How Disruptive Technologies can Strengthen Urban Mobility Transformation. The Experience of URBANITE H2020 Project

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ABSTRACT

URBANITE (Supporting the decision-making in URBAN transformation with the use of dIsruptive TEchnologies) is an H2020 project (started in April 2020) investigating the impact, trust and attitudes of civil servants, citizens and other stakeholders concerning the introduction and adoption of disruptive technologies (e.g. AI, Decision Support Systems, big data analytics) in decision-making processes related to the planning and management of urban mobility. The project experiments and validates its approaches and tools in the context of four real use cases in the cities of Amsterdam (NL), Bilbao (ES), Helsinki (FI) and Messina (IT). This article summarises the main findings matured during the first half of the project in the four cities, their main mobility issues and how disruptive technologies can play a role in supporting the decision-making process to solve them. Despite the four cities face different kinds of mobility issues and are characterised by different levels of IT maturity, we identified a chain of three categories of technologies that can improve the efficiency and effectiveness of decision-making processes in all four cities: data access and harmonisation, data analysis and data visualisation.

KEYWORDS

Urban transformation, disruptive technologies, urban mobility, URBANITE project, decision making, data access, data analysis, data visualisation.

1 INTRODUCTION

Today's cities are facing a revolutionary era in urban mobility; this is due to different factors, among the others their continuous growth and the concentration of human activities. To prevent and solve problems related to mobility such as traffic congestion and air pollution (for instance due to $PM_{2.5}$) and its potential link with other risk factors (e.g. Covid-19 spread, as envisaged in recent studies [3], [4]), cities are in continuous search of adequate mobility solutions to satisfy the demand of the growing population, both living in or moving around the cities every day. As a result, decision-makers have to face more and more complex challenges when managing and planning mobility, combining new forms of mobility, that must coexist in the urban structure of modern cities, in compliance with the well-being of citizens and protection of the environment.

The concrete adoption of disruptive technologies in the decision-making processes can represent the pivoting point for a paradigm change in the management of mobility. Decision Support Systems, Artificial Intelligence, predictive algorithms, simulation models, Big Data analytics, etc. offer the opportunity to analyse the current mobility situation, identify present and future trends allowing to predict potential future mobility scenarios [6], [9].

Our investigation focuses on four European cities distributed in four different countries: Amsterdam, Bilbao, Helsinki, and Messina. Each of them offers a different perspective on urban mobility, in terms of characteristics, offered services and challenges. Section 2 presents the four cities, their general characteristics, the specific urban mobility issues they are currently facing, and which kind of disruptive technologies (e.g. artificial intelligence, decision support systems, big data analytics, predictive algorithms, simulation engines) can improve the decision-making processes and how. Final considerations and conclusions are reported in Section 3.

2 URBANITE CITIES

2.1 Amsterdam

Amsterdam, the capital of the Netherlands, in recent years has been growing rapidly in terms of inhabitants and visitors; this growth leads to increased mobility and traffic issues. The city has complex traffic streams with massive amounts of bicycles combined with cars and public transport; this drives the need for finding solutions that can conciliate the ever-growing use of bikes with the other means of transportation (from public transportation to private cars) resulting in more sustainable mobility for the whole city. Part of this view is a strategy tending to increase the appeal of bikes as the main mobility option [5]. This strategy goes through the improvement of the city network of bike lanes and of the overall cycling experience within the city, encouraging virtuous behaviours (e.g. respect of traffic lights) to avoid potential discomfort.

What Amsterdam is aiming for. To reach these objectives the city of Amsterdam would like to align the mobility policies to the real needs of bike mobility, realise a data-driven decision

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mechanism, strengthen the safety and comfort of cycling, and encourage citizens to make sustainable mobility choices.

The role of disruptive technologies in Amsterdam. From a broader perspective, a unique point to access data coming from different sources can support the decision-makers in the identification of the required information, reducing the time spent to search it and speeding up the decision-making process. Since different departments of the municipality (i.e. civil servants) are involved in decision-making, the possibility to easily share information among them (such as data, results of analysis/simulations, map layers, charts, graphs) would improve collaboration and overcome inefficient communication and silos, allowing at the same time the reduction of policy fragmentation and the subsequent uncertainties. From a more specific perspective, data analysis tools can support decision-makers in understanding different aspects of bike mobility (through the analysis of bike-related data) and in identifying dependencies among factors that could influence directly or indirectly bike mobility and its adoption. In this sense tools and models to simulate how decisions and policies can potentially impact on traffic and mobility would offer predictions and the possibility to compare different scenarios. This would allow decision-makers to make choices with minimal negative impact and to minimize related costs. Finally, effective visualisation of information is essential; a dashboard offering map layers, charts and graphs that summarise the status of bike mobility in the city would allow decision-makers to have, in a single view, the overall and relevant information they need to gain new insights about bike mobility in the city (e.g. type of road infrastructure/ bike paths, road safety level, traffic mix/sources, congested routes, cleaner routes in terms of air quality, greener routes, faster routes).

2.2 Bilbao

With an area of 41,60 km^2 and around 355,000 inhabitants, Bilbao is the heart of a metropolitan area that extends along the estuary of the Nervioén River with a population close to 1 million people. In the last 25 years, Bilbao has suffered an important urban transformation from an industrial economy to a city based on a service economy. This has helped to balance the city and provide a friendly environment for pedestrians with wider pavements, reduction of on-street car parking in the city centre, traffic light control system to cater for pedestrians and promenades for walking and cycling. Today, 65% of internal movements are produced on foot. In this context, the Sustainable Urban Mobility Plan (SUMP) [8] in Bilbao plays a significant role; its main objectives are:

- Reducing air and noise pollution.
- Improving safety by reducing accidents and fatalities.
- Guaranteeing universal accessibility.
- Improving energy and transport (passengers and goods) efficiency.
- Contributing to improve the attractiveness and environmental quality of the city.

Of particular interest is the “Pedestrian mobility strategy” aiming to promote non-motorized modes of transport (especially pedestrian displacement) since these best suit the sustainable mobility objectives. Part of this strategy is the transformation of Moyuéa plaza, for exclusive use of public transport, pedestrians, and cyclists, prohibiting private traffic.

What Bilbao is aiming for. To reach its objectives, the city of Bilbao aims to obtain a global vision of the city in terms of sustainable mobility, to take decisions based on updated data (predicting the impact resulting from applied measures), follow a more agile decision-making process (facilitating communication between stakeholders involved in the definition and development of the SUMP), translate measures impact into health and life quality indicators and access data coming from scattered sources that is automatically collected and integrated.

The role of disruptive technologies in Bilbao. In the context of Bilbao, it is essential that decision-makers can easily access the most updated data; in this sense tools that facilitate the connection of data sources and the data harmonisation (leveraging common and well-defined data models) would support decision-makers in their daily activities. Once data is collected, a data catalogue (as a unique point of access to the data) would offer the capabilities to search data considering different criteria; among them, the possibility to filter the available data by for example the “transport mode" would allow the decision-makers to reduce the time they spend to identify the data they need. Facilitated setup and execution of simulations (for instance, to forecast impact on traffic, mobility patterns or SUMP’s KPIs resulting from a measure/policy applied) would support the decision-making process reducing the time spent in performing those simulations. Tools to create charts and graphs that summarise the status of mobility in the city from the sustainability point of view would allow the decision-maker to have, in a single view, the overall and relevant information to globally monitor the mobility in the city. On the other hand, the possibility to define and create customised KPIs and indicators would allow the decision-makers to fine-tune the dashboards with all the relevant information that they need to take into account in the planning of the mobility in the city. To this aim, checking if the data is updated would allow the creation of analyses and simulations based on correct information that represents the real status of the city, whereas pre-processing of collected data would reduce the time needed to setup the analysis and simulation for decision-making processes.

2.3 Helsinki

Helsinki, the capital of Finland, is a continuously evolving and developing city. In this sense a particular example is represented by the Jaétkaésaari area. The shore area of Jaétkaésaari, literally meaning “Dockers’ Island”, was previously used for industrial and harbour purposes; now it has gradually transformed itself into a residential area offering workplaces and services. At the same time, Jaétkaésaari is also a growing passenger and transport harbour due to its location (right adjacent to the centre of Helsinki). The harbour is the main connection between Helsinki and Tallinn, with growing mobility and opening of a new terminal in 2017. Annually 1 million private cars travel on the connection where a single main road leads in and out of Jaétkaésaari. This road feeds directly to the largest car commuting junction (70.000 cars daily) from the city centre to the western suburbs of Helsinki, creating interference. The Jaétkaésaari area is emblematic of the overall development Helsinki is facing, in particular, concerning mobility. In this context, to correctly cope with this evolution, the City of Helsinki’s traffic planning and traffic management need up-to-date and high-quality traffic information to support data-driven decision making. In addition, proactive and forward-looking approach is needed as the population of the metropolitan area grows and traffic situation changes.

What Helsinki is aiming for. In this context, the City of Helsinki aims to check the status of traffic and its development, analyse how traffic could evolve, perform traffic forecasts, simulate traffic planning and land use, check the development and implementation of new infrastructures and policies, develop a master plan for city development (e.g. land use, mobility, housing). To reach these objectives it is essential to establish a unique view and understanding among traffic planning and urban planning, allowing the exchange of information among different departments (overcoming information silos). In doing so, the city of Helsinki faces some issues related to the availability of different map layers with different information representations moving from a department to another, the lack of people with competences for demanding analysis, the lack of time to get deep understanding of data and problems related to obtain raw data to be analysed with external tools.

The role of disruptive technologies in Helsinki. A data catalogue as unique point of access that brings under the same umbrella the data produced by different departments would simplify the discovery and access of needed data, avoiding complications caused by scattered repositories managed by different departments of the same organisation. The data catalogue could leverage tools for the integration with existing ICT software and applications. This would allow on the one hand, the automatic check of information (e.g. automatic detection of inconsistencies in the data, such as missing mandatory fields, infringement of time constraints about updates) and on the other hand, the automation of repetitive tasks (e.g. extract relevant information and provide it in a more usable manner). Leveraging the data made accessible it would be possible to define pre-packaged simulations that need only minor operations to be executed (e.g. few parameters and/or initial input data). This would simplify the use of this kind of technology by personnel without specific competencies and skills who would be able to set up an entire simulation from scratch, and reduce the time needed and the acceptance of this technology, since the personnel will not spend too much time to learn how to use it.

2.4 Messina

The metropolitan area of Messina is one of the most extended urban areas in the south of Italy and the first in Sicily and counts over 620.000 citizens. In the city of Messina alone, there are over 250.000 inhabitants and most of them are commuters between Sicily and Calabria regions. Geographical peculiarities (the geographical shape of the city of Messina is stretched for 32 km beside the Tirrenian sea, and tight between its hills and the sea) and its role of main connection point between Sicily and the Italian peninsula have a huge impact on mobility in the city of Messina. The local transport system of the city consists of sea transport (hydrofoil and ferry boats fleets) and land transport (buses, tramway and rail transports network), operated by public and private companies. One of the main issues that affects both kinds of services (sea and land transport) is the lack of interoperability among the different departments of the Municipality that are involved for different reasons in the management of the mobility.

What Messina is aiming for. Concerning mobility, the main challenge of the city of Messina for the upcoming years is twofold: on the one hand, to build mobility services able to fulfil the needs of citizens, dwellers, commuters and visitors, allowing them to move around and through the city seamlessly; on the other hand, the challenge consists in optimising the management and interaction among the different mobility and monitoring systems and services available in the urban area of the city of Messina reducing the waste of resources and costs for the Public Administration. A particular attention is paid on light mobility (e.g. extension of the cycle network with new bike-lanes and links between the centre and suburbs zones of the city to spread the use of bicycle mobility [2]) and pedestrians (definition of an integrated system of pedestrian areas and paths).

The role of disruptive technologies in Messina. The different Departments of the Municipality would benefit of a unique data-access point to their data, avoiding the complication generated by the need of accessing scattered data sources (for instance, in the case of data hosted and managed in different repositories for the different departments). This would simplify the discovery of and access to the data needed by the decision-makers. In this context, tools to facilitate the connection to data sources (also from third parties) are vital. Data is the fuel of any activity related to analysis, simulation and the more information is available (not only in terms of amount but also in terms of variety), the more accurate and precise can these analysis and simulations be. In this context, advanced smart devices and virtual devices [7] (abstracted component characterized by specific high-level functionalities) offer the chance to access the needed information with the most appropriate frequency and accuracy, avoiding information overload and allowing a more efficient computation. In the management of urban mobility, analysis and simulations would support decision-makers in the identification of potential solutions (such as multimodal paths and possible intervention to increase public safety) [1] and hidden problems (such as related to public transportation and for planning maintenance interventions of road and public transportation vehicles). Customisable dashboards to represent the information a decision-maker needs would allow to obtain a clearer view of the status of mobility, supporting the decision-making process in the most appropriate manner. Finally, the possibility to share information (such as data, results of analysis/simulations, map layers, charts, graphs) with people working in the same or a different department would improve the collaboration and the efficiency of the decision-making process, overcoming inefficient communication and information silos.

3 CONCLUSIONS

Despite their specific peculiarities such as organisational approaches and mobility needs to be satisfied, the cities of Amsterdam, Bilbao, Helsinki and Messina have some commonalities in terms of potential application of disruptive technologies that can help their decision-making processes. The main aspect that emerged is related to the need of data, as a vital element to perform any decision-making activity; in this sense it is important to underline that here the need is related to the easiness of accessing the data, that in most of the cases is scattered, or represented using different data structures with non-uniform standards. Uniform access to the data drives to another common point among the four cities, that is the exploitation of the possibilities offered by simulation tools, in particular to forecast and predict the impact of decisions taken on traffic and mobility (such as the building of a new road, the creation of a LTZ). This kind of technologies would allow the decision-makers to better design mobility solutions and policies, giving the possibility to tackle complex problems and to evaluate the implications of new policies. The third common point is the data visualisation. Accessed data and results obtained from simulations and data analysis must be visualised in an easy-to-understand manner, this includes not only the data visualisation per se, but also the possibility of creating customisable dashboards in which the decision makers can arrange the information they need and represent it according to their preferences. From the result here summarised, it is possible to clearly identify a chain of needs with their corresponding solutions. The first link of the chain is the need of **accessing data**. Here tools facilitating the connection to data sources and the integration with existing IT systems can offer a valuable solution to overcome information silos and to build a unique data-access point to available data, allowing also the harmonisation of the data thanks also to common and well-defined data models and highlight the relevant information reducing the time to find it. The second link of the chain is the **analysis of the data** made accessible through the previous step and the execution of simulation. Here it is important to highlight that beyond the possibility to perform analysis and simulation, availability of tools that simplify and reduce the time needed to set them up play a key role. In this sense, pre-packaged simulations ready to use, that guide the users in their setup, and tools, that allow the creation of customised KPIs and indicators, represent an advantage for the decision-makers. The third and final link of the chain is the **data visualisation**. Here, tools (e.g. Wizards) guiding the users in the creation of charts, graphs, map layers, etc. offer the opportunity to speed up the decision-making process by reducing the time of interpreting and understating the information. At the same time, the possibility to visualise different data in the same view through customisable dashboards offers the chance of obtaining a bird's-eye view on the information that is relevant for each decision-maker, according to their specific needs. Considering the reported results, a final consideration can be made; even if cities could be characterised by a different IT maturity level, the most suitable way to effectively improve mobility decision-making processes is not a single technology, but a combination of disruptive technologies, that glued together unlock their respective potentialities and benefits.

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REFERENCES

[1] Lorenzo Carnevale, Antonio Celesti, Maria Di Pietro, and Antonino Galletta. 2018. How to conceive future mobility services in smart cities according to the fiware frontiercities experience. *IEEE Cloud Computing*, 5, 5, 25–36. DOI: 10.1109/MCC.2018.053711664.

[2] Alessio Catalfamo, Maria Fazio, Francesco Martella, Antonio Celesti, and Massimo Villari. 2021. MuoviMe: secure access to sustainable mobility services in smart city, (September 2021).

[3] Silvia Comunian, Dario Dongo, Chiara Milani, and Paola Palestini. 2020. Air pollution and covid-19: the role of particulate matter in the spread and increase of covid-19's morbidity and mortality. *International Journal of Environmental Research and Public Health*, 17, 12. ISSN: 1660-4601. DOI: 10.3390/ijerph17124487. https://www.mdpi.com/1660-4601/17/12/4487.

[4] Chiara Copat, Antonio Cristaldi, Maria Fiore, Alfina Grasso, Pietro Zuccarello, Santo Signorelli, Gea Conti, and Margherita Ferrante. 2020. The role of air pollution (pm and no2) in covid-19 spread and lethality: a systematic review. *Environmental Research*, 191, (August 2020), 110129. DOI: 10.1016/j.envres.2020.110129.

[5] 2019. *CYCLING MATTERS 2019, How Bicycles Power Amsterdam.* CITY OF AMSTERDAM.

[6] Alina Machidon, Maj Smerkol, and Matjaž Gams. 2020. Urbanite h2020 project. algorithms and simulation techniques for decision – makers. *Proceedings of the 23rd International Multiconference INFORMATION SOCIETY*, A, 68–71.

[7] Francesco Martella, Giovanni Parrino, Giuseppe Ciulla, Roberto Di Bernardo, Antonio Celesti, Maria Fazio, and Massimo Villari. 2021. Virtual device model extending ngsi-ld for faas at the edge. In *2021 IEEE/ACM 21st International Symposium on Cluster, Cloud and Internet Computing (CCGrid)*, 660–667. DOI: 10.1109/CCGrid51090.2021.00079.

[8] 2018. *Plan de Movilidad Urbana Sostenible (PMUS) 2015-2030 de la Villa de Bilbao, Fase II. Propuesta.* Ayuntamiento de Bilbao, Área de Movilidad y Sostenibilidad.

[9] Maj Smerkol, Žan Počkar, Alina Machidon, and Matjaž Gams. 2020. Traffic simulation software in the context of mobility policy support system. *In Information Society 2020.*