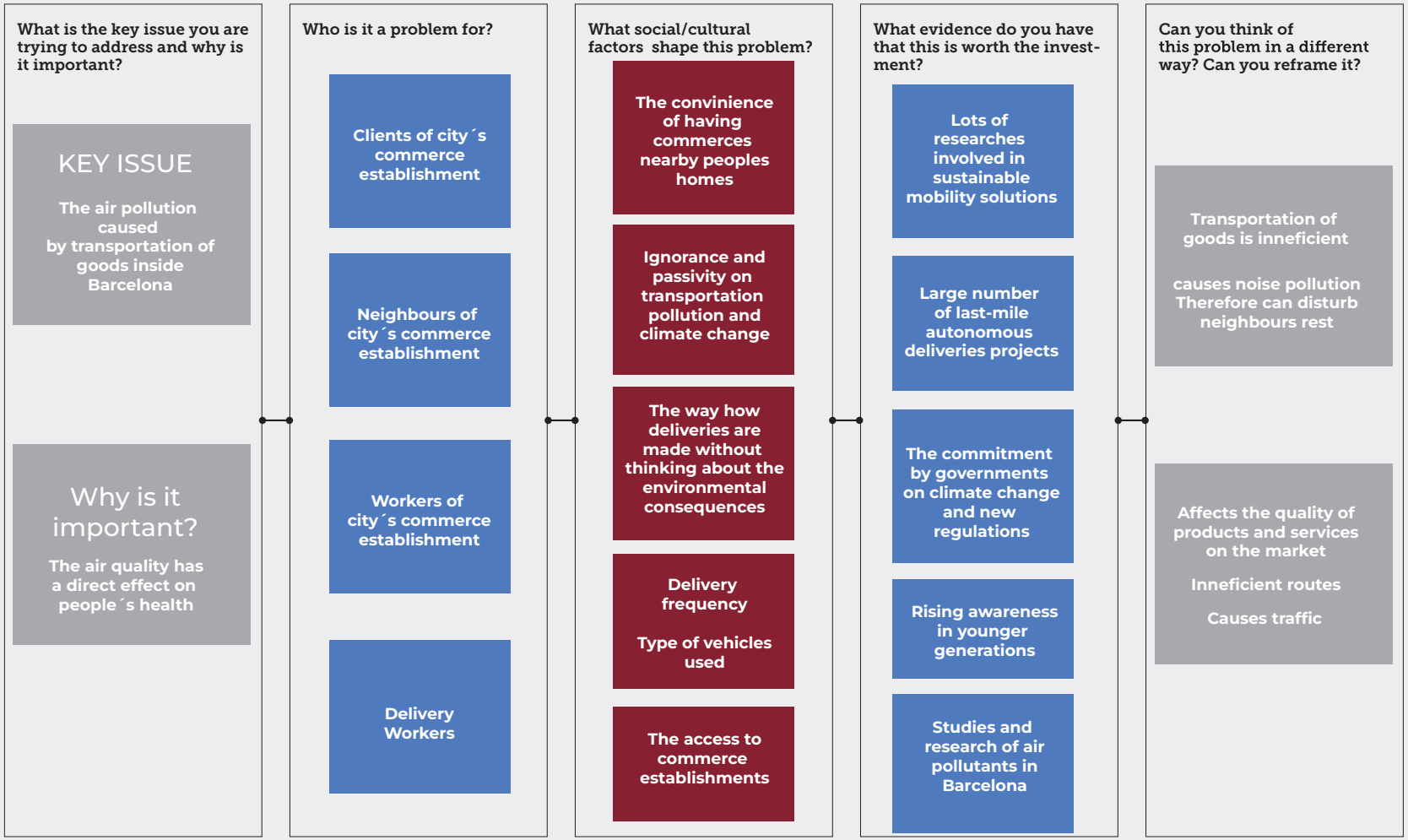
PROBLEM DEFINITION | INSIGHTS

REFRAMING THE PROBLEM

1.7

I want to clarify my priorities
by focusing on key critical issues

PROBLEM DEFINITION



PROBLEM DEFINITION | INSIGHTS

BENEFITS

Provide more space to other eco friendly typer of transportation inside the city

Reduce air pollutants

Descrease noise pollution

Improves air quality and people´s health

REDUCE GOODS TRANSPORTATION INSIDE BARCELONA

Affects the quality of products and services on the market

Efficient routes

Less use of resources

Decrease traffic

IDEATION

HOW MIGHT WE?

2.1

STRATEGIES

Offer an alternative to the current **goods distribtion methods** to **reduce the number of commercial vehicles on the streets**.

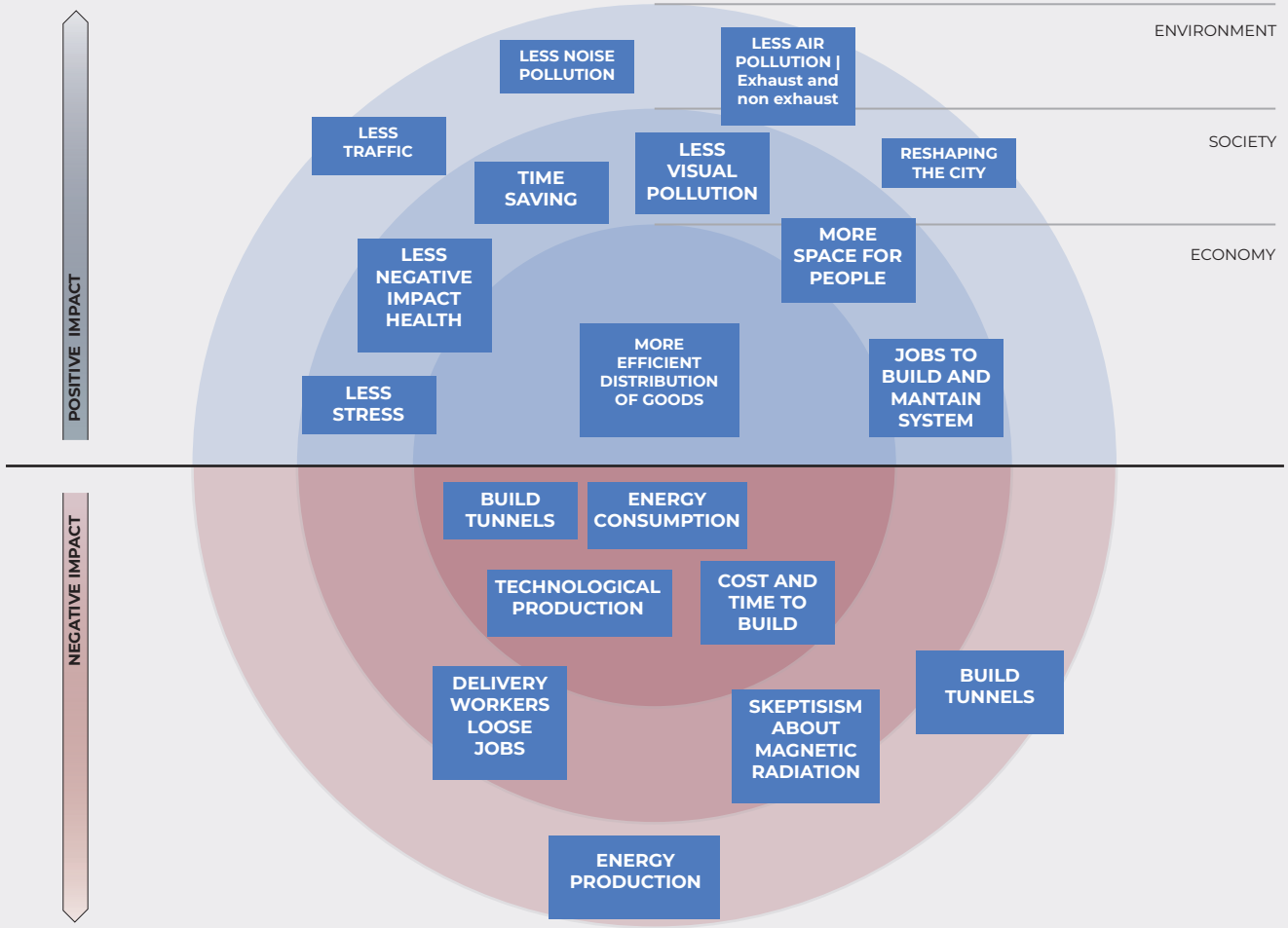
Reduce mass concentration of air pollutants in living areas, **coming from transportation of goods**, where air quality has a direct effect on people´s health.

LAST MILE UNDERGROUND TRANSPORTATION

This idea provides a systematic solution for goods transportation whithin cities. It will replace trucks and vans that deliver all types of good inside Barcelona, polluting the air and causing noise and traffic.

This will reduce the number of commercial vehicles on the streets and provide an effective and optimize solution for goods transportation.

POSITIVE | NEGATIVE IMPACTS

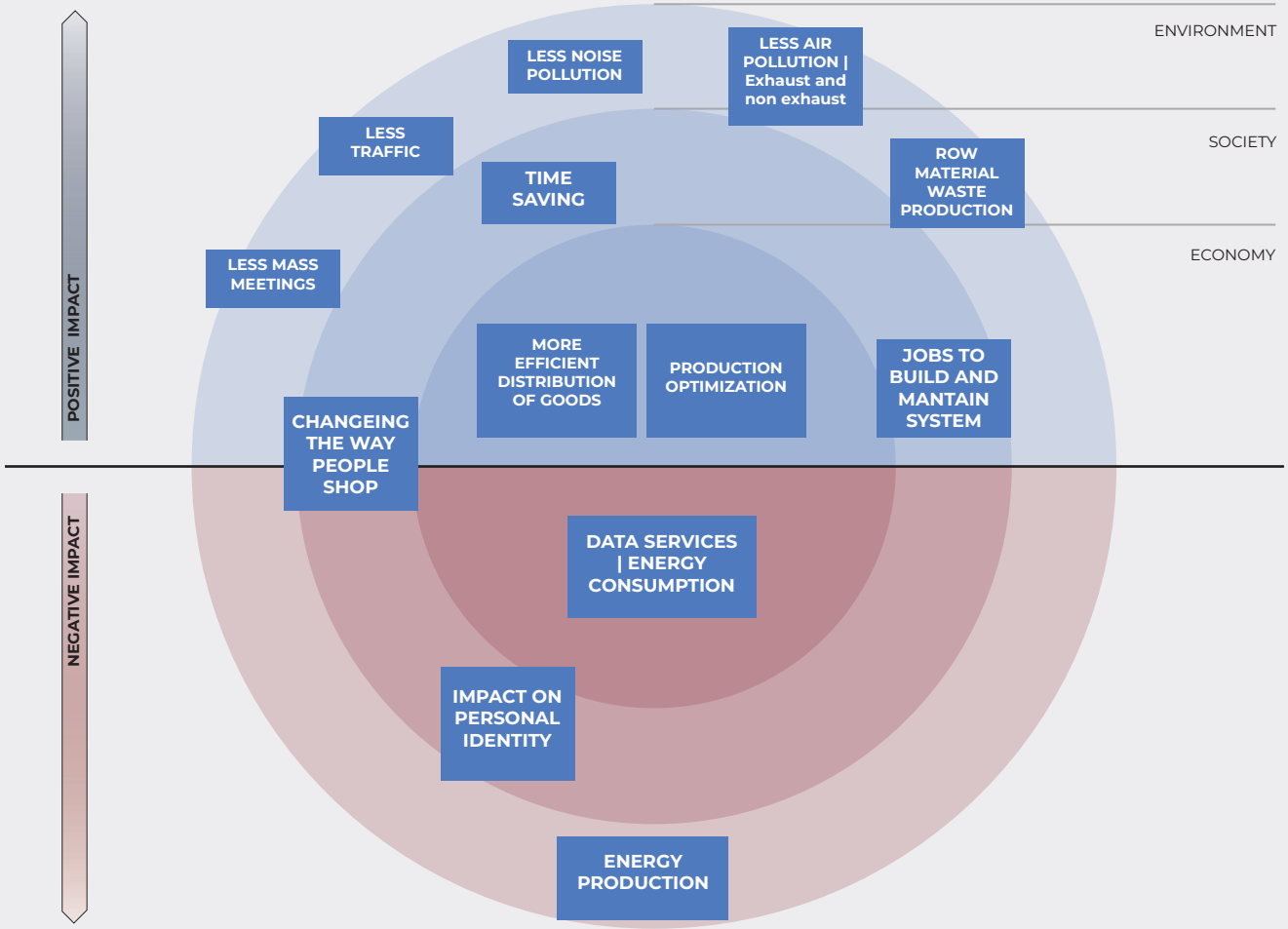


DIGITAL DRESSING TWIN

This idea consist on providing a scan system to model peoples bodies in 3D so we can optimize e-commerce of cloaths. We will provide the way that costumers buy cloaths in an effective way, withaout ordering pieces they would return because doesn´t fit them well.

This will reduce reverse logistic and traffic, optimizing the supply chain, saving costumers time and money, and improving their shopping experience.

POSITIVE | NEGATIVE IMPACTS

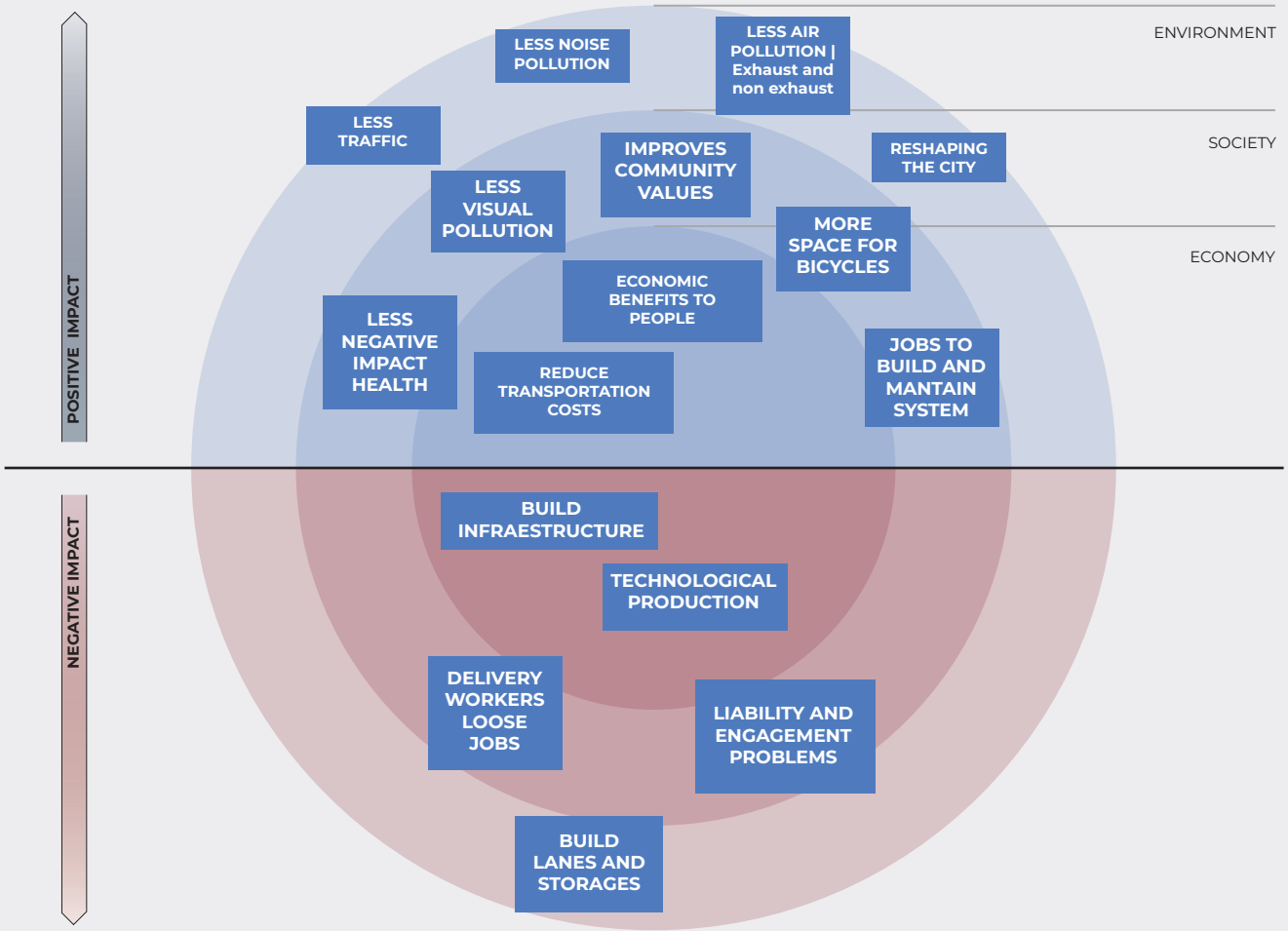


COLABORATIVE TRANSPORTATION SYSTEM

This idea consist on designing a new way of delivering goods inside the city. This system transform common citizents that commute in bicycle in collaborative partners where their daily travels are use to deliver groceries.

This will imrpove community spirit and reduce traffic inside the city, demanding the improvment of bicycle lanes and infraestructure.

POSITIVE | NEGATIVE IMPACTS



RE-DEFINITION

GETTING DEEPER

2.3

MAIN REASONS	MAIN RISKS	TRADEOFFS WITH THE OTHER IDEAS
USING ALREADY EXISTING INFRAESTRUCTURE TO START	BIG STARTING COST	3RD IDEA IS SIMPLER
USING ALREADY EXISTING INFRAESTRUCTURE TO START	COMPANIES ENGAGEMENT	2ND IDEA HAS MANY WEAK POINTS AND LACK OF RELIABILITY
	SCALABILITY OF THE PROJECT	EASIER IMPLEMENTATION

HUBS FOR LAST MILE DELIVERY SOLUTIONS

UNDERGROUND TRANSPORTATION SYSTEM OF GOODS

SWISS FEDERALISM

There are a number of similar initiatives currently being considered in Europe, with some already approved and under the initial phase of construction. Most notably, the Swiss Federalism project, which is drastically changing how long-haul freight is transported across Switzerland and to its cities. The project aims to move a significant amount of cargo delivery underground and transported to delivery hubs close to city centres. Swiss Federalisms will be overhauling how the country sees logistics by having stretches of distribution tunnels spanning hundreds of kilometers.

Similarly, a startup in England called Magway is experimenting with underground deliver using small tunnels with fully automated and electric cargo trains. Unlike Swiss Federalism, Magway would focus on shorter and smaller deliveries with its proposed tunnels being only 1 meter in diameter.

GOOD WAY

cleaner deliveries,

cleaner cities

PROJECT

GOOD WAY

INTRODUCTION

3.1

VALUE PROPOSITION

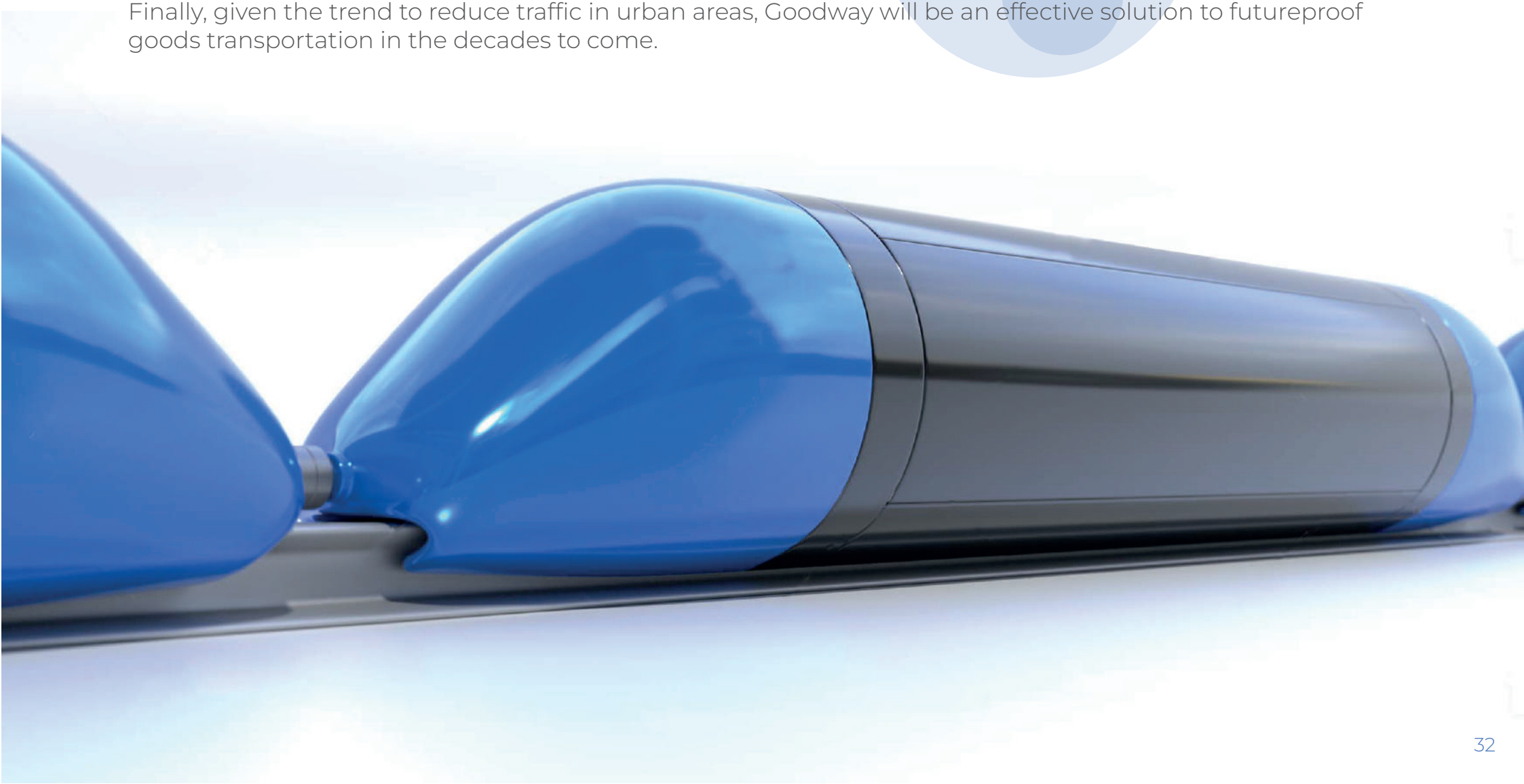
Goodway is an underground transportation system that will cut down on the emissions within the city of Barcelona by reducing its reliance on short haul delivery trucks. By utilizing a network of micro-tunnels and strategically placed distribution hubs, Goodway can realize its goal of reducing carbon emissions and toxic pollutants by transporting goods from exterior of the city to interior locations underground. If run at full capacity, Goodway has the potential to reduce the amount of total carbon emitted from city transport by 80%. Moreover, Goodway will reduce the total number of transport vehicles on the roads, thereby reducing urban traffic and lowering total emissions in Barcelona.

INTRODUCTION

VALUE PROPOSITION

Goodway, being a largely automated and traffic-independent system, has the potential to reduce delivery costs and will improve the reliability of delivery times.

Finally, given the trend to reduce traffic in urban areas, Goodway will be an effective solution to futureproof goods transportation in the decades to come.



DESIGN DEVELOPMENT

3.2

MOODBOARD

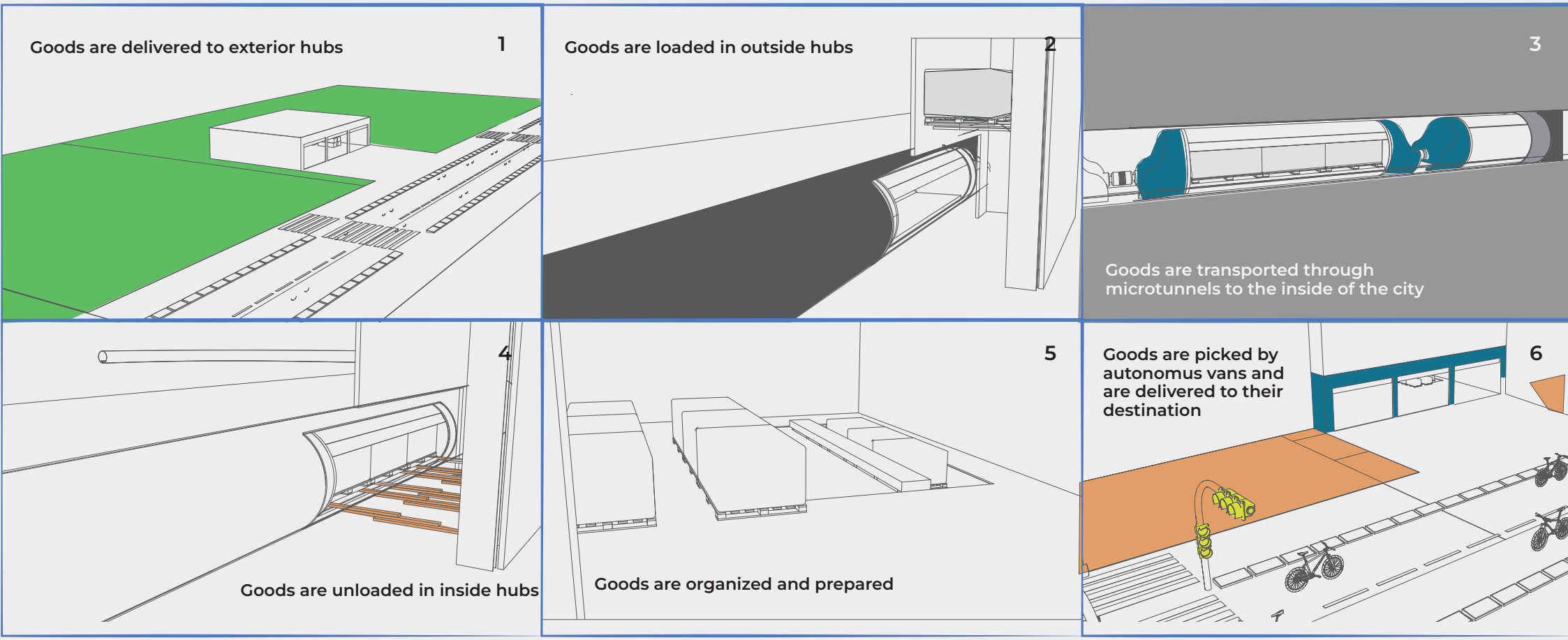
Collection of visual materials that evoke the certain style or concept that Goodway will use for its design. This representation consist on a collage of images, material samples, color palettes and sometimes descriptive words and typography that will guide the work.

DESIGN DEVELOPMENT

3.2

STORYBOARD

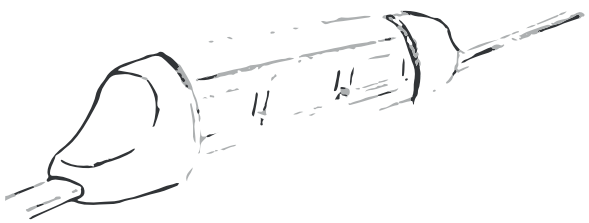
Wedesign this graphic representation of how the system should work, shot by shot. This give us an idea of the stages we must think on and in how we represent each shot, with notes about what's going on in the scene and what's being said in the script during that moment in the system.

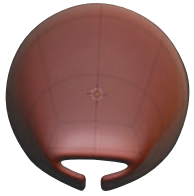


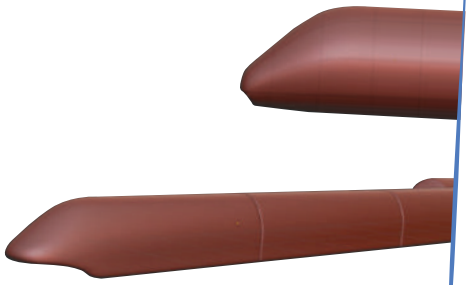
DESIGN DEVELOPMENT

SKETCHES AND MODELS

First drafts and models







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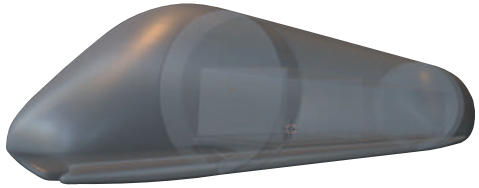
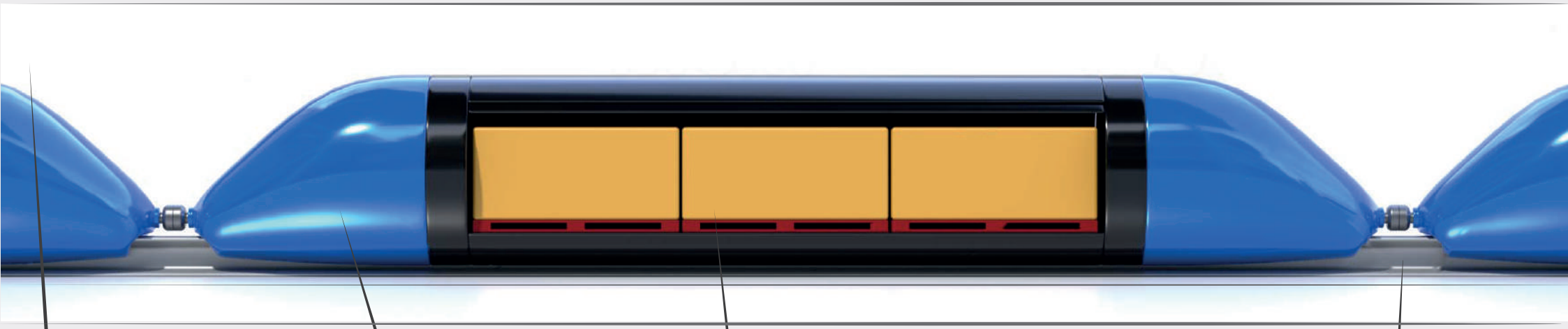


TECHNICAL ASPECTS

4.3

SYSTEM COMPOSITION



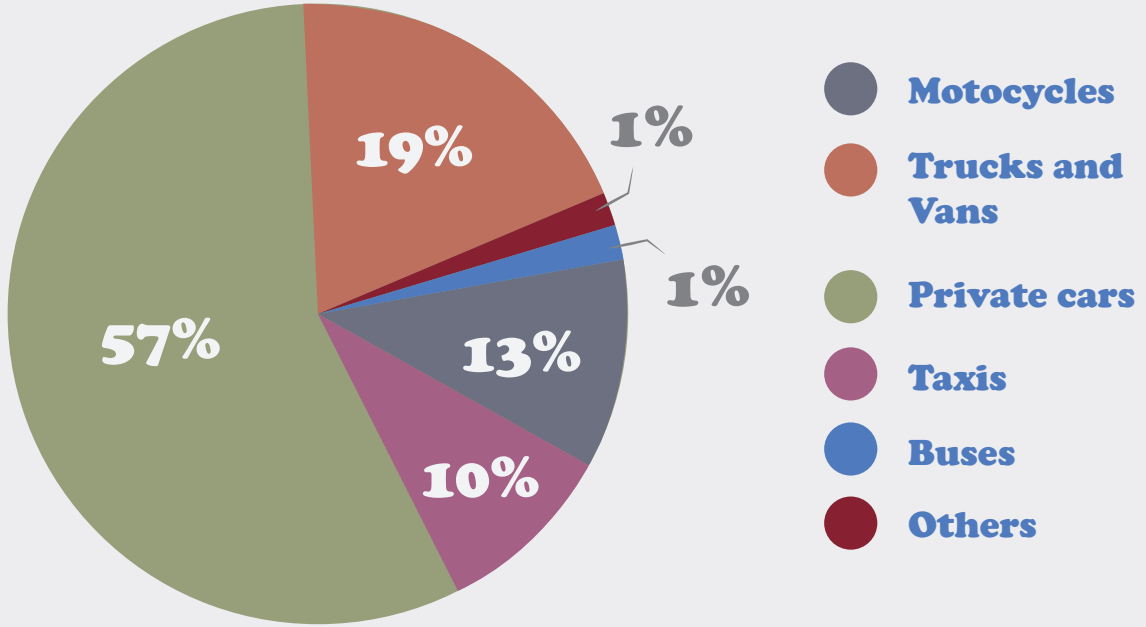
TECHNICAL ASPECTS

EMISSION CALCULATION

As our project has been more about providing a transportation of goods system that would help meet or vision rather than focusing on the actual transport vehicle for this system and in this technical part we are going to describe some calculations that we have taken into account in order to justify why this project would be feasible and would have the impact desired.

GoodWay plans on being the alternative to the current transportation of goods systems in the city, as previously stated. To know the effects of traffic in a metropolis, specifically Barcelona, and to be able to calculate the outcome of GoodWay in pollution and costing, we have used the article "caracterització del parc circulant de vehicles a l'área metropolitana de Barcelona - 2017", providing a record of the vehicles circulating in Barcelona's metropolitan area divided by types of vehicles and their main activities.

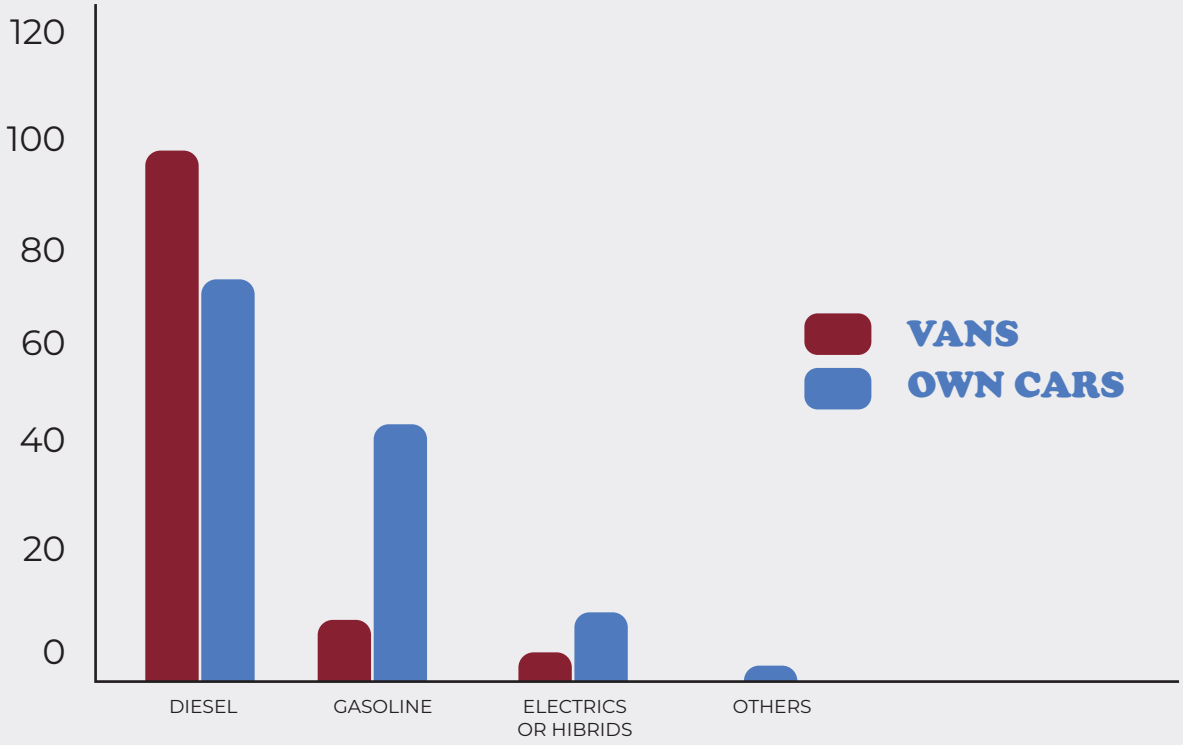
In this report, 92.365 vehicles emissions have been measured correctly, out of this number, 13.5% of vehicles circulating around Barcelona are vans and 5.7% are trucks. Therefore, we see that 19.2% of traffic is coming from transportation of goods. In addition to that, the percentage of trucks driving in the highways surrounding the city raises up by 3%, however we do not know whether or not they transport goods.



Propulsion of transportation vehicles:

It is in our interest to know the contribution to air pollution of the different propulsion systems that this 19,2% of vehicles that transport goods within barcelona have.

On the one hand Gasoline engines emit 11% more carbon dioxide (CO2) than diesel engines, a gas that is the main contributor to the greenhouse effect. On the other hand, diesel powered engines release four times more nitrogen oxides (NOx) during combustion than petrol, another gas which, in its case, has very negative effects on health.



The following table shows the comparison between the number of private use vehicles and vans by their type of propulsion.

It is then proved that almost all the vans, 97.6%, use diesel as their propulsion fuel, because of that will assume in the calculations done afterwards that all the vans use diesel fuel. In addition to that, diesel is the main fuel across all vehicles, 65% out of the total vehicles driving around the city use it.

Another point to take into account is that trucks that do not enter the city are usually not over 16 tons of maximum authorized mass, by approximation, an urban truck is said to have a maximum authorized mass of 14 tons or less and is powered by diesel as well.

Economic consumption of the transportation of goods vehicles: The following table sums up the economic consumption of trucks and vans taking into account some of the information mentioned previously, as well as the fuel consumption to transport 2 tons of goods.

VEHICLE	FUEL PRICE	FUEL CONSUMPTION
VAN (<3.5 t)	**1.868** €/L (diesel)	11L / 100Km
URBAN TRUCK (<14 t)	**1.868** €/L (diesel)	25L / 100Km

TECHNICAL ASPECTS

3.3

POWER CALCULATIONS

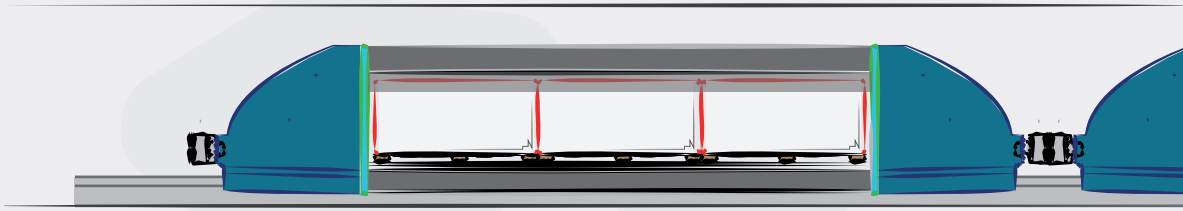
In order to calculate the necessary power of the engine mounted in each wagon of the goodway system, we have assumed that each wagon would weigh around 1 ton, and if we add the 2 tons that we plan on transporting in each wagon, the total gross weight to move is 3 tons. The power necessary for the electric engine has been calculated with 60 Km/h as the constant driving speed of each wagon, since the distances covered by the wagons between hubs would not exceed 10 Km.

The coefficient friction for an electric locomotive system as a function of its speed is:

$$\mu = 0.265 \cdot \frac{1+0.403 \cdot v}{1+0.522 \cdot v}$$ with v being the velocity in m/s

Converting 60Km/h to m/s:

$$60 \cdot \frac{Km}{h} \cdot \frac{1000\,m}{1Km} \cdot \frac{1\,h}{3600\,s} = 16.67\ m/s$$



Then,

$$\mu = 0.265 \cdot \frac{1+0.403 \cdot v \cdot 16.67\ m/s}{1+0.522 \cdot v \cdot 16.67\ m/s} = 0.21$$

Therefore, the necessary force to move a wagon is:

$$F = -F_r = \mu \cdot m \cdot g = 0.21 \cdot 3000\ Kg \cdot 9.8\ m/s^2 = 6180.30\ N$$

The power deloped by this force is equal to the product of force times velocity, which is assumed to be constant.

$$P = F \cdot v = 6180.30\ N \cdot 16.67\ m/s = 103.03\ kW$$

In order to have more power margin, we have decided to use a 115kW electric motor in each wagon, having then an extra 11,6% more powerful engine.

In order to have more power margin, we have decided to use a 115kW electric motor in each wagon, having then an extra 11,6% more powerful engine.

TRUCK

$$\frac{1.868\ €}{1\ L} \cdot \frac{25\ L}{100\ Km} \cdot \frac{1}{2\ t} \cdot \frac{100\ Cents}{1\ €} = 23.35\ Cents/Km.t$$

VAN

$$\frac{1.868\ €}{1\ L} \cdot \frac{11\ L}{100\ Km} \cdot \frac{1}{2\ t} \cdot \frac{100\ Cents}{1\ €} = 10.27\ Cents/Km.t$$

GOODWAY

$$115kWh \cdot \frac{0.1\ €}{1\ kWh} \cdot \frac{1\ h}{70\ Km} \cdot \frac{1}{2\ t} \cdot \frac{100\ Cents}{1\ €} = 8.21\ Cents/Km.t$$

Comparison of pollutant emissions in the city during transportation:

When it comes to air pollutant emissions, the vehicles use to transport goods that have been discussed are huge emitters, in fact they contribute to 33% of air pollution caused by vehicles despite just being 20% of the vehicles circulating.

The table below summerizes useful information to be able to asses the effectivness of GoodWay's implementation, if that meant a reduction of combustion vehicles discussed by 80%.

NOWADAYS	WITH GOODWAY
The total number of transportation of goods vehicles (19'6% of the total number of vehicles circulating) is equivalent to 17448. A diesel truck emits 2'61 kg CO2/L A diesel truck emits 539'7 gCO2/km The total gCO2 emitted by all the trucks to cover 1 Km is: 17448 × 539'7 ≃ 10g CO_2 /Km	Reducing number of transportation of goods vehicles by 80% means that there would just be 3466 transportation of goods vehicles, which would approximately be 4'5%of the total number of vehicles circulating. The total gCO2 emitted by all the trucks to cover 1 Km is: 3466 × 539'7 ≃ 106g CO_2/Km

As we can see the total emissions of CO2 caused by traffic in Barcelona would drop by one order of magnitude with the development og GoodWay.

IMPACT
REDUCTION

3.4

POLLUTION GENERATION

PM10 31%

NOx 34%

In the city of Barcelona, vans and lorries account for 23% of all city traffic and generate 31% of PM10 and 34% of NOx particulates detected. Through Goodway, these toxins could be reduced by up to 80% thereby putting Barcelona well below the World Health Organization's recommended threshold of atmospheric pollutants. Moreover, Urban delivery trucks emitted on average 307 gCO2/t-km, which is over five times as much as a long-haul tractor-trailer with emissions of 57 gCO2/t-km. Through Goodway, the amount of carbon emissions could be cut by up to 80% which amounts to 9000 tonnes of carbon dioxide emitted each year. In visual terms, this is equivalent to 4 million trees capturing carbon for 1 year.

IMPACT

SEGMENTS

3.4

Goodway has the potential of having a significant impact on large metropolitan areas, specifically on citizens, local governments, and retail businesses.

Retail businesses, in particular franchises, can update and optimize their supply chain by adopting a cleaner, more reliable, and cheaper transportation system to take their goods downtown a metropolis. Local governments can innovate urban planning and reduce traffic in their cities. The lower number of vehicles in the streets will open possibilities to reshape urban areas, potentially increasing green spaces and re-purposing the surface covered by streets. Finally, citizens will be impacted by such a change in the urban landscape in the form of a lower air pollution, noise pollution and a potential re-definition of neighborhoods.

IMPACT MODEL CANVAS

3.5

STORYBOARD

CANVAS: GOODS TRANSPORTATION SYSTEM

BY: GOODWAY

23 / 03 / 2022 ITERATION 2

KEY PARTNERS ⑦

- TMB
- LOCAL RETAILERS
- BARCELONA´S CITY COUNCIL
- CITIZENS
- TRANSPORTATION COMPANIES

KEY ACTIVITIES ⑤

- DESIGN, TEST, QUALIFY
- MUNICIPAL APPROVAL
- COMPANIES ENGAGEMENT
- APPROVAL TO USE METRO TUNNELS

KEY RESOURCES ⑥

- ELECTRICITY
- BUILDERS
- CITY PLANNERS
- DESIGNERS

VALUE PROPOSITIONS ②

- LOWER LEVELS OF CITY POLLUTION
- CHEAPER DELIVERY COSTS
- LOWER CARBON FOOTPRINT
- FASTER AND MORE RELIABLE DELIVERY OF RETAIL GOODS
- IMPROVED VEHICLE MOBILITY DUE TO REDUCED TRAFFIC

CLIENT´S RELATIONSHIP ④

- PARTNERSHIP WITH LOCAL TRANSPORT COMPANIES
- B2B RELATIONSHIP ESTABLISHED WITH THOSE SUBSCRIBING TO THE SERVICE

CHANNELS ③

- DIRECT MARKETING
- MUNICIPAL ADS
- RETAILER ENGAGEMENT

CLIENT SEGMENT: ①

B2B

- RETAIL STORES
- CITIZENS
- PUBLIC HEALTH

COSTS STRUCTURE ⑧

- CONSTRUCTION COSTS OF BUILDING THE TRANSPORTATION INFRASTRUCTURE
- FIXED COSTS: MANTENANCE, SALARIES, LOAN, PAYMENTS, MARKETING
- VARIABLE COSTS; DELIVERY COSTS SUPPLIER COSTS

FUNDING ⑨

- TAXATION OF HIGH CARBON EMISSIO DELIVERY METHODS (LIKE TRUCKS)
- REVENUES FROM BUSINESSES USING THE SERVICE
- GOVERNMENT GRANTS AND SUBSIDIES

PROJECTED COSTS

Boring	100.000.000-150.000.000 USD/Km
Exterior Hub	5.000.000 USD
Interior Hub	3.800.000 USD

Estimates can vary significantly when it comes to constructing underground transport tunnels. The cost of constructing 1 km of metro tunnel in Barcelona in 2009 was 151 million USD. Inflation and construction costs have increased since then, bringing the average cost up, however the Goodway tunnel systems will have a significantly smaller diameter than standard metro tunnels making the overall project less costly on average. Using the Barcelona Metro cost as a benchmark, we can roughly estimate the cost of constructing the Goodway tunnel system to be between 100 to 150 million USD per kilometer.

Using market prices of real estate in Barcelona we can estimate the cost of constructing the transport hubs that Goodway would need. In the exterior of Barcelona, the price per square metre of real estate averages to 2000 euros. With an estimated exterior hub size of 1000 square meters, and a construction cost of 3 million euros, the average exterior hub cost would be roughly 5 million euros. Using a similar model, the interior hub price per square meter of real estate averages to 4500 euros. With an estimated interior hub size of 400 square meters, and a construction cost of 2 million euros, the average interior hub would cost 3.8 million euros.

Ajuntament de Barcelona

Transports Metropolitans de Barcelona (TMB) owns and operates the metro system that runs throughout the city. If Goodway is a publicly owned operation, it would be funded by the Barcelona municipality and transportation ministry. Should the venture be both privately and publicly owned, funding could be secured by a combination by government grants and subsidies, alongside private investment.
In general, the fixed costs linked to building the infrastructure will be covered by government (local, national, EU), while the variable costs of running the system will be covered by the revenue stream.

BUSINESS

REVENUE

3.5

The main clients of Goodway will be large retail businesses like grocery, drug, department and fashion stores. These commercial businesses typically have large shipments delivered regularly with a high frequency of turnover.

Goodway's revenue model would be based mostly on charging its clients per pallet delivered. Since the cost of delivery is significantly cheaper compared with delivery trucks, Goodway would be able to undercut the competition while still maintaining a higher margin.

FUTUROLOGY

BACKCASTING VISION

ROADMAP

2023: Project conception, analysis, due diligence, financing.

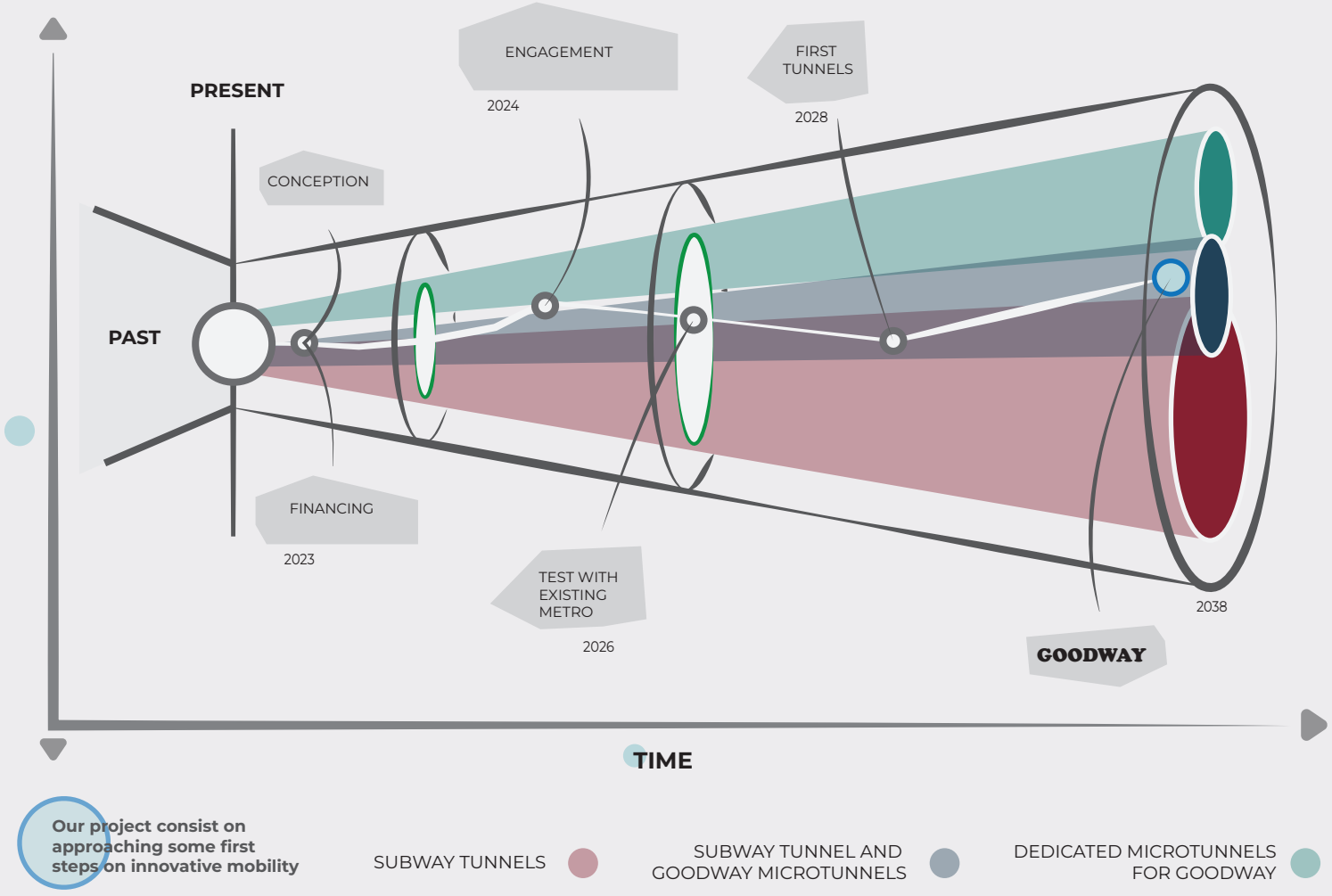
2024: Engagement with city planners, TMB, architects, engineers.

2026: use of exiting metro lines to test the concept of Goodway, specifically the L1 line from Bellvitge to Placa Catalunya.

2028: Begin construction of initial distribution tunnels and transport hubs.

2038: Completion of the Goodway underground infrastructure and all transport hubs.

FUTURE ANALYSIS



GOOD WAY

CBI Fusion Point

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