🏆 *reviewed paper*

Mobile Territories as a New Unexplored Layer towards Sustainable Mobility: the Case of Istanbul 1850-2022

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1 ABSTRACT

Everyone is enveloped by a “bubble” of information that accompanies them in the urban space of the 21st century. Each one is equipped with an individualised technical object, manages his/her own information bubble. These objects and information bubbles act as tools for socio-spatial reading of territories thanks to the Internet of Things.

We have sought to launch a reflection on the cartographic reading of mobility in territories via mobile technical objects. This paper proposes to deepen this reflection according to a cartographic methodology around the case of Istanbul: how the global technical knowledge transformed into a technical object is assimilated to the logic of the axes of mobility, makes it possible to read the transformation of Istanbul. According to this logic, what scenarios of sustainable urban mobility systems are possible for Istanbul in the future?

We hypothesised that technical objects could lead us to the development of mobile territories. These moving territories would allow us to map the sustainable mobility networks of the future and would constitute a continuity with those of the past.

Our results showed that non-visible factors such as digital traces of individualised technical objects create mobile territories. These territories are like a tool to better understand the organism of the city with its inhabitants as urban designers over time.

Keywords: Istanbul, mobile territories, individualized technical objects, mobility systems, transportation

2 INTRODUCTION

The integration of geolocated information with the Internet of Things opens the way to understanding the physical territory and its current modes of mobility. The connectivity obtained thanks to the Internet becomes a defining characteristic of the urban condition of the 21st century. (Mitchell, 2003, p.11) When this connectivity is considered as a tool to understand the movements of populations, the design and the management of urban areas can allow us to realise the invisible layers of physical territories that form "urban dark matter". (Malleson et al., 2018, p.616) If these layers are related to the modes of mobility existing in the territories, they are transformed "into keys for territorial readings". Their otherwise unpredictable history certainly appears and communicates with the future of 21st century cities.

As André Corboz says, the territory is not a given but results from various processes. (Corboz, 1983, p.14) The human interventions that are part of it do not represent the totality of the process. Our interest in the various modes of use of the travel networks of the citizens of the city of Istanbul will guide us throughout our work. While knowing that the physical, mobile and connected bodies of citizens form new territories, the different modes of travel chosen by these citizens will be closely examined following a remote reading via the study of their physically invisible and digital traces. (de Souza e Silva and Sutko, 2019; Licoppe, 2017, p.122)

3 STATE OF `THE ART

We assume that in our study, it is important to be aware of the mobility systems of the city of Istanbul that bring us to the basics of the city's travel networks. We know that the urban spaces of Istanbul drawn by these travel networks have undergone several metamorphoses over time until 2022. The links between the networks, the ways of moving over short distances and the transport systems on the major infrastructures are studied in this transformed context. (Lévy, 2001, p.20) First of all, our readings of the traces of individual technical objects need above all the pivotal elements of the history of the movements of the physical bodies of the citizens of the city. Then it is possible to link the history of the structuring axes of Istanbul's mobility systems to the traces of new individual technical objects used by their citizens.

3.1 Getting around in Istanbul: structuring axes between 1839 and 1988

Three events have marked the history of Istanbul mobility systems. The first is the beginning of a regular steam ferry service since the mid-1850s, the second is the establishment of rail transport systems such as streetcars, tunnels (as part of the system) and commuter trains in the 1870s. The last is the operation of a large electric tram system in 1914. (Tekeli, 2010, p.23)

These three mobility systems did not appear suddenly. There was a whole series of events that marked the history of urban mobility in Istanbul and allowed it to evolve.

We can briefly look at the great waves that have shaped Istanbul's current mobility systems by analysing them in three phases. The first driving wave began with the Tanzimats (“reorganisation” in Ottoman Turkish was an era of reforms in the Ottoman Empire) in 1839, the second in the 1930s with the appearance of new master plans and the last in the 1950s with the significant urban expansion of the Istanbul conurbation.

Concerning the first wave which begins with the modernisations of the Tanzimats in 1839 and which ends in 1908, it is important to underline that the aim was to develop an urban imaginary based on Western culture and technology. (Çelik, 1986, p.135; Dupont and Mayeur-Jaouen, 2016, p.59) Even if the design and reconstruction projects had not achieved the ambitious objectives of the managers, permanent changes to the urban fabric were recorded. (Çelik, 1986, p.213) In addition, these modifications formed the basis of the current structuring lines of mobility. If we look at the master plan proposed by Helmuth von Moltke, we can see that his desire to think of the city as a set of coherent elements resulted in several projects that still exist today.

The second wave in the 1930s, after the establishment of the Republic of Turkey, was marked by the master plans of consultants of French and German origin. The recommendations of Agache, Elgötze and Lambert in areas such as growth, integration, historic preservation and the creation of regions have not been implemented, but their reports have survived to our days. It was also at that time that Henri Prost's recommendations played a vital role. Seeing the population grow rapidly, he decided to develop an underground metropolitan network project. (Angel, 1993) His projects related to this underground network for Istanbul are still relevant. (Çelik, 1986, p.217)

The third and last wave which drew the city of Istanbul and which draws it currently began with the Nedeco report in October 1951. The technical assistance office Nedeco of the Netherlands presented a survey on the question of navigation in Istanbul. The proposal was presented as a metropolitan project limited to both sides of Haliç (Golden Horn) and sought to solve mobility problems. The report was based on the guidelines of Henri Prost's plan. (Witteveen & G.S. Bos, 1951; Çelik, 1986, p.217) On the other hand, in the second half of the 20th century, it was the Turkish urban architects who dealt directly with the urban problems of Istanbul. In 1961, the Municipality of Istanbul formed a new planning office which had the task of studying a metropolitan master plan from Tekirdag to Gebze-Izmit for a maximum period of 20 years. (Angel, 1993) Between 1961 and 1988 the municipalities tried to find solutions with soft mobility systems in order to satisfy the needs of the inhabitants of Istanbul. They focused mainly on city planning through bus lines. However, these solutions were not satisfactory for a city that kept growing. A new page has opened for the city with “Metro İstanbul” which was established in 1988 by the Istanbul Metropolitan Municipality to operate urban rail systems.

3.2 Crossing the Bosphorus: users in action

The start of a regular steam ferry service made it possible to cross the Bosphorus with public transport in the mid-1850s for the very first time. It is the foundation of “Boğaziçi Şirket-i Hayriye” (Ahmed Ihsanet and Partners, 1914) which managed this transport network. (Orhanlu, 1966, p.109) Before the mid-1850s the attention of urban planners of the time was rather focused on the structure of the Ottoman capital between the more traditional side of Istanbul and that of Galata (Fig.1). It was Haliç (the Golden Horn) which was more central to the territorial occupations.

The second major step for the direct crossing of the Bosphorus is long after the founding of the Republic of Turkey. The opening of the Bosphorus Bridge and its peripheral boulevards on October 29, 1973 began this second phase which leads us to the territorial issues of today. The European part (Beyoğlu at the time) and the Asian part of the city were attached to each other by a fast road connection with a strong structuring axis. (Tekeli, 2010, p.66) We can say that it was from then on that the citizens of Istanbul faced more than one

choice of public transport to cross the Bosphorus. In terms of urban planning, from then on it was easier to visit the Asian side of Istanbul. The creation of this very first large-scale infrastructure paved the way for the construction of today's major surface and underground railway projects.

Many researchers are interested in multimodal transport systems around the theme of morphological transformations in history and the major infrastructure axes of Istanbul. (Dökmeci and Berköz, 1994, p. 189; Yazgi and Dökmeci, 2006 Ozus et al. 2011, p.331; Kırmızı and Çalışkan, 2012; Kolcu and Dökmeci, 2013, p. 477) It is nevertheless rarer to find research that focuses on the inhabitants of Istanbul and their ways of living and travelling via existing infrastructures in order to establish better proposals for future mobility systems. These studies are very often either in the form of surveys carried out among citizens (Tuna et al., 2014), or in the form of observations of the use of infrastructures, for the understanding of its use by the inhabitants.(Ilicali et al., 2014, p. 413)

4 STUDY SET UP: MOBILE TECHNICAL OBJECTS AND CARTOGRAPHIC APPROACH

According to the cartographic approach that we have implemented, we have mainly examined the physical movements of the inhabitants of Istanbul recorded digitally via the individual technical objects. Bringing new images obtained through technical objects into dialogue, deducing representations and finally providing reproducible solutions (Mortamais, 2018) to travel problems are at the heart of the implementation of the study.

Our study was developed in two phases. During the first phase, we compared the visual and perceptible characteristics of the geolocated data of the Istanbul megalopolis from 2007 to 2022. These data were obtained and studied via the users of the OpenStreetMap website who freely shared the traffic data of their individual technical objects (Smartphone and/or laptop and/or navigation assistant) and who have used the city's public transport. Usually, when internet users uploaded and shared their GPS tracks on the OpenStreetMap site, most of them also tagged their GPS tracks with text descriptions, such as movement type, date or other relevant information. on the GPS traces. (Li, 2014, p.69) We only studied the traces whose additional information was relevant.

For the realisation of the first phase, we limited ourselves to a work area of 115 km2 which is centered on the Galata and Kadiköy districts as well as the historic peninsula of Istanbul (Fig.1). We retained 144 journeys in total for our investigation. We studied journeys that included at least two different modes of transport. This is why we have studied 108 journeys in detail. We have also eliminated the different journeys of the same person. We eliminated 35 journeys because these routes belonged to the 9 people who had already shared their journeys. Finally, we selected 73 journeys, 18 of which were experienced and shared after the Covid-19 health crisis.

The second phase of the study was dedicated to a chronological work on the development of the city's mobility infrastructures (1850-2022). The two phases were studied together simultaneously. The logics of infrastructure development strategy before the new communication and information technologies were confronted with those after them.

Fig.1: The territorial area studied as part of the research in the megalopolis of Istanbul.

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5 RESULTS

5.1 "Momentary appearances" as a new research approach

We found that the "images produced through the intermediary of the individual technical objects" that we had hypothetically identified are visible in the form of "momentary appearances". (Sontag and Blanchard, 2008, p. 217) Ephemeral appearances give rise to the results obtained thanks to technical objects as partners in scientific exploration. The results belong to the citizens of the city.

Our investigation is accomplished using the free software QGIS. Reading the traces of the routes allowed us to understand that 50% of the journeys shared on OpenStreetMap for our study area between 2007 and 2022 belonged to tourists. Among the journeys studied, the most used mode of transport was travelling by car (28% of journeys). The second most used mode of transport was tram/metro/train (24.6% including 17.8% tram and metro; 6.8% train). The bus followed the tram/metro/train just after (15%). Ferry use followed bus (13.6%) with bicycle (2.7%) and plane (2.7%) travel. (Figs. 2 and 3).

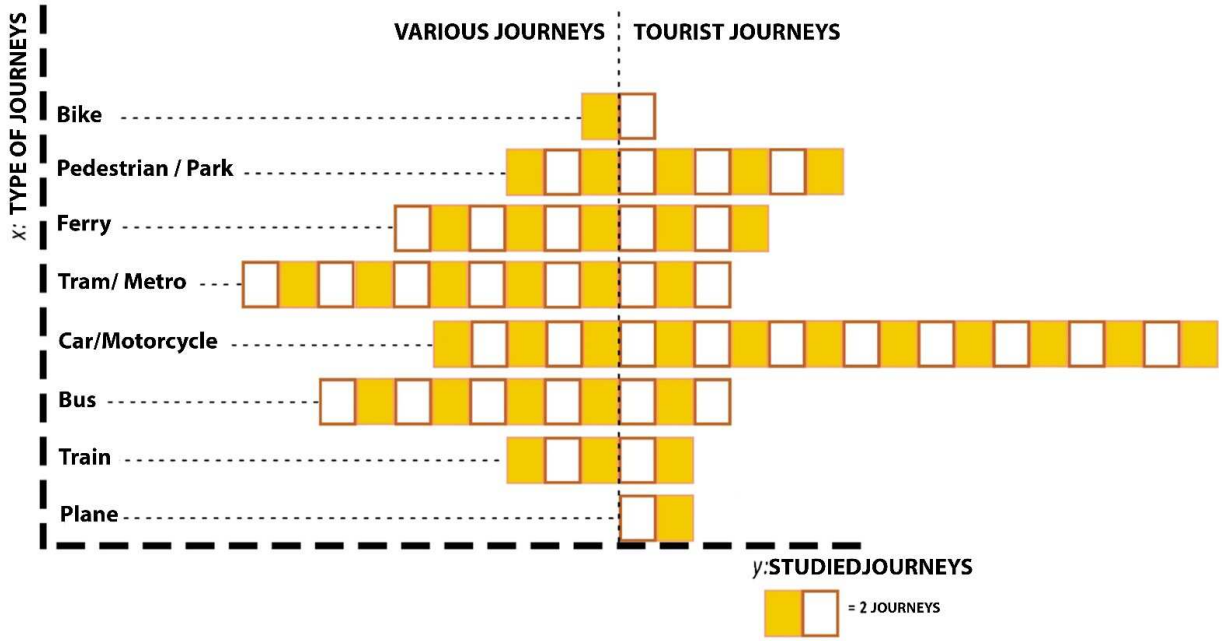

Fig. 2: The nature of the journeys shared by citizens by theme and by nature studied in 2022.

The combinations in the modes of transport are very clear when we read the journeys. Among these most interesting journeys were those made by ferry, tram/metro, car and at the same time on foot (Fig.3). The follow-up of these journeys showed us the territorial nodes taken by the citizens. We have seen that these nodes were not always marked by the presence of stops (tram bus stops, etc.). Some pedestrian behaviours were repetitive and contributed to node morphologies.

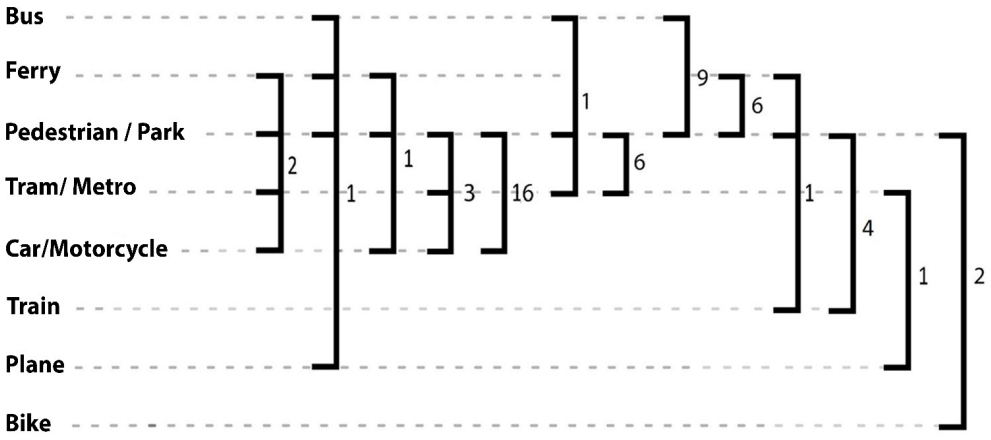

Fig. 3: The nature of the journeys chosen by citizens.

We distinguish many pedestrian journeys (a total of 52 journeys). We counted all the pedestrian journeys whatever their importance/percentage in a single path. Figure 2 shows the qualitatively correct number of pedestrian journeys (9 journeys); these journeys are marked mainly by walking.

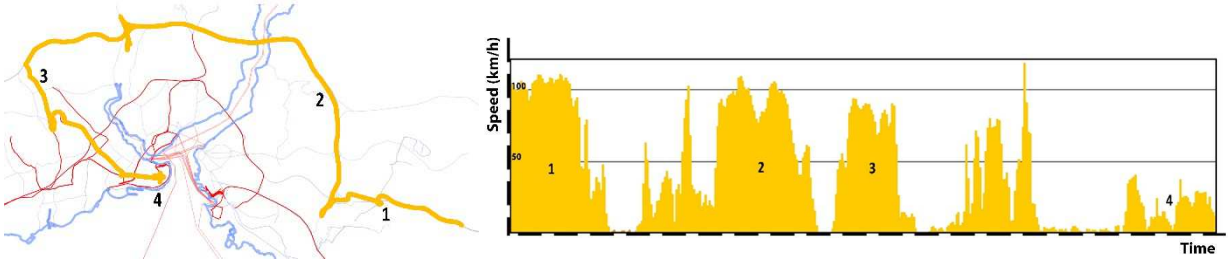

Fig. 4: Example of a journey recorded in OpenStreetMap in 2012.

In the example above we can understand that the trip is made by car. The arrival in the Istanbul conurbation is marked by a drop in speed (1). There are some obstacles inside the agglomeration (2,3). The destination – the historic peninsula of Istanbul – (4) is reached by bypassing the city to the north.

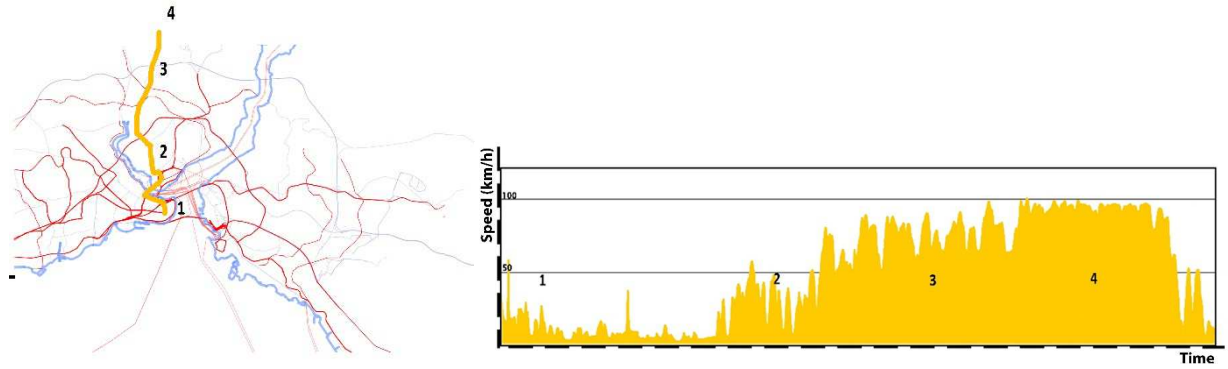

Fig. 5: Example of a journey recorded in OpenStreetMap in 2019.

In the example above we can understand that the journey is made by car and by bus. The person in motion departs from the historic centre, more specifically from Topkapi, for the new Istanbul airport which is inaugurated on October 29, 2018. The arrival in the peri-urban area of Istanbul is marked by an increase in speed (1 -2-3 -4). The moving person takes the bus to go to the airport there are some stops we can read them thanks to the speed-time graph (2).

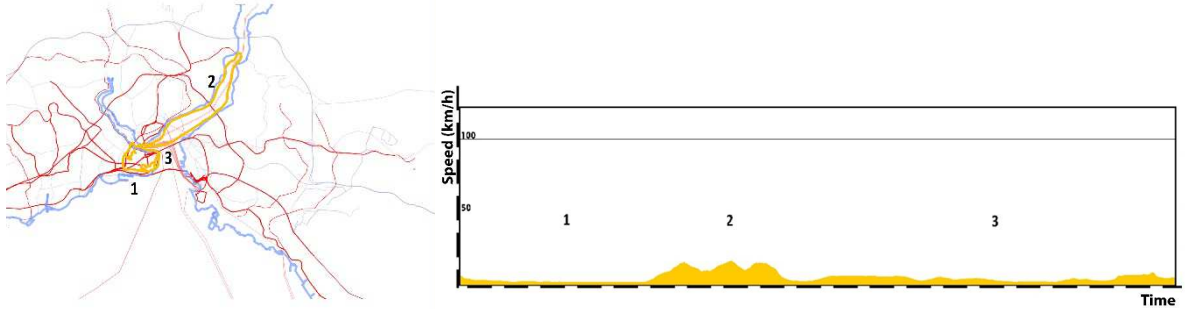

Fig.6: Example of a journey recorded in OpenStreetMap in 2019.

In the example above we can understand that the journey is made on foot (1-3) and by ferry (2). The moving person leaves from the historic centre, more specifically from the Eminönü pier, to walk and then by boat along the Bosphorus (2). As a whole, it is a tourist journey that took place in 2019 before the Covid-19 health crisis. The person who records his journey returns to Eminönü by ferry, then moves to his starting point on foot in the historic district of the megalopolis (3).

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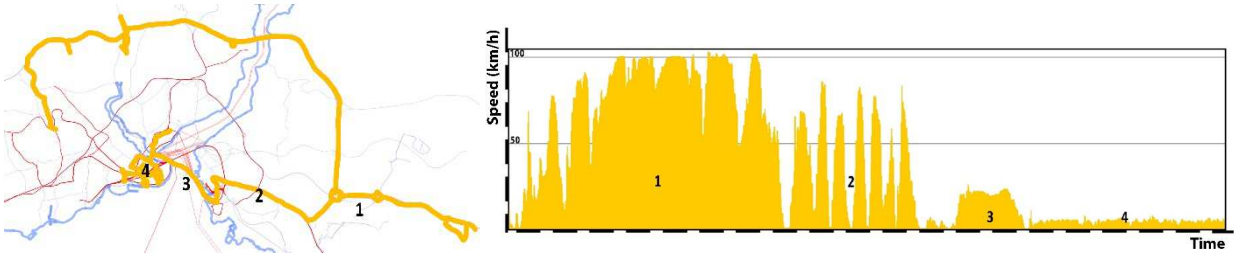

Fig. 7: Example of a journey recorded in OpenStreetMap in 2015.

In the example above, an extract from a trip of several days focused on Istanbul, we can understand that the first part of the journey is made by car (1) then by metro (2- line M4 Kadıköy-Tavşantepe inaugurated at the end of 2012), by ferry (3) and on foot (4). The trip to the south is achieved in a way thanks to the opening of the M4 metro at the end of 2012. It is a journey of several days made in 2015.

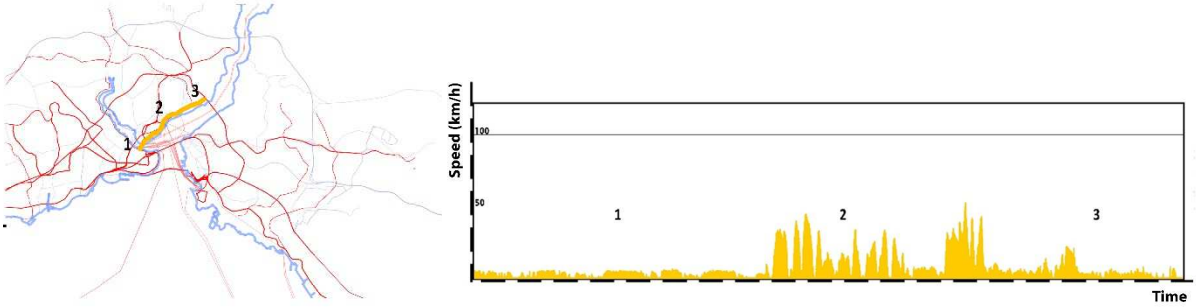

Fig. 8: Example of a journey recorded in OpenStreetMap in 2022.

The example above is very recently recorded on the OpenStreetMap free sharing platform. We can understand that the journey is pedestrian (1-3) and made by tram, via the T1 (2). The moving person starts from the historic centre on foot, more specifically from Karaköy. Then it continues along the Bosphorus using the tram to Kabatas. This mobility system, as a network, is not continuous. We presume that this is why the person making the journey continues his/her journey on foot (3) after getting off at the Kabatas stop. We are sure that the person took the tram, because the georeferenced plot of his journey and the speed-time relations of the graph coincide with the plot of the T1 tram and the number of stops where the speed of the person in question is 0 km/h (2).

5.2 Research, an urban look before and after Covid-19

The Covid-19 health crisis has marked a cultural break in all areas of urban life. This break was visible in our results. From March 2019 to January 2022, downloads of journeys on OpenStreetMap decreased. Regarding the megalopolis of Istanbul, we studied 18 journeys after the health crisis (in our studied territorial area which is 115 km2). The crisis has drastically changed the data obtained. Among the producers of the 18 journeys there are very few tourists (only 3 journeys). We see an increase in trips made by tram/metro.

Figure 3, which shows “the nature of the routes chosen by citizens. by theme and by nature in 2022" was drawn like Figure 9 in 2019 (March data): 54.6% (compared to 50% between 2007-2022) of shared journeys on OpenStreetMap in the study area between 2007 and 2019 belonged to tourists. Among the journeys studied, the most used mode of transport was travel by car (48.6% of journeys compared to 28% between 2007-2022). The second most used mode of transport was the bus (28.6% of trips compared to 15% between 2007-2022). The ferry followed the bus just after (22.9% against 13.6% between 2007-2022). The use of metro/tramway and train came last (8.6% of metro and tram journeys and 5.7% of train journeys compared to 17.8% tram and metro; 6.8% train between 2007-2022) with cycling (1.8% of trips compared to 2.7% between 2007-2022).

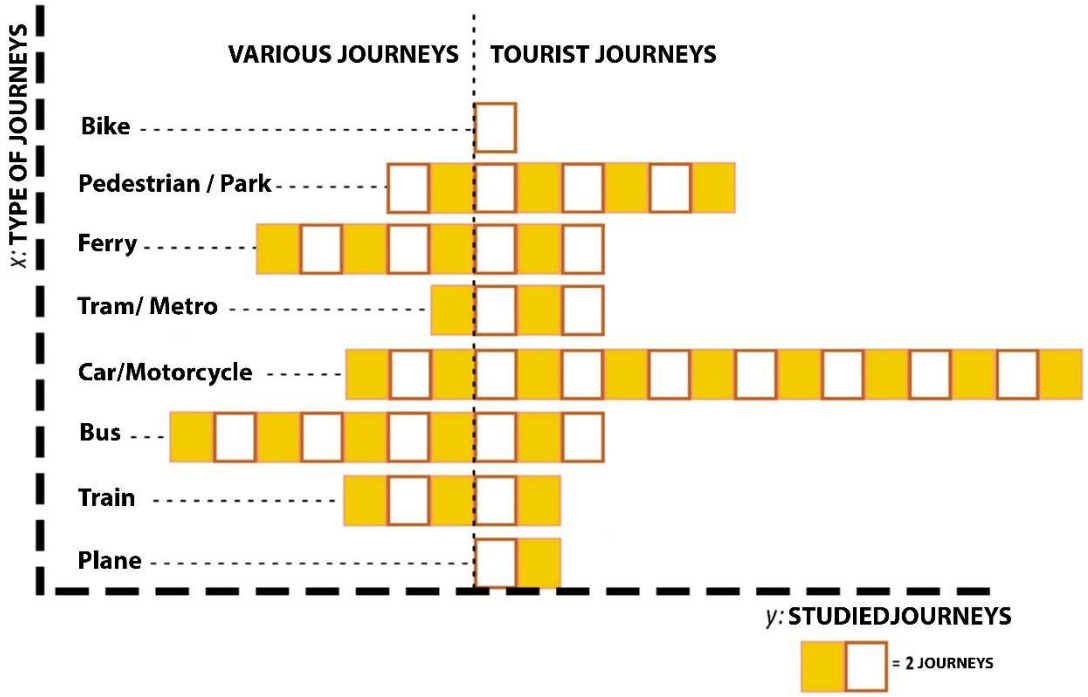

Fig. 9: The nature of the journeys chosen by citizens. by theme and by nature studied in 2019.

Before the health crisis, it was possible to find “test” journeys where the ownver of the journey wrote comments before sharing it. With Covid-19, several walking journeys with specific comments have been uploaded to the OpenStreetMap platform. These comments were no longer intended to carry out essays but to make critiques of the urban space. The profile of the designers was also different. We studied 3 critical journeys of urban morphology between March 2019-January 2022. The journey “K_pr__olsayd_.gpx 2020” which was downloaded on August 6, 2020 at 7:32 p.m. particularly caught our attention. From the title, which means “if there had only been a bridge”, the designer criticised the urban space and showed his disappointment with the planning. He had to bypass “Kurbagali Dere” to be able to cross it. (Fig.10)

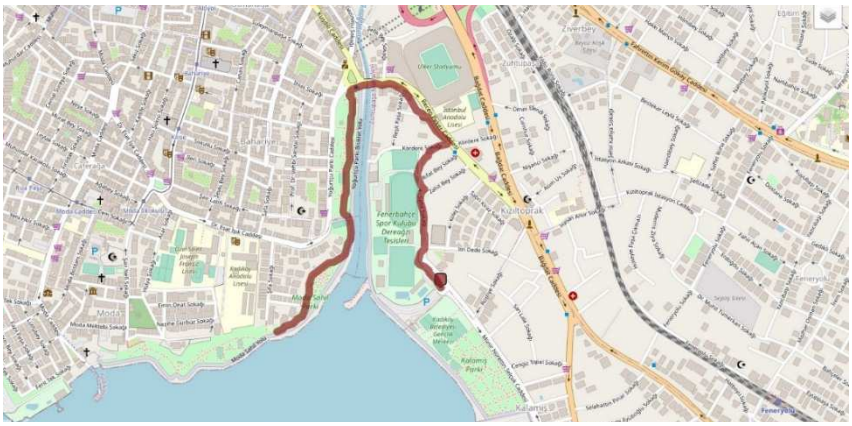

Fig. 10: Example of a citizen's critique of urban space. using OpenStreetMap.

Following our analyses of geolocated traces, we see that from 2009 the territorial goal is to have continuity in the layout of public transport axes. These traces superimposed on the major axes of infrastructure remind us of the master plan proposed by Helmuth von Moltke. Parallel connections between the Asian side and the European side of Istanbul increase by 150% in just 8 years. The arrival of Marmaray in 2013 (the railway linking, partly underground, the Istanbul districts of Fatih and Üsküdar across the Bosphorus), already predicted by Strom, Lindman and Hilliker in 1902, can also be considered as a major change in the history of the Istanbul conurbation (Fig.11). The stages of development of travel networks are organised and designed according to the different rail and road type mobility systems which essentially require material and financial resources. (Fig.11, Fig.12)

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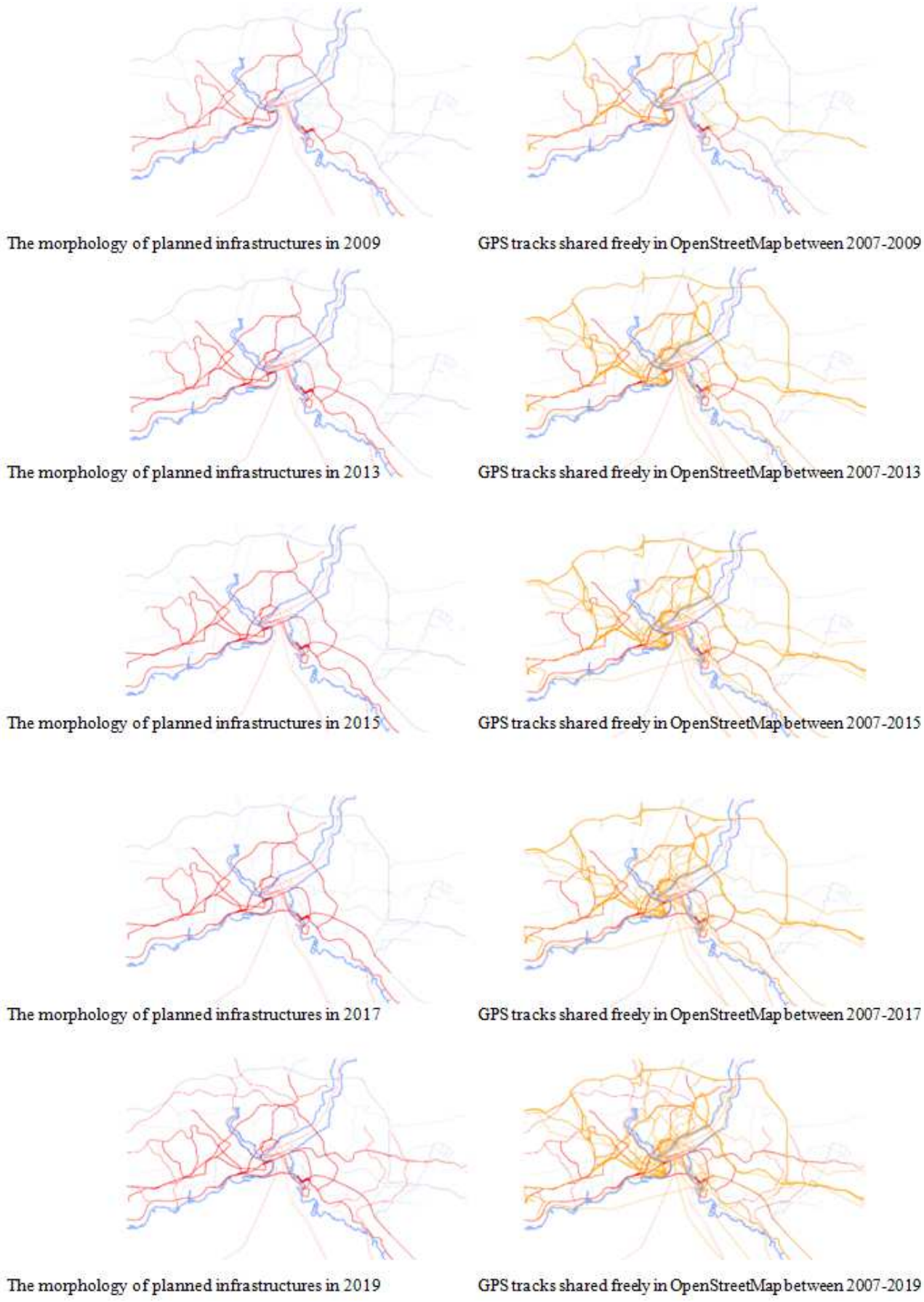

Fig. 11: The chronological development of the development of mobility infrastructures in the megalopolis of Istanbul with the superposition of traces of shared journeys on OSM. The infrastructure plan (red lines) includes networks such as metro, tram, train and primary road axes. Tracks shared on Openstreetmap are yellow.

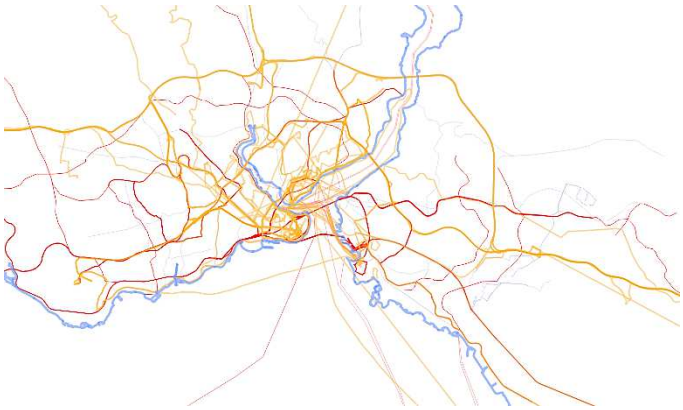

Fig. 12: GPS tracks shared freely in OpenStreetMap between 2007-January 2022.

The authors of these traces, passing through the territorial area that we have studied, use at least two means of transport.

6 DISCUSSION: WHICH SCENARIOS FOR TOMORROW?

With the Tanzimats which began in 1839, the aim of planners was to link the two sides of the Golden Horn. Today's urban issues are located on both sides of the Bosphorus. According to the results of our study, we understand that there is a real difficulty in crossing the Bosphorus. However, it has great potential. Increasing the parallel connections between the two sides is a solution (Fig. 13: a, b, c, 2, 3). In addition, the traces studied by the inhabitants have shown us that it is also necessary to sew these parallel links with radiating structuring axes of mobility (Fig. 13: 1, 4, 5). In the figures below, plots a, b and c refer to bridges and peripheral boulevards which are in a situation of formation and reinforcement. Line 1 is Metro 4 inaugurated in 2012. Line 2 is Marmaray inaugurated in 2013. Line 3 is Avrasya Tunnel inaugurated in 2016. Line 4 is Metro 5 inaugurated in late 2017. Line 5 is the tramway 5 which is currently in development. Lines 6 and 7 represent the axes of recent developments started to develop with the new Istanbul airport. (Fig.5) When we look at the traces shared between 2007 and 2022 we understand that the importance of these axes (1, 2, 3, 4 and 5) is already underlined by the choices in the movements of the inhabitants of Istanbul (Fig. 13). Axes 6 and 7 seem to be a response from local actors to allow users to move freely in a logic of radiant movement.

The actors of the urban space manage, at a certain moment, to understand the needs of the users. However, having studied some journeys in detail (like the one from 2015, Fig.7), we understand that they underestimate the potential of soft journeys. We believe that thinking about the city of the future with soft travel has the ability to allow the megalopolis of Istanbul a better future. Designing small interventions, in the form of intermodality, taking into account the importance of soft mobility systems along both sides of the Bosphorus can certainly meet a part of the needs of users (densification of the network for example). The potential of the Bosphorus can be exploited by considering water as a unifying element and not a physical limit. It should be thought of as a centre of natural and gentle linear intermodality.

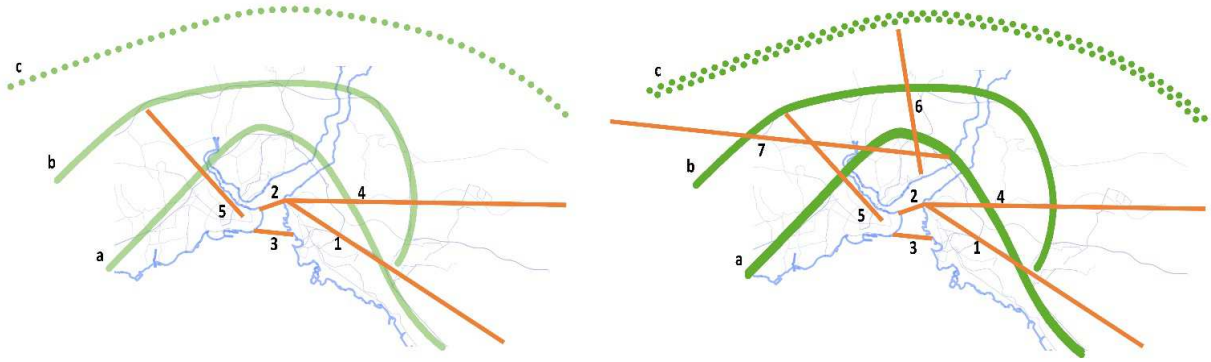

Fig. 13: The two stages of the axes of development of the agglomeration of the city of Istanbul.The first stage corresponds to 2017 and the second to 2023.

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7 CONCLUSION: "SOFT" DISTANCES TOWARDS INTELLIGENT MODELING AND OPTIMISATION

Non-visible urban factors such as digital traces of individualised technical objects create territories of mobility. These territories can be understood as a tool to better understand the organisation of the city with its inhabitants as urban designers.

In the case of Istanbul, more than 150 years have passed since the creation of the Tanzimats. During this long period, the city's transport network has developed, new roads and squares have been designed. Today's Istanbul has spread over a very large area. This city is now accompanied by new information and communication technologies (NICT). In addition to the internal and rich functioning of this city, the digital traces of the inhabitants also seem to bring new knowledge about the territory in which Istanbul is inserted as well as new ideas to design other elements of mobility.

A new field of possibilities has opened up through the use of the individual technical object (Porada, 1993; Hatchuel, 2006). The new use has diverted the function of these objects by making them "everyday tools" for city users. Used in a collaborative and open-access way, these tools are certainly affecting the work of designers.

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