DESIGNING FOR SUSTAINABLE MOBILITY

Preparing to advance the urban bicycle structure of Madrid

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ABSTRACT

Madrid currently hosts car dominated mobility, partially mitigated by an extensive public transport service. The city started developing a bicycle infrastructure and the number of cyclists steadily increased. However, the network of bicycle lanes is not yet finished nor well connected in most of its points, and the cyclist group has not yet reached so-called 'critical mass'.

This project investigates the current mobility conditions, particularly regarding cycling. We propose interventions that look at fast bicycle infrastructure creation, widening the approach by including complementary and supporting elements. The proposal advances the general discussion and considerations, and contributes to the development of non-motorised mobility with conceptual suggestions.

It is widely agreed that sustainable improvements do not rapidly occur. Rather, they happen due to a set of small adjustments and events placed over a long timeframe, with complex interactions between competing groups of actors. The coordination of these events and actors reinforces the transition towards a more sustainable system.

The directions given by international and institutional reports, and by the authorities and personalities interviewed have been considered, and are a significant part of the conceptual development. The methodology includes interviews, planning tools, boundary objects and experts' observations. The theoretical framework includes Multi-Level Perspective (MLP) as the analytical backbone, and Strategic Niche Management (SNM) for practical guidelines.

The project concludes by providing a group of interventions that will reinforce the four dimensions of the niche, namely: (1) articulation of expectations, (2) facilitation of social networks and (3) learning processes, and (4) creation of external links. Additionally, a transition to urban sustainability requires incremental actions by both the local governance and the citizens, to facilitate the coexistence of diverse means of transport, empower sustainable ones and moderate ineffective energy consumption. Complementary approaches embracing multiple perspectives can improve the development of effective solutions.

FOREWORD

The following report is the fourth semester project on the master's programme in Sustainable Design, corresponding to the final thesis and it is comparable to 30 ECTS points. This project investigates Madrid's mobility system paying extra attention to bicycle conditions and takes a strategic and conceptual approach towards urban sustainable development. The research has been accomplished by the usage of theories and methods from the courses within the programme and supported by external guidelines.

The referencing system follows Chicago style, distinguishing references by author and date. Bibliography is presented at last, and is ordered alphabetically. Quotes have been written in italics, and page has been referred. Figures and tables have been numbered and described below each of them; moreover, a table of figures is presented adjacently.

I would like to thank Aalborg University for funding; the interviewed personalities and the institutions they represent for their constructive inputs; the European Commission and the European Platform on Sustainable Urban Mobility Plans for making possible the Third European Conference on Sustainable Urban Mobility Plans; colleagues, friends, family and others involved for their deep and detailed reviews, comments, insights and support.

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INTRODUCTION

1. MOBILITY, PROBLEMS AND CONTRIBUTIONS.

1.1 Mobility problems.

Transportation between and within settlements is a basic social, and economical need. The problems it derives are commonly known, and become specially evident in dense cities where air and noise pollution are not just environmental problems, but also social and health issues. It has been widely reported that some air elements such as sulphur dioxide, carbon monoxide, benzene and nitrogen dioxide can be extremely harmful for human health, as well as for the rest of the biosphere. These gases also contribute to acid rain generation and accelerate global warming. Furthermore, long exposure to noise pollution can cause mental health issues, for instance stress.

Humanity as a whole must urgently modify their activities not to exceed planetary boundaries (Rockström et al, 2009). Transportation is highly responsible for consumption practices in cities, as shown in figure 1. Indeed, transportation is responsible for more than a 60% of the global oil consumption. This fact does not only threaten the environment due to greenhouse gas emissions and other pollutants, but also local and global economies, as the energy return on energy investment (EROI) (Murphy and Hall, 2011) decreases, making oil extraction less profitable, thus increasing oil prices which makes them less accessible.

These problems are derived directly from the fuel combustion of motorised transport. Certainly, sustainable actions can strongly mitigate many of the problems it creates. Te facilitation of infrastructure supporting sustainable urban transport becomes a key element, as it assists making transportation cleaner. Additionally, in city centres, these sustainable actions can affect great amounts of people within a rather small area, thus increasing the effectiveness of the process itself.

With an increase in the global population living in cities, traffic congestion is becoming a bigger problem, which affects productivity significantly. This also expands these consequences to the public transport sector. The streets and the activities they hold can be reconsidered and prioritised as the city grows, by modifying the space to adapt it to the city contemporary needs and demands. In the same way, as space is a limited resource which is very valuable in cities, some elements may become obsolete, and see their spaces being reduced as some others begin taking it. A well balanced distribution of the street spaces between the different activities and modes of transport becomes crucial to absorb present demands and promote a conversion towards a more sustainable lifestyle.

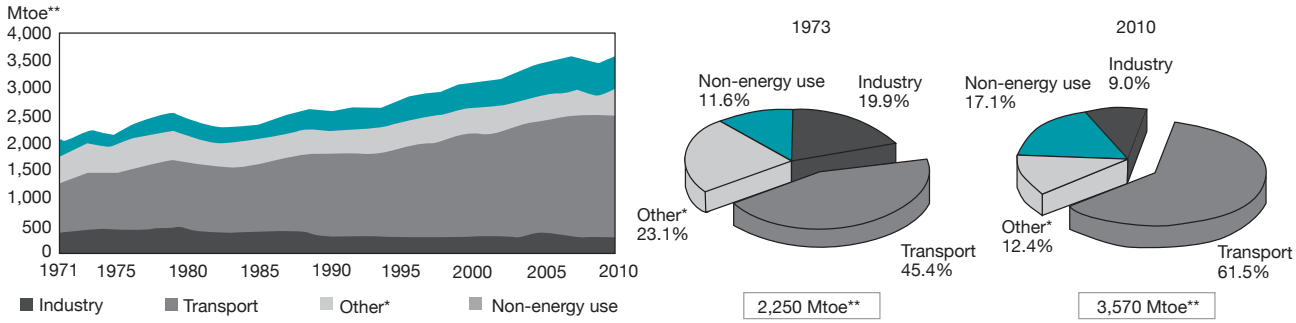

Figure 1. World oil consumption by sector. Source: UN-HABITAT.

1.2 Non-motorised mobility.

In the report 'Together towards competitive and resource-efficient urban mobility', members of the European Commission argues that: '*Mobility within cities is increasingly difficult and inefficient*' (2013, p1), recognising the big challenges existing and the need to act to tackle them.

Non-motorised transport can often substitute the motorised one and, in some cases, even improve the mobility experience to the users as '*in densely packed urban centres, non-motorised transport provides access to places that motorised modes cannot reach, and is often the fastest means of getting around*' (UN-HABITAT, 2013 p11).

It has been demonstrated that is possible to face the circumstances if the issue is on the political agenda of the local agents, some interesting instances can be found on the European Green Capitals (EGC). In Ljubljana, EGC 2016, the entire city centre has been pedestrianised and has shifted its focus from car dominance to non-motorised transport network development. Another interesting capital to learn from is Copenhagen (EGC14), well known for being one of the best bicycle cities, counting with an extensive and interconnected bicycle infrastructure and a political system that supports green mobility and limits car usage by tax implementation and a high influenced liveability urban design. The City of New York is also a good example on how one of the most populated cities of the world can achieve a yearly bicycle growing average rate greater than a 12% during the last 14 years by reducing its cycling risk indicator (The City of New York City Council, 2014), a device used to mitigate fears and increase awareness regarding safety problems while bicycling.

2. PROBLEM FORMULATION.

The problem formulation establishes the main research question to be addressed during the analysis and design phases of this report.

As we have seen, it is possible to tackle unsustainable practices by promoting sustainable ones. Regarding mobility, non-motorised transportation has to be promoted over motorised means. A complementary approach could be working on reducing the need for transportation; however it is not the focus of this report.

The city of Madrid is experiencing a great relative bicycle growth, mainly since the amount of cyclist still being considerably low. The challenges are numerous and have multiple particularities: large size of the city, abrupt orography, lack of space and aggressive environment are the primary difficulties that have been found during the analysis.

Hence, the problem formulation is stated as following:

HOW CAN CYCLING PROMOTION BE ARTICULATED AND STRENGTHENED WITHIN MADRID'S CAR-BASED CONTEXT?

After this introductory chapter, the report will be structured in three blocks: the framework analysis, the design process, and the considerations chapter. The framework analysis explores theoretical concepts and employs them to analyse the mobility system of Madrid; the key findings can be found at the end of each block. The design process makes use of the findings and theoretical recommendations to start a concept development, which brings a set of interventions as result. The final considerations chapter reflects upon the project findings, results, and the further opportunities that they bring.

FRAMEWORK ANALYSIS

1. THEORETICAL APPROACH.

In order to find paths to address the problem formulation stated previously, it is needed to introduced the concepts of Multi-Level Perspective (MLP), Strategic Niche Management (SNM), and the articulation of pressures. The aims of this section are to introduce the theoretical background needed to analyse the mobility system (MLP), and elaborate the directions to be taken when designing for bicycle support (SNM and articulation of pressures).

MLP theory will be understood from Geels (2005). SNM will be understood from Smith and Raven (2012), Schot et al (1994), and Schot and Geels (2008). Finally, governance of transitions will be assumed through the lens of Smith et al (2005).

1.1 Multi-Level Perspective (MLP).

MLP studies transitions at societal levels, such as housing, mobility, communication, etc. Such societal functions and needs are addressed by socio-technical systems, which are a set of aligned elements. In this case, the need for moving people and goods is satisfied by the mobility system, composed by infrastructure, vehicles, public transport system, energy suppliers, commercial and maintenance industry, traffic and parking regulation, and socio-political narratives.

A mobility transition will occur when, without changing the need for moving, a new (sustainable) socio-technical system is able to fulfil such need, and then, replace the initial mobility system. This happens thanks to a de-alignment and re-alignment process. This process is characterised by the emergence of internal tensions and external pressures, which destabilise the system; this instability is used by new elements to be introduced in the system and start a technology coexistence scenario. This coexistence occurs over long timeframes, and eventually the elements will re-align and create the new system.

Additionally, MLP understands that '*transitions come about through the interplay between processes at* [three] *different levels*' (Geels, 2005, p451). These three levels are the socio-technical landscape, the socio-technical regime and the niches. Moreover, MPL also understands that the levels to be described below are configured by three interrelated dimensions, the socio-technical system explained above, social groups and actors, and a regulatory framework. They interrelate as following: the socio-technical systems are built by social groups, who continue and copy the aspects and relations of the system; while the rules '*form a coordinating context that guides and orients action*' (Geels, 2005, p449). MLP, thus, believes the existence of three interrelated levels: macro, meso and micro; which are named landscape, regime and niche levels.

The regime is characterised by shaping the meso-level of the transition scene. It is appointed by the contemporary societal system, containing all the elements that are between the landscape and niche levels, and having the stability as one of the main characteristic of its basis. It fulfils its social needs by the usage of incremental innovation, and achieves such stability by orienting and coordinating traditional activities, creating positive loops that reinforce and stabilise the regime. This activities occur over long timeframes (often several decades), making regimes greatly path dependent, specially when looking at their modification costs, for instance: a highway requires large investments, thus, once it is

built, it becomes highly stable over time. The main industrial activities also contribute to maintain the stability and path dependency of the regime, aiming at keeping their dominant position; e.g.. car and engine manufacturers, dealerships, and repair facilities.

On the second place, the macro-level of the transition is formed by the landscape, affecting socio-technical development through the establishment of an exogenous environment. The aspects contained in the landscape are wider than the ones that can be found in the regime and niche levels, usually, they are further the direct scope of single actors, which cannot influence it directly. This wide policies and trends evolve quite slow as they require a high degree of alignment, nevertheless, this strong commitment makes processes on this level hard, if not impossible, to be reversed. Some examples of these elements can be the raise of climate change awareness or the international regulation changes.

MLP also defines the niches level, it does it as the place where radical innovation resides. In opposition to the landscape, the niches are small and weakly linked networks of actors that coexist and interact in an effervescent manner. As it can be expected, the low alignment and relatively short age of the systems make them perform below optimal levels. This networks are created, destroyed, reshaped, gathered and divided as they seek at providing a space that facilitates the generation of stronger niches that may fulfil the social requirements better than current practices. An example of niche emergence can be seen in the evolution of the smartphone; where different designs, features, and software were experimented, until reaching a generalised arrangement of elements.

According to the literature linked to the principles of this text, a transition starts when an artefact or technology emerges in niches and is used in some of them, while competing with the mainstream (regime) technology. Afterwards, thank to external and correlated circumstances, windows of opportunity are created, which are used by the new technology with the purpose of totally replacing the old artefact or technology. This process is defined by Geels in four phases, which are going to be described below.

During the first phase of the transition, the situation consists in a dynamically stable regime which faces certain pressures coming from both the landscape and niches levels. Within these niches, innovation technologies emerge and are quickly reshaped. Still they have not yet become potential replacements of mainstream technologies.

During the second phase defined, the technology starts to gain users in the niches and have a relatively considerable growth. This phase is understood as the maximum level a niche can reach itself without any external collaboration by forces of the regime. The niches have small room to be further developed and the regime may remain stabilised and mostly unaltered.

During the third phase the niche technology starts obtaining conditions to compete with the mainstream technology. This happens thank to external pressures coming from the landscape and the articulation of the pressures by the regime, situation that opens windows of opportunity. This windows are tensions and conflicts that may be originated externally by the landscape or internally by the dynamism of the regime. Moreover, during this phase the niche technology have reached a certain level of expertise and social knowledge and

acceptance. The niche accumulates experience and support, and refines the technology preparing it for the next stage.

The fourth phase concludes the transition once the niche technology has successfully replaced the previous regime one. This situation defines a new regime, where different pressures are applied, fuelling incremental advancements on the new regime technology as well as the creation of new potential replacements, starting the first phase of a new transition.
Figure 2 shows a visual representation of the theory.

Depending on the level analysed, the elements vary in nature, number and influencing power. While the landscape level is characterised by wide institutional processes, and the regime by maintaining traditional combinations; the niches experiment new solutions by using a large number of elements. Additionally, MLP helps to structure the elements spectrum. However, it is challenging to make distinctions between levels, specially between the regime and landscape levels; this difficulty can alter the focus of the transition when approaching to it. In addition, the conception of a stable regime can mislead to a loss of expectations of change. Although it is clear it is a dynamic stability and the embracement of this concept helps to analyse the situation, it may be more influenced by the landscape and the niches than the theory leads to picture. In other words, it is suggested to emphasise on the 'static instability' dimension of the regime instead.

MLP will be used to analyse the three socio-technical systems in the context of Madrid mobility system. Furthermore, the findings will bring insights about the status of the de-alignment and re-alignment process, and determine if the actions required are to favour instability, coexistence or to re-align the system back.

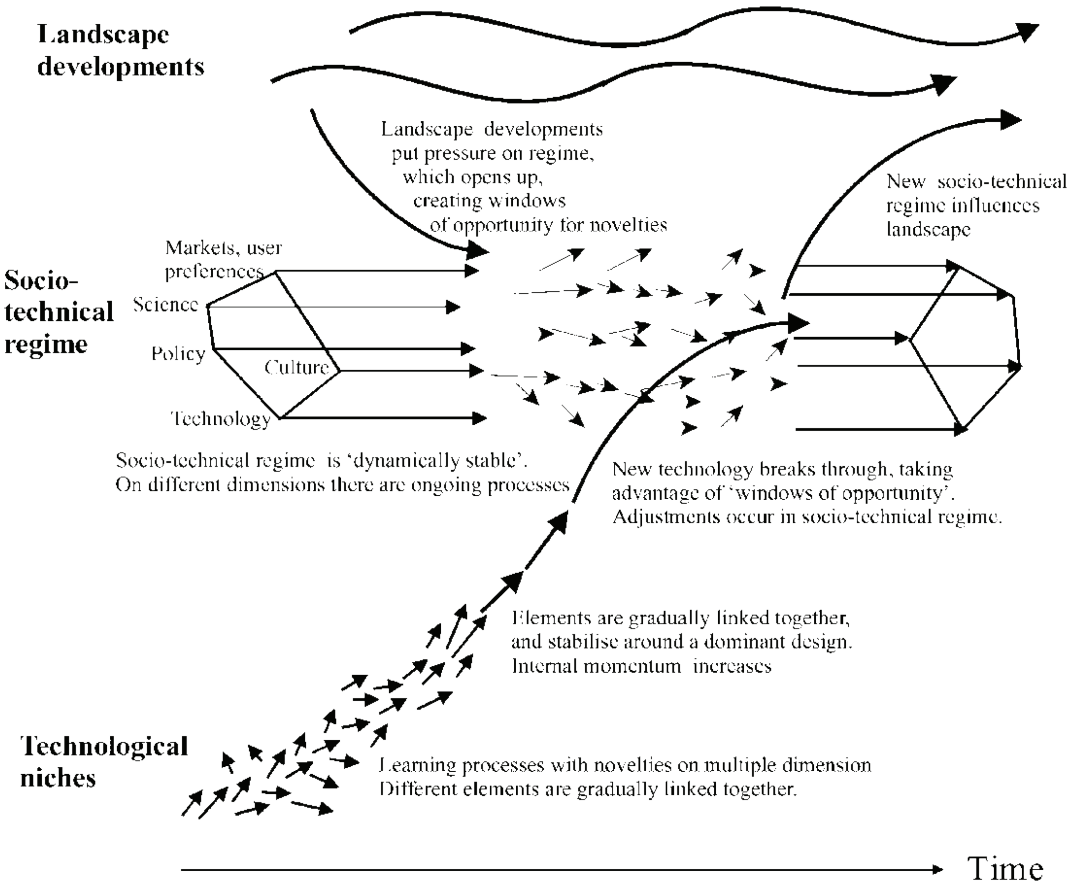

Figure 2. Multi-Level Perspective transition. Source: Geels (2005).

1.2 Strategic Niche Management (SNM).

The use of SNM is justified due to the high influence niches have in transitions, specially during the de-alignment process. As bicycle is considered the niche to be articulated, it then requires further theoretical support. SNM will be used as a set of guidelines providing solutions to be adopted during the design process.

It has been explained how a system transition commonly starts from niche levels and moves up until reaching the regime. Thus, literature has emphasised and discussed processes and strategies, regarding the importance of niches in transitions in order to advance amongst the different phases of a transition.

Niches are characterised by following non-traditional processes. These processes are based on experimentation and creation of safe habitats for the niche, called selection environment. The creation of a selection environment depends on the path made by the series of experiments carried out by the niche, these experiments will generate niche accumulation, which eventually will form an alternative proto-regime able to compete with the existing regime. This experiments can be, for instance, the creation of satellite programs, supportive narratives, or social events.

A niche is assisted by employing certain processes, here there are two theoretical approaches that will set the guidelines of the design process. Smith and Raven (2012) propose three processes, namely: shield, nurture and empower the niche. On the other hand, Schot and Geels (2008) propose four: articulation of expectations, create social networks, facilitate leaning processes, and develop external links. During the theoretical analysis there have been found several coincidences. Thus, the articulation of expectations seems a way to shield the niche (although it also contributes to nurture it); the facilitation of social networks and learning processes are considered methods to nurture the niche; and the creation of external links is a way to empower the niche.

1.2.1 Shield the niche, articulate expectations.

Smith and Raven (2012) consider that niche protection (shielding) can be an approach to move forward between transition phases. It aims at creating an environment where the niche technology can compete with regime technologies by protecting the first one. This is considered as the regulatory activity needed to protect the niche; i.e.. tax reduction for electric cars, exclusive infrastructure for sustainable means, etc. These actions will recognise the competitiveness of the niche technology and create the conditions to ensure a clean competition between traditional (regime) and upcoming (niche) technologies. The creation of such protective environment seems almost coincident with one of the strategies suggested by Schot et al (1994), the modification of the selective environment by using regulatory devices that entitle the potential societal benefits the niche can bring. Policies become highly important in this strategic approach; regulation, tariffs and taxes can play an important role to develop alternative technologies and user practices.

Niche members will apply pressure on the regime by demanding certain interventions; these interventions can be either physical, financial or regulatory, however, it hardly happens that these demands are regarding just a single element, they usually are a combination of two or more of them. The way the agents articulate these expectations and

which expectations are indeed articulated, directly affects to the niche development and expansion. Schot and Geels (2008) suggest the creation of robust, specific and qualified expectations to reinforce the niche, be more precise and detailed, and be connected and supported by ongoing processes and regime strategies (both internal and external to the niche). An example on articulation of expectations can be found in the facilitation of infrastructure to make public transport more competitive and less dependent on private traffic conditions (bus lane).

To extend insights for the articulation of expectations it has also been used literature regarding governance (Smith et al, 2005). This approach studies the transformations of the regimes and understands them as a set of two processes: shifting the pressures and coordinating the resources. The regime is continuously receiving pressures and adapting to them. This adaptation is possible by using the resources of the regime and coordinating them, it is the articulation of selective pressures.

Depending on the location of the resources needed for the transition, they can be internal or external. If the capability to innovate resides in the regime and it can satisfy its social needs by incremental innovation, then the resources are internal. On the other hand, the resources are external if the regime requires outer knowledge or new technological directions, this new resources are very likely coming from new niches. The coordination of such resources is also an element of analysis in the text studied. In a sense, it can be considered as the direction the different members of the regime are taking, and when they occur. The combination of both factors is defined as the adaptive capacity of the regime, which will be higher when the resources are internal and coordinated.

Smith (et al, 2005) facilitates the identification of selective pressures and their articulation by the governance; it also provides a vision of the transition context that complements MLP vision. This concept of articulation of selective pressures seems aligned with the first niche intervention suggested by Schot and Geels (2008), the articulation of visions and expectations, and with the shielding strategy proposed by Smith and Raven (2012). The text also includes a definition of four contexts, depending on the location of the resources and their coordination. Nevertheless, it is limited to a set of historical examples that demonstrate the existence of the contexts and their differences, however, it does not give advice nor set a strategy to cope with the challenges may be found on the context itself. Therefore, Smith et al (2005) has contributed to clarify and facilitate a better understanding of the concepts of articulation and adaptive capacity, concepts that will be included in and combined with the other appraisals found within SNM.

1.2.2 Nurture the niche, create social networks and learning processes.

If the niche has reached a status where it is not facing threatening pressures, either because they are inexistent or mitigated by the shielding created in the previous phase, the niche can be moved forward by nurturing it.

Regarding the facilitation of social networks, a niche is characterised by an effervescent interaction, frequently building and reshaping new social engagements. This constant dynamic can and should be employed to reinforce the niche. The creation of social networks is key to promote a product, an innovation or a strategy. Schot and Geels (2008) argue that, in order to

reinforce a niche, the social network should be wider and deeper; in this case it is understood as the inclusion of elements, experts and powerful actors that participate actively and can influence in decision making processes and the articulation of expectations.

To facilitate learning processes, they can occur at several dimensions, namely: '*technical aspects and design specifications, market and user preferences, cultural and symbolic meaning, infrastructure and maintenance networks, industry and production networks, regulations and government policy,* [and] *societal and environmental effects*.' (Schot and Geels, 2008, p540). This knowledge comes from both, data and experiences, coming from local contexts (i.e.. first-order knowledge). When such knowledge is then assembled and upscaled to global contexts, it is considered second-order knowledge. For that, the importance of data collection, and combination methods is key, as data has become a more valuable resource, and its storage, and combination has become cheaper and easier during the last decades.

All these processes can occur at two different levels, local and global. Acting locally is related with the generation of experiments (Schot et al, 1994) in particular locations, looking for the support of internal networks and direct knowledge generation in order to prepare the technology for a broader context through learning and adaptation processes. In addition, applying these processes in a global context is understood as linking the niche technology with '*an emerging institutional field or proto-regime* [...] *transcending local contexts*' (Smith and Raven, 2012, p1029).

1.2.3 Empower the niche, create external links.

Finally, MLP and SNM literature aim at modifying the regime to include and embrace the niche, they also aim at adapting the niche to take advantage of the windows of opportunity that tensions and pressures create in the regime.

Empowering is, thus, the third process to expand a niche. Using a parallelism aiming for a better understanding of the contrast of these approaches, after protecting the niche from an 'aggressive' environment (shielding) and supporting its back-end elements to allow the niche to be self-sustained (nurturing); empowering could be expressed as the latest set of actions to be performed before the innovation is in the regime. It has two contrasting approaches: 'fit and conform' and 'stretch and transform'.

Fit and conform empowering phase aims at making the niche fit into an almost unchanged environment. Smith and Raven (2012) have identified two challenges for this approach. The first challenge is linked with the transformations the niche has had during its implementation into the regime; meaning in a sense that sustainable niche adaptation into an (in comparison) unsustainable regime would make the first less sustainable as a result of modifications on it to make it fit into the environment, for example due to rebound effects. The second challenge found is related with the responsibility of maintaining the niche performing at a competitive level over time, to finally remove the protections. It is, for instance, the case of the electric vehicles market, which, in most of the cases, still need governmental relief to empower the sales until the technology performs at truly competitive levels.

Stretch and transform empowering phase aims, in contrast with fit and conform, at intervening

on the environment, modifying it to include the niche rather than transforming the niche to make it fit. ''*Stretch-and-transform niches' will create capabilities and attract resources that empower participation in political debates over the future shape of institutions and regime selection pressures*' (Smith and Raven, 2012, p1031).

To take advantage of the windows of opportunity it is needed a strong niche. This is expected to be achieved by improving the three previous dimensions; however, it would not be possible if the niche is isolated and does not create links with external elements belonging to both the landscape and the regime. Therefore, the connection of the niche with the ongoing political agenda, broad institutional agreements and other niches becomes key to reinforce and develop bicycle niche. Such links can be achieved by finding common goals that will group the elements and create a more rounded result, able to face the traditional regime and, eventually, substitute it.

Summing up, the theories suggest an analysis of the actors regarding their different influences on Madrid's mobility system, dividing them into landscape, regime and niche levels. Then, the bicycle niche has to be shielded, nurtured and empowered to promote a stronger emergence into the regime. For that, SNM, and, more specifically, the four dimensions defined by Schot and Geels (2008) (articulation of expectations, creation of social networks, facilitation of learning processes, and creation of external links) provide strategic lines. These approaches are to be considered during the design phase, trying to reinforce bicycle niche dimensions. Next section will address the explanation of the methodological framework followed during the project process.

2. METHODOLOGY.

In order to address the problem formulated and support bicycle niche in Madrid, this section will introduce the methodological framework applied. Throughout the project process, the insights gotten during the analytical phase will be used to, supported by the strategic lines set by SNM, design a set of interventions to assist bicycle niche emergence. In other words, the aim of this project is going from an abstract framework to the development of a set of propositions that protect, nurture and empower the bicycle niche, in order to improve bicycle infrastructure extension within Madrid's urban constitution.

The project has used a combination of inductive and deductive approaches. Several theoretical approaches have been considered, MLP, SNM, and governance articulations make a theoretical combination, which will set the guidelines to follow a deductive attitude towards the analytical phase. Afterwards, the design and validation of the interventions followed an inductive approach, although it also employed theoretical deductions to reinforce the argument. This chapter is divided in two sections, the first one defines the methodology used for the analytical phase, while the second explains the way employed to design the interventions.

2.1 Analytical methodology.

During the analytical phase, it has been identified the problems mobility brings in dense cities as well as the traditional solutions used to tackle such complications. MLP has been the analytical backbone, dividing the actors' spectrum in three separate levels: the socio-technical landscape, the socio-technical regime and the niches. However, a single actor

or method frequently provided insights on two or more levels (for instance, regime and niche), therefore, the methods should be explained separately.

In order to analyse the european-level forces and performance, it has been attended to the third European Conference in Sustainable Urban Mobility Plans, held in Bremen. This event, with its target on professionals, gave the student information about concerns that urban planners (regime members) will have to deal with in a future. A broad and complete set of talks was prepared with different focuses, from smart-cities conversion to public transport nodes, through measurement and diagnosis tools. During the two-days event, a better understanding on landscape forces, and the ways they have to influence regimes was grasped. Additionally, desk research helped to find institutional documents to understand trajectories of landscape forces, for instance guidelines for 'Developing and implementing a sustainable urban mobility plan' (European Union, 2013), or for 'Planning and designing for sustainable urban mobility' (UN-HABITAT, 2013).

To study the status of Madrid's mobility system, it was needed to identify the different city areas and the activities they hold, as well as their communication levels in terms of transportation (location of important public transport hubs, surrounding car and bicycle infrastructure, pedestrian areas, etc.). The modal share was also a basic element of the analysis as well as the historical evolution of the modes and the actions behind such changes.

Furthermore, the roles and competences of the agents that can, indeed, intervene in the system need to be understood, as well as the future interventions that are to be planned. Moreover, bicycle niche actors have to be identified and their concerns have to be known. For both, regime and niche members, several interviews have been carried out.

The interviews had a large weight regarding the amount of actors and their influences. These are: Pablo Rodríguez, General Director of Transport of Madrid Region; David Bartolomé, Business developer of Car2Go Spain; Álvaro Fernández, Marta Serrano, and Rafael Orihuela, CEO, Communication and Consulting Director, and Sanchinarro Operations Centre Coordinator of EMT, respectively; 'Fundación Vida Sostenible', pro-sustainability foundation; and Adrían Fernández, content editor at 'ecomovilidad.net', member of Madrid's Mobility Table, and experienced cyclist.

Generally, the interviews have taken a semi-structured form and were conducted individually (besides few exceptions). This form allows a more casual data gathering, fact that facilitates communication and opens up further discussions (Saunders et al, 2012).

During the interview, the use of news has served as facilitators for the conversation and the questions, taking a role of boundary objects. A boundary object '*play*[s] *in establishing an infrastructure or process where knowledge can be represented, learned, and transformed*' (Carlile, 2002, p454). Following this line, the news were the base of the discussion, where a common understanding and basic knowledge is taken for granted and the relevant information was easily shared between interviewer and interviewee.

A prioritization game was performed to add a quantitative and easily comparable set of ranked values. A design game is useful to create

a framework for participation, activate the actors and create interest (Brandt, 2006). Its name may lead to think it is part of the design phase, however, it has been used to identify and categorise agents' and users' concerns. The prioritization game was developed as a way to gather data on the interviewee's perceptions of the most conflictive elements and on the greatest values and relevant criteria when planning. Providing images of the different means of transport and asking the participants to place the most conflicting ones on top, allowed the student to interact with relevant actors and to locate problematic elements. To give bricks with different values, such as 'Universal public transport', 'Improve air quality' or 'Improve pedestrian and cyclist mobility', and asking the actor to prioritise them, stood the relevant information for understanding decision-makers' and users' general values regarding mobility planning and practices in Madrid.

Additionally, citizens' and cyclists' demands have been identified as a key dimension to be studied, for that, public surveys and cyclists' blogs have been consulted.

This analytical arrangements provided relevant insights with double functionality: on the one hand, they have been used to make an analysis of the landscape, regime and niche levels, addressing theoretical terms. On the other, they served as the bridge linking the analysis and design phases, becoming as well the starting point of the design goals.

2.2 Design methodology.

Moving forward to the methodology applied for the design phase, it followed the next structure. After analysing the levels suggested by MLP approach, there have been identified key findings (either problems to cope with or opportunities to take advantage of). Then, these insights have been observed using SNM, which brought strategic lines to be used when designing for supporting niches (Schot and Geels, 2008). These advices focus the attention on the reinforcement of four niche dimensions: the articulation of expectations, facilitation of social networking and learning processes, and link of the niche with external elements. This combination of empirical and theoretical contributions concluded by setting the design goals.

Once the goals were defined, the next step has been the creation of a wide field of alternatives that can contribute to solve the problems identified by using the opportunities found during the analysis. For this, the contributions have come from the interviews, the data collected, and, also, from a tool presented during the conference in SUMPs (KonSULT). KonSULT is a knowledge base, specialised in policy measures on transport and land use, developed by the Institute of Transport Studies and the University of Leeds, and co-founded by the EU. During the conference, it has been presented the Measure Option Generator, this tool ranks suggested measure instruments based on a given context. Due to its reliability and planning oriented approach, this tool has been used to suggest interesting measures to be controlled on a wide strategy (general) and to support bicycle niche (specific).

Secondly, the alternatives created have been combined, experimenting different sequences and connections. The use of sketches and drawings has been the main process employed in this design part. The sketches have worked as visual representations of cognitive processes, and, although they commonly work also as boundary objects, that only occurs when they

are shared over actors. In this case, they were internal documentation to facilitate the design, as the sketches have the flexibility to be easily observed and modified (Henderson, 1991), and the ability to be easily produced by the student.

Thirdly, the theoretical approaches and the appraisals found during the interviews have been recalled to conduct a selection process, aiming at valuing the propositions and keep the most valuable alternatives. At the same time, the propositions have been further developed and refined, making sure they were addressing the design goals set previously.

In fourth place, the concepts were materialised by using visual representations of the ideas. These graphic devices were more developed than the previous sketches, as they would be shared and, therefore, work as boundary object to communicate the values of the interventions proposed.

Finally, such graphic elements have been sent to agents and external expert to receive feedback and validate the proposal. The student carried out several consults to value the acceptance of the proposed strategy, its values and weaknesses. The first member consulted was Luis Fernández, Deputy of Madrid's Planning Department. He was invited to evaluate a version of the proposal, his feedback included a technical perspective regarding the implementation of the plan and legal requirements related with emergency services requirements. Eva Ramos is the head of Madrid's Sustainability and Mobility Department. The same as Luis, Eva was asked for feedback after presenting her a version of the plan. Her comments detailed and completed the analysis made by the student and clarified the differences between the strategy proposed and the current strategy of Madrid. Lastly, Estela Alemán, Agent of Catie at Nicaragua and specialised in Sustainable Rural Development, was contacted to receive professional and external (unbiased) feedback. In her evaluation she shared knowledge about the motivation behind a choice and found potential conflicts the strategy could bring, specially regarding parking.

This design methodology, then, has served to link the analytical findings with the theoretical strategies by setting the design goals. Moreover, it has also been used to generate and validate a set of interventions, which are the primary contribution of this report to a reinforcement of bicycle niche. Next sections analyse landscape, regime and niche levels by using empirical material collected throughout the project process.

3. LANDSCAPE ANALYSIS.

In order to have a better perspective about the current situation of Madrid, the political context at its different levels, the main historical pressures, and their evolution over time are going to be described and supported by empirical material. It needs to be emphasised the political uncertainty that Spain has been facing since the third third of 2015, which has partially befogged the performance of the analysis. This section aims at locating relevant actors and links of the socio-technical landscape. Next chapters will find insights regarding the socio-technical regime and niches.

3.1 International.

International agreements aiming at establishing a more sustainable planet have been taking place during the last decades, mainly coming from conventions organised by the United Nations. During the Conference of Parties (COP) of Kyoto (1992), a protocol aiming to reduce greenhouse gasses emissions was agreed (Kyoto protocol), this document set the starting point of a new sustainable span where international arrangements are key to add pressure on the regimes. Afterwards, at the COP11, 2005, the Montreal Action Plan was set in order to extend and reinforce the arrangement of Kyoto protocol, emphasising on the need of tackling climate change and gas emissions. The COPs 15 (Copenhagen, 2009), 16 (Cancun, 2010) and 17 (Durban, 2011) led to the establishment of the Green Climate Fund, giving financial help to developing countries carrying sustainable actions on. The most recent case can be found at the COP21 (Paris, 2015), when an universal agreement on sustainability started its process with the objective of becoming effective and legally binding by 2020. All these agreements are reflecting the enormous size of the global warming dilemma as well as the urgency needed to cope with it.

3.2 European.

Stepping down to European policies, the concerns of sustainability started materialising around the 2000s, with the 'Lisbon Strategy 2000-2010' as one of the most sounding examples. It is on the line of Kyoto protocol and seems to be highly influenced by it, however, it is considered a failure in terms of reaching the goals set. Nevertheless, the inclusion of sustainability on the European agenda, even from a quite broad approach (as the strategy also includes plans for youth and digital era affairs), is seen as a great and needed advancement that pushes on the regime, attempting at making it more sustainable. The development of a second set of targets, 'Europe 2020', shows the interest of EU on keeping broad and integral strategies for Europe, including sustainability affairs.

Moreover, regarding mobility, the EU 'support[s] Member States and local authorities by providing Europe's best practices, facilitating their widespread use throughout Europe and encouraging effective networking and exchange of experiences between cities' (European Commission, 2006). Following this line, the EU has been organising great amount of events and conferences for professionals, such as the yearly Conferences on Sustainable Urban Mobility Plans (see methodology section, page 11).

Practically, commitment with sustainability is steadily raising within EU, which is playing an unifying role between its members, supporting leading organisations to keep its competitive position and funding sustainable projects and initiatives such as Connecting Europe Facility

(CEF), Trans-European Transport Network (TEN-T) or Fuel Cell and Hydrogen Joint Undertaking, just to mention some of the most relevant ones.

This plans, agreements and events, added to the upcoming legally binding contract of COP21 Paris, are considered sustainability pressures, which are coming from the landscape and are being applied to the regime. Moreover, these pressures have been increasing over time, which leads to assume that they will keep their raising trend, confirming that the existing socio-technical regime is facing selective pressures coming from the socio-technical landscape level, requiring sustainable articulations and allowing the emergence of windows of opportunity.

3.3 National.

To briefly schematise the competences of Spain's national government, it has competences on the road infrastructure through the Development Ministry, specially on the six radial highways of Madrid as well as on the M40 and M50 highway belts. It also has the environmental responsibility, through the Agriculture, Food and Environment Ministry. The public company Renfe, train operator, has all the competences regarding with trains and their infrastructure and administration. Finally, the Metropolitan Mobility Observatory is a State analysis organism.

Within the legal and strategic actions Spain made during the last two decades, one of the firsts that give sustainability a voice is the 'Saving and Energy Efficiency Strategy' of 2003, which seems quite connected to Kyoto protocol and Lisbon Strategy, calling for a more efficient use of the energy to reduce emissions. Also, the 'Infrastructure and Transport Strategic Plan 2005-2020' set procedures to improve transport and its infrastructures. One of the latests laws regarding pollution and sustainability is the 'Air Plan 2013-2016', which was later applied and adapted to the different Regions and cities. Its objective is to '*prevent and reduce air pollution and its transboundary effects and to minimize the negative impacts*' (Air Plan, 2013, p5). It also points at tropospheric ozone, particles and nitrogen dioxide as the main emissions to be tackled and relates the last two with car traffic in big cities.

3.4 Regional.

The Region of Madrid starts having more detailed competences in terms of mobility in the city, specially regarding public transport. Madrid's Transport, Housing and Infrastructure Counselling, and specially the General Direction of Transport (part of the counselling), execute all the regulatory competences regarding regional transport, including the taxi licenses (Pablo Rodríguez interview).

Although the Region of Madrid has great responsibilities in this field, it gives the impression of being the less committed with sustainability in relation with the other three. The main political actions to boost sustainability have been rather low, the most relevant ones are the creation of the Pedestrian Priority Areas (starting in 2003) and the 'Air Quality and Climate Change Regional Strategy' (2013), also known as 'Plan Azul+', which is a regional adaptation of the national Air Plan. The design of the Pedestrian Priority Areas, conceived to avoid car indisciplined parking by emphasising the physical division between the road and the sidewalk, have been criticised by technicians of the municipality, which argue 'the pedestrian does not perceive its priority and simply a decreased velocity

occurs' (Madrid SUMP, 2014). This simple fact points at the need of a street design that does not only comply with current legislation and further articulations, but that also promotes sustainable practices by using physical elements and external facilities.

Other legal interventions are not particularly aggressive, like the mobility section of the 'Sustainable Economy Strategy', which, despite recognising a critical element such as social participation on decision-making processes, establishes voluntary transport plans for organisations and very few invitations for investing on non-motorised transport.

These four linked networks of institutions and international and regional actors, looked through MLP, are the ones generating the landscape of the system. Next, the local competences will be mentioned before a brief discussion on the current political circumstances. The local competences are the ones linked to the City Council and the Regional Consortium (or CRTM), which belongs to the Regional government but has a great influence on the mobility patterns and routines of the city as it administers and controls the whole public transport service network on the city and the region. These two actors are an important part of the socio-technical regime of MLP theory. Which is to be define in the following section.

4. REGIME ANALYSIS.

In order to have a better perspective about Madrid's mobility system, it is needed to define and analyse the system previously.

Madrid, with a population between three and four millions of inhabitants, is one of the largest metropolitan areas of southern Europe and the biggest city of Spain. It is located in the centre of the Iberian peninsula and is the biggest rail and air international hub, followed by Barcelona, which also counts with a harbour in the Mediterranean sea. This chapter will analyse the mobility system of Madrid regarding its mobility patterns, the evolution of infrastructure and mobility interventions, and the governance and political influences of the system. Afterwards, the key findings and openings found during the analysis will be shown..

4.1 Mobility patterns.

Starting with the modal share of the city, in 2011, almost all the journeys were nearly equally distributed between motorised private transport (29,9%), public transport (38,4%) and walking (29,4%). On the other hand, cycling was the least used mean of transport used, with a thin 0,3% (Soot free cities, 2011).

4.1.1 Private vehicle.

Car mobility in the city represents almost a third part of the journeys made, this share has been reduced over time as mitigation devices have been applied by local and regional governments. Such interventions will be analysed in the next section.

4.1.2 Public transport.

Shifting to public transport, metro is the largest provider with more than 600 million

passengers per year; followed by the urban bus (EMT), 408 million; train (Cercanías), 179 million; interurban bus, 179 million; and tram (Metro Ligero), with 30 million passengers per year (MadridSUMP14).

a Metro (Metro de Madrid).
Metro is the most used public transport service, counting with a radial structure that allows fast connections of the suburban areas with the city centre. On the other hand, it penalises the connection between outer districts as the communication between them has to be done either passing through the city centre or by using complementary means of transport (commonly urban buses).

b Urban Bus (EMT).
The urban bus service, it is the second biggest public transport provider. Its network is tighter than Metro's and highly flexible, facilitating last mile mobility which is specially required by disfavoured people (children, disabled and elderly). To have a denser network with closer stops, added to the fact that buses also have to stop due to traffic lights, traffic jams and undisciplined parking, reduces the average speed of the service and makes it inefficient at long distances. Together with the slow speed of buses, even having certain facilities to make them faster, comes the lack of an integrated fare system. The the travellers have to pay as many times as buses they take, which is, added to the density of the network, another big difference with Metro's operational approach, as Metro's price is the same regardless the amount of trains user has to take, facilitating its use even more for longer distances.

c Train (Cercanías).
The next service in terms of volume of passengers is the train Cercanías. It quickly connects the outer regions of Madrid with the city centre and helps Metro moving people along the 'Paseos' (Castellana, Recoletos and Prado), coinciding with it in several stations along these boulevards. The key of the service is a big distance between stations, what makes the service fast, combined with a further geographical scope. On the other hand, it frequently requires a complementary mode for last mile mobility as the number of stations in the city is rather small compared with Metro and EMT networks.

d Interurban Bus (Several private operators).
With a very similar amount of travellers than the train, the interurban bus service connects the metropolitan areas with the hubs located in the city. The routes of this network are highly linked with the radial highways and have to finish in the hubs, what makes them less flexible that they might seem at first sight.

e Tram (Metro Ligero).
The smallest, and newest, public transport provider is Metro Ligero, this tram service started in 2007. It has never been designed to become a main provider, although it is performing under expectations. This might be due to the slow speed of the vehicles, added to a lack of connections with other means, and the small size of the network (only three lines).

4.1.3 Other means.

Wrapping up with the rest of the modes of transport, and starting with taxis, the taxi/citizen ratio is 2,52 per thousand citizens, which, according to MadridSUMP14, is around 70% higher than Paris' ratio; moreover, the data shows that, in 2008, more than 60% of the taxis were circulating without customer. This data directly points to a number of taxis way above the demand of the service. There are planned financial benefits to renew the taxis' fleet and make it cleaner. The rise of

market competition with newer technologies, together with the financial crisis has reduced the demand of taxi. However, taxi collective have greater influence than assumed at first, is a quite strong actor trying to maintain its force by pushing on the regime to remain static, thus, market competitors will have smaller room for development and taxi drivers will keep their market share (Pablo Rodríguez interview). This change resistance burdens the transition process as some relatively powerful groups of actors position themselves as change oppositors.

Part of this competition comes from car-share services. With the existence of two established companies with several years of experience and a very low rate of users, Respiro and Bluemove, this sector changed its status during the second half of 2015, when the German multinational organisation Daimler started operating Car2Go in Madrid, placing 500 electric Smart Fortwo in almost the entire inner part of M30. This project has a completely different business model than the two other car-share providers, and had a greater acceptance in the market, with more than 53.000 users in less than half a year. This cars have favourable conditions for parking, making an attractive service (David Bartolomé interview).

4.2 Infrastructure and interventions.

The infrastructure provides a supporting framework for the different means of transport, and, thereby, favours the conditions for driving a car, using the metro, bus, etc.. This part will explore the evolution of the infrastructure for the different means, as well as the key interventions carried out to improve the efficiency of the system and its sustainability.

4.2.1 Urban form.

Madrid municipality is connected to the surrounding areas by a set of belts and radial patterns. Taking a look at the highways, the most used infrastructure, we can see the six main radial highways (A1 to A6) combined with three belts of highways (M30, M40 and M50), although the M50 does not complete the circumference as it would cross the protected forest area of 'El Pardo' and the M30 has a small section where it is not a highways. Commonly, although Madrid's municipal term extends beyond the M30, the area enclosed by it is considered the city, and culturally the areas outside the central almond (name given due to the shape of the M30) are considered suburbs.

When looking at the streets configuration of the city, two more belts are identified, there are not highways but a set of wide boulevards and avenues, frequently avoiding intersections by the usage of tunnels and bridges, they are commonly known as the M10 and M20, the city centre district is mostly the area enclosed by the M10, while the M20 is a set of streets between the M10 and the M30. It also needs to be highlighted the north-south backbone generated by the 'Paseos' (Castellana, Recoletos and Prado).

As the transport infrastructure of the city is rather diverse, it needs to be classified. In this report the areas are divided in old towns, expansions and parcelling. The streets composing these areas are classified according to the General Plan of Urban Development of Madrid of 1985 (PGOU) (Madrid City Council, 1985): highways, primary arteries, secondary network and local roads.

Highways: they serve to embrace high transit volume, specifically motorised and basically used for interurban mobility. The six radial

highways and two of the three highway belts (M40 and M50) are regulated by the State. The urban highway belt (M30) was governed by the State until 2004, when it was ceded to the municipality, the same as the A1 and A5 sections between the M40 and the centre and the A2, A3 and A6 between the M30 and the centre.

Primary arteries or urban roads: they serve for long distance metropolitan transit, focussed on motorised traffic but allowing non-motorised. They are the sections of the radial highways contained within the M30, the two urban belts (M10 and M20) and the Castellana axis. All these roads are administered by the municipality.

Secondary network or district roads: their main function is to communicate districts and to connect with the primary arteries. Commonly they coincide with the neighbours limits.

To give some examples, 'Gran Vía', 'Sinesio Delgado' and 'Marqués de Viana' are considered district roads. Their governance belongs to the municipality.

Local roads or streets: they finalise the urban fabric and connect the roads with the surrounding elements. They embrace motorised and non-motorised transport, as well as commercial activities. All the local streets contained in Madrid's boundaries are regulated by the municipality.

Figure 3 shows the highways (blue) and the primary roads (pink).

After classifying and locating the roads, it needs to be mentioned their saturation levels, which, according to MadridSUMP14, only 6% of the roads suffer loads higher than 80% of their capacity.

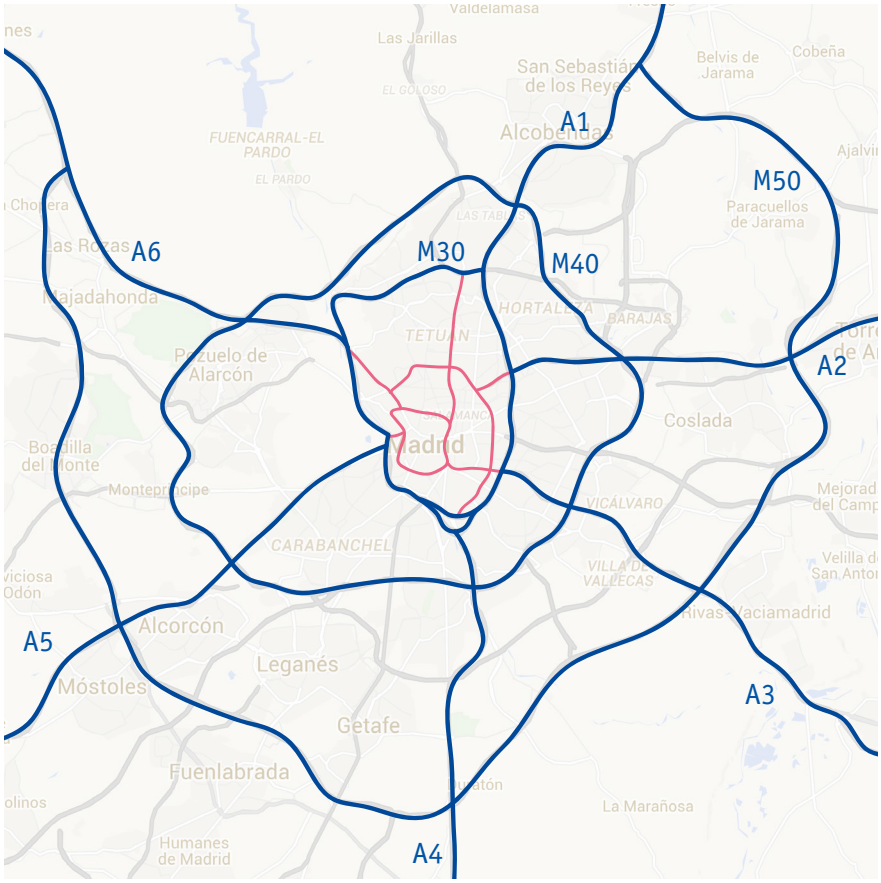

Figure 3. Main car infrastructure: highways and primary arteries.

The old towns are all the areas prior to the expansion plans of 19th century. As the city grown it absorbed the surrounding villages, consequently, there are more old towns than just the central district. The streets of this areas are irregular and generally following the landform, they rarely exceed 15 meters of wideness and then they are part of the secondary network and the local roads.

The expansions are the results of planning aiming to embrace the urban growth. In the case of Madrid, the expansions are important

entities as they now represent central areas, both economic and geographically. The streets of these areas are strictly orthogonal and their widths are between 15 and 40 metres, thus, some of them have become primary arteries that connect fast with metropolitan areas, while the rest are part of the secondary network.

The parcelling are urban growths coeval to the expansions, they generally occurred close to the radial highways, there the areas are harder to plan at such scale, and also after the expansions trend ended, at the beginning of 20th century. Their streets are characterised by a mixed character: on the one hand, a certain degree of regularisation was achieved and the areas can count with a few primary arteries that follow patterns; on the other hand, such limited operations could not change big landforms and then some irregular secondary network and local roads were built to complete the infrastructure.

Figure 4 shows the different infrastructure configurations of Madrid's old town (dark grey) and its main extension plan: Castro (pink). It can also be identified the shape and location of some primary arteries (M10, M20 and Paseos).

4.2.2 Interventions.

Regarding sustainable actions that the different agents have been carrying on over time, they have been reconfiguring the urban space by applying different devices. Firstly, some centric streets were pedestrianised during the 1970s, decision that increased the commerce activities in the area, although commerce owners were unenthusiastic about it before it got applied. During the 2000s the frequency of sustainable legislative actions increased. In 2009, an extensive part of the city was declared Low Emissions Zone (LEZ) and, although the restrictions are quite modest, it was another step towards a sustainable city. In 2004, two of the most effective solutions on car usage mitigation were applied: the Regulated Parking Service (SER) and the Residential Priority Areas (APRs).

a SER.

An important characteristic of car use is the parking practice, it is estimated that 60% of the cars parked in the city are in subterranean garages, however, 500.000 cars are parked in the streets. Accompanying them, undisciplined

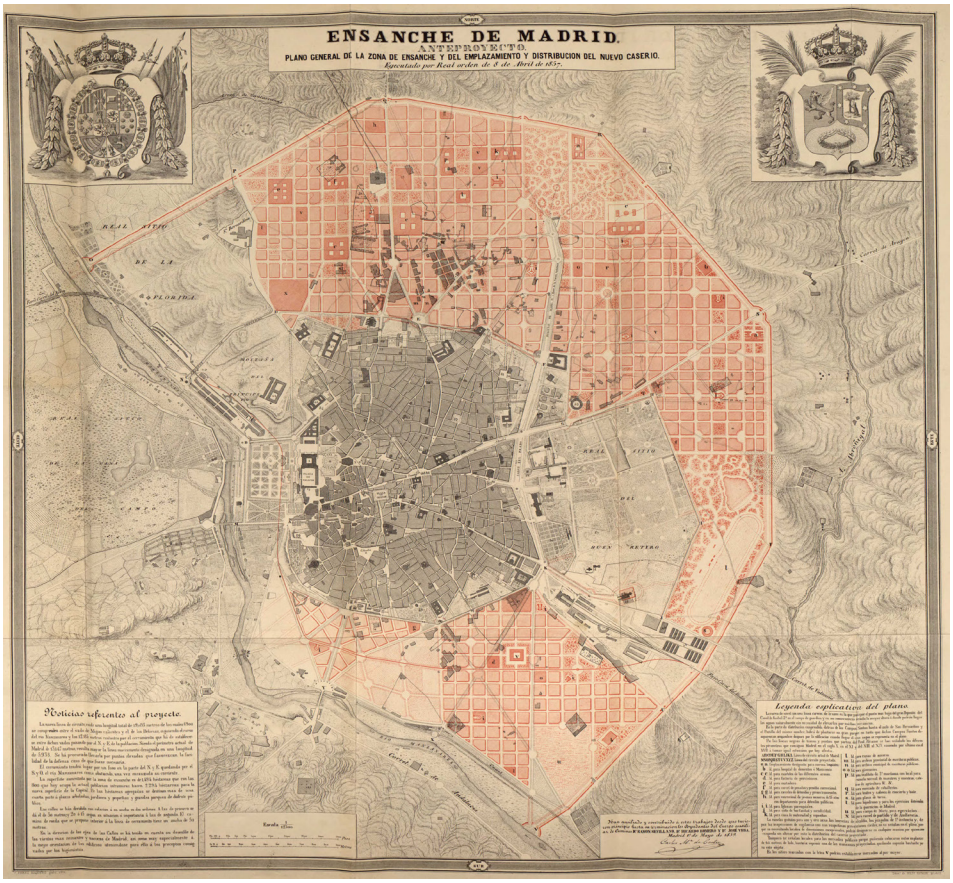

Figure 4. Old town and expansion. Source: Madrid City Council.

parking entails a daily average of more than 6.000 sanctions.

To encounter undisciplined parking was the main reason for the creation of the SER in 2004. This parking regulation consist on the tarification of the parking space, distinguishing green (resident) and blue (foreign) places. Around 77% of the spaces are for residents, entailing an extra cost for foreigners. Since its origin this service has been expanding its area of regulation, as well as raising and modulating its prices, benefiting cleaner technologies and smaller cars. Currently this regulating tool affects to the inner part of the M30 and the old towns Madrid has been absorbing during its different expansion periods.

The implementation of SER entailed a great reduction of traffic on its area of influence, becoming one of the most successful devices in car traffic reduction. On the other hand it also brought critiques from citizens as they considered it a recaudatory device to compensate the increasing debt of the city..

Although the SER was an effective regulation on its area, due to an understandable citizens behaviour (they want to save money), it was generated what is called 'border effect', which is an increase of the cars parked in the areas adjacent to the area of SER; increasing transit traffic on these zones and the problems it brings: increase of travel time, undisciplined parking and lack of space on these areas.

b APRs.
Another strong articulation by the local governance was the creation of the APRs. These areas have strong car limitation, prohibiting the access to non-residents and limiting it to good deliverers, taxis and motorbikes; with the exception of 'access' streets to cross the areas. These policy started by the creation of 'Letras', 'Cortes' and 'Embajadores' APRs in 2004, 2005 and 2006 respectively, in 2015 'Ópera' APR was the fourth and last APR to be established. These areas are all located within the central district, where space problems are more evident, and cover between 40 and 50 percent of the area of the district. Moreover, these areas need a great investment and exploitation costs, hindering the exportation of the system to other, bigger areas. However, some other neighbourhoods have asked to become part of these areas, what leads to believe that APRs brought valued benefits for the residents.

c Public Transport.
Transport Regional Consortium.
The Transport Regional Consortium (CRTM) was created in 1985, its organisational configuration will be defined in following sections, here the main interventions will be analysed. One of the most successful interventions CRTM has applied is the tariff integration with the Travel Pass in 1987, allowing customers to benefit of loyalty advantages. This action led to an immense increase in public transport use, almost 70% more users between 1987 and 2008 (CRTM, 2012). This growth of the demand, eased by the Travel Pass and followed by a sustained expansion of the city, made the CRTM start contributions on intermodality. The different operators started assuming complementing roles and their networks were expanding and adapting according them. Moreover, the use of Interchange points as gathering nodes of modes facilitated a competitive intermodal system, capable to attract even more users, which now can cover a vast area of the city by linking different means of public transport.

Metro expansions.
The public transport represents nearly 40% of the urban mobility, specially supported by

Metro with 293 km of network and more than 600 millions of travellers every year. Since the inauguration in 1919 of the first 3 km line with 8 stations, the Metro has received several expansions due to its great success (14 millions of passengers on its first year), the most significant ones occurring after the creation of the CRTM in 1985.

During the 1990s the network was already 114 km long and one of the referents on expanding a metro network with a contained budget. Since 1995, the proposition of a metro expansion became a main political advantage; during 1995-1999 period they were constructed two new lines, five more were expanded and, for its first time, the metro network exceeded the municipality boundaries to reach the neighbouring town of 'Arganda del Rey', as it was planned to build an airport there. The sixth line (circular) closed its course and proclaimed as the busiest line with more than half a million passengers moved daily, it connects with most of the main metro and train stations and hubs.

The extension plan 2003-2007 is the most ambitious metro extension plan Madrid has ever had. It was planned by the PP (People's Party) once they get to win municipal and regional elections for fourth and third time in a row respectively. This alignment between two of the three main administrations made easier the coordination to project the plan. During this period nine out of 13 lines were extended, three extra stations were built in the existing network, Metro Ligero was created and part of the fleet was renewed. These actions supposed 80 more kilometres and 90 more stations, increasing the existing data by 33 and 43% respectively. The approach of such expansion was on the surrounding towns and a few weakly communicated areas, with the creation of Metrosur (Southern Metro, 2003), Metronorte (Northern Metro, 2007), Metroeste (Eastern Metro, 2007) and Metro Ligero (tram service, 2007). After this large plan, the network has not been further extended and the approach was to optimise the service by reducing incidences, specially in the oldest lines.

Urban bus infrastructure.
The urban bus service has increased its facilities to increase its efficiency. In order to improve the safety and the speed of the service, the infrastructure buses use is a segregated lane that allows them avoid some of these traffic issues. These lanes started to be implemented in 1966 in the centre. However, this intervention seem to be developed quite slow, as nowadays only 12% of the bus network has a segregated lane; these lanes are usually in the primary arteries of central districts, which are the ones that had the space available for a rather straightforward intervention.

Currently the bus paths are shared between buses, taxis and motorcycles; it has been proposed by users' and experts' blogs the modification of the regulation regarding these lanes, from leaving them for an exclusive use for buses, to the inclusion of the bicycles, passing through the exclusion of taxis that are not carrying any passenger. These suggestions show the pressures that experts and niche members are applying to the existing regime, encouraging a more sustainable (and/or efficient) use of the space and available infrastructure by conducting a selective process. However, the voices seem to be unaligned as the diversity of opinions is quite broad and an agreement between actors seems unlikely to happen in the near future.

Interurban bus infrastructure.
To facilitate the operation and speed of the

interurban bus service, it counts with the Bus-High Occupancy Vehicles (Bus-VAO) lanes, which are segregated lanes that change direction depending on the surrounding traffic conditions. Private cars can also circulate on them if they meet a minimum number of passengers, thus, encouraging a more efficient use of cars. Unfortunately, there is actually only one Bus-VAO lane (A6 highway) and, although more have been outlined, there are no plans for future implementation of this solution. The reason behind it may be the large investment needed to create and maintain such infrastructure.

Tram infrastructure.
Metro Ligero's network only shares three stations with the rest of the Metro network, what constrains the multimodality such a small service needs. It has plans to be extended and connect with Cercanías and more Metro stations, this would come together with another Metro expansion.

Intermodality.
While in a smaller city it might be easier to move by using only one mode of transport, the key of Madrid's mobility system is its intermodality, specially when referring to public transport. Intermodality becomes key when a big distance needs to be covered by public transport services, the network of nodes and interexchange points is well organised, concentrating a big number of lines from different modes in a rather small area, facilitating and encouraging the use of public transport. The nodes strategy, which counts with five big hubs and 13 smaller intermodality areas, ensures a quite competitive service in terms of modes available, ease of change and area covered by the node. Although they have room for further improvements, both in capacity and number of nodes, they are currently supporting a key service towards private car reduction. The figure of the CRTM becomes highly relevant in this case, unifying the public transport rates with the Travel Pass (to be explained in further sections).

4.3 Governance arrangement.

Politics have a great influence on modifying the urban form and facilitating infrastructure improvements, benefiting certain means of transport. This section aims to clarify the competences each political body has regarding mobility.

4.3.1 Local competences.
The Municipality of Madrid has two Government Areas (GAs) related with mobility; the GA of Environment and Mobility, responsible of environmental quality and protection, green zones and operation and planification of the M30; and the GA of Sustainable Urban Development, responsible of urban and mobility planning and strategic urban projects.

4.3.2 CRTM competences and configuration.
Within the Region of Madrid, including the city, public transport is coordinated through the CRTM, created in 1985. It administrates, regulates and coordinates several competences of the different operators, however they also have an independent status.

The public transport network is a set of services coordinated by the CRTM, a central administrative organism that controls Cercanías (train), Metro and Metro Ligero (tram), and urban (EMT) and interurban buses. The figure of the CRTM is key relevant as Cercanías is owned by the State, Metro by the Region of Madrid, the EMT by the City of Madrid and the Metro Ligero and the interurban bus services are provided by private companies. Hence,

the force and operation scope of the CRTM is above the providers. Every organisation works as an independent company and CRTM has competences on planification of infrastructure and services, tariffs approval, inspection and sanction, advertising and information, and revenue collection and redistribution.

CRTM is a separate property of the Regional government, founded to link the different public transport providers, coordinating them in a single body. It is created by the junction of the political institutions on three levels: the Ministry of Public Works, Madrid Regional Government and Municipal Administrations. These three bodies have a stake on CRTM and can influence it with top-down techniques. On the other side of the CRTM are the providers or operators, a group of public and private entities, acting in different geographic regions and following different strategies, with the authority of supplying the service itself to the final users. This operators can also influence the CRTM, as they also have assets and are a significant part of it. Figure 5 facilitates the envision of the structure of CRTM.

However, the activity of the CRTM has been lately questioned due to political influences in the organisation (Álvaro Fernández and Rafael Orihuela interviews). The political alignment and stabilisation Madrid Region and City have experienced during the last two decades have allowed internal political appraisals to be included in CRTM priorities, politicising a nonpolitical institution and reducing the veracity of its decisions and interventions. Political influence has commonly been a barrier for the desired confidence and equity of public interventions, being hard for the society to unlink both concepts, as pointed out in the Mobility Forum evaluation (Endurance, 2013).

4.3.3 Political context.

Due to the influence political affairs have demonstrated to have, the basic historical political situation of Spain, the Region and the City of Madrid should be clarified in order

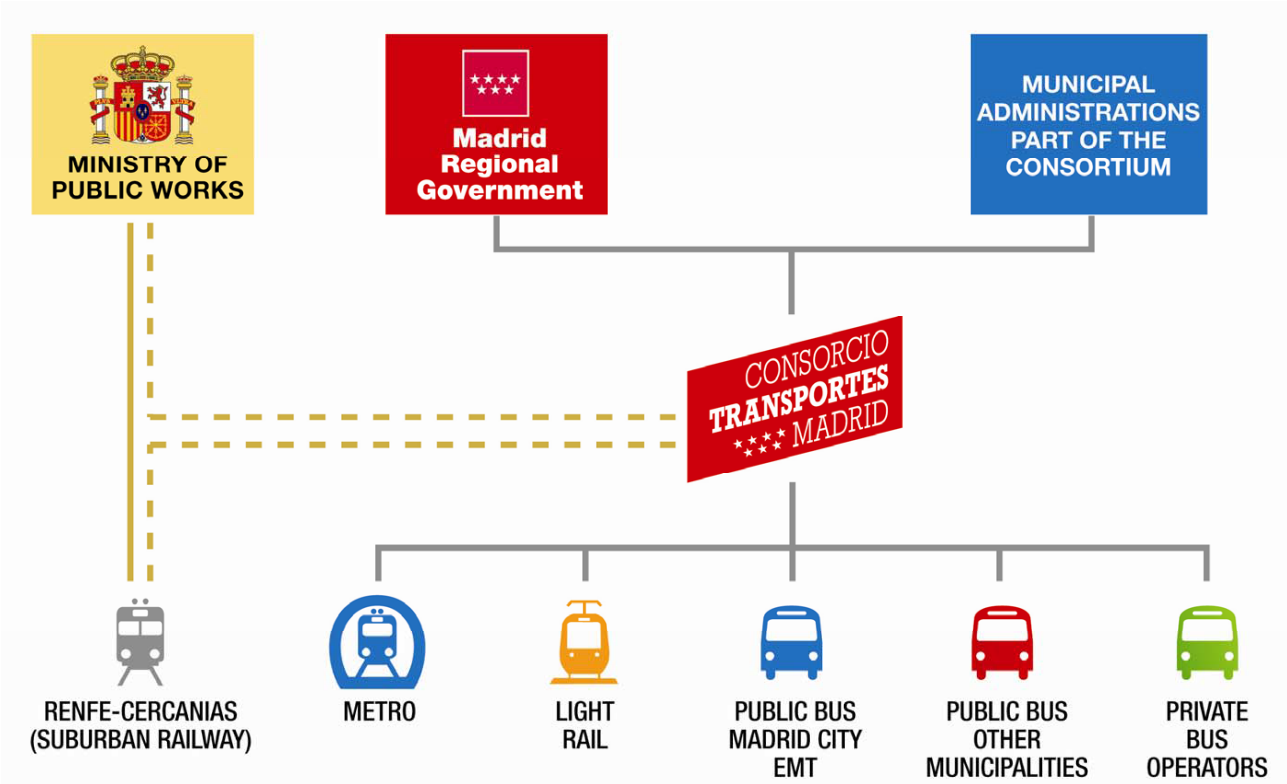

Figure 5. Institutional constitution of the transport regional consortium. Source: CRTM.

to understand the conditions of the current political context. After the political transition, started to the death of dictator Franco in 1975, the political scenario was quite complex and diverse; however, it did not take many years to form long and stable government periods. In 1982, a socialist government (PSOE) was elected and it remained governing during 14 years, since that moment PSOE and PP (conservative) have been the only two parties governing the country, alternated in four governments. In the regional government, PSOE governed during eight years and, since 1995, PP has been the only governing regional party. Stepping down to the local level, PSOE governed from 1979 to 1989 and PP has been governing since 1991, after two years of CDS's (social-democrat) government.

As can be seen, bipartisan has a great weight in Spain's society, and this stabilisation of the political framework led to a distancing between political and civil social spectrum, giving more freedom to the first. The coincidence of the same political party governing both city and Region, eventually also the State, led to an increased agreement between levels; however, it also drastically decreased the diversity of appraisals and internal debates.

As a picturing instance affecting mobility, sustainability and liveability, the burying project of the M30 followed the next process: In 2004, the competences regarding M30 were transferred from the Ministry of Development to the Municipality of Madrid in order to bury and renew southern and western sections of the highway and build a park on the area occupied by the road. After three years of constructions the tunnels were inaugurated and the results were an improved mobility in the area, a reduction of noise in the surrounding buildings and a new park, Madrid Río, awarded for its 'exemplary contribution to the public realm of a city' (Veronica Rudge Green Prize in Urban Design, 2015). Nonetheless, Ecologist in Action NGO used legal devices attempting to modify the project as it did not include any environmental impact evaluation; the court resolution declared the project should not have been approved, however, this latest fact occurred after all the constructions were finished, having no practical influence. This example shows how a local government can carry unsustainable practices on if it has the political support and resources from upper levels.

The burying intervention is also an instance of the economic management of the city, which has increased its debt since the early 2000's, as figure 6 shows. The series of big interventions occurred since then includes the M30 burying project, three consecutive Olympic games candidatures (in 2005, 2009 and 2013), the planification of and investment on vast urban projects that have been cancelled (justice city, convention centres, etc..) added to the hit of the global financial crisis in 2008.

However, the political stability starts ceasing as the socio-economic situation of the country got worse and new parties arose. In May 2015, regional and local elections were celebrated, the governance of capitals such as Madrid and Barcelona moved from traditional parties to the most recent ones. In the case of Madrid, 'Now Madrid' (citizen candidacy) is governing in alliance with PSOE and having PP as the strongest opposition party. Regarding regional levels, PP keeps its governance, which is planned to last until 2019. Additionally, at the national level, Spain is facing a political deadlock with an acting government since December 2015.

4.4 Findings.

To conclude this chapter, the key findings discovered during the regime analysis carried out will be summarised.

It has been found that private vehicle and public transport are the two main mechanised means of transport, which have been stabilised over time thank to incremental improvements on their infrastructure. On the other hand, taxi has been a small but influencing actor, commonly opposing for change. Additionally, there have been identified recent regime members, such as car-sharing, which can be considered as a 'successfully emerged niche'.

Regarding the infrastructure evolution, due to the urban form of the city, the centre has traditionally been transformed to facilitate car mobility. However, it has been identified a bigger focus on liveability and walkability, starting with pedestrianisation interventions in the 1970s, and specially after the 2000s with car mitigation devices such as SER, APR, and LEZ. Moreover, most of the traffic is condensed in wide boulevards, belonging to the primary arteries and part of the secondary network of streets; this fact brings the opportunity to modify local streets without altering car traffic conditions too much. Moreover, the public transport sector has been receiving improvements and acquiring space to create infrastructure, this happened quite slowly but stable over time, excepting certain periods with big political alignment, when infrastructure development occurred faster (latest metro expansion, M30 burying process, etc..)

Shifting to the governance arrangement of the mobility system of Madrid, the existence of superior organisms such as the CRTM has been identified as key for the development of sectors like public transport. Even out of the scope of this project, it has been pointed the importance of this administrative bodies and the relevance to keep them depoliticised. Moreover, the new political situation may bring a large set of modifications that, one way or the other, will definitely affect mobility. The relevance of

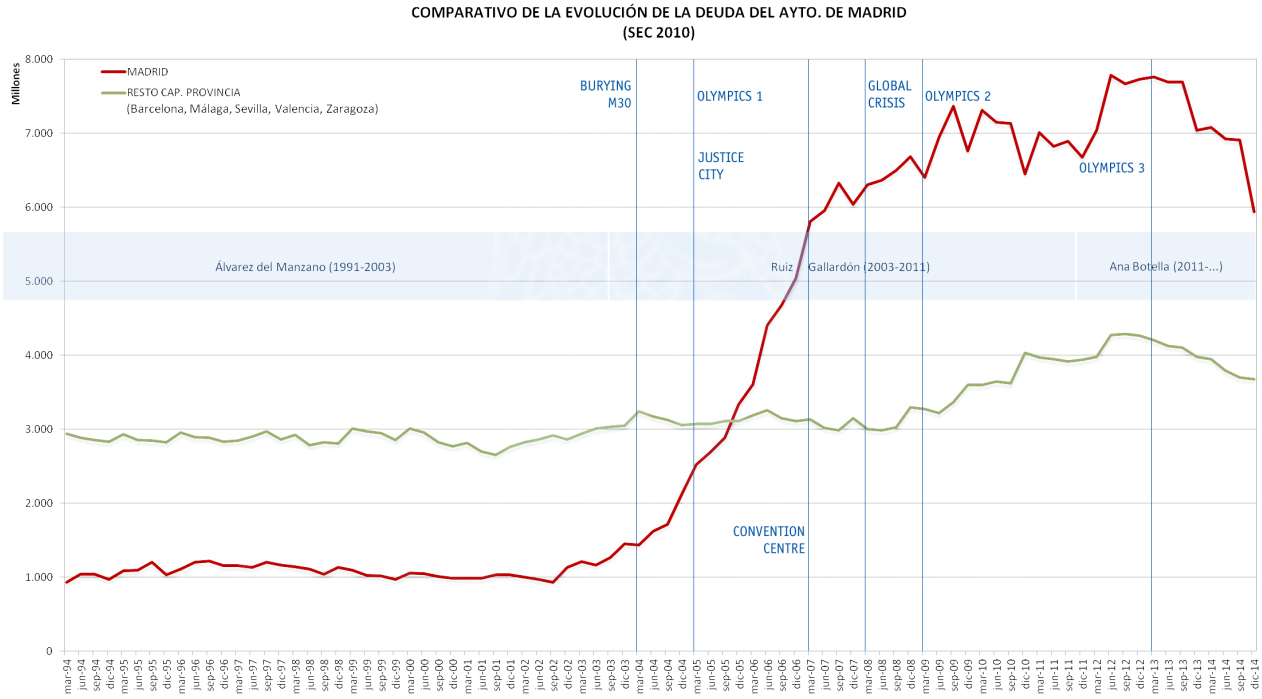

Figure 6. Madrid's debt (red) compared with the rest of the capitals (green). Source: Absolutexe.

bicycle promotion has been identified before the local government change, however, this new group of agents seem, according to their political programmes, highly committed with sustainability and non-motorised mobility (Now Madrid Program, 2015); this might mean the mobilisation of attention and resources that have commonly being placed on public transport improvement to an extensive bicycle promotion strategy.

In this section it has been shown the appearance of mobility system, and, together with the previous section, defined the landscape and regime levels. Henceforth, the niches level will be defined focussed on bicycle niche, and linking groups that can reinforce it.

5. NICHES ANALYSIS

Continuing with the analysis of the three levels contemplated by MLP, the niche level will be analysed. An important element is the identification of selective pressures (Smith et al, 2005). These are mobilisations of actors towards a common objective, pushing on the socio-technical regime. The regime articulates (or not) these pressures according to its adaptive capacity, which is affected by the location and the coordination of the resources to make such change. These selective pressures come from the socio-technical landscape (defined previously), and the niches, which will be defined here. This phase, then, aims to identify the niches, the different pressures applied, the governmental articulations and the common points the different niches have, in order to find elements where two or more niches can create a synergy to reinforce each other; creating external links in order to reinforce the niche.

In this case, the scope has been widened up to include niches that, a priori, might not seem directly related with mobility. Moreover, the interrelation of the niches created between themselves challenges the division of the sectors. These niches are bicycle promotion, NO2 reduction and air quality, parking and land use, and green and cultural public spaces.

The general purpose of the project is to improve bicycle presence in the city, hence, bicycle niche has receive bigger attention than the other niches, and the analysis of the rest of the niches has been performed in order to find potential external links with bicycle niche.

5.1 Bicycle niche.

Bicycle niche is the given name for all the local actions asking for a bigger presence of cyclists, such as a better infrastructure, an increase of safety and a rational amount of additional facilities. To follow the structure set by Schot and Geels (2008), the bicycle promotion niche will be classified in the following dimensions: aims and expectations, social network and learning processes of the niche. The fourth dimension regarding the creation of external links is covered by defining the complementary niches.

5.1.1 Aims and expectations (selective pressures and articulations).

The bicycle pressures and articulations have increased exponentially during the last 12 years. With a barely non-existing mobilisation during the 1990s and the early 2000s, it was in 2004 when Bicicritica started, with less than ten participants, demanding greater presence of bicycles in the city, moving between 4000 to 5000 supporters by 2010. Bicicritica is a bicycle association that applies pressure into the system by the mobilisation of monthly bicycle demonstrations, trying to overload the system to show the need for improvement (Bicicrítica, 2016).

One of the earliest responses by the administrations was based on providing a safe network of paths at the outer parts of the metropolitan area, where the natural landscapes and forests are located; emphasising the leisure aspect of cycling (madrid.es).

In 2008 the municipality creates its first (and only) bicycle-oriented plan (PDMC), generating an ambitious vision about the bicycle use on the city and creating a detailed implementation plan. This plan shifted the attention towards the use of bicycles at urban areas rather than at natural, outer areas. However, it has been documented the plan has not totally been applied; during the interview with Adrián Fernández, he mentioned the case of the street López de Hoyos, a district road in Chamartín district, which was completely renovated in 2014; it was planned this street would hold a cyclist-axis (set of bicycle streets and paths), still it was never achieved; as many other planned interventions.

Moreover, in 2011, the bicycle-focussed blog 'enbicipormadrid' developed a quiet-streets map, where the most peaceful and flat streets are shown and promoted for bicycle use. This map was the base for the creation of Madrid's Bicycle Map, developed by the municipality. The creation of bicycle streets started by allowing bicycle coexistence at some of these quiet streets (David Bartolomé interview). This articulation has two lectures: on the one hand, even though slower than planned, the bicycle promotion is being embraced by the municipality and the number of users is also growing; on the other hand, it seems quite hard to extend this practice out of the local streets, to district or urban roads, and to generate segregated paths. Thus, the bicycle path network appears to have shifted from a leisure to a capillarity approach, which, combined with the perseverance of the users, have a greater number of cyclists as result.

Moreover, in June 2014, Bicimad, the public bicycle renting service, started to operate with 2000 bicycles in the city. After solving the initial problems regarding computing failures and the theft of a third part of the initial fleet; Bicimad counted with 65.450 subscribers at the 30th of June of 2016 (Open Data Madrid), showing the great acceptance the bicycle has on citizens.

However, the inclusion of Bicimad on the Travel Pass is an arising pressure as the bicycle has increased its influence and, in the case of Bicimad, is also a public transport service that can finalise the shortest distances of the public transport network. This solution can be considered as halfway applied as the users can include the Travel Pass on their Bicimad subscription, but still have to pay for each minute they use the public bicycle, changing the meaning Travel Pass used to have (unlimited rides in all the public transport means).

The negotiations to its total inclusion have been started by the regional government; on the other hand, the municipality argues that Bicimad's system needs to improve first, which is an urgent need as the service has been nearly collapsed by an unexpectedly high demand (Adrián Fernández interview).

Regarding current bicycle infrastructure, Madrid uses five types of bicycle paths, namely: bicycle-lanes, bicycle-sidewalks, bicycle-tracks, bicycle-pathways and cycle lanes. The lack of detailed information available, forces this study to group the first four into one group; then, there are two groups of bicycle paths: segregated and shared lanes. The group of segregated lanes uses parts of public spaces to give it exclusively to bicycle use, either using existing car lanes, pedestrian sidewalks or alternative routes. A cycle lane is a standard car lane, limited to 30km/h and shared between cars and bicycles. Figure 7 shows the location of segregated (red and green) and shared (blue) lanes in the city.

Bicycle users and specialists coincide at giving the current main barrier found, which is the aggressivity of the environment, specially in the shared lanes (interviews and several blog articles). The danger perception can be a powerful impediment for new users (Fernández-Heredia et al, 2014). However, these actors differ at providing specific solutions (consults with Luis Fernández and Eva Ramos); while some of them strongly support

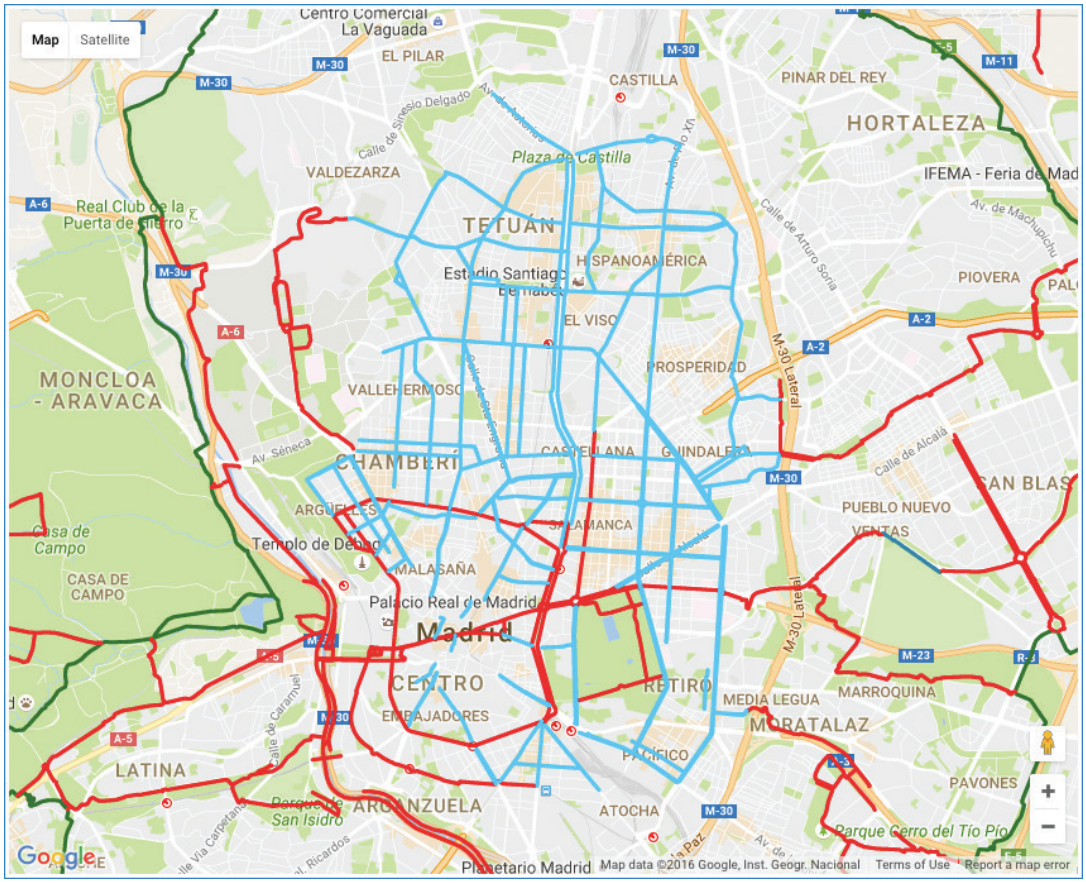

Figure 7. Segregated (red and green) and shared (blue) bicycle lanes. Source: infobicimadrid.es

segregated lanes, some others do not see them as the final solution, and think that other actions, like vandalism protection or a stronger car regulation, may be more important. They also point at a small internal coordination of resources, stating that some interventions could be executed immediately (Adrián Fernández interview).

Currently, the main demands of bicycle users are two: the reduction of danger perception, and an interconnected bicycle infrastructure. They are both based on safety, and are key elements demanded by current cyclists (interviews and experts blogs), potential new cyclists (interviews) and academic studies (Fernández-Heredia et al, 2014). An interconnected infrastructure is aimed by cyclists, landscape pressures (KonSULT, and European toolboxes), experts (interview with Adrian Fernández), and implicitly by other interviewed actors (novel cyclists are only brave enough to use the bicycle in parks and areas without car traffic).

5.1.2 Social network.

Currently the pro-bicycle collectives are well organised structures with a substantial identity, able to attract new followers faster than other groups; as can be seen in the increase of cyclists, Bicimad subscriptors, demonstrators, etc.. They also have created a heterogeneous network of actors complementing and supporting each other, which strengthens their actions and mobilisations, and makes them able to reach both political, social and technical characters for further growth and acceptance of the bicycle (Adrián Fernández interview).

The fast growth of the bicycle use and activity is also generating some rejections and conflicts. First of all it exists the experienced conflicts at Serrano street between cyclers and pedestrians, as the action in that case was to take space from the sidewalks to give it to a bicycle path, which was confused with the former sidewalk (MadridSUMP14). Moreover, taxi drivers qualify them as dangerous due to their reduced speed (while shared paths are limited at $30^{km}/_{h}$) and, during an informal interview, it has been declared they are partially responsible of taxi's market reduction. Additionally, particular car drivers have reduced their tensions with bicycles as they adapted to share the roads with them (Adrián Fernández interview), still few conflicts can be found.

The current status of social influence by bicycle niche is already quite deep as experts and experienced cyclists are involved in 'Mobility Tables' (decision maker with agency, influencing upcoming strategies of the regime) (Adrián Fernández interview). However, and although it has achieved a rather broad expansion of the relations, the niche has room to be linked with more niches or regime actors, the relation with public transport seems key as the distances covered by an intermodal journey are greater and with a more competitive speed and convenience than using a single mode of transport. Currently it is allowed to bring the bicycle in the public transport under certain tight schedule and capacity conditions. Finally, links with ecologists groups are existing but weak and can be reinforced, for instance, by creating of calculative devices that fulfil the aims of both groups.

5.1.3 Learning processes.

Learning processes should be used to accumulate knowledge from different local actions, and create a path towards a global niche goal. In this case, the knowledge is mostly stored in websites and pro-bicycle blogs, which continuously carry out surveys

and respond to both, common questions beginner cyclist may have, and detailed issues experienced users and experts want to share. The connection between these cycling associations (blog owners) and the municipality is stable, the associations are carrying on a double function regarding this aspect: they communicate citizens' suggestions to the city council, and help citizens to understand the latest city interventions and regulative changes, and their consequences for bicycle and car users.

On the other hand, the municipality accumulates data and shares part of it in its open data website. Nevertheless, the data shared is often incomplete as cyclists have been considered an statistical error as there was a lack of technological instrument to properly measure them (Adrián Fernández interview), not updated (in some cases the newest data available is from 2012, very early if we consider the fast development bicycle niche has had during the last five years), and commonly hard to be found and manipulated (only few formats available, which require specific software to work with it).

5.2 Linked niches.

As mentioned beforehand, the social network of the bicycle niche has room to be broaden up, it has been identified some common aims with other niches, which are the followings:

The second niche identified is the NO_2 reduction and air quality. This is a set of actors concerned with health issues and trying to reduce pollutant emissions. As it has been demonstrated, traffic is one of the main particles and NO2 emitters, therefore, one of the main aspects of this niche resides in its effort on reducing car use by applying restrictions to them.

Scientific researches are the main driver of this niche; through the use of technical diagnosis tools and calculative devices (Jens et al, 2015), set the direct consequences the pollutants have in our health and identify their origins, easing the task of regulating them in order to improve air quality and health. Ecologist organisations are often collaborating with scientists, providing resources, contacts and promoting the results, usually accompanied by proposals to tackle the problem.

Common citizens, when, through district and resident associations, have been presenting complains about the daily problems they face, are an important active part of the niche, however, their interest is personal and they do not tend to organise in bigger bodies than residents' communities. Nonetheless, the new local government has activated a website where citizens can propose their solutions and, if they get the necessary support, will be studied and applied (Decide Madrid, 2016). This action shows the intention to bring down the institution to the population, giving more power to non-organised citizens.

Moreover, all the regional and national Air Quality Plans, in addition with the European and international policies, add bigger pressure to the regime, in this case coming from the socio-technical landscape.

One of the main articulations has been the NO_2 protocol and the local Air Quality Plan 2011-2015 (or AQP11). The first one is composed by a set of scenarios depending on the pollution levels, these scenarios add extra regulation to the system, from reducing speed limits in the highways to the prohibition of parking for non-residents. This protocol has been highly

criticised from both car users and higher rank politicians. One of the main solutions proposed is the regulation of car traffic regardless the pollution levels, the supporters of this modification argue that it would allow a better and easier planning for the car users and the prevention of reaching undesirable pollution levels. The local AQP11 maintains most of the strategic lines of the AQP06 and add 70 more actions, 60% of them regarding mobility and car mitigation, followed by educational and informative actions. Regarding bicycle infrastructure, this plan projects almost four millions Euros for the creation of cycle lanes within ZBE and only mentions the segregated bicycle lanes of M10 and Mayor-Alcalá streets axis.

The cluster regarding parking and land use, tries to reflect on the amount of space the city has and the use given to it. This niche is composed by housing and infrastructure construction organisations, private parking companies, residents' communities and affected commerces owners. It has to see with urbanism and long term regulation, with PGOU as the regulative cornerstone, this land managing plan is being reviewed and the new version will be presented soon, it regulates the requirements for new buildings such as minimum percentages of renewable energy generation, the number of parking places it has to hold and where (usually underground) or the constructible/ green areas ratio. Major urban projects are having ongoing negotiations such as the Northern Castellana District or the 'Calderón' Operation, the government change has delayed the negotiations as new appraisals scaled some positions.

The most effective tool to reduce car use is the SER (described in page 21). As a survey carried on by the municipality shows, parking regulation is the main driver for car owners using public transport, either because of a lack of free places or because the price it has, followed by the intention to avoid traffic jams.

Another strong articulation by the local governance was the creation of the APRs. These areas have strong car limitation, prohibiting the access to non-residents and limiting it to good deliverers, taxis and motorbikes; with the exception of 'access' streets to cross the areas. These policy started by the creation of 'Letras', 'Cortes' and 'Embajadores' APRs in 2004, 2005 and 2006 respectively, in 2015 'Ópera' APR was the fourth and last APR to be established. These areas are all located within the central district, where space problems are more evident, and cover between 40 and 50 percent of the area of the district. Moreover, these areas need a great investment and exploitation costs, hindering the exportation of the system to other, bigger areas. However, some other neighbourhoods have asked to become part of these areas, what leads to believe that APRs brought valued benefits for the residents.

The niche claiming green and cultural public spaces is the least mobility related one, however, it could be directly linked to the previous one. Although its name refers to a pretty narrow element, it also includes cultural and artistic elements, understanding that they can support each other and create a convincing combination. Due to this diversity of actors within this niche, it becomes challenging to define a clear inclusion/exclusion line, however, and as always, citizens' voices are an important part of it, and a clear example of that is the result of the survey carried on by the municipality regarding the renovation of 'Plaza de España', a central main square. On the survey presented, citizens shown their interest on greener open areas holding

cultural activities. The strong cultural roots Spain has, lead to a generalised acceptance of cultural elements and events; some artistic collectives have increased cultural awareness, while renovating degraded areas of the city and beautifying big grey facades by painting them (Espacio Tetuán, by Intermediæ, is a good example of it). Something similar occurs with urban art, which has usually been welcomed in the city with artistic collaborations between art agencies and other disciplines; for instance, the art collective 'Boa Mistura' collaborated with singer 'Leiva' to modify the crosswalks and include inspiring sentences and poems, and agreement with and support from the municipality is therefore taken for granted. Additionally, in the interview with David Bartolomé, links between bicycle and liveability concepts have been identified.

These four identifies niches are, naturally interrelated, as they coexist in the same geographical space and commonly have shared interests. To give an instance, a street art intervention that has visual elements regarding the smoke of the cars, is an example of how two niches are supporting and benefiting from each other (in this case, air quality and green and cultural public spaces). On the other hand, removing car parking to install urban facilities or bicycle infrastructure is another way to link two niches by finding common goals.

5.3 Findings.

Summarising this section, bicycle niche will be diagnosed. The status of the niche seems to be in a rather early stage, with uncoordinated demands and an obvious lack of public infrastructure. The ways users have shown such demands can be divided in two groups, which are adding pressure in the regime by executing demonstrations (the case of Bicicritica), and collaborating by sharing knowledge, experiences, and recommendations (like happened when enbicipormadrid provided the quiet streets map). Some challenges to improve the performance and development of the niche have been identified. One of them is the lack of space available for interventions, requiring extra interventions to obtain such resource. Secondly, a lack of aligned demands weakens the niche; although diversity of opinions always enrich the debate; visions should be structured and consensual in order to apply a coordinated pressure on the regime.

However, the great amount of information available can facilitate bicycle development. International and European reports, conferences and supporting programmes (landscape pressures) can be used to perform a better diagnosis of the situation. Moreover, experts and experienced cyclist are very active actors, continuously contributing to bicycle development. On the other hand, the municipality has been embracing some of these contributions, articulating selective pressures coming, in this case, from niche levels. The Sustainable Urban Mobility Plan of Madrid of 2014 (MadridSUMP14) shows that 12% of the roads hold more than 50% of the traffic; while the other 50 is distributed between the remaining roads, giving these latest streets great room for sustainable actions to encourage non-motorised transport.

By coding the information obtained during the interviews and desk research of bicycle blogs, the lack of infrastructure is identified as the main problem of the bicycle niche. This fact places bicycle as a marginal mean of transport, which is not only a symbolic message to the society, it also discourages new users by maintaining its danger perception.
Figure 8 sums the theoretical structure of the

framework analysis carried out, and closes it before introducing the design process chapter. Next chapter introduces the design goals and the concept development carried out to address them by the proposition of a set of interventions.

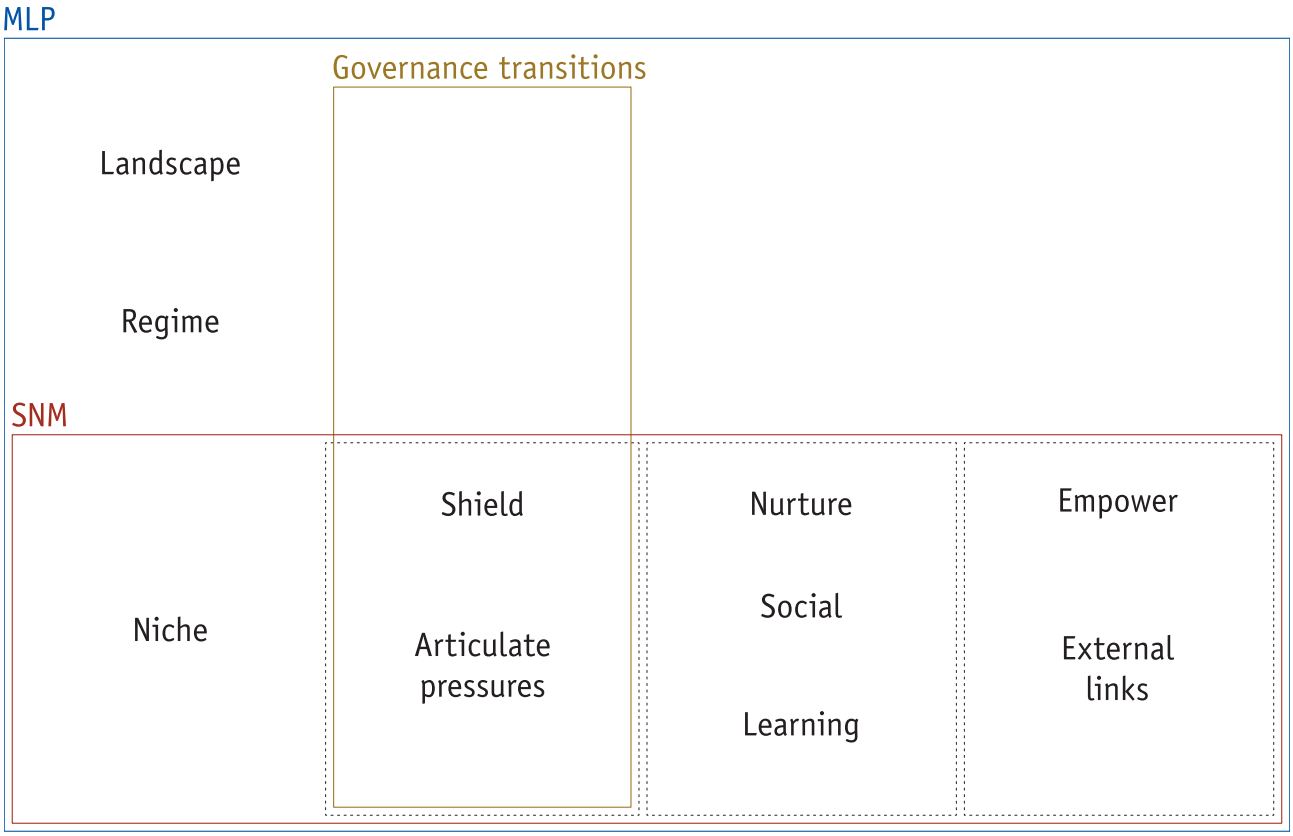

Figure 8. Theoretical complementation diagram.

DESIGN PROCESS

1. DESIGN GOALS

After having described the problem to be addressed, and the findings discovered during the analytical phase, the design process starts by setting certain goals and recommended actions. Such goals are structured following Schot and Geels (2008) approach, and are an intermediate step towards bicycle niche reinforcement.

1. The articulation of visions and expectations. The solution must compile a moderated combination of the current regime status with the momentum and pressures coming from the niches and landscape. This is the creation of a vision that addresses the general priorities found during the research, and that does not differ much from current Madrid's one in its key values, focussing on the niche barriers and drivers, and on the adaptive capacity of the city.

2. The facilitation of social networks and learning processes. In order to maintain and improve the effect the interventions will have, it is required to include niche nurturing elements into the design. This is the accumulation of data and its application into calculation processes that can bring empirical findings. It is also the definition of elements that can create a social space where social activities and learning processes can take place.

3. The creation of external links. The creation of external links is key to join forces, process that will lead to a stronger bicycle niche, as it is supported by actors and activities. Here is where the general expectations of the population should be included in the project, linking bicycle mobility with the liveability agenda or the SER expansion demand.

2. CONCEPT DEVELOPMENT

After setting the design goals to be addressed, the development of the interventions proposed followed student's industrial design background. This process has five phases that follow a divergent-convergent process (Dym et al, 2005). The first phase consists in the set of the design goals to reinforce the niche by; they can be summed up as strengthening the bicycle niche by protecting and extending four dimensions: articulation of expectations, creation of social network, facilitation of learning processes, and link with external niches and actors. The second step was the creation of a broad field of possibilities through the generation of multiple ideas, this has been a key phase as this is the broadest phase of the design process and the elements that are not included in this phase cannot be considered later. Thirdly the early ideas generated have been joined following different combinations, reducing the number of elements and making more specific sequences that aim to tackle particular problems, and, thus, reinforce niche's dimensions. This combination process is connected with an evaluation and selection process, where certain solutions are excluded and some others remain, this process has several iterations, continuously combining, evaluating and excluding (or keeping) the resulting combinations. Finally, the unfolded combination has been materialised by representing it graphically, the results have been sent to experts in order to receive feedback.

This design approach allowed the student to use his former experience and to follow a familiar process, easing the development and encouraging creativity during it. However, the actors to be mobilised are Madrid's urban planners, which have a different background

than the student, this professional gap could not have been totally covered, although it has been tried to be complemented by the usage of planning manuals and advises. Therefore, the final proposition does not look at the detailed implementation of the strategy but at providing valuable insights for professional planners with richer experience and know-how skills.

In the following paragraphs the most significant parts of these phases are going to be described, although the design process did not follow a straightforward sequence of well defined elements, rather, it was a seamless and iterative journey from the uncertainty to a final focus or result (figure 9). This situation may be seen as a weakness, as it does not look like a solid process; however, there are some abilities linked with design thinking that make these processes needed, namely '*tolerate ambiguity that shows up in viewing design as inquiryor as an iterative loop of divergent-convergent thinking, maintain sight of the big picture by including systems thinking and systems design, handle uncertainty, make decisions, think as part of a team in a social process, and think and communicate in the several languages of design*' (Dym et al, 2005).

The structure of this section follows the interventions suggested and explains their development over the mentioned phases.

2.1 Bicycle network.

The key findings found during the research phase, point at the importance of the fear factor as one of the main barriers to attract (and keep) new cyclists. The interviews with non-experienced cyclists, and articles like 'Understanding cyclists' perceptions' (Fernández-Heredia, 2014) are the main sources of such information. This is understood as the main expectation that potential niche members have regarding the development of bicycle niche. On the other hand, multiple landscape pressures, like international planning manuals (UN-HABITAT, 2016)(EU Commission, 2016), and tools (KonSULT), recommend the creation of an interconnected bicycle network. Additionally, SNM literature shows the necessity of protecting the niche, specially by articulating pressures (Smith et al, 2005) and expectations (Schot and Geels, 2008).

To show an example of how landscape pressures encourage public administrations to construct bicycle infrastructure, the policy tool KonSULT (Leeds University, 2016)) has been used in order to get interesting measures to be controlled

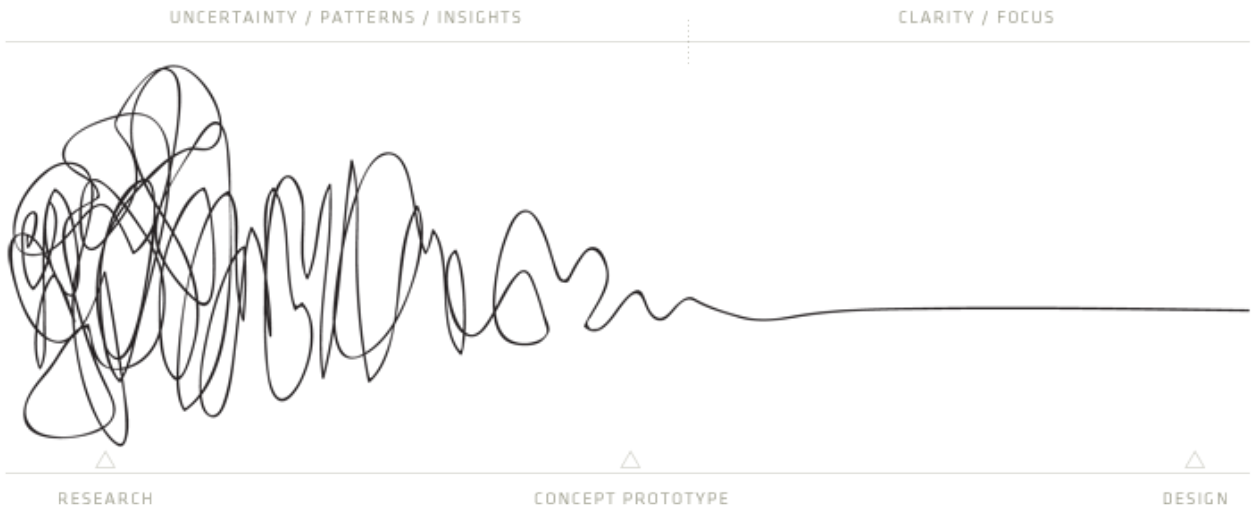

Figure 9. Design squiggle. Source: Damien Newman.

by planners. This tool asks for city data and a set of objectives the city wants to address, then, it provides an ordered list of measures that need to increase in order to achieve the objectives set; these measures can be grouped in synergy packages, which bring a more solid and coherent set of complementary measures. For this project, this tool has been used twice. In the first case, it has been used placing different priorities gotten in the interviews and prioritisation games; while, during the second use, it focussed on sustainable development based on improving cycling conditions.

The information gathered during the interviews and design games bring the following order of priorities: universality, sustainability, and competitivity. This information has been included in the objectives (although the names changed to equity, protection of the environment, and efficiency). These objectives, applied to any strategy (general), give a synergy measures package formed by: cycle networks, accident remedial, road user charging, pedestrian areas and land use to support public transport, with a package score of 59/100. These measures are, according to KonSULT, the most relevant policies to be applied to achieve the objectives set, based on the prioritisation game used with the interviewees.

In the second use of KonSULT, it is considered that the main objective to be achieved is to protect the environment and the strategy to be applied is to improve walking and cycling conditions. The resulting package of measures is as following: cycle networks, road user charging, pedestrian areas, promote low carbon vehicles and create low emissions zone. This package has a score of 62/100.

Analysing the results of the tool, cycle networks, road user charging, and pedestrian areas appear in both of the contexts, becoming extremely relevant policies to achieve multiple objectives. Moreover, the recommendation of the creation of a low emissions zone was already applied by 2009 with the LEZ covering most of the central almond of Madrid. Regarding bicycle use, it seems the creation of an interconnected infrastructure of bicycle paths is key to promote this mean of transport. However, the tool does differentiate between the creation of a cycle network and segregated cycle facilities, this second policy appears on ninth position with a score of 40/100, pointing this policy should not be undervalued although some others are preferred. Summing up, the final understanding of the use of this tool is that, in order to promote bicycle use between citizens, it is needed to create a connected bicycle network, segregating it from traffic wherever it is possible and needed; while, on the other hand, if the objectives were car reduction and walking promotion, tolls and pedestrian areas would be the paths to follow.

The use of KonSULT has been done as it is a representative of landscape pressures, key to be articulated by the regime and create openings that can be exploited by the niches to emerge, according with MLP approach (Geels, 2006). The creation of bicycle paths, however, is also motivated by citizens' and cyclists' demands, as well as by part of the experts interviewed and cycling associations' blogs.

Together with KonSULT, and the demands identified that aim at having an interconnected bicycle infrastructure, the danger perception identified by Fernández-Heredia et al (2014), and the aggressive environment defined by both Adrián Fernández and members of 'Vida Sostenible' Foundation (interviews), point at the creations of segregated bicycle tracks.

This will highly mitigate the fear factor, and, therefore, encourage new citizens to use the bicycle, what, in other words can be defined as the creation of a protecting space that has two functions. First, it recognises the existence of the bicycle niche as a competitive mode of transport that can provide social and sustainable benefits for the society. Second, it provides a physical space for it in a public space, favouring the interrelation between actors and strengthening current niche activities. On the other hand, it is known that the creation of segregated infrastructure has higher costs, plus the social and environmental impacts generated by the construction and implementation of such device.

The possibility of creating shared lanes with cars has also been observed, they are currently the most common type of infrastructure for bicycles in the city, specially in these locations where the space has an extra value due to a high transit received or a small capability for transforming the place. Moreover, it does not require a high investment and its implementation could be finished in shorter time than segregated tracks. Nevertheless, and although the creation of new bicycle infrastructure would always favour the niche, it does not help to reduce the fear factor, which may lead to an inefficient use of the solution. Regarding a common disagreement between cyclists in this field, it is not uniformly agreed that this design provides real agency to the bicycle niche; a part of the cyclists believe that sharing path with cars and other means gives them the status of an established mean, circulating in equal conditions with the rest (Luis Fernández and Eva Ramos consults, and multiple cyclists' blogs discussing about the topic); on the other hand, the other part reclaims a 'private' infrastructure to be used only for bicycles. Regarding this issue, it is needed to recall the theoretical approach followed: SNM states that a niche protection and nurturing will help its development, the

Figure 10. Shared bicycle lane. Source: enbicipormadrid.es.

creation of a protective space is needed to leave the niche grow; however, this protection should not be neither over-protective nor too long in time. Linking the issue with the theory and considering the current status of the niche, it seems more legit to provide a protective space (segregated lanes, amongst other interventions) until the niche is strong enough to compete equally with the rest of the means.

Part of the design process is to combine primitive ideas after analysing them, joining benefits and mitigating potential problematic consequences (third design phase, combination). Additionally, an analysis on MLP used in transport, found that: '*The results indicated a take-off in alternative technologies most closely aligned with the regime (hybrid-electric, low-emission and biofuel vehicles), but no diffusion (yet) of more radical technologies (e.g., battery- electric, hydrogen-fuel cell vehicles)*' Whitmarsh (2012). Therefore, it was needed a design capable to mitigate the fear factor and that provides cyclists their protective space, while, at the same time, does not entail a large investment and can be easily reversed if the intervention does not receive the expected amount of users, in order to follow Madrid's strategy approach. This is a way of moderate a radical solution (totally segregated bicycle track) to make it closer aligned to regime's appraisal, following Whitmarsh's observations. Then, a detailed observation at the appliance of the different types of infrastructure and their costs is needed.

A shared cycle-lane starts with an existing standard car lane, the intervention consists in the use of paint to create horizontal signs that set the speed limit in $30^{km}/_{h}$ and a bicycle icon with arrows (figure 10). It has been demonstrated that this solution has had a greater success that expected, however it does not provide the optimal conditions to engage non-experienced users. The strong point is the low cost this design has, which has been

Figure 11. Low cost segregated bicycle lane. Source: enbicipormadrid.es.

projected to be between 6 and 270€/m (45 and 2025kr/m) (PDMC, 2008).
Segregated bicycle lanes have higher costs range, according with the bicycle blog 'enbicipormadrid' (cycling in Madrid, 2016) the projected interventions that include bicycle-tracks have a cost between 220 and 950€/m (1650 and 7125kr/m), this price includes all the secondary interventions needed, such as the creation of vertical signs, modification of public furniture, relocation of bus stops and, in the case of the most expensive ones, the intervention is almost an entire renovation of the street and surroundings. Focussing on the lowest price range, between 220 and 400€/m, it allows the implementation of horizontal and vertical signalling and small modifications of the structure such as protective curbs and reposition of public facilities (primarily litters); the expected result of these low cost segregated lanes can be seen in figure 11.

Although the creation of a protective bicycle infrastructure would probably invite a greater amount of cyclists and, therefore, increase the sustainability of Madrid's mobility system; the coordination between and combination of different successful actions in a single intervention is expected to bring two extra benefits: the first one is the creation of a more solid intervention that will send a stronger message to the population; the second one is the saving of resources, an increase in efficiency would entail less monetary costs and a shorter construction time, with less environmental and social impacts than two separate constructions. Between all the interventions mentioned and analysed during the framework analysis (page 4), it must be highlighted again the great car use reduction that parking regulation policies brought. The combination of facilitating sustainable mobility alternatives (non-motorised transportation) with the regulation of pollutant means (private combustion car) would not just force some citizens to stop using the car and look for alternative means (car and ride sharing, public transport, etc..), it would also ease the election of the bicycle as the primary mean even if the person does not own or use car. Therefore, parking regulation was included when combining the diverse elements that would create the final proposal, it could have been included in several ways; extending SER influence area, reducing parking capacity, suggesting a price raise, or reducing non-residents parking have been the most discussed alternatives.

As could have been seen during the framework analysis (page 4), the articulation of landscape and niche pressures by the governance (Smith et al, 2005) is essential to favour sustainable transition processes, specially when they are in the de-alignment phase, as is the case of the city of Madrid regarding bicycle mobility. Additionally, SNM literature encourages niche protection to accelerate niche emergence into the regime (Smith and Raven, 2012; Schot et al, 1994; and Schot and Geels, 2008). Moreover, Whitmarsh (2012) found that interventions aligned to the regime have more possibilities to be successful. Consequently, the creation of segregated bicycle lanes thank to a low cost intervention, contributes actively to bicycle niche protection.

2.2 Indicators and narratives.

The decision of using narratives comes from the goal of reinforcing the social dimension of bicycle niche. Jensen et al (2005) uncovers the relatively high relevance that calculative devices had during bicycle transition in Copenhagen, constructing strong socio-technical networks by the use of practices

produced by the knowledge generated. Some of the most salient devices used to create narratives and practices have been the accident risk, which is also being used in larger cities with a later bicycle transition such as New York (The City Of New York City Council, 2014); perceptions about the cycling experience; and financial savings due to health production by cycling.

International planning guidelines (Switch, 2016; and Ch4llenge, 2016) also recommend the use of measures to prove the effectivity of the interventions applied. Ch4llenge manual (2016) suggests a set of indicators organised in categories, the indicators suggested here have been chosen and adapted to facilitate the construction of narratives. Figure 12 shows the ten selected indicators, a brief description and their contributions.

Schot and Geels (2008) suggest the facilitation of social networks and learning processes, in order to nurture the niche. Many challenges have been found to obtain a solution, even more when taking into account current political status in Spain, and specially in Madrid. However, the political change, after 24 years of the same governing party, made media and public opinion way more sensitive about new interventions carried out. Former government is linked to a traditional party with a long history, it means common belief will hardly change over short timeframes, as it is already a deeply established belief. On the other hand, the rise of a new government without previous exposition to public opinion, means that public opinion still being formed, and, then, has higher plasticity than former government's belief. This plasticity is considered as an opportunity to create visions, which importance is emphasised in SNM literature to favour transitions. These visions can be developed with narratives, Smith and Raven proposed that

INDICATOR	DEFINITION	CONTRIBUTION
Average time saved per passenger.	Average difference between time required to travel in actual conditions for motorised traffic, public transport, pedestrian and cyclists, classified in 5km sections.	Location of ranges where motorised means are the most competitive, to reinforce future strategies.
Average cost saved per passenger.	Average difference between travel cost for users in actual conditions for motorised traffic, public transport, pedestrian and cyclists, classified in 5km sections.	Support narratives that have monetary savings as their main argument towards non-motorised mobility.
Share of liveable streets perception.	Share of streets considered pleasant and with a safe environment for walking and social interaction.	Finding patterns and elements that increase such indicator.
Non-car accessibility to main services.	Percentage of non-car households within 30 or 60 minutes of city centre or main suburban centre with shopping and medical service provision.	Location of areas with a poor accesibility to reinforce alternative means.
Accidents, injured and killed persons.	Total number of accidents and of persons injured and killed in traffic accidents, classified by transport mode and area.	Identification of the most dangerous modes and areas, to reinforce safety and justify mitigation strategies.
Perceived safety by transport mode.	Average difference between perceived safety in actual conditions for motorised traffic, public transport, pedestrian and cyclists.	Identify the elements that make a transport mode be perceived as safe or dangerous.
Average business satisfaction.	Percentage of businesses rating transport provision satisfactory, for both goods and employees mobility.	Location of industrial areas with a poor transport provision.
Economic losses due to health.	Working days lost through illness and their monetary impact. Health contribution or loss by transport mode.	Monetise transport modes' impacts, create a cultural division between health producers and obstructors.
Cost recovery for transport investments.	Average difference between economic investment and revenue ratios, including health production and other macroeconomic indicators.	Wider elements inclusion in financial balances evaluations. Creation of broader external linkages.
Travel behaviour characteristics.	Total passengers, number of trips, trip frequencies, trip lenghts, number of transport modes and trip purposes by transport mode.	Link and evaluate transport modes diversity, to improve multimodal mobility experience.

Figure 12. Indicators and contributions. Adapted from Ch4llenge.

narratives '*will show a number of characteristics: (a) positive expectations about the future that justify the niche to wider audiences; (b) explicit claims for present-day niche friendly institutional reforms; and (c) statements that re-frame the past to criticise the prevailing regime in ways that emphasise future opportunities for the innovation*' (2012, p1034). These narratives are to be developed and applied by the governance, this project points at the importance of narratives to wide-up the social network of bicycle niche, and suggests their creation supported by empirical data, which comes from the above suggested indicators.

2.3 Social spaces.

In order to strengthen bicycle niche, it is recommended to promote social interaction around it; additionally, it is advocated to create external links, so cycling activities will seep over time into daily activities (Schot and Geels, 2008). The identification of potential spaces that can hold social activities, is needed to start designing a reconfiguration of such space. Site selection has been carried out by locating large public open areas, uniformly distributed over the city. This ensures the existence of one of these social spaces within a relatively low distance from citizens' houses and/or workplaces, and reinforces the open character that these spaces should have in order to attract interactors.

Eight places (figure 13) have been identified by the student as suitable to host the social activities that are to be described; nevertheless, it is to be seen if local citizens are willing to assist to the selected places, or if they would prefer private closed areas (sport or cultural centres). Private interventions have been considered, however, as the main intervention (create an interconnected network of low-cost, segregated bicycle lanes) is designed

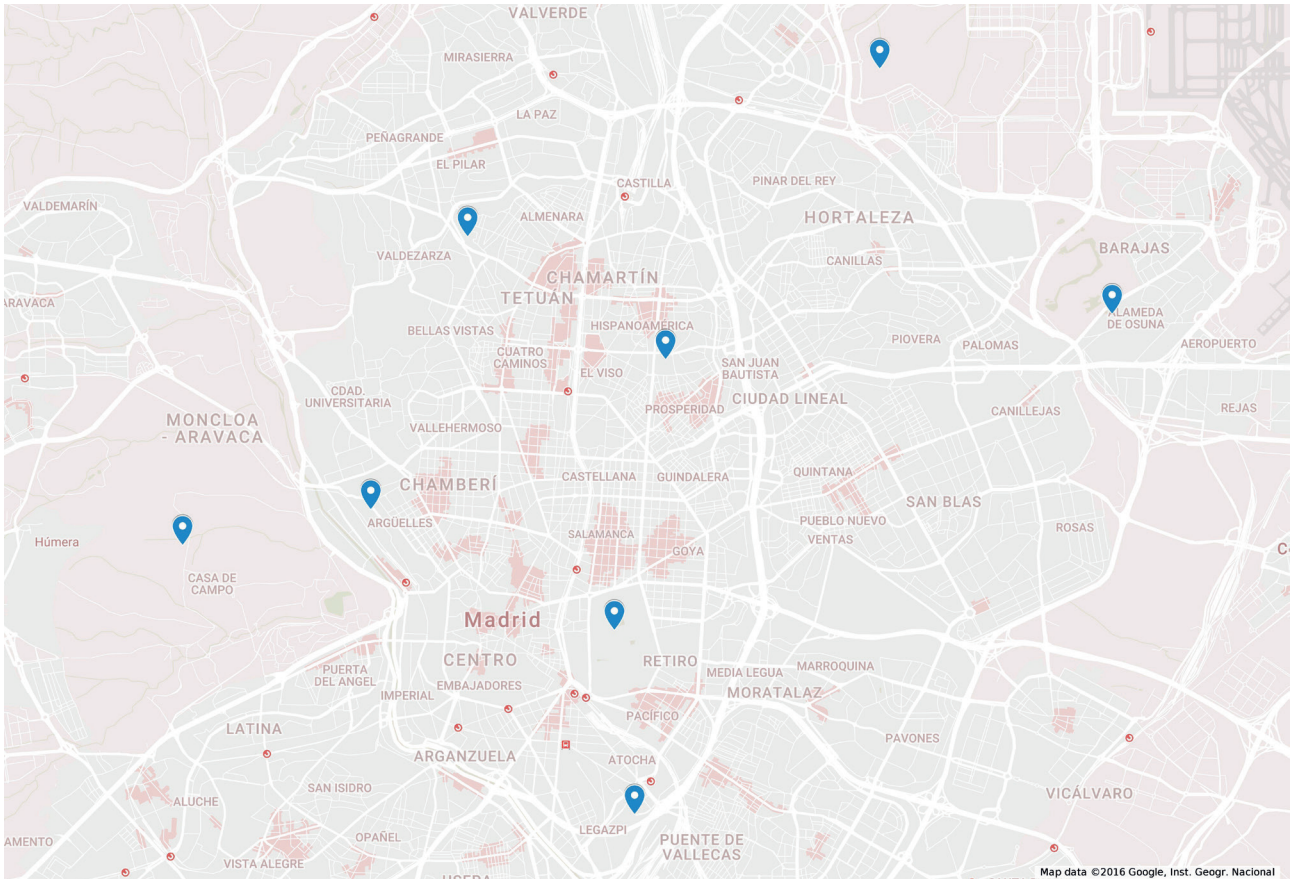

Figure 13. Potential location of social spaces.

for public agents, the first consideration has been excluded to provide a set of suggestions that can be performed by a single group of actors. Thus, coordination of resources can be optimised, key for a proper articulation of pressures (Smith et al, 2005), and helpful for stronger narrative construction.

The selected spaces already host some social activities, some of them are promoted (such as yoga or capoeira classes), while others are common ubiquitous activities (walk, chat, lay on the grass, or have dinner). The spaces have room to accommodate more social activities, in this case related with cycling. This project suggests the reconfiguration of these spaces to ease cyclists gathering, by placing integrated furniture and bicycle-related urban art. These bicycle-friendly areas should hold bicycle promotion activities, in order to create a protective spaces for bicycle niche. These bicycle promotion activities should be workshops where different experts share their experiences and advises regarding cycling in Madrid, or teach how to repair and maintain the bicycle. Moreover, one of the selected areas counts with a skate park (Agustín Rodríguez Sahagún Park, Tetuán District). This park can hold the above mentioned activities, and brings opportunities for organising bigger events, such as competitions and courses for beginners, as it already counts with an infrastructure that can be used for bicycle promotion purposes.

This intervention aims at expanding bicycle niche social network and facilitating learning processes. Schot and Geels (2008) consider social networks can be either broad or deep. A broad social network is characterised by a wide range of diverse actors, not necessarily within bicycle niche; while, on the other hand, a deep network counts with a bigger amount of bicycle experts and agents at different levels. During the framework analysis it has been identified that bicycle niche counts with a rather deep social network. Thus, this intervention will favour to broad it up, by linking it with outer actors. Furthermore, the action of sharing knowledge through workshops and events, will lead to learning processes, as novel user will acquire information that can apply to improve their cycling experience.

3. RESULT

This section aims to describe the resulting proposal made after the concept development phase, to look at the design goals set and to evaluate their degree of achievement. The analysis of the regime and the niches shows unachieved expectations of the bicycle niche, which have been articulated in a certain way by the municipality of Madrid. The strategies that the municipality has applied (and plans to apply) to the city structure, the data and knowledge obtained by their analysis, and the identification of niche expectations and landscape pressures; pictured the status of Madrid's mobility system and its opportunities to promote bicycle activities. Thus, the student proposes a set of three interventions, which have been developed following SNM advises.

3.1 Description.

The resulting proposal is set of three intervention aiming to reinforce bicycle niche. They have been addressed by considering the favouring of four dimensions. These dimensions are: (a) the articulation of expectations, (b) the facilitation and reinforcement of social networks, (c) the facilitation of learning processes, and (d) the connection of bicycle niche with the regime and other external niches (Schot and Geels, 2008).

The main action suggested is the creation of an interconnected bicycle network. This action will articulate bicycle niche expectations, and landscape pressures. The suggestion of creating a low-cost segregated bicycle lane brings regime and niche positions closer, key for an intervention that can create a better alignment between these two levels (Whitmarsh, 2012). The mere gesture of creating bicycle infrastructure will support the niche by recognising its rights and satisfying part of its needs. Moreover, such intervention would be an action to be carried out in public spaces, therefore, promotion and visualisation of bicycle niche would also contribute to niche social expansion.

The development of a stronger social network regarding bicycle can be supported by the creation of segregated bicycle lanes, to provide an exclusive physical space for bicycles would generate higher social response as it is a more aggressive action than shared lanes and the visualisation of the intervention would also be higher. It also contributes to accomplish the demands coming from a considerable part of the bicycle niche and most of the potential new cyclists interviewed, as safety perception has been pointed out to be one of the main barriers to attract new users. This type of positive discrimination will create a protective space for cyclists coexistence, where learning processes and knowledge share can be eased by social interaction.

The combination of the proposed bicycle lanes with a stronger parking regulation has different lectures regarding the dimensions analysed. First of all it highly contributes to reduce unsustainable transportation use. A tighter parking regulation can be performed in several ways, i.e. fare raise, limited schedule, reduce capacity, expand regulated area, etc.. It is needed to remind that all of them would entail a car use reduction; however, this project bets for a reduction on parking capacity as it will provide extra space for other infrastructure, such as the mentioned bicycle lane. This coordination of available resources is essential to demonstrate a high adaptive capacity of the city, which facilitates regime transformation (Smith et al, 2005). Regarding the social reaction a reduction on parking capacity

would entail, by looking at past parking interventions, it seems such reaction would not be very optimistic; therefore, conflict is to be expected. However, conflicts should also be taken into account, as they allow the creation of alternative visions that can lead to learning processes and improved future solutions (Schot and Geels, 2008). Nevertheless, the combination of bicycle lane creation and parking reduction aims to mitigate the previously mentioned negative reactions; a sole parking reduction would reduce municipality's reputation for car users (almost a third part of citizens), however, combining both interventions will justify car parking reduction for sustainable purpose and, additionally, will provide infrastructure for alternative means of transport, which are experiencing a large relative growth. By making both actions at the same time, it is possible to build a stronger message, making more evident the purpose of both interventions and how the space given by car infrastructure is being used for sustainable and life quality improvements.

The use of the indicators proposed in figure 12 is one of the most effective ways to classify data, some of the measures are direct (first order, i.e. number of accidents) while some other need further calculations and analysis (second order data, i.e. cost recovery for transport investments or economic losses due to health). The creation and share of knowledge is key to visualise and analyse the evolution and impact of the interventions, which should draw a better picture leading to more effective future strategies. However, the indicators could also facilitate social network strengthening, and links with elements outside bicycle niche. If the information collected is also shared, it can be used to promote a more sustainable lifestyle, these indicators are the starting point of the creation of calculative devices (Jensen et al, 2012). An illustrative example has been found in some bicycle counters, these devices do not only count the amount of daily cyclists in a certain location, they also show such information in a real time basis, which makes more evident the contribution of the cyclists; this knowledge share aims to make prouder bicycle users, and therefore a stronger niche. This kind of devices are widely used in several cities, such as Copenhagen or Barcelona. Moreover, some other indicators relate bicycle niche with external actors and networks, for instance, the analysis of the average time saved per passenger can be used to share how many days per year a cyclist has used in other activities rather than commuting. More clearly, it can be said how much time a car user has lost in traffic congestions (currently about two weeks per year). Wrapping up, the indicators suggested will bring a large amount of data that can be used to improve future actions; however, an important point of this paper relies on the creation of social network and external links, which would only be achieved if the information collected is used to create discourses and narratives that include multiple social dimensions supporting bicycle use, such as economic optimisation or life quality perception increase thank to bicycle incorporation.

The creation of bicycle promotion activities is basic for social network and learning processes, then, the arrangement of spaces that allow such activities is needed. This intervention is not the response of specific demands (articulation of pressures), but a way to facilitate knowledge share (learning processes) and social interaction in public spaces. Additionally, it allows the connection with external elements and facilitates the inclusion of cycling in daily activities. The connection with other practices will happen due to the nature of the spaces selected, as they are already holding social

activities and receive a fair amount of citizens and tourists. The facilitation of bicycle mobility and parking, and bicycle-related elements over the selected area, will connect cycling elements with other sports (football, basketball, running, etc..), and activities (having snacks, enjoying the nature, being with the family, etc..). Integrated furniture refers to the inclusion of bicycle facilities within common urban equipment; such as benches that allow bicycle parking (figure 14), fountains containing air pumps, and street lamps including wrenches. The frequency and topics of the workshops must be flexible enough to maintain and increase the amount of attendants. Specially during the early stages of the workshops, it will be key to identify attendants' profiles, base knowledge, cycling experience, and concerns; in order to satisfy their needs.

The inclusion of aesthetic elements and greenery does not generate a large amount of practical knowledge. Instead, it contributes to articulate expectations of the bicycle niche and to link it with other sectors. The aggressivity of the environment has been identified as an unfriendly element for both pedestrian and cyclists, although technically it should not suppose a big barrier, it directly affects the cycling experience and the life quality perceptions. Moreover, it also helps to link cycling with other generally desired features (beautified streets instead of plain and grey, and rise of green architecture), helping for its social acceptance and reinforcing the niche by building up external links.

Once the different suggested elements have been described and their potential benefits regarding the four dimensions are analysed, the combination of them into a single and more complex process will be analysed according to the theoretical approach followed. The aim of ordering and combining the different

Figure 14. Integrated bicycle parking into bench. Design: Jorge Sanz, 2016.

elements is to create a reasonable set of actions leading to a stronger intervention that uses the elements complementary, strengthening benefits and softening weaknesses.

The analysis and the design process have left as a result a broad concept, including a wide spectrum of actors and elements, that aims at providing inspiration for urban planners and decision makers. It tries to provide a complete suggestion, considering different actors and niches identified during the analysis and giving them a voice, a presence and a status of stronger network as they play interlinked roles that support each other reinforcing their relation and positive consequences. It has been tried to generate a balanced answer to the different points of view, prioritising the sustainability but adapting it to fit in the current system, generating a non-expensive and easily-returnable intervention on the roads. The concept is also a way of creating graphic awareness, making the 'bicycle' element more visible as a way to promote it; it visualises a more desirable future, creates a vision, and promotes sustainable practices. The concept, however, does not attempt at providing detailed results, creating a strategy, nor finalise the implementation phase.

To be closer to current Madrid's strategy, and consider easily-returnable infrastructure, it is suggested an implementation of the interventions following the next structure. The first moments will be characterised by an extensive creation of bicycle lanes. These lanes are exclusive for bicycles and with a 'soft' segregation (excluding curbs and complementary infrastructure). During this phase, data collection regarding the number of cyclists, and categorised by time frequencies and geographic areas, has to be active. Approximately one year after applying the first phase (depending on the season it is finalised), the data collected by the measuring instruments should already give some valuable findings (areas or periods with a large cycling activity), then, small modifications and adaptations could be made in order to improve the primary network. During the second and third years, the data should reveal which parts of the infrastructure should be reverted due to small use and which other should be reinforced and finalised with better cycling conditions, paying extra attention to intersections, thank to an extensive use of them.

The concept is also representative, giving voice to sectors that need protection according to the theories employed, and citizens' and experts' demands expressed during the analysis and interviews. The approach followed during the design process (allowing ambiguity and iterations) has helped to reinforce internal links, but specially to create external ones, such as the connection with parking regulation, and social and artistic activities. This approach has been followed in order to generate wider relevant data during the research, this led to the finding of common goals that, at the end, support both niches and link them, helping, at the same time at the creation of broader social links. Simultaneously, the concept suggestion intends to be a balanced response to the pressures found, mainly pushing to favour bicycle niche but also trying to moderate its responses according to current regime status and wider expectations. Creating interventions closer aligned with the regime, which presume to have a more successful journey (Whitmarsh, 2012).

In every design process it is needed a post-design evaluation, to look at the degree of achievement the design goals have. Here it is going to be analysed the design goals set (page

37), how far and how they have been attempted to achieve.

3.2 Articulation of expectations.

The articulation of visions and expectations is key according to SNM theories and advises (Schot and Geels, 2008), in this case it has been identified the demand of cyclists and experts regarding a proper bicycle infrastructure (interviews). Moreover, potential new bicycle users and academic researches (e.g.. Fernández-Heredia et al, 2014) point at safety perception as the main barrier to increase the number of bicycle users. Additionally, landscape forces such as UN (UN-HABITAT, 2013; UNEP, 2016) and EU agreements and professional documents (European Commission, 2008; Endurance, 2013; European Union, 2013; Ch4llenge, 2016; and Switch, 2016), encourage developed countries to shift their mobility modal split towards sustainable means, by providing the infrastructure and facilities needed for their correct development and expansion. These demands and pressures coming from the three levels MLP considers, led the student to design a low-cost, easily-returnable segregated bicycle network, that gives a response and articulates selective pressures facing the regime regarding bicycle infrastructure demands. In addition, the concept includes the extension of parking regulation, which is demanded by experts (Adrián Fernández interview), and is an effective way to reduce car use (Madrid City Council, 2014); nevertheless it is known the controversies such intervention would entail (Estela Alemán consult) and admitted the complexity of the situation.

Further studies are needed regarding car regulation, and different strategies are proposed (greater fare reduction for sustainable vehicles or residents, concentrate parking places in nodes while cleaning the rest of the streets, etc..), this project suggests an uniform reduction of parking capacity that leaves enough space to include bicycle infrastructure. Furthermore, the concept also answers some other peripheral (not directly related with mobility) pressures, such as the desire for cultural and green public spaces by including elements of 'slow city' such as more greenery, pedestrian facilities and aesthetic elements (samples are in page 54). The articulation of expectations in this project is not holistic as its focus is on reinforcing bicycle niche dimensions, however, it has been tried to address a large amount of goals and needs of bicycle niche, and to link and combine them with the main external expectations that have been identified.

3.3 Social networking and learning processes.

The social network broadening is covered by two of the interventions, the 'social-spaces' and the indicators. They work complementary, while the 'social-places' have the purpose of holding and gathering citizens with a certain interest on cycling, the narratives will help to create such interest and favour social acceptance on those citizens with strong difficulties to become cyclists (due to health, age, or working location reasons).
As stated previously, the status of the social network related to bicycle niche is already quite deep, however it has room to be broader. Schot and Geels (2008) argue visioning processes are crucial to develop concepts and support niche activities. Political situation is currently exceptional, both in the State and the city of Madrid, after the political change after 24 years of the same political party on charge. The change made media and society way more sensitive to political discourses (and actions). One month, for instance, of bicycle promotion,

would mean a small amount of time within the 24 years of the previous government, this would hardly make a social change about the identity of the political party, even harder when it has been focussed on expanding Metro network. On the other hand, if this new government uses one month to promote bicycle activities, public opinion is suitable to change faster than with the previous government. This 'plasticity' is a favourable circumstance to use narratives that can create the visions advocated by Schot and Geels (2008). Following this premise, the narratives have to be constructed based on empirical data, which comes from the indicators. The indicators and data collected (number of cyclists divided by hour, day, month, neighbourhood; number of accidents, perceived safety by mean, etc..) will also be used by urban planners, to keep a continuous diagnosis of the status of mobility.

So-called social spaces are the second element bringing support for social network expansion. The location of bicycle-related elements facilitates the use of bicycles in the selected areas (figure 13). Moreover, the fact that these places are already holding social activities, makes rather easy to integrate cycling elements without risking potential conflicts. In this case, and unlike bicycle network, the infrastructure is ready to be used without extra interventions. These two advantages brings the opportunity to fluently introduce the concept of cycling into daily activities, having an expected result of a much higher visualisation and acceptance of the elements to be included. The elements suggested for the social spaces in this report are three: facilities (included in the integrated furniture), artistic elements (inspired by cycling), and workshops.

Figure 14 has shown an instance of integrated furniture; furthermore, Raúl Rey, a Munich based designer and art director, has been consulted and has supported the project by creating an artistic drawing inspired by cycling components, which can be seen in figure 15.

Another approach towards nurturing a niche is knowledge creation. This facet's reinforcement is addressed in this project by the workshops, which are to be determined. The early stage of this concept development difficults its materialisation over a short timeframe, in addition to a lack of information regarding available resources and citizens' expectations, knowledge, and willing to attend regarding these type of events. Nevertheless, the potential contributions project a large range of knowledge creation. The experts or volunteers can share their experiences regarding cycling in Madrid, cycling regulation, quiet streets, riding advises, bicycle reparation and maintenance, etc.. The attendants will keep such information and, eventually, use the bicycle more often (or

Figure 15. Artistic sample. Author: Raúl Rey, 2016.

for first time), and share their experiences by complementing experts' comments in the next workshop. The unpredictability of the outcome burdens the establishment of a detailed plan, fact that is highlighted by Schot and Geels when they argue: '*Open-ended learning processes are emphasised in SNM. From this perspective, resistance and conflict is to be expected, and should also be embraced since it may enhance learning processes and allow for the exploration of different futures*' (2008, p549).

3.4 Creation of external links.

Finally, and highly related with the expansion of the social network, the suggested proposal has several actions that include external elements into the project. This inclusion process is another attempt to reinforce bicycle niche, in this case by embracing, adopting and adapting citizens' demands and wishes that would generate a better acceptance of bicycle promotion interventions in the society.

The attention on external processes, that connect the niche with the current political agenda and ongoing processes, is indicated by Schot and Geels (2008), thus, exogenous elements have been found, and some of them have shown their potential to be linked with cycling practices by improving the experience of the user. 'Green and cultural public spaces' niche welcomes artistic and cultural interventions and is a niche that thickly tries to facilitate the link with an extensive number of external networks. Within this situation, this project has paid higher attention to liveability concerns as the aggressivity of the environment has been reported as an main inconvenience (Adrián Fernández and 'Vida Sostenible' Foundation interviews). Elements that can make more attractive surroundings, such as urban art, have been included and modified to fit with the aims of the project, reinforcing the power of the intervention and aligning both actions to complement and support each other. The number of the external elements included can, naturally, be extended by the creation of extra events, expositions and other interventions related with cycling; then, the inclusion of bicycle element into citizens' daily life would be a constant process that slowly prepares the society to visualise, accept, include and encourage longer transition processes.

During the analysis phase it has also been investigated the demands of 'parking and land use' and 'green and cultural public spaces' niches, these demands are peripheral to bicycle demands, however the possibility of linking them becomes highly interesting to reinforce external links. SER is one of the elements that has been already included in the design, element that belongs to the 'parking and land use' niche. In addition, the increasing demand of the APR's shows the valuable benefits it has bring to the residents of the central district: calmed traffic, pedestrianisation of some streets and increase of street life are the main ones.

Finally, in order to keep expanding the contributors to the proposal and to prove if it accommodates decent professional appraisals, three sustainable experts have been contacted to evaluate one of the late versions of the proposal, they are, as mentioned in the Methodology chapter (page 11), Eva Ramos and Luis Fernández on behalf of Madrid municipality, and Estela Alemán, sustainable developer. The feedback received clarified key elements that have been modified during later development steps, such as a better fitting within Madrid's mobility department's vision, parking concerns and users' and citizens' demands. The knowledge received during the concept development has

been assorted through the theories applied, and the purpose and shape the proposal was getting according to the design goals established in earlier design phases.

So far, they have been defined and diagnosed the suggested set of interventions, which are proposed by the student to be applied by the agents (Madrid City Council members), in order to strengthen bicycle niche, as a part of a broader sustainable urban transition process. The co-evolution and further development of them is required in order to reach an adequate implementation. The three interventions (low-cost, easily-returnable and segregated bicycle network; construction of narratives based on indicators; and connection of cycling elements in social places) have been designed according to the reinforcement of the four dimensions of niches considered by Schot and Geels (2008) (articulation of aims, facilitation of social networking, facilitation of learning processes, and linkage with exogenous elements), which can be compared with the three processes recommended in most of SNM literature (protect, nurture, and empower the niche). However, the interventions do not have the need of competing with the prevailing regime, instead, they can be incorporated into it.

4. SAMPLES

In order to provide a better understanding of the proposed interventions defined previously. There have been developed three visualising examples. For that, three different types of streets have been considered to provide insight on the appliance of the design in different contexts and circumstances. During the definition of the result it has been pointed out the lack of available space to create segregated bicycle lanes, as well as the acquisition of some of the space required from car parking. Therefore, it has been understood that visualising elements will contribute to the further development of the interventions. In addition, the combination of facilities and aesthetic elements supporting and accompanying the interventions is exemplified and shown in the samples.

The role of this samples is considered as boundary objects (Carlile, 2002) that will help to start a discussion about the potential solutions and serve as bridge between the conceptualisation and planning phases, which have different knowledge boundaries and disciplines involved. This objects contribute to conceptualise the interventions. On the other hand, planning and implementation phases should be addressed by public authorities and agents, in collaboration with external actors, such as experts, providers of technology, and residents.

The following figures show the original and suggested status of the streets, using two points of view (top view and human perspective), and different symbolic elements. In the top view, the white boundary is the pedestrian area, the black surface is the space dedicated for car traffic, the green (residents) and blue (non-resident) areas represent the space dedicated for car parking, the red surface is the new bicycle lane, and the green lines and dots are identified opportunities to provide pedestrian facilities, liveability elements and artistic interventions.

4.1 Seminario de Nobles

The first sample is based on a local street in the neighbourhood University ('Seminario de Nobles' street, Central district). This sample:

1. Provides a segregated bicycle lane, with a low impact intervention, by using paint.

2. Reduces the number of parking spaces by rearranging the parking, shifting it from diagonal to linear parking, gaining some space and slightly reducing the parking capacity of the area. The position of the parking is also studied to provide cyclist a barrier between bicycles and car traffic.

3. Reduces the width dedicated to car traffic. The street counts with one car lane, although two vehicles could fit, showing the opportunity to reduce the width without compromising circulation. This intervention has three benefits: it will calm car traffic, reduce the possibility of indiscipline parking, and provide the rest of the space needed for the bicycle lane.

4. Increases the space dedicated for pedestrians in a small amount, while also provides facilities for them like benches.

5. Adds aesthetic elements, related with bicycle experience in the surrounding walls. Beautifying the area and giving the municipality the opportunity of sending a stronger message for citizens.

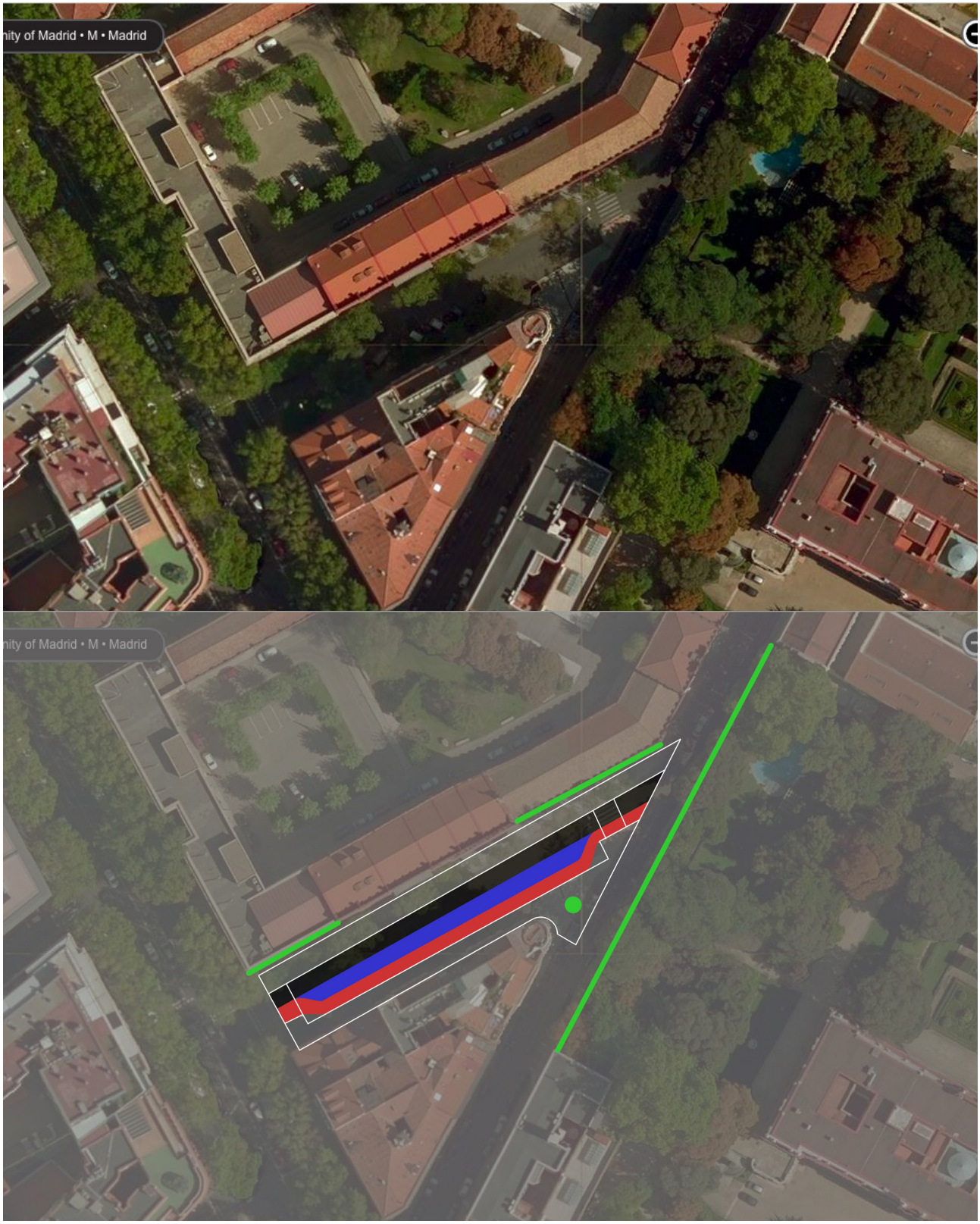

Figure 16. Current status and proposal. Seminario de Nobles.

Figure 17. Current status and

4.2 Marqués de Viana.

The second sample goes one step up in street size, taking a secondary district road located in the northern part of the central almond ('Marqués de Viana' street, Tetuán district). This sample aims at:

1. Creating a segregated bicycle lane by a low impact intervention, using paint, facilitating its reversal to its original state in case of an unsuccessful intervention.

2. Providing a solid message for commuters and residents. By removing one car lane on each direction, pressures on car traffic will increase. Supplying, at the same time, the space needed for the bicycle intervention.

3. Upgrading cycling experience. An increased presence of urban art and green elements, will improve the visual appearance of the street, improve the liveability of the area, and link cycling with street beautification.

Figure 18. Current status and proposal. Marqués de Viana.

Figure 19. Current status

proposal. Marqués de Viana.

4.3 Paseo de la Castellana.

The third sample uses a primary artery as the base for the proposal, completing the spectrum of street types considered (excluding highways). In this case it focussed the efforts in the lateral part of 'Castellana', main north-south axis of the city, in the surroundings of CTBA, one of the latests financial district built. This last sample attempts at:

1. Creating a segregated bicycle lane by using an easily reversible implementation method such as paint.

2. Reducing non-residential parking (blue) using the same technique as in the first sample: shifting diagonal to linear parking. This intervention does not only moderate car infrastructure, but also provides the space required for implementing the bicycle lane.

3. Reducing the width of the area dedicated for car traffic. By removing one car lane, the car capacity of the street will be reduced, and the space dividing cars and cyclists increases. This turns higher comfort and safety perception to cyclists.

4. Not greatly affect traffic flow in primary arteries. An intervention in the lateral, will maintain traffic levels in the central part of the street. This is needed as primary arteries are also used by public transport and good deliveries. A more radical intervention in this areas would generate problems that may not be able to be solved by an increase of bicycle use.

5. Creating symbolic interventions. The creation of bicycle infrastructure in primary arteries also works as a symbolic action that shows a clearer intention from the municipality.

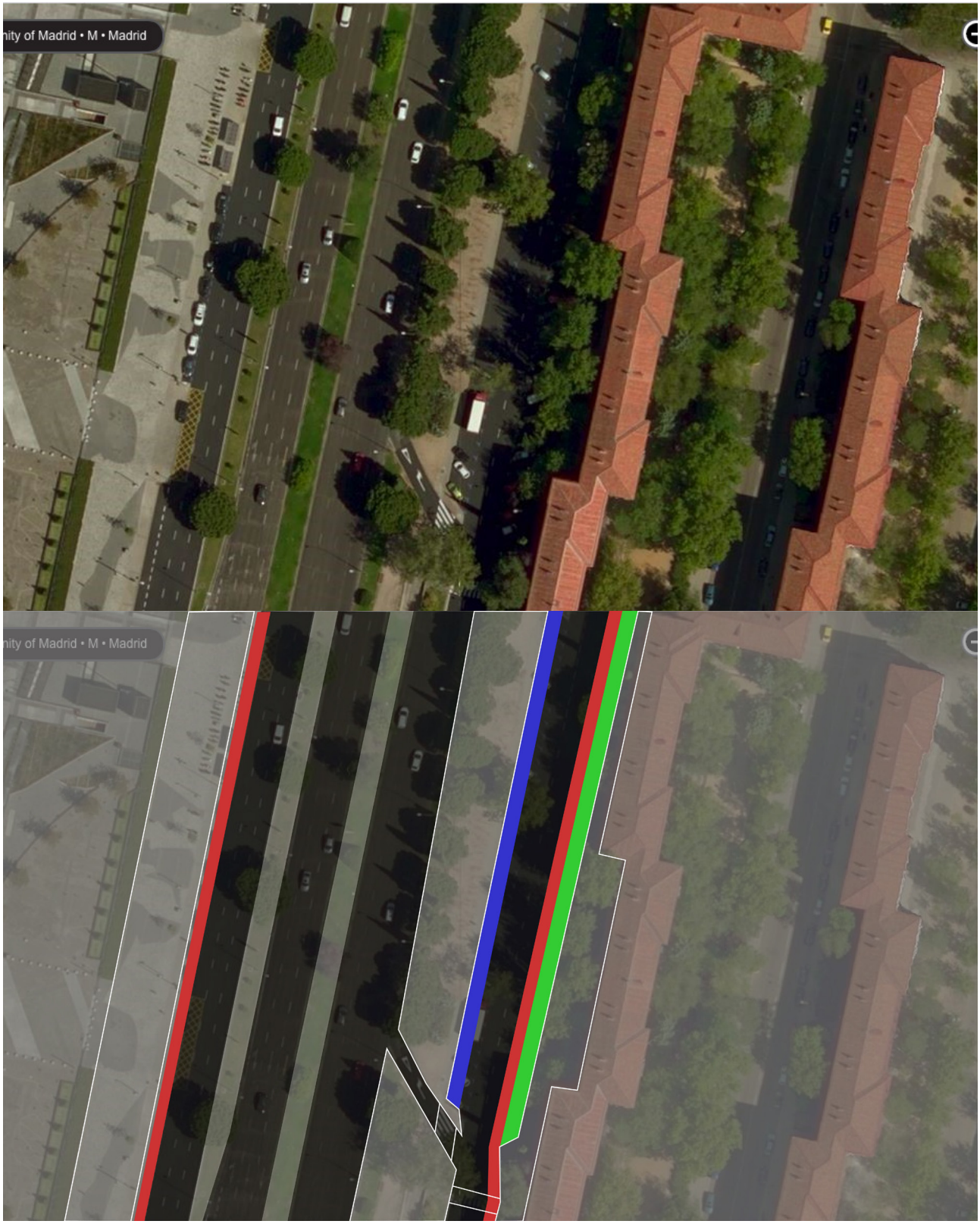

Figure 20. Current status and proposal. Paseo de la Castellana.

Figure 21: Current status and

roposal. Paseo de la Castellana.

CONSIDERATIONS

DISCUSSION

The considerations chapter includes a discussion, evaluations and conclusions about the analysis and interventions described previously. It aims at determining the value and contributions of the project to the bicycle niche and to a sustainable transition from a car dominant mobility scheme towards a sustainable mobility structure.

1.1 External feedback.

To start the discussion it needs to be highlighted the feedback asked to experts and agents, coming both from the municipality and external expertises. Luis Fernández and Eva Ramos are heads of Madrid's Planning, and Sustainability and Mobility Departments, respectively. In addition, Estela Alemán carried out an external query, in order to get an unbiased feedback from both Aalborg University and Madrid municipality appraisals, as a specialist in Sustainable Development in Catie Nicaragua. The feedback received included comments that clarified the role of the suggestions presented as vision generators, supported by the visualisation contribution of the samples (in line with the role of boundary objects).

The barriers the project has, have been one of the main discussed issues; in this case, the parking capacity reduction has been one of the most discussed elements. Madrid's strategy differs in this aspect with the proposed intervention, it aims at totally removing car parking in several areas and to relocate such places in bigger streets and squares, creating a 'hub-based' parking structure. This different approach seems to provide 'cleaner' streets, which will provide the space needed for the bicycle infrastructure required, while, at the same time, would force car users to walk for a slightly longer period, indirectly promoting walking. On the other hand, the proposed interventions suggest an uniform reduction on car parking capacity, which will provide part of the space required. The rest of the space would come from reducing car traffic space, aiming at calming and mitigating car movement, which would generate a safer environment for all users, and introduce elements of 'slow city' (Gehl, 2010). Additionally, Estela Alemán finds key to know the reaction car users would have when they see their parking space being reduced, suggesting it may bring more conflicts. Regarding this fact, it is known that any car restriction, either in parking, taxation or circulation, has historically brought complains coming from car users; however, it has also been demonstrated that such restrictions, specially the ones regarding parking (SER), have been extremely effective to reduce car use and promote more sustainable means of transport, such as public transport; moreover, parking reduction becomes necessary to coordinate the resources needed for cycling promotion interventions (Smith et al, 2005). The student, therefore, expects a negative reaction from car users regarding a tighter parking regulation; this reaction, however, is intended to be countered by a positive reaction from the rest of the users and citizens (car drivers included), as life quality elements are incorporated and more present.

Another barrier of this project has been identified on its lack of a detailed implementation plan, which points at the need of presenting this project to the public authorities and experts that could contribute to finish this set of suggestions. This project creates a conceptual set of proposals, that aims to drive agents to improve Madrid's bicycle strategy by including proposed elements, which

will bring some advancements to the current plan. It is not the aim of this report to show a detailed technical plan, as it was firstly assumed (and lately confirmed) that such phase entails meticulous case studies and a technical knowledge, background and experience that cannot be fulfilled by the student and are out of his scope. The future needed actions regarding the development of these suggestions will be discussed afterwards (page 71).

The feedback taken also points at the contributions and benefits the suggestions bring. In this case, the wide actor inclusion, the complementary approach of the interventions, and their expected benefits on mobility, have been approved and appreciated. During the analysis phase (page 4) it has been tried to include as many actors as possible, as mobility system is considered a broad and extensive network with multiple interactions and dependencies. These actors, as well as their evolution over time, have been analysed and included throughout the project processes. The combination of diverse, and eventually opposite concerns and appraisals, has been a challenge during the project development, as the number of elements became larger, and an exclusion process during early phases of the project was considered a negative process that would jeopardise the diversity of the study.

Additionally, another contribution identified by the experts consulted is the role of the samples presented, addressing the aims for what they have been created: communicate graphically the suggested interventions and serve as a bridge between disciplines. The samples are able to transmit the changes suggested and their aims in a shorter time than the accompanying text, facilitating the understanding of the proposals and generating higher interest and engagement of relevant actors. Naturally, the samples cannot provide a complete information and further explanations should come along. Moreover, the samples work as boundary objects with a rather high degree of pragmatism. They combine overlapping knowledge of the disciplines involved, facilitate communication, and allow the transformation of the knowledge they reflect, by creating modified and optimised versions of the presented proposals (Carlile, 2002).

1.2 Internal review.

This project analyses Madrid's urban mobility system, identifies its historical development and current opportunities, and combines different potential solutions into a set of conceptual actions, which aim at reinforcing bicycle niche in its different dimensions, identified by Schot and Geels (2008).

During the analysis phase, the lack of safe bicycle infrastructure has been identified as the main barrier to be tackled. This has been identified by applying different methods, such as the reading of articles and planning guidelines; and the use of interviews with experts, agents and users. The analysis of the regime and current status of the mobility system, lightens the need and demand of a bicycle infrastructure able to cope with the fear factor, which is the main obstacle when attracting new bicycle users (Fernández-Heredia et al, 2014). Peripheral demands have also been identified, such as the desire for greener and cultural public spaces (decide.madrid.es), the international pressures regarding pollution and air quality (several international references coming from UN and EU), or the unfavourable conditions for a journey combining bicycle and public transport (Adrián Fernández interview).

By finding support on the recommendations

of the theories, the project also aims at creating visions. The creation of visions and aims regarding a desirable future have several relevant functions, according with Smith et al, they are:

'*1. Mapping a 'possibility space': Visions identify a realm of plausible alternatives for conceiving of socio-technical functions and for the means of providing for them.*
2. A heuristic: Visions act as problem-defining tools by pointing to the technical, institutional and behavioural problems that need to be resolved.
3. A stable frame for target-setting and monitoring progress: Visions stabilise technical and other innovative activity by serving as a common reference point for actors collaborating on its realisation.
4. A metaphor for building actor-networks: Visions specify relevant actors (including and excluding), acting as symbols that bind together communities of interest and of practice.
5. A narrative for focusing capital and other resources: Visions become an emblem that is employed in the marshalling of resources from outside an incipient regime's core membership.'
(2005, p1506).

These visions created can be used as a base to work for bringing them a step closer to their real implementation, by developing a process that would contribute to their achievement. This can be considered as the materialisation and specification of the visions, suggesting particular uses of the available resources and pointing at explicit scenarios. Moreover, these visions can also be modified as they still have plasticity and flexibility, allowing adjustments to make a better fit of the solution into the current regime. In this project, the role of the visions has been addressed by a meaningful combination of the implementations into a coherent set, and by the use of the presented samples, which have been discussed, and can be modified, to provide larger benefits and avoid potential conflicts when the interventions are applied in real circumstances.

The project's overall goal is to promote a mobility transition from a car dominated mobility system to one with higher presence of non-motorised transport means, by suggesting actions that will protect and reinforce bicycle niche. A car-based mobility system brings several problems, one of the most important in this report is the space cars occupy. On the other hand, it has been identified a lack of an appropriate infrastructure for sustainable means. By modifying the car parking arrangement and reducing car traffic space, two results are obtained, the first one is the mitigation of car use, while the second is the obtainment of a certain amount of space. Such resource is then employed to reinforce bicycle niche by creating bicycle infrastructure that can tackle fear factor, at the same time, a set coordinated and complementary facilities (bicycle parking, aesthetic elements, social events, liveability features, and knowledge-sharing workshops) will create an inviting context to accompany bicycle lanes, creating a welcoming environment which aims at making cycling a more attractive experience. Secondly, a monitorisation of the effects the interventions generate, will provide a large amount of data and first order knowledge, which can be directly used to improve future strategies and optimise resources use. Furthermore, a refined data collection, combined with external elements, will create indicators, which will serve as a base to generate narratives. The narratives will be used for further protection and promotion of non-motorised transport means, specially regarding its social acceptance; reinforcing,

then, the benefits brought by the infrastructure implementation. Moreover, the use of social spaces for bicycle-related activities will provide a proper environment to develop knowledge-sharing workshops and events; these workshops reinforce social network and allow open-ended learning processes. A simplified graphic definition of the key elements and interventions to be carried out are shown in figure 22.

In case the interventions suggested complete their development journey until they are finally part of the reality, they are expected to bring several benefits for different actors. On the one hand, the creation of a convenient, accessible and safe bicycle conditions, accompanied by an inviting and non-agressive environment; may make cycling more attractive for users, specially for those with a small cycling experience (a big majority of the population). On the other hand, the creation of an inexpensive and easily reversible set of interventions, backed by the data collected in the monitorisation of the elements, aims at making more interesting for the municipal agents to intervene, and take a more active role regarding sustainable mobility contributions. The use of Information Technologies (ITs) ensures a large spectrum of possibilities regarding data collection (bicycle counters, speed radars, or online surveys), combination (obtain data from health costs or life quality perception) and calculation (statistical software), with small (and decreasing) investment costs and a large (and increasing) data outcome; therefore, the use of ITs and big-data management is highly recommended for the monitorisation and data creation phases of the intervention.

1.3 Future developments.

The further steps needed to bring this analysis and set of recommendations to real interventions are challenging and will require a more complete, detailed and updated analysis. This could be carried out by experienced academic groups and public researchers, which would have guaranteed the majority of the resources needed, as well as the experience and know-how skills. Moreover, to complete the implementation phase it is required a detailed study of every case, street and intersection. This can only be carried out by local authorities

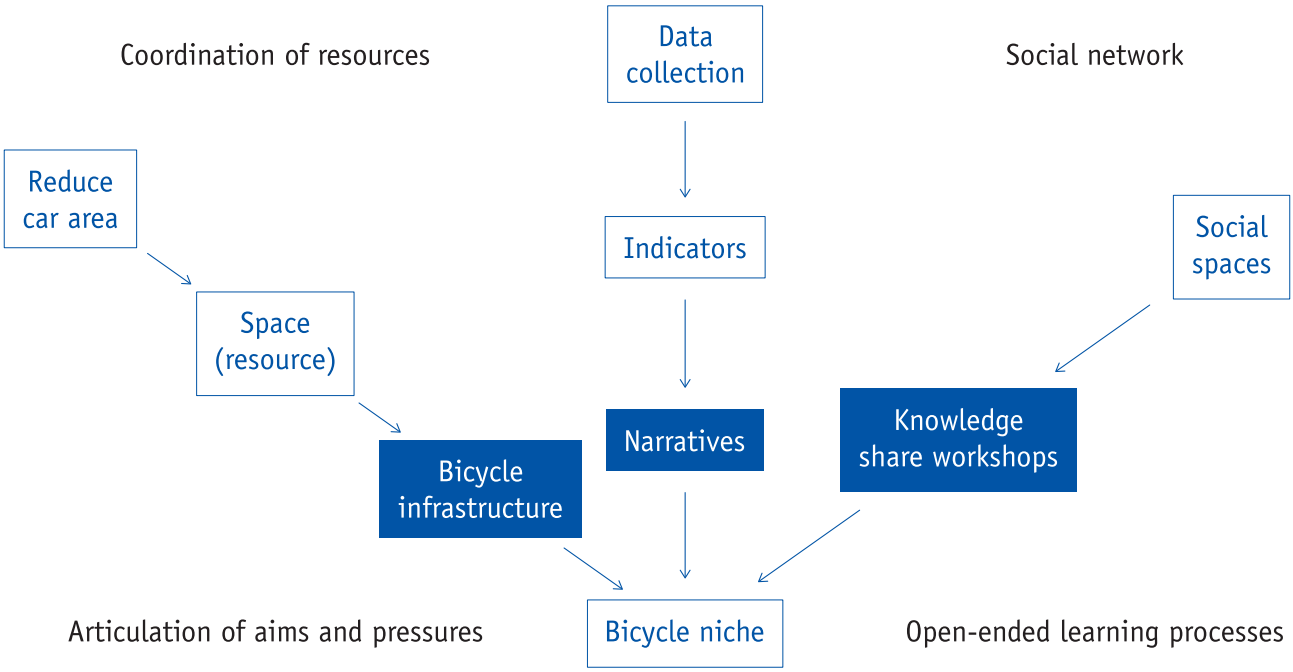

Figure 22. Three main interventions, complementary interventions, and contributions.

with potential external (private) support; practice that can be seen in several public structures, such as the outsourced companies responsible for the cleaning and maintenance of the streets and parks, and the operation of some public transport services. Additionally, the political use of the interventions, and their reinforcement by linking them with the current political agenda, can be achieved by the local government, which has the agency and control in most of the priorities and strategic actions that will take place in the city. This point becomes controversial if it is taken into account the current political situation, in both the State and the EU, paying extra attention to the exceptional uncertainty period experienced at national level. Nonetheless, it has been identified the opportunity regarding the plasticity of public opinion regarding the new political party in the local government.

These are the actors that should be mobilised in order to expand, develop and implement the interventions designed, specially the agents members of Madrid municipality. To be more specific, the two departments responsible of bicycle infrastructure development are the Department of Planning and the Department of Sustainability and Mobility. Both have been contacted in order to analyse and evaluate earlier design proposals (less refined), and future conversations are needed, specially regarding a prioritisation of the streets that need urgent interventions. The reasons behind the mobilisation of such actors are several, three of them are highlighted: (a) the interventions are within Madrid's possibilities, this project tries to align actors and soften differences with the purpose of developing a more sustainable and efficient mobility. (b) The interventions will bring positive repercussions regarding citizens' opinion on the political actors supporting the interventions; moreover, it is expected the interventions will bring a higher international weight of the city regarding sustainable development. (c) The interventions can create employment and private economic growth in two ways: directly, if part of the implementation is outsourced; and in a long-term basis, by allowing bicycle-based businesses, such as street-food, bicycle-taxis, bicycle trade and maintenance shops, etc..

While the contributions the project will have, in case it is taken further and implemented, have been previously described, the project has yet certain limitations and restrictions. The further needed steps, mentioned previously, are an example on how this project can expand its boundaries and achieve a greater scope. In addition, this report contributes on the construction of socio-political narratives, which could affect positively the social perceptions about a higher presence of bicycles in the city. These narratives will be highly dependant on the early reactions regarding the interventions, and the prevalent socio-political framework taking place at that time. It is also a process that uses tiny actions building upon each other, creating a sensemaking statement, specially if they are also supported by the most influencing social actors, such as mass media or some reputed personalities. This report, then, suggests the creation of narratives that should not be understood as static elements, but as potential directions that narrative and decision makers can follow to create a convincing argument. Likewise happens with the implementation of the interventions; this report has clear delimitations and does not aim at exceeding its academic limits. Hence, this project points at influencing and inspiring decision makers and public urban planners, which own the necessary agency and mechanisms to complete the materialisation of the suggested interventions. On the other

hand, this project is aware of the forces that agents have to cope with, such as narrow and strong regulative limitations. Such constrains could have affected negatively the visions the student has developed throughout the project, threatening creativity, and innovative insights during the broad-up design phase; therefore, this project makes use of the opportunity that this non-constraining environment facilitates.

1.4 Theoretical reflection.

The different approaches employed by MLP, SNM must also be clarified. The student applied these theories in order to structure Madrid's system analysis, and get a deeper understanding on the approach needed towards a sustainable urban mobility transition. The arguments complement each other in the following manner. A MLP approach has been used to look at the mobility system of Madrid, and to create a structured categorisation of the elements identified during the research, which have different characteristics and ways to interact and affect each other. However, '*because the linkages between processes at different levels are made by actors in their cognitions and activities, the dynamics are not mechanical, but socially constructed*' (Geels, 2005 p453). Additionally, '*the dynamics are not linear, because perceptions and strategies of actors change over time*' (Geels, 2005, p453). These socially constructed and inconstant linking dynamics require two processes to accomplish a set of design goals to work with: first, an analysis on how these social links and actions have occurred over time; secondly, a set of theoretical guidelines able to push forward the findings discovered during such analysis (SNM).

According to the previous interpretation of the theories, it has been found beneficial the use of SNM to complete the path from observing to acting. An abundant amount of literature pays attention to the niches identified in MLP, as they are the main character in the first phases of the transition. Within this literature span, several recommendations have been found, such as the need for protecting, nurturing, and empowering niche dimensions; however, the project has taken the niche processes that make possible its success (Schot and Geels, 2008) as a fundamental part of the use of the theories. It brings three internal processes; namely articulation of expectations, creation of social networks, and facilitation of learning processes; and emphasises on the need to extend the influence of the niche beyond its own boundaries, calling for the need of finding external links that can support niche development.

Complementary, some other academic articles have been studied, applied, and included in the valoration of the situation, such as the concept of boundary objects (Carlile, 2002) to facilitate the project development, the governance in transitions (Smith et al, 2005) to understand articulation processes, calculative practices (Jensen et al, 2015) have facilitated the creation of the indicators, the evolution of policies (Jones, 2014) have eased the detection of the current political perspective, and transportation researches (Fernández-Heredia et al, 2014) have been the base to understand cyclists' findings.

2. CONCLUSION

In this research and design project, it has been recognised and tried to be fulfilled the problem formulation: **'How can cycling promotion be articulated and strengthened within Madrid's car-based context?'** For that, sustainable transition interventions have been advised and supported by empirical data.

Sustainable transition theories (MLP and SNM) have been the cognitive base that has guided the study, supported by relevant insights coming from international and institutional documents and guidelines, and from the interviews carried out with relevant agents, niche members, and authorities. The complementary approaches MLP and SNM have, have strengthen the alignment between analysis and design phases. Moreover, the interviews provided a detailed and multiperspective picture of the past, present and potential future conditions of Madrid's mobility system; this information have been used both, to analyse and comprehend the specific case to be studied, and to find associations between theory and facts, contributing, thus, for both the analysis and design processes.

The design of the interventions, their interrelations and potential effects have been developed and estimated according with the theoretical and empirical framework, backed and corrected with the feedback received by internal and external (to the regime) experts. The suggestions aim at fulfilling societal needs uncovered by the regime and demanded by both the niche and landscape levels. Because of the different origins of these demands and the different ways the regime has to articulate them, it becomes highly challenging to bring a finalised set of interventions aiming at answering both pressures equally; the advises given in this report aspire at bringing a balanced answer to the problem formulation, considering a wide spectrum of actors, elements and dimensions. Nonetheless, the use of another theoretical framework, or a different actors inclusion/exclusion appraisal may lead to a different set of suggestions, with distinct effects and outcomes.

Further studies would highly contribute for a better fit of the suggestions, optimising them and expanding the scope of the consequences. Practice theory (Kuijer, 2014), for instance, could provide a quantified comparison between moving around the city by using different means of transportation, finding key elements to be improved; this study can follow the path that the indicators suggestion opens. A different transition approach can also bring further improvements to the interventions suggested, Arenas of Development (Jørgensen, 2012) can shift the focus towards the conflicts between socio-technical structures and bring potential solutions aiming at solving them, specially regarding the different perspectives identified within Madrid municipality departments.

Concluding, the three interrelated levels studied by MLP approach have guided the analytical process, while, on the other hand, SNM identified the dimensions to be highlighted during the design phase towards the suggested set of interventions. However, it is necessary to acknowledge that niche development is a continuous process, which requires ongoing evaluation. The main contribution of this project is a vision of a new reorganisation of space for sustainable purposes. The importance of designs supporting environmental and social sustainability are accentuated in this report, as well as the

benefits that external links creation can bring to incremental urban progress, within the avobementioned challenges.

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