The Information City:

INFORMATION SHARING SYSTEM FOR LOCAL GOVERNMENT DECISION-MAKING

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Part I
RESEARCH FRAMEWORK

Part II
PROJECT DEVELOPMENT

ENGLISH ABSTRACT

Digitization is changing the way people experience information, from the way it is created to how it is retrieved and then shared. This process has been perfectly integrated into our everyday life, as we have access to plenty of tools aimed at organising, sharing, or storing information for later use.
But what happens when people have to monitor a context that is as complex as a whole city?
This thesis will try to investigate the way city managers collect information about the urban environment, and how they shape their own knowledge to make informed decisions for the city's wellbeing.
In this day and age, one of the most precious sources of knowledge is data: we are so immersed in this new technological framework that almost every action we perform leaves a digital trace of some sort. Managing data is not an easy task, but it gets all the more difficult when it comes to smart cities, areas where infrastructures, services, and even citizens produce data on a daily basis.
City dashboards are among the most widespread tools addressing the issue of organising data coming from an urban environment, turning them into functional visualisations that can aid decision-makers while informing citizens about city management. Nevertheless, what emerges from the current dashboards' analysis is that these platforms appear to have some limits, being mainly focused on technical efficiency and on including as much data sources as possible. Furthermore, final users were never involved in the dashboard design process, and this might be the main reason these platforms are not employed in the first place. Therefore, an alternative development process will be laid out, based on design principles and user-centred approach, integrating feedback from decision-makers and citizens to build a more meaningful informative experience. This theoretical background will then been applied to a real case study, the design of a city dashboard for the city of Milan, and the efficiency of the platform will be verified based on whether it can speed up information retrieval and sharing between users.
As closing note, a reflection on the project context will be laid out, as the platform tries to place itself within a framework in which innovation is held back for various reasons, hoping to pave the way for a change in mindset, rather than a simple change in the tools.

ITALIAN ABSTRACT

La digitalizzazione sta cambiando il modo in cui le persone si interfacciano con l'informazione, da quando essa viene creata fino a quando viene recuperata e condivisa. Questo processo è perfettamente integrato nella nostra vita quotidiana, dato che abbiamo accesso a numerosi strumenti per organizzare, condividere o conservare le informazioni per servircene successivamente. Ma cosa succede quando c'è la necessità di monitorare un sistema complesso come un'intera città?
Questa tesi indagherà le modalità con cui gli amministratori della città raccolgono informazioni sull'ambiente urbano e esplorerà il modo in cui essi formano la propria conoscenza, per prendere decisioni mirate al benessere cittadino.
Attualmente, una delle fonti più preziose di conoscenza è senz'altro rappresentata dai dati: siamo così immersi in questo nuovo contesto tecnologico che quasi ogni nostra azione crea una traccia digitale di qualche tipo. Gestire i dati non è un compito facile, ma diventa ancora più arduo quando si è nel contesto delle smart cities, aree in cui le infrastrutture, i servizi e persino i cittadini producono dati su base quotidiana.
Le city dashboard sono tra gli strumenti più diffusi che affrontano il problema dell'organizzazione dei dati provenienti dall'ambiente urbano, trasformandoli in visualizzazioni funzionali che possono sia aiutare i decisori politici sia informare i cittadini sulla gestione della città. Tuttavia, ciò che emerge dall'analisi delle dashboard attuali è che queste piattaforme presentano dei limiti, essendo focalizzate principalmente sull'efficienza tecnica e sull'inclusione di quante più fonti di dati possibili. Inoltre, gli utenti finali non sono mai stati coinvolti nel processo di progettazione della dashboard, e questo potrebbe essere il motivo principale per cui queste piattaforme non sono utilizzate in primo luogo. Per questo motivo, sarà definito un processo di sviluppo alternativo, basato un approccio centrato sull'utente, integrando i feedback dei decisori politici e dei cittadini per costruire un'esperienza informativa più efficace. Questo background teorico sarà poi applicato ad un caso studio reale, alla progettazione di una dashboard per la città di Milano, e l'efficienza della piattaforma sarà verificata in base alla sua capacità di facilitare il recupero delle informazioni e la loro condivisione tra gli utenti coinvolti.
Come nota conclusiva, verrà delineata una riflessione sul contesto del progetto, in quanto la piattaforma cerca di collocarsi in un quadro in cui l'innovazione è spesso ostacolata per vari motivi, nella speranza di aprire la strada ad un cambiamento di mentalità, piuttosto che ad un semplice cambiamento negli strumenti digitali impiegati.

RELEVANCE AND METHODOLOGY

The project at the core of the thesis arose from the joint effort of Comune di Milano, AMAT, Cefriel, and a2a Smart City: each of the institutions involved felt the need for common ground in urban decision-making, a common ground that, according to their previous experience, was still missing.
The theme of city management in the digital era is of primary importance, and it gets all the more relevant considering that some of the involved stakeholders have access to meaningful technologies, that could support city managers in running the city.
What was lacking was a vision, a direction guiding this technological potential towards a more general benefit, in order to improve citizens' wellbeing and help city managers improve the urban performance.
Among the variety of solutions and systems that could have been developed, partners opted for a city dashboard.
I wanted to clarify the steps followed throughout the thesis development, in order to better display the timing and the results ensuing from each phase. The whole process was summarised in the GANTT diagram in the following page. Despite the linearity of this representation, each and every phase had an iterative course, as the result of each process step was later integrated thanks to the suggestions emerging during the thesis further development. Even the literature review kept growing after the preliminary research was over, as some aspects of the platform development provided me with many insights on the topics that could have been deepened.
Therefore, I divided the work into two macro categories.
The first phase was dedicated to researching on the issues and opportunities related to smart cities, on how government approach to urban problems evolved over the decades, and on collective decision-making, from the cognitive and operative standpoint.
The final aim was to frame the processes and methodology regulating city government in the present day, and to map them in a clearer way, in order to identify a possible project direction.
In the meantime, I started gathering more information about city dashboards, since they were identified as one of the most widespread tools supporting local government. I carried out a research based on these platforms' structure and content. Afterwards, I went on to verify their compliance with usability principles.
Part I ended with the definition of the project direction, namely designing a dashboard that could support information retrieval for decision-makers and citizens.
The second phase was opened with a session of user analysis, focussed on users living in the city of Milan. The user analysis phase is possibly the one in which the project value is at its highest, but in this case the number of involved users was lower than I was expecting to get, especially on the decision-makers side. This might be one of the reasons why such projects never get to be fully employed, as the needs setting phase is hindered by the low rate of active participation of the final users.
After framing their needs, I used the pain points to define OKRs (Objectives and Key

Results). The main key result I came to identify was the percentage of time users could save by replacing their current work method with the dashboard.
After recollecting the results of the user analysis phase, I started developing the new platform: in order to gain feedback in the quickest and most efficient way possible, I began by working on a prototype, so that I could show it to users and gather their impressions.
After this first feedback session, I had to steer the project towards a new direction, that was more compliant to users' daily necessities.
As a closing note, I tested the final prototype with users and verified whether the platform was helping them save time in some of their everyday tasks.
All things considered, the interactions with users were the true shaping force of the overall experience: I involved them in different moments throughout the process, so that the final output would have effectively answered to their needs. The user analysis features a high level of value, and the main aim was trying to keep this value throughout the following phases (OKRs, Information Architecture, wireframing) before getting back to the users themselves for feedbacks and testing.

LEARNING OUTCOMES

The project featured different levels of complexity, varying based on the particular standpoint it was analysed from. That is the main reason it was such a formative experience from my perspective, as I was in charge of all the different phases, each of which brought about fundamental key learnings. I will try to lay out the most important ones, based on which design process phase they were generated from.

The user analysis phase was possibly the most insightful one: I had the opportunity to shed a light on a category of users which, if I hadn't been working on such platform, I would have never get the chance to meet. It helped me understand what is hiding behind the city we all see every day and how even a small decision has to be pondered, in order to maximise the positive effects and minimise the negative ones that may ensue.

Nevertheless, it was also a precious occasion to deepen the mindset of that particular category of users, which helped me understand the obstacles and biases the platform needed to address.

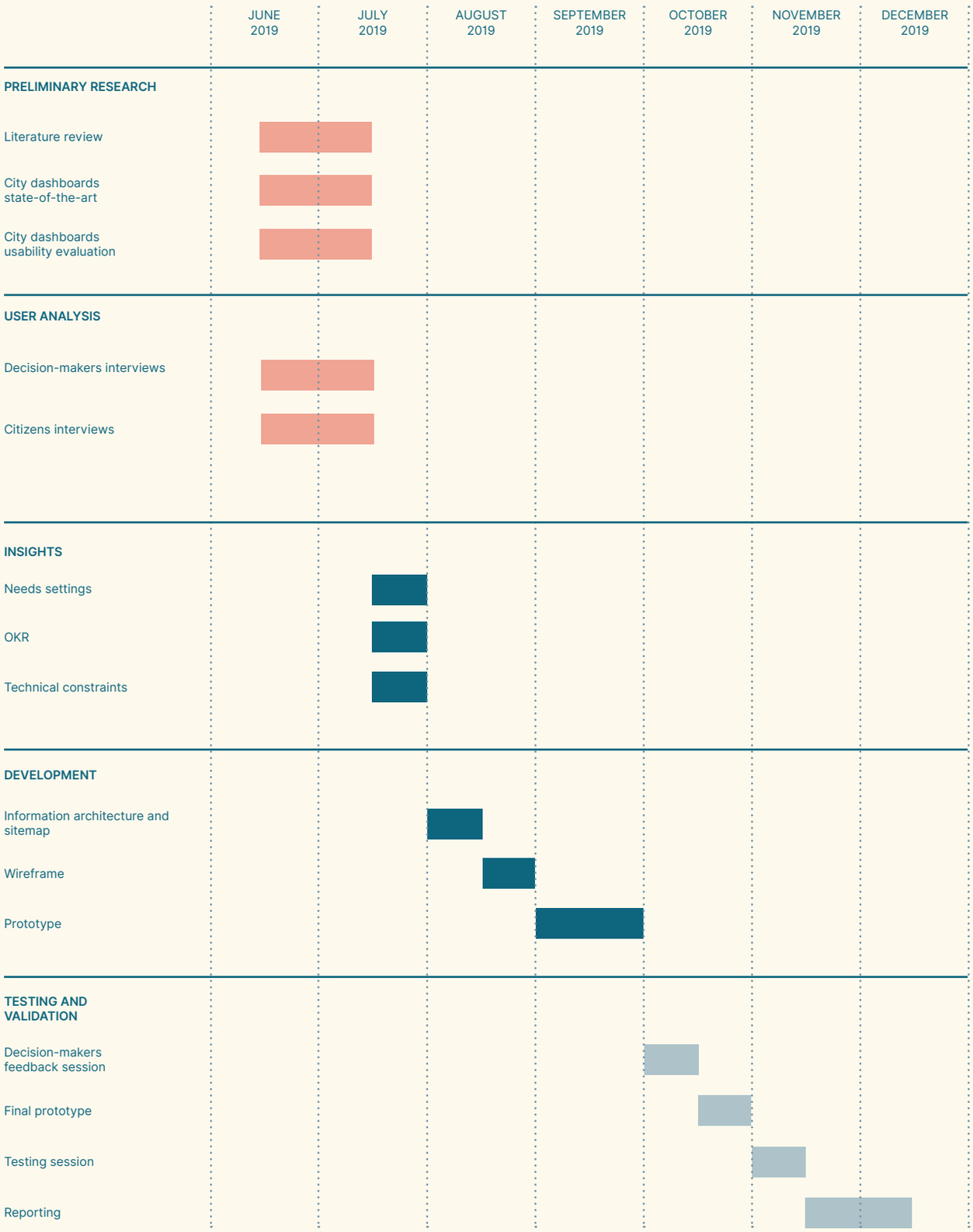
It was also a precious opportunity to hone my interviewer' skills, applying in the field the notions I had been learning about.

Lastly, it was possibly the first time I was dealing with users that were completely different from me: I had to work out their needs, and such needs were based on processes and tools I had no previous knowledge about.

Moreover, the project was a fruitful opportunity to deepen the process phase I prefer, namely the one moving from the insights to the interaction definition. Considering the nature of the project, the final platform became as complex as the needs it was answering. The most challenging and interesting part was trying not to be overwhelmed by complexity, always keeping redundant details at bay and trying to focus on minimalism.

Lastly, I managed to learn more about user testing techniques, like how to write an effective script and how to draw useful details from the users' actions.

As a consequence, my previous set of skills was constantly challenged during the project, but in the end I got a higher level of experience and a better structure methodology than when I started.


JUNE 2019
JULY 2019
AUGUST 2019
SEPTEMBER 2019
OCTOBER 2019
NOVEMBER 2019
DECEMBER 2019
PRELIMINARY RESEARCH
Literature review
City dashboards state-of-the-art
City dashboards usability evaluation
USER ANALYSIS
Decision-makers interviews
Citizens interviews
INSIGHTS
Needs settings
OKR
Technical constraints
DEVELOPMENT
Information architecture and sitemap
Wireframe
Prototype
TESTING AND VALIDATION
Decision-makers feedback session
Final prototype
Testing session
Reporting

Part I

Research framework

1 THE RISE OF SMART CITIES

A NEW PARADIGM FOR CITIES

The shift from rural territories to cities has been a recurring pattern in different times in history, but the extent of such migration flows didn't manage to make the urban population outnumber the rural one. Until 1960, there were twice as many people living in rural areas than urban ones, but an opposite force unfolded over the last 60 years, leading to a first disruptive result **in 2007** when, for the first time in history, **rural and urban populations in the world were nearly equal in size** (with more than 3 billion people each) (73). 12 years on, it seems like this trend is not going to change anytime soon: as a matter of fact, according to the United Nations World Urbanization Prospects, **70% of world population will live in urban areas by 2050**. As a result, the majority of city councils have to deal with an unprecedented number of people, and it comes without saying that these complex **urban congregations will inevitably bring about complex problems**, like difficult resources management, waste disposal, pollution increase, infrastructures renewal, population distribution, services availability and many more. This makes the work of urban planners ever more difficult, as the level of fulfilment of such urban needs ultimately influences the quality of life in the city. In this ever-changing situation, **the word "city" itself is now not enough**, and further differentiation in the terms must be made, namely **a differentiation between all the cities that took a stand against all these complex problems and the rest of cities that still haven't worked out a good solution.**

FIG. 1: Creating digital twins of buildings is one of the cutting edges technologies in the city (source: www.helixre.com)

The term "smart city" identifies the former. Even if the principles of smart cities can also be applied to medium-sized and small cities, it seems like the effects of smart solutions are to be more effective when it comes to reducing the range of negative impact due to big cities: huge urban agglomeration, as we claimed before, bear a higher pollution rate, traffic congestion, significant energy consumption and waste production, all problems that can be diminished or solved thanks to e-services supplies, data analysis and knowledge sharing.

Although the term "smart city" is now widely used, it is still not exempt from uncertainty and doubt. The word "smart" itself is extremely controversial, in a world where everything apparently became smart: phones, houses, TVs, electrical grids, cars, even fridges and dishwashers. Nevertheless, by tracing all the common features of such products, the true meaning of the word can finally be unfolded.
The attributes they share are the following: **the connection between different touchpoints** (like it happens in smart houses); **the successful integration of several functions** (smartphones); **the aim at resource and money-saving** (smart grids, smart houses).
If we widen the scope of these features, we can easily apply them to cities, imagining them as systems in which every part cooperate with the others, all for the benefits of citizens and the environment.
Over the last twelve years, several scholars gave their own definition of "smart city": the clear rendition of this concept will not be further deepened, as it happens to be out of the scope of this thesis work. Nevertheless, in order to frame the project in a clearer way, some of the main definitions will be pointed out, in order to provide a background for the following chapters.
The first use of the term "smart city", by **Giffinger et al.**, dating back to 2007, was "*the idea of smart cities is rooted in the creation and connection of human capital, social capital and Information and Communication Technology (ICT) infrastructure in order to generate a greater and more sustainable economic development and a better quality of life*" (37). **The effectiveness of such definition is proven by the fact that several scholars**, in the following years, **provided their own interpretation**, but **the conclusions they reached are very much alike and based on the same assumptions.**
Another effective attempt is the **"Smart Cities in Europe" research** (12), that mapped all the previous definitions of "smart city" and identified six main pillars at the basis of each of them.
The growing and expanding presence of a networked infrastructure: this category comprises all services aimed at sustaining business, leisure, and telecommunications activities. Here the study stresses how such infrastructure must not be used for the sake of technology, but to bring a real improvement to the economic, political, urban, and social situation of the city. This is particularly interesting for the aim of the project, as it stresses the importance of connectivity as a tool for growth.
A tendency towards "business-led urban development" (42): it refers to the idea of business-friendly cities that generate more value by supporting local businesses and attracting external ones. Predictably, this consideration attracted many critiques, as giving too much importance to economic principles is linked to many potential risks. Nevertheless, data shows how business-oriented cities are the bearers of the best social and economical stability.
An attempt to involve all social classes in the city growth, claiming all new technologies should be accessible to everyone, without any restriction. This is possibly one of the hardest results to

achieve, as spreading technology has to overcome all sorts of issues (lack of budget, obsolete infrastructure…) but if only a small portion of population benefits from new technologies and services, the social wellbeing will never truly thrive.

The growing importance given to skilled workforce, represented by technology focused-companies and creative industries. This aspect was particularly stressed by Richard Florida (34), who's claiming cities should attract creatives types, that are considered "the wave of the future". The reason for this is that skilled workers, working on soft infrastructure (like knowledge and creativity sharing), might be a critical factor for cities in this knowledge-intensive society.

Focus on the primary importance of people, part a community that has learned to learn, adapt, and innovate (18). This is linked to point 3 since, if relationships between people and classes are not properly managed, social polarization may arise, thus hindering the holistic development of the city.

Importance of social and environmental sustainability: this last requirement is possibly the most fundamental one, and it actually influences all the above-mentioned pillars. A balance must be respected, both between the city and the natural environment it stands in and between the city's parts, to ensure improvements in one area don't damage or negatively influence another.

Pardo and Nam (63) carried out an effective recollection of all definitions found in literature, tracing three recurring themes in all of them:

technology dimension, namely the use of ICT infrastructures to improve the way people live and work in the city. The two scholars consider it to be a fundamental prerequisite and enabler for a smart city, as it's the fertile ground from which all further solutions originate;

human dimension, namely people, education, learning and knowledge, all key drivers for the smart city. This concept has been referred to in the literature as "smart people". The smart people concept comprises various factors like "affinity to life-long learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism or open-mindedness, and participation in public life" (58).

institutional dimension, meaning governance and policy: the cooperation between stakeholders and institutional governments is critical to design and implement smart city initiatives. Without it, they are doomed to fail or be developed on a small scale, without influencing the city as a whole.

The latest attempt is the one performed by **Vittoria Polese** (69), who instead is talking about six interconnected dimensions.

smart living (richness and accessibility of cultural offer, urban and residential quality, personal safety, other levels of inclusion and social cohesion);

smart economy (e-business and e-commerce promotion, innovation through smart clusters and startups, openness and internationalisation);

smart people (increase in skills and education access also through ICT, support for creativity and innovation, promotion of decision making process participation);

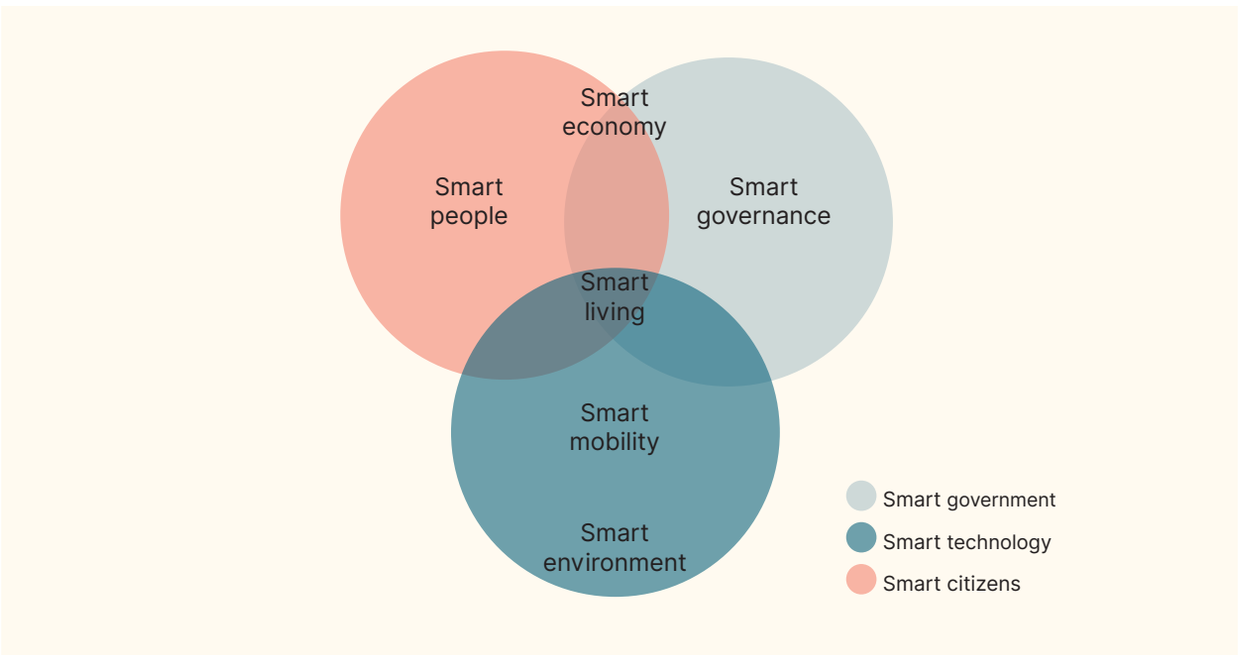


FIG. 2 - Comparison between Pardo and Nam's three features for smart cities and Polese's six features

smart governance (efficient and transparent service management, dialogue between institutions, enterprises, associations and citizens, promotion and management of the other 5 smart fields, use of ICT to activate and facilitate sharing processes);
smart environment (sustainable energy, smart waste management, measuring and control network to monitor pollution);
smart mobility (sustainable mobility, increased accessibility, users feedback management for future planning).
The concept of smart city has been increasingly dealt with not only by scholars, but **it was also encouraged both by public institutions and by private entrepreneurial initiatives.**
In 2005 the Kyoto protocol forced governments to develop smarter initiatives for environment safeguard; in 2009 IBM launched the Smart Planet concept, to put forward an idea of the Earth which is intelligent and interconnected and to "*transform enterprises and institutions through analytics, mobile technology, social business and the cloud*" (43); in 2010 the European Union launched the Horizon 2020 Strategy, focusing on five major goals for the following decade: employment, research and development, climate change and energy sustainability,

education, poverty and social inclusion.
Such initiatives try to grant a fertile ground for innovative solutions, providing technological support for their development and diffusion.
All the above-mentioned efforts can be reckoned as attempts to **find a balance between the components making up the urban system**. Moreover, all the different categories laid out by scholars can be traced back to **three main elements (technology, governance, and citizens).** Despite being incredibly different from each other, **they share the same shaping power,** as they all play an active role in the smart city framework and **can interact in unexpected and unprecedented ways**. The next sections will focus on the role of these three components, on their effects on the city environment and on the kinds of relationships they establish with each other.

SMART TECHNOLOGY

Given the above-mentioned premises, **the rise of smart cities seems to be linked to the fruitful compound of an urgent problem** (the emergence of unparalleled issues in city management and the necessity to satisfy citizens' needs as effectively as possible) **and a solution** (the enabling factor represented by technological solutions).

It's undoubted that, hearing the term "smart city", the first thing coming to mind is an urban environment featuring cutting-edge technology. This is due to the fact that, most of the times, **the most efficient way to fulfil the 6 requirements** shown in Section 1.1 **is relying on innovative technological solutions.** Moreover, according to an analysis of 125 smart city literature reports, **91% referred to advanced technologies and ICT as fundamental factors for smart cities to thrive** (76). The number of technologies shaping smart cities is extremely wide, and mapping them all would be out of the scope of this thesis. Nevertheless, for the sake of this project, **it would be useful to understand the general trend of technological innovation**, in order to understand the possible present and future implications in a broader and clearer way.

First of all, **some analogies can be identified in the most widespread technological solutions**, like Internet of Things (IoT) and cloud computing. The former allows users to have a platform by which sensors and actuator devices communicate with the urban environment to implement intelligent systems (smart grids, smart retail, smart homes and smart energy among others). Cloud computing, instead, denotes computing models, allowing the connection between computers or clusters of them in a real-time communication network. The combination of IoT and cloud computing is at the base of technologies which allow handling and processing a large amount of data (monitoring, storage visualisation and analytics). The aforementioned technologies are implemented in several applications, where **the role of data contributes to optimal management of urban resources.** Considering its importance for the project scope, a clearer definition of data and its role in urban policy-making will be discussed in Chapter 2. As a closing note, what emerges is that **the natural tendency of these technological solutions is enhancing communication between systems, rather than radically revolutionising the systems themselves.**

Technology puts itself in a mediator role, as an enabling element empowering both citizens and decision-makers, supporting the way they communicate with each other and with the environment surrounding them. Nevertheless, many studies on the matter, promoted by the likes of **PwC** (70) and **World Economic Forum** (97), **go as far as to identify a set of key technologies, that would become the foundation to build any smart city**. Nevertheless, **I reckon the relevance of another part of scholars**, claiming that this assumption is a misconception that must be demistified, since **technology is a necessary but insufficient condition for a smart city to thrive**. For instance, in his book "Inventing Future Cities" (3), Michael Batty, from University College London, writes "*The kinds of automation*

that currently characterize the smart city are only intelligent or smart insofar as we, ourselves, use them intelligently. It is we who must potentially be smart rather than the devices we use."

Therefore, **a technical solution is never an end in itself, but it's the means with which a broader goal can be reached**. All the technologies that don't fall within the solutions aimed at answering needs may increasingly grow superfluous, if not harmful.

This happens because of the high number of ethical implications of smart city's technical solutions: for this reason, **over-emphasizing technologies in the ranking of priorities can make decision-makers lose focus on the real needs**, especially when new solutions are developed at all cost, without a real and pending necessity.

The endeavour to keep citizens' needs at the core of each initiative is not an easy one, since it means giving regulations not only to government representatives, but also to private companies: in fact, in the majority of cases, **corporations and private institutions are the ones paving the way for new solutions to be implemented,** as they have access to advanced technologies and precious know-how on their possible applications.

Therefore, their direct involvement is often inevitable but, from this standpoint, **Kitchin** (50) **raises the concern that some companies may rely on cities to test their technologies in a real-world framework**, with their aim being to sell their solutions rather than improve the urban environment. This may lead, in the long term, to negative consequences, as the delicate balance of the urban environment may be disrupted for no relevant reason rather than profit.

In order to keep negative consequences at bay, the most important aspect is possibly **recognising the shaping role non-human elements can have on other city actors**: this is in line with **Latour's theory** (56) according to which **non-human elements**, namely city's infrastructure, services, technologies etc... have a role that doesn't make it subject or secondary to anything.

The environment we live in is not passively enduring the changes people impose on it, but **it has its own agency**, intended as *"anything that modifies a state of affairs"* (31). **Ferronato and Ruecker** (31) propose an interesting perspective on this matter, claiming that such power is not infused in non-human elements by human actors, as they can only partially control their broader effects. **The real source of this "inanimate" agency is the interaction between** the above-mentioned elements, namely **technology and its human counterpart**, made by decision-makers and citizens.

This approach tries to **look at cities from a different standpoint**, that may be defined as a **non-anthropocentric view**: such perspective must be borne in mind while embarking on the design of a new technological solution, as this thesis aims at doing.

SMART CITIZENS

While cities undergo all the radical transformations described in the previous section, **citizens are bound to change too**: the last decade saw a radical shift in the way people communicate, move, and experience the reality around them. For this reason, they just cannot continue to live in the city in the same way they did in the last 50 years. Smart cities are now becoming a thriving place for what is defined as **information society**, which is a new principle that has grown to become a different paradigm for citizenship. The shift from industrial society to information society dates back to the 1970s, but **it's all the more relevant in this day and age**, as this new era was defined as *"a new form of social existence in which the storage, production, flow, etc. of networked information plays the central role"* (48). This new social tendency is due to many factors, both technological and inherently social. **Beniger** (11.3) effectively recalls the origin of such change, **linking it to a greater need for interrelation**, in a society that was growing more and more diverse, and detaching itself from the pre-WWII local dimension. **This information exchange** becomes so central it **starts to influence each and every aspect of society**, from communications to economy, from healthcare to education. For instance, as shown in Figure 3, **a major increase in knowledge-related jobs is recorded**, to the detriment of primary sector workers (4). This renewed centrality makes people more sensitive to the knowledge surrounding them. Evermore so today, **people are connected and informed on a daily basis**, and a growing number is gaining access to digital tools allowing them to make their voice heard. This compound of engagement and tools was referred to by Unesco as **digital citizenship**, defined as *"a set of skills that enables citizens to access, retrieve, understand, evaluate and use, to create as well as to share information and media in all formats, using several tools, in a critical, ethical and effective way to participate and engage in personal, professional and social activities"* (17). Before going any further, one important aspect to bear in mind is that **living in a smart city is not a sufficient condition to be considered a smart citizen** (11.2). Smart citizenship goes beyond that: **it requires people to become active stakeholders and take part in the urban development and changes**, without passively enduring legislation and changes. Technology is seen as an enabler, but it should also be used in a proactive way. Citizens should prompt changes in the city, in order to improve its status, but also be **well-disposed to change their own behaviour and attitude for the city's benefit.** Communities are growing more numerous and diverse, but when people come together they can really shape the future of the urban environment. Although there are inherent limits to what citizens can achieve by themselves, and this will be further discussed in the following chapters,

"We shape our buildings: Thereafter they shape us."

—W. Churchill

they can influence the framework they live in and therefore the policies they have to stick to. Sometimes the initiatives promoted by citizens don't even involve local authorities and stay at a grassroots level. Therefore, granting citizens an active role will also prevent smart cities from becoming "ghettos" for the richer, places in which the access to technology is far from being widespread and in which some citizens groups are excluded by the main benefits innovation can bring about.

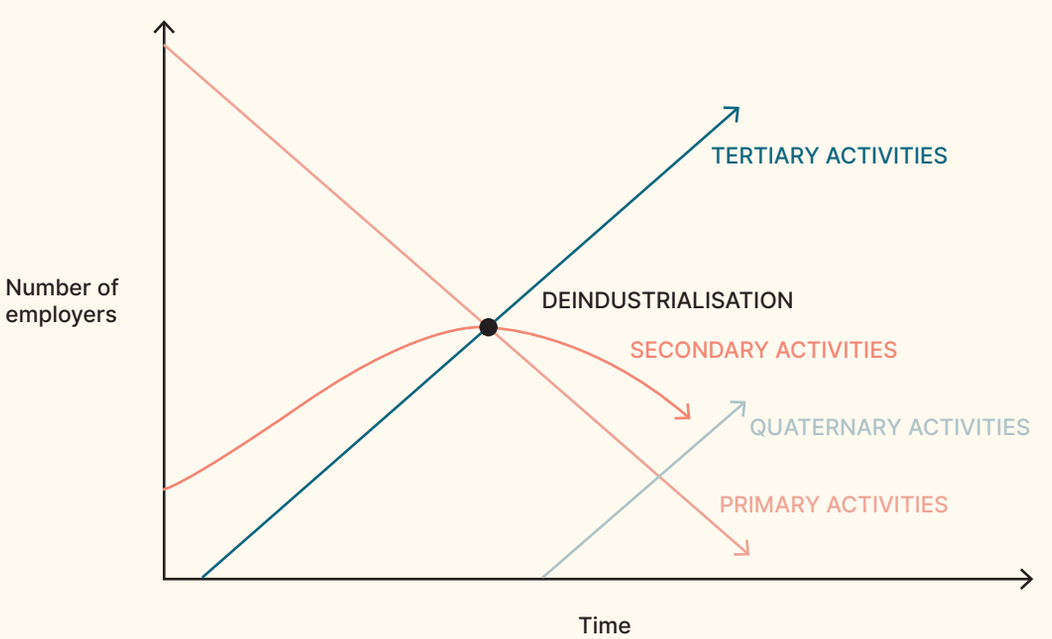


FIG. 3 - The state of economy in a society undergoing a technological improvement (source: Colin Clark)

SMART GOVERNANCE

Government is inevitably affected by urban change too, and the nature and consequences of such change have been steadily attracting experts' attention.
First of all, a differentiation between the terms *government* and *governance* is needed. **Pereira et al.** (68) **smart government is just a component of smart governance**, that is originated by the cooperation with other urban stakeholders and by the use of innovative technology to improve the quality and diffusion of the governing actions. Therefore, the government is slowly abandoning its former hierarchical structure, paving the way to **a horizontal model including all the urban actors** involved in the city environment. Now, more than ever, cooperation has become a key concept for effective policy-making. This is also in line with **Alawadhi & Scholl's standpoint** (77), according to which two of the fundamental elements for government's success are *"reshaping administrative structures and processes across multiple local government agencies and departments"* as well as *"stakeholder involvement in governance"*.
The vast majority of scholars identified three main areas in which ICT can play a fundamental role: **administrative efficiency and interoperability, service improvement** and **citizen centricity** (11.2).
Administrative efficiency involves all the ICT applications aimed at improving the internal structure of public administration, in an attempt to increase effectiveness, coordination, and productivity across different departments.
Interoperability, on the other hand, is the ideal status in which all government sections **share the same set of tools and systems**, both from the hardware and software point of view, to make sure every information exchange happen in the smoothest and most efficient way possible. ICT can also facilitate **service improvement**, and put policy-makers in a more convenient position to answer citizens' demands. By relying on a vast set of technologies, **many procedures that used to be quite long and time-consuming in the past**, like legal processes, form filling, or other requests, **can be significantly simpler**, allowing citizens to get information in a quicker way and potentially from wherever they are. The last identified field of application is **citizen centricity**, that was already mentioned in the previous section and that will be further detailed in the following one. Digital citizens are eager to make their voice heard, and decision-makers can draw precious insights from their involvement.

"The digital citizen is here, are governments ready?"

—J. Clastornik

The situation described above is, most of the times, an objective that still needs to be reached.
Unfortunately, most of the times, **complex urban issues shed a light on the weakness of a certain government mentality**: political institutions are too often bound to outdated procedures, while they should try to shift towards the private industry mindset, based on lean and constant

innovation, risking only when it's "safer" to risk, and always with citizens in mind.
There is no fixed set of rules governments should stick to, as each city operates in a unique framework and has certain necessities, budget, services, and available infrastructures. Nevertheless, some best practices may be extended to the majority of cases.
First of all, **government representatives don't always need to generate their own ideas about the city evolution**, but quite the contrary, as they must **ensure the city becomes a safe environment in which companies, profit and nonprofit associations, or even single citizens can express their suggestions**, and provide the most favourable conditions for such ideas to become viable.
Therefore, sometimes the best choice for government could be stepping back and leave room to other urban actors, while keeping an effective legislative framework. **This may result** not only **in cashflows coming from private investors**, but also **in more fertile initiatives, developed with skills that may not be present in the government sectors**. Still, city authorities must always keep their role of regulators.
Consequently, politicians bear a huge share of responsibility for the success or failure of smart city initiatives that, generally speaking, can follow two opposite paths.
The first one is related to **top-down dynamics**, and its final achievement would be a "city control room", that acts deterministically for the city's benefit, based on measurement and optimisation (44). This vision is still at the centre of harsh criticism, since it's been **accused of representing corporate interest**, and not citizens', due to their blind faith in technology. Plus, its environmental sustainability (as said in Chapter 1, one the pillars of every smart city) it's still to be fully proved by experts and scholars.
The second approach relies instead on the city users to prompt projects and modifications in the urban environment, and can be considered a **bottom-up approach**. Nevertheless, this approach could not be applied independently, since citizens often lack the power to act or the right awareness about the general situation of the city (5, 39).
Given that *"change seldom arises from purely top-down or bottom-up systems and processes"* (8), a combination of the two approaches is to be preferred, as more balanced and effective: **people should try to imagine the city** in a different way, **not as a "battleground"**, where each stakeholder tries to impose its belief, but **as a meeting point** for public sector, private investors, citizens and city users, as a platform to which everyone can give their active contribution.

CITY-CITIZEN COMMUNICATION

Despite the premises mentioned above, **the effective technological and economic development of a city may not be sufficient to produce benefits** in terms of social and environmental condition.
Cities evolution must be facilitated by a wider combination of factors, including the creation of platforms and infrastructures through which governments, businesses and citizens can communicate and work together, and **follow the evolution of the city sharing the same degree of knowledge**. Digitalisation operated a disruptive change in the way people communicate, **bridging the geographical distance together with the social and institutional one**. This means not only that people from different classes (at least in most parts of the world) get the same access to online information, but also that social categories that seemed unreacheable for a variety of reasons (famous people, politicians...) nowadays look nearer than ever, often engaging with followers on social media and providing updates about their everyday lives.
Given these premises, and in the effort to find common ground with citizens, **institutions have often resorted to channels that would have been unimaginable a few years ago, like social media.** This new trend of e-government has registered an equal amount of critics and supporters: the former group, mainly made by academic representatives, claims ***"very little suggests collaborative problem solving"*** **after social media adoption in public administration** (7).
Nonetheless, on the other hand, **government representatives themselves and citizens appear to be more supportive towards this solution**, claiming it helps both parts to cooperate in a smoother and definitely quicker way. Although this debate is far from being solved, **James Toscano (87)** offers an interesting insight: he has a unique point view, as a scholar-practitioner who bridges these two worlds, and claimed to be a supporter of city governments being active on social media. According to Toscano, **the vast majority of academic studies on the matter fail to keep up with the latest advancements in the field** (e.a., Brainard's paper focused on Yahoo, a website that's been out of vogue for a long time). Toscano, despite admitting the current flaws and problematic aspects of current social media platforms, hopes that, in this technological ferment, solutions will grow refined as technology is further developed.
One of the most complete studies on the matter was carried out by **Choi and Kwon (13)** in 2019: such research highlights an **increment in political participation when citizens are engaged through SNS (social networking sites) instead of traditional means.** One possible reason for this result is that people spend time on these platforms in their everyday lives, eliminating the "formality" barrier that could have discouraged many people.
Moreover, engaging on these platforms means constant participation, **involving citizens more often than how it would be done traditionally, in sporadic moments**.
The increasing efficiency of services and their constant availability bear one possible risk: the passive fruition of the city by citizens. For this reason, **governments seeks to recover an active relationship**

with citizens through digital technology, in order to create a direct relationship and stimulate participation (social networks, services-line, apps) for him or her to be able to understand the effects of his or her actions on society and city as a whole.
For what concerns Italy, a thorough analysis on social media adoption has been carried out by **Twig**, a digital agency based in Bergamo (89): according to their report, **the most widespread platform used for this purpose is Facebook**, which has already been adopted by around 80% of Italian cities and many of these manage to respond to citizens' requests within a few hours. Twitter and YouTube are used respectively by 70% and 65% of municipal administrations. Finally, Instagram is still used only by 29% of municipalities, but it's possibly the one with the highest growth rate. Some administrations have also developed **systems of Customer Relationship Management (CRM)** to provide citizens with targeted and personalised information. This model includes more traditional forms of interaction, such as call centres (the percentage of adoption is 98%), and more modern forms, like templates to send reports (e.g. falling trees, holes in the streets, etc.), developed by 65% of the Municipalities. Many cities are starting to use, for the benefit of their citizens, instant messaging apps like Telegram (16%) and Whatsapp (12%). Some others have started developing platforms for enabling citizens to take part in municipal decisions. In particular, **56 cities allow the consultation of intervention proposals, while 18 cities have developed their own participatory formats**, offering citizens the opportunity to present, consult and vote proposals. Nevertheless, as it would be later confirmed by the user analysis phase, these platforms offer a series of challenges in terms of usability and reliability, and the consequences can be more complex than what could be foreseen.

2 DATA-DRIVEN DECISION-MAKING

THE SHAPE OF DATA

The word *data* and its declinations (big data, data analytics…) have steadily become **one of the most pervasive terms in any sort of business and academic field**, but for many its true meaning is still covered with uncertainty: for the sake of clarification, some definitions must be borne in mind before going any further, as the core of the project is rooted in what data really means.

As **Ronda-Pupo and Guerras-Martín** (74) claim, **having a definition that's agreed upon by experts of a certain scientific field is the most essential requirement to verify the advancement of such field**. Nevertheless, big data implications have evolved so quickly that they still lack a clear and shared definition. Moreover, the main issue with existing definitions is that **they often equate data to information**: for instance, the **Cambridge Dictionary** (21) refers to data as *"information, especially facts or numbers, collected to be examined and considered and used to help decision-making, or information in an electronic form that can be stored and used by a computer".* **Buckland** (10), claims data can be equated to *information-as-thing*, processed in some way for use. Such definitions may be misleading and lead to confusion, since data and information are two different concepts.

De Mauro, Greco and Grimaldi (24) tried to cope with this issue by **carrying out a thorough analysis of all the previous definitions**, and proceeded to propose the following explanation: *"Big Data represents the information assets characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value"*. We can settle on this definition to clarify the next step of the work. Further analysis would be needed, but it would be out of the scope of this thesis. Breaking down the above-mentioned definition, we can understand how **data is bound to three different dimensions: volume**, the scale of data; **velocity**, the speed and direction from which data come from; **variety**, the range of data formats. The higher these dimensions, the harder it is to display data effectively and produce value. That is what data does: **it has potential value**, it can produce something if certain requirements are met. To sum up, it's the "raw material" from which more complex processes are originated. This idea of value is useful to introduce the second concept that must be borne in mind, that is *information*. Simply put, **information is what emerges after data has been processed and filtered according to the current needs.** They are part of the same process, but not the same thing. Considering data as raw material is particularly meaningful in understanding this difference, considering also that the term information comes from the Latin word *informare*, meaning "*give form to"* (45). **It is possible to infer different pieces of information from the same datasets**, based on how they are processed, on the skills of the receiver of the information, and so forth.

In fact, while data is objective and detached from current circumstances, **information is** (or, at least should be) **tailored on the needs of the people that have to understand it**, as its fundamental aim is to generate value, in the form of

FIG. 4 - Information without a proper legend becomes unreadable (source: Giorgia Lupi, Stefanie Posavec - Dear Data)

understanding or insights, these people. The shift from data to information is crucial in any data-driven design endeavour, but information definition is not where the process stops. As it will be laid out also in the following sections, information can "trigger" cognitive processes in the receiver, that starts shaping an individual form of **knowledge**. This concept, knowledge, can be better outlined by linking it with the previous steps, namely data and information.

One interesting attempt to define these three concepts was carried out by **Zins** (99), **who relied on the Critical Delphi approach** to tackle this question: Critical Delphi is a **methodology for qualitative research based on the involvement of experts on a certain field**. Through moderated discussions, the people involved provide their opinion on a particular topic. Once participants' responses are aggregated, further discussions are prompted, in order to agree upon a particular topic or to clarify disagreements and misunderstandings.

The session, related to data, information, and knowledge, involved 57 people coming from different 16 countries. Despite coming from far-flung backgrounds, there are some common aspects that are featured in every definition. From what emerged during the session, it appears the shift from data to knowledge could be delineated starting from various standpoints. For

instance, **analysing the process from the cognitive perspective**, we might consider **data as stimuli** that we intercept through our senses, **information as the result of the stimuli processing**, *"in a form that is meaningful to the recipient"* (22), and **knowledge as what the recipient decides to make of such information**, by structuring it inside a cognitive system, for later use or for immediate action.
On a more general level, these three concepts can be differentiated also based on their level of related objectivity: **data is objective, as it is made by matter, in the form of light, soundwaves, temperature, height, and so forth** (97). It can be recorded and gathered in different ways, but its nature is undeniable. **Information**, on the other hand, **implies an individual and subjective component**, as it means **gathering, filtering, and aggregating data based on previous knowledge**, in order to generate information. At this point, **new information can proceed to generate new knowledge**, that will come in handy when dealing with new forms of data.

DATA	INFORMATION	KNOWLEDGE
is objective	is objective	is subjective
has no meaning	has a meaning	has a meaning for a specific person
is unprocessed	is processed	is processed and understood
is quantifiable, there can be a data overload	is quantifiable, there can be an information overload	is not quantifiable, there is no knowledge overload

FIG. 5 - The state of economy in a society undergoing a technological improvement

Scholars actually extended this process with one further steps, that later became the paradigm of knowledge management.
This sentence from T.S. Eliot's poem "The Rock" serves as an introduction to the model known as **Data-Knowledge-Information-Wisdom pyramid** (Figure 6).
The pyramid is considered the main model **systematising all the elements contributing to the creation of knowledge and wisdom**, and it follows a hierarchical structure that puts data at the bottom.
Jennifer Rowley (75) provides a first introduction to the process taking place within the different parts of the pyramid: *"Typically information is defined in terms of data, knowledge in terms of information, and wisdom in terms of knowledge."*
This means that data, starting from the lower part of the pyramid, has to make its way to the top, passing through the two intermediate "states" (information and knowledge) before ending up becoming wisdom.
Throughout these steps, not all the "material" coming from the previous phase is processed: as the poetry claims, **a part of data, information, or knowledge is inevitably lost in the elaboration**, as this is the only way to get a result that's not redundant and suits the current needs.
This model became the canon for knowledge management field but, over the last decade, **several critical points were highlighted by scholars**, who shed a light on its inherent limits, especially within the context of information society. As it will be laid out in the following sections, **humans tend to experience information in an unorganised and dynamic manner**. Therefore, trying to define this process according to a structured model is inherently limiting. Furthermore, as claimed by the **Harvard Business Review** (92), the pyramidal structure may suggest that moving from one step to the following one is just a matter of filtering, when it is actually quite the opposite. In fact, this view doesn't take into account two fundamental aspects: first of all, **different pieces of information can be inferred from the same datasets**, thus increasing the range of "cognitive material" for that particular process step. Secondly, **knowledge is not based only on acquired information, but from the combination of it and a wide range of other factors**, like individual previous knowledge or other people's advice.
Some went as far as to propose a "redesign" of the model structure itself: **Varisco** (91), for instance, **discarded the pyramid structure**, that suggests only a bottom-up sequence of the phases, and proposes a linear structure instead.
Lastly, scholars claim that wisdom should be followed by a further step (92), that has been defined in different ways, but it refers to the action or practical result triggered by wisdom. This shift can be traced back to the introduction of digital supports for information, that quickly became central in a company framework. For this reason, the DIKW model needed to be reconsidered from a strategic standpoint, and adapted accordingly.
One of the most active advocates of this change is **Venkatraman** (92), who proposed a whole new model based on the previous one. What he tried to do was

showing businesses that information management was not simply a routine job with lower priority, but a **fundamental process with the potential to generate real value**, if structured in the proper way.
The new model was called **DIKAR** (Figure 7), as it comprises five steps: data, information, knowledge, action, and result. In this way, **he tried to prove the potential of data**, showing how the decisions based on data analysis could have a tangible effect (the Result featured in the model).
Data-driven decision making is based on the possibility to **make more informed decisions based on the insights generated by datasets**. This trend has been gaining relevance in the private field, where businesses make use of a significant amount of data to gain knowledge about their own performance and about competitors'.
From this perspective, municipalities share various common traits with a private company: first of all, **the municipality can gather data on** everything taking place within its range, namely the efficiency of services, the state of the infrastructure, the changes in population's composition, and so forth. **The ideal consequence of this inquiry is information density**, namely a situation in which a considerable number of people have access to a high degree of knowledge, thanks to radical transparency, making everyone more entitled to act or to simply express their opinion.
On the other hand, **decision-makers may try to acquire information also on external factors** that may increase or hinder the city's growth. This research on the external world might unfold in **two different ways**: it can result in **an analysis of** the environmental, social, or legal **phenomena that could influence the city's balance**, and lead to a strategy to limit the negative impact or exploit the opportunities that may arise; it could also be translated into **a comparison with other cities' performances**, aiming at understanding how other Municipalities tackled similar issues, in order to adapt the internal policy accordingly.

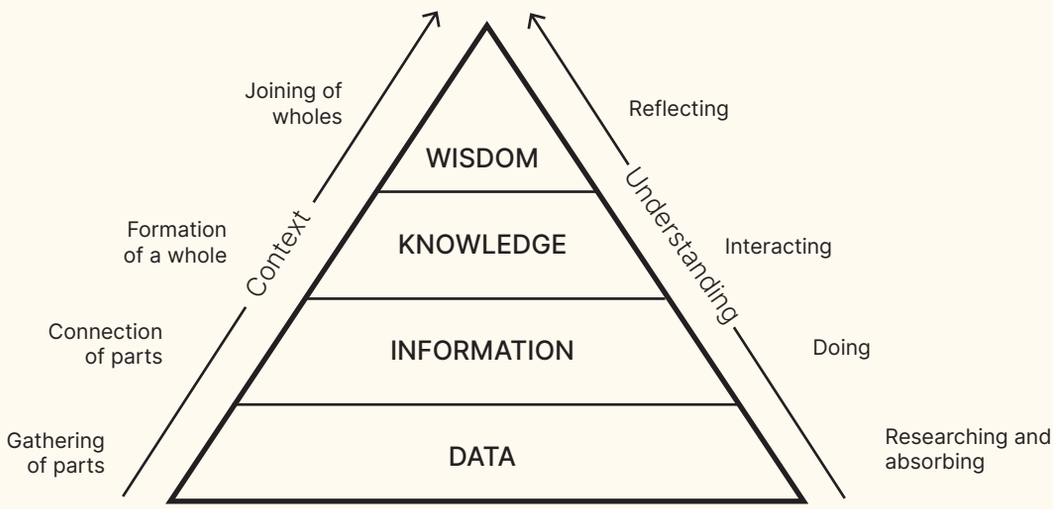


FIG. 6 - DIKW model

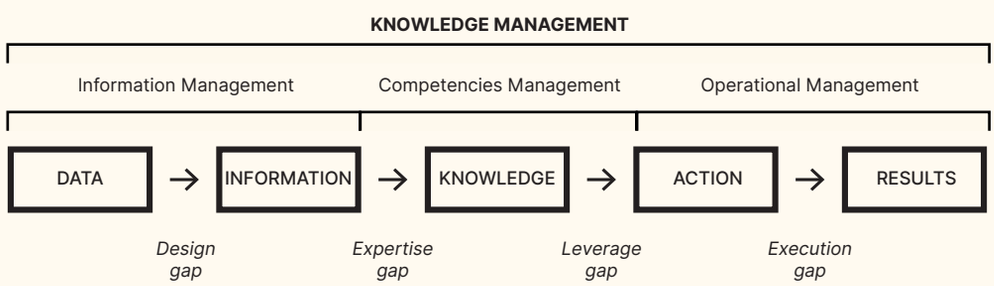


FIG. 7 - DIKAR model

COLLECTIVE KNOWLEDGE MANAGEMENT

As it has been claimed in the previous chapter, knowledge-intensive work is on the rise, thus requiring higher attention to the themes of knowledge sharing and information retrieval. Moreover, given the complexity of the tasks to be tackled in any professional environment, an individual worker cannot deal with them anymore. This directly influences the concept of **knowledge**, that suddenly **becomes a social matter**, rather than an individual one.

According to the models discussed above, knowledge stems directly from related information. For this reason, in order to establish a body of knowledge, information must be clustered and stored properly.

The most used term to identify this whole process is usually information management, in relation to **a series of activities aimed at acquiring, storing, distributing and eventually archiving information** (11). Being such a complex process, it involves several professional roles, that are responsible for a single part of the procedure: there are stakeholders in charge of data acquisition and quality assessment; others in charge of data visualisation and publication; others will eventually use the displayed information to support decision making.

Having a proper information management system is an important factor contributing to competitive advantage, and a fundamental building block to shape a company or group know-how. However, despite all these premises, **there are still many obstacles preventing people from sharing their expertise with other group members.**

This issue can be traced back to the concept of **social dilemma**, namely **a situation in which people in a group**, while pondering over a choice, **evaluate one or more egotistical alternative**, aimed at an individual benefit. If this alternative is eventually chosen, **it may lead to negative consequences to the group in the long term**, especially if more group members opt for the same behaviour (49).

Regarding the specific case of knowledge management, it appears that people are more drawn towards avoiding information sharing: this happens because, by doing so, **they save time and resources while still keeping the access to that information** (95).

What emerges is that a person deciding whether to share knowledge or not is performing **a cost-related choice**. For this reason, the benefits related to sharing must outnumber the costs, namely the time needed to share, the cognitive effort, or the fear to contribute in an incomplete or incorrect way. Another way to overcome the social dilemma is **trying to understand which are the cognitive and social drivers motivating people towards the act of sharing**. First of all, **people may be drawn to sharing because they possess some kind of expertise**, as studies proved that experts give a significantly wider contribution during collective discussions, even if the rest of the group is already heading towards a single solution (85). This benefits the whole group, as the discussion will become more fruitful, lead to a better solution and, in addition, all the members of the group will acknowledge a particular member the role of expert, to whom they

will resort to when in need. **The second driver** urging people to share knowledge **is the need to maintain a certain status or reach a higher one**. Status plays a central role in the way information is delivered in a collective context, as people with a more important role will steer the conversation towards the matters they care more about. The risk is that people with a lower status but with nonetheless important know-how will remain unheard, unable to give their contribution to the discussion (96). Thirdly, **people share information when they need to validate the knowledge they possess**, and compare it with the knowledge provided by other people, in a tendency called social validation of information (93). All these drivers must be taken into account while building a goal-oriented team, as knowledge sharing is an undeniable condition to make sure every member points towards the same objective.

Another degree of complexity is given by the framework in which the communication takes place, that's mainly a digital, impersonal one. **Having an online space for information storage and retrieval is undoubtedly an opportunity, but it may also create some issues in terms of accountability**. One of the most controversial themes is **anonymity**, intended as choosing not to disclose the identity of the people contributing to the information growth.

This choice has quite different effects based on the nature of the group: if the group is made by people that have the collective interest at heart, anonimity won't affect their performance and their willingness to

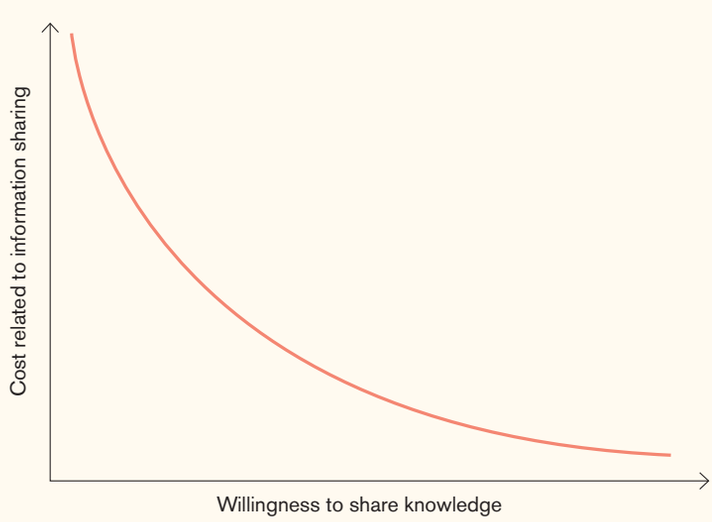


FIG.8 - Relationship between cost of sharing and willingness to share

share information. This happens because all they need to know about other people is that they are part of the same group. On the other hand, anonymity can keep people from taking part to the group interest and preserve their personal interest. One possible solution could be the introduction of the **identifiability** concept, **as claimed by Lea** (57). It refers to the **possibility to understand who contributed to the information**, so that everyone can be held accountable for their effort. This is in line with the above-mentioned drivers prompting people towards the act of sharing: **thanks to the introduction of identifiability, people can then gain respect and enhance their own reputation**, and this might also result in their **recognition as new experts** or in their **status improvement**. In both cases, it should increase their willingness to share more, as they will start to see the benefits of their actions, counterbalancing the costs coming with sharing.

"Perhaps a better way is to make memory unnecessary: Put the required information In the world."

—D. Norman

Another critical aspect is the way information is processed in a collective context. **Kimmerle et al.** (49) divided such process into **four phases: attention, encoding, storage, and retrieval**. The first step requires group members to focus their attention on a particular piece of information. The second phase is encoding, namely the moment in which the object of attention is turned into mental models: this is possibly the most crucial part of the process, as the subjective representations we create on a matter influence all our future knowledge on that particular matter. This gets all the more difficult within a group, considering members can develop different mental models, and this may, in the long term, lead to conflicts and misunderstandings. **The creation of a shared mental model must be supported in any way possible**, in order to allow fruitful and effective cooperation between members. In the third phase, the memorisation one, groups result to be particularly effective, as they are able to store a higher amount of information. Nevertheless, this skill may be held up by the lack of coordination between members. The fourth phase, retrieval, is deeply linked with the previous one, as the only way to effectively memorise information is to know exactly where to find it.

Wegner (93) expanded the flow of the four phases by introducing the concept of ***transactive memory***: according to his theory, **people can retrieve pieces of information not only from external repositories, but from other people too**: each member of the group starts by learning more about the background of others, and tries to map all the information other members have access to, based on their area of expertise. In this way, each person will become the "location" of a certain amount of knowledge, that members can gain access to by simply communicating. **Consequently, transactive memory's**

efficiency is directly linked with the efficiency of the communication within group members. The most direct consequence is that, when transactive memory is established in the proper way, information cannot get lost.

This is partially in line with a similar theory advocated by **Norman** (64), who makes a distinction between ***knowledge in the head*** and ***knowledge in the brain***. The author claims **correct behaviour can emerge from incomplete or partial knowledge**, given that there is a combination between what people preserve within themselves (memory, previous knowledge base) and what they see in the outside world (constraints, indications...). In this way, a mutual adaptation can take place, so that people can avoid memorising too many information, while they can adapt the external environment so that it can support their need for information.

As a consequence, knowledge sharing, as any other phenomenon with social implications, **thrives in an open and supportive environment**, fuelled by proactive people that will prompt others to voice opinions. This is of primary importance to allow people of different statuses to feel involved in the same way, considering that each of them can provide a precious contribution to the group's knowledge base.

THE PSYCHOLOGY OF DECISION-MAKING

In the past, local governments tended to **focus exclusively on the legitimacy of its decisions and on the administration democracy**: this mindset finds its roots in the bureaucracy theory, supported by Weber. Principles of thinkers of the likes of Newton and Taylor granted **predictability** and **increased control** over what happened within the government ranks (47).
Such approach can no longer be pursued in recent days, as the level of complexity governments have to face on a daily basis underwent an exponential growth: cities grew bigger and more densely populated, services and infrastructure are all the more difficult to sustain, information is coming from all variety of sources. Another crucial aspect is the demand for more participation expressed by inhabitants, that want to make their voice heard in the urban decision-making.

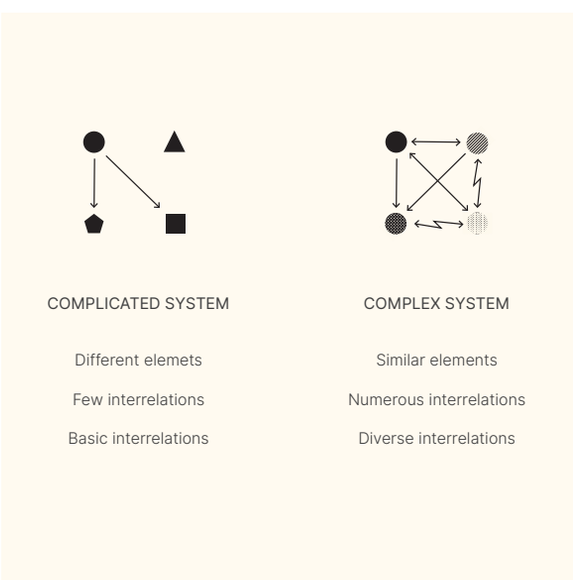


FIG. 9 - Comparison between complicated and complex systems. When it comes to defining a government structure, the latter model is the most appropriate

Before going any further in this dissertation, a clearer definition of *decision-making* must be provided.
According to the **classical theory**, it is **the process of selecting an alternative between two or more**, trying to infer the positive aspects that might ensue from each option (20). The choice is based on foreseeing the outcome of each alternative and on comparing the options with past experiences.
The classical decision-making process was seen as a rational endeavour, following six consequential steps (53): institution of proceedings, preparation phase, draft resolution, decision making, and enforcement.
However, the idea that political decision-making is always achieved in the light of rationality sparked criticism among scholars: **such theory doesn't take into account those choices that are made in a condition of high uncertainty and unpredictability**. Moreover, saying that the choice was rational means there was no other course of action but the rational one, thus ignoring the fact that human perception is inherently faulty (41) and that, on a more general note, the rational choice might not always be the best choice.
Secondly, decision-making is most of the time about **generating alternatives**, rather than about choosing among the existing ones (19.5). This gets even more in contrast with the previous statement, as dealing with unknown possibilities further reduces the importance of rationality.

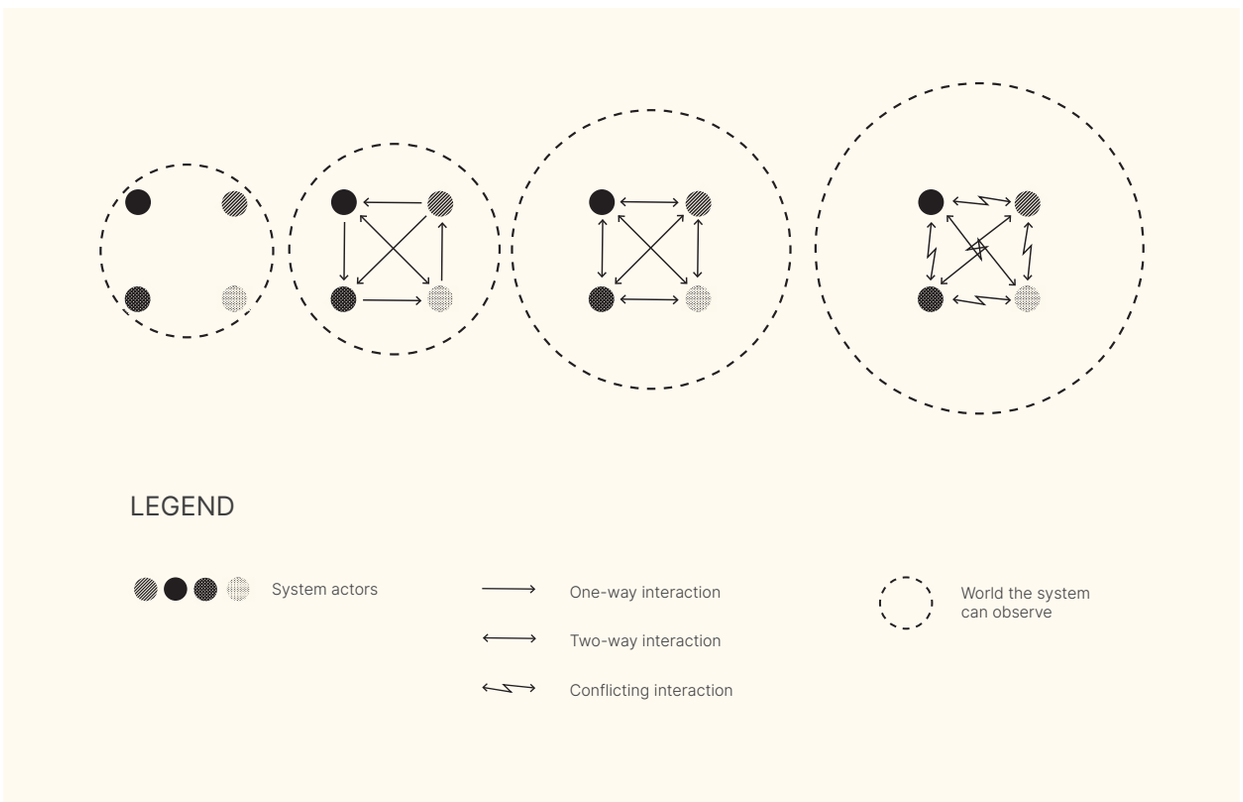


FIG. 10 - How contrasting relationships between systems' actors increase the observable portion of the world

All these premises are **in line with the post-modern view of the world**, refuting the existence of an absolute truth and claiming complexity is at the core of every aspect of reality, including decision-making. This statement arose from a body of theories from different fields of knowledge, like physics, chemistry, biology, and computer science, and it supports the **difference between a complicated system** (very different elements with simple interrelations) **and a complex system** (elements that are more alike but displaying a wide variety interrelations). When it comes to government, **the latter system description seems to be more accurate** (60), as shown in Figure 9.

As a matter of fact, **all the three actors of urban environment share a complex structure, thus exponentially increasing the kinds of relationships they can establish with each other.**

The postmodern view of systems is integrated by other scholars: Simon (79), for instance, considers organisations as entities in which people can overcome the limits of their own partial knowledge and make informed decisions together.
On the other hand, knowledge and information are not necessarily seen as the core of the process, but rather as an element that might get confused in the opposing interests of the people involved.
Therefore, many scholars claimed an **organisation efficiency is due to the relationships bonding people, rather than on their ability to make rational decisions** (9). **This is in line with the idea of transactive memory by Wegner**, laid out in the previous chapter, giving more relevance to the relationships between members than to the knowledge they hold.
Jalonen (47) clearly described these relationships in Figure 9.
There are three different kinds of interrelations: **one-way, two-way, and conflict.**
To fully understand the potential of these connections, we can start from **Kooiman** (52), who claims that, considering how dynamic, complex, and diverse current societal problems are, the only way to tackle them is for the government to **follow procedures that are dynamic, complex, and diverse.**
According to Kooiman, dynamics can be equated with entropy. In the context of social systems, entropy is seen as the efficiency in increasing and decreasing information.
Consequently, increasing the diversity of the system relationships increases the system's observational skills, as shown in Figure 10.
Therefore, **conflicts between actors in a system can be seen as a precious resource, as they force it to make a decision to solve the conflict, avoid stagnation and increase entropy.**
As Jalonen puts it (47) *"information and knowledge should be seen not as a static resource, but as something that is socially and dynamically constructed".*
However, gaining a satisfactory degree of knowledge might not be sufficient, as there is evidence that **new information could be perceived as a threat rather than a resource** (40).
Humans tend to judge future outcomes based on the past experiences they gathered, so any detail that distance itself from the expected course of action may be seen as an obstacle. This is true for every aspect of life, but **the consequences of this mindset may resonate even more widely when it comes to political decisions**, and Kooiman (52) sees this as the root of many issues affecting local governments. The effective introduction of new information in government schedule is of primary importance: trust and reliability must be the main priorities guiding this process, in order to let decision-makers understand the tangible benefits of steering away from their current methods and embrace novelty. Some strategies to achieve this result will be laid out in the next chapter.

3 MONITORING THE CITY

DEFINING DASHBOARDS

A growing amount of aspects of human life, in particular the ones related to the interaction of people with the urban environment, generate data that, when aggregated, can reveal interesting patterns. All of this data, as emerged in the previous chapter, are useless until someone interprets it and make use of it to base decisions; that's when dashboards come in handy.

The term dashboard has been around for quite a long time, as **it comes from the automobile control panel**, the part where drivers can monitor the major functions and possible problems of the vehicle, thus **allowing the driver to perform actions that can solve the current issue**, and avoid bigger problems that may arise in the future if nothing is done (33).

In order to provide a definition in a broader sense, it can be stated that **dashboards provide an at-a-glance rendition of a process, situation, or business status**, conveying the details about it that are relevant to a particular user objective.

The definition itself is extremely general, and it comes without saying that it comprises very different kinds of interfaces with various degrees of complexity.

For instance, the simplest example is possibly the "dashboard" application featured on MacBooks (Figure 11): it is a page on which the user can monitor general information, ranging from local time to weather conditions, or access some basic functions like calculator, memos, or converters. Other examples are shown in the following pages: I grouped different kinds of platforms in order to visualise the differences between them, both in the structure and in the themes they deal with, **ranging from health to finance, from smart home applications to events management**. Dashboards' complexity is not the only parameter on which they can be evaluated, as features change based on their role, that can be either strategic, analytical, or operational (33).

An **operational dashboard** is possibly the one recalling the functionalities of a car dashboard most.

It is a **reporting tool providing updates about all those processes, phenomena, and situations that are changing quite frequently**, thus requiring users to monitor the platform on a regular basis. Real time data are fed into the dashboard and, **if the information displayed shows some kind of anomaly, the user has to act promptly in order to restore balance**. The quickness with which users act upon the problem is key in order to avoid worse consequences. For this reason, operational dashboards should provide users with at-a-glance information. The most important requirements that must be met are highlighting anomalies, providing effective updates, and, if possible, helping the user understand what they need to do in order to solve a problem.

"Visualizations act as a campfire around which we gather to tell stories."

—A. Shalloway

A **strategic dashboard** is used to **monitor**

the status of key performance indicators (KPIs): while operational dashboards are usually aimed at mid-level workers, that are usually in charge of corrective measures, strategic dashboards are **typically monitored by executives**, that often just need to get a general idea about the business performance over time. It ensues that strategic dashboards' datasets updates with a lower frequency than operational ones: they may be checked once a day and help executives stay updated about the business status. In this case, the dashboard should be as concise as possible, and the most challenging aspect of designing such platforms is providing users with the right indicators. In fact, they must provide just the right amount of insights, without turning out to be confusing or misleading.

An **analytical dashboard analyses datasets from the past to support future decisions**: users must be put in the condition to find patterns and correlations, so that they can act accordingly. As the name suggests, such platforms cannot simply provide high-level indicators, but **they should allow users to "drill down"**, in order to gain further knowledge about the topic by toggling granularity.

Although such platforms must fulfill slightly different requirements, **a dashboard has served its purpose if it is able to tell users that there's the need to act**, that a human needs to take a decision to solve a problem or to take advantage of an opportunity; as a bonus point, it may also point users towards more detailed or additional information that can make response even better and more timely.

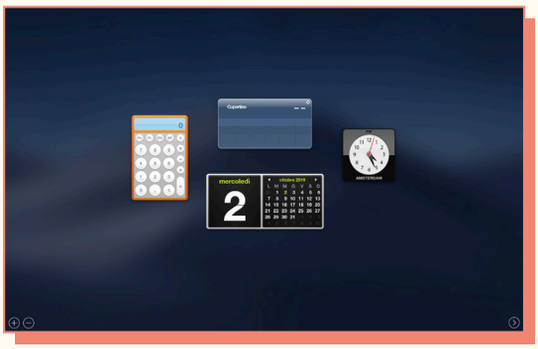


FIG. 11 - Macbook dashboard
(source: author's photo)

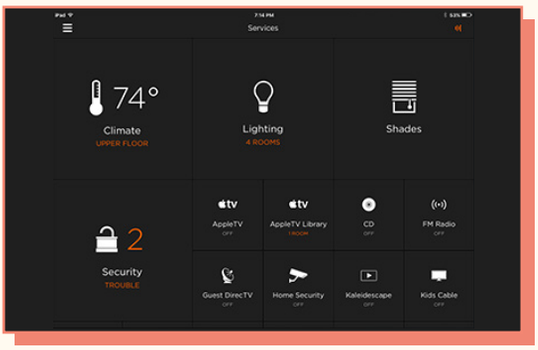


FIG. 12 - Smart Home dashboard
(source: Paradigm System Integration)

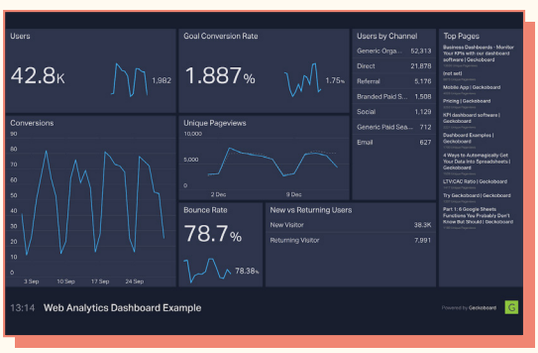


FIG. 15 - Web traffic dashboard
(source: Geckoboard)

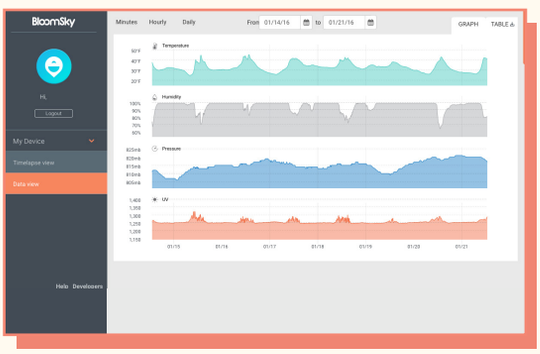


FIG. 16 - Environmental parameters dashboard
(source: Bloomsky)

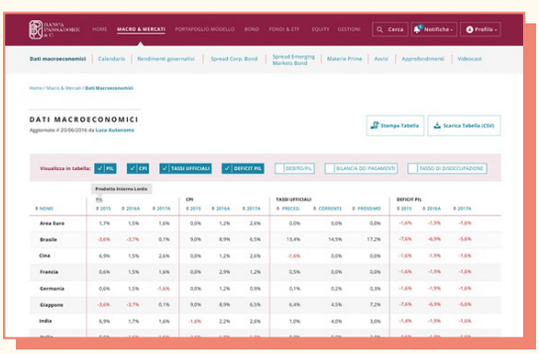


FIG. 19 - Financial advisor web tool
(source: Banca Passadore)

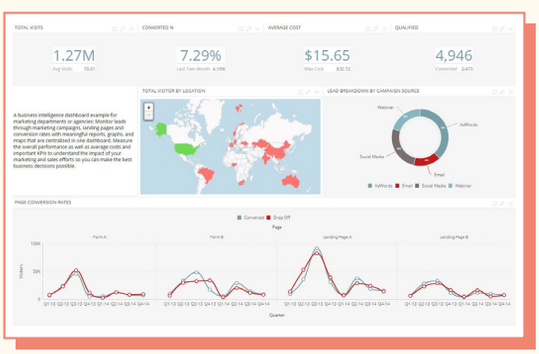


FIG. 20 - Business Intelligence
dashboard(source: Sisense)

FIG. 13 - Physical activity dashboard
(source: Fitbit)

FIG. 14 - Emotional monitoring dashboard
(source: Affect-tag)

FIG. 17 - Agricultural dashboard
(source: IDC Precision Irrigation)

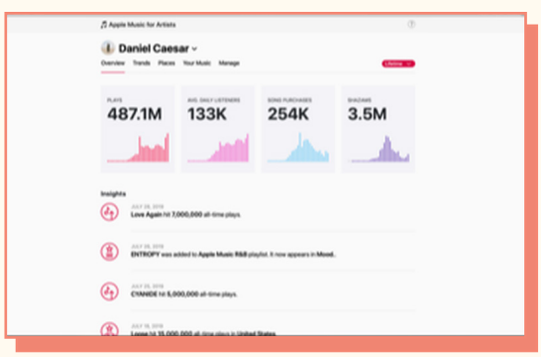


FIG. 18 - Music streaming dashboard
(source: Apple Music)

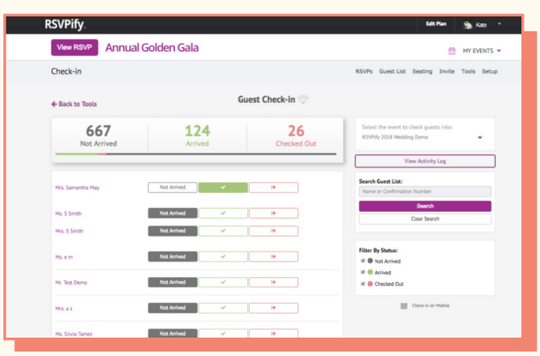


FIG. 21 - Event management dashboard
(source: RSVPify)

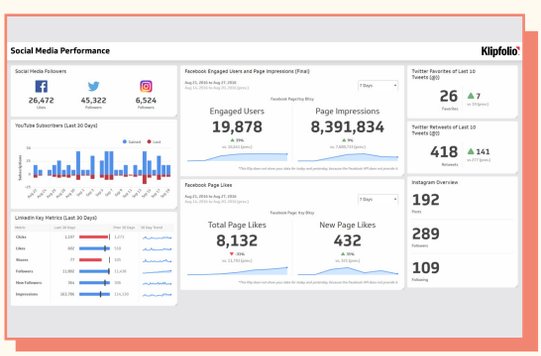


FIG. 22 - Social media monitoring dashboard
(source: Klipfolio)

ASSESSING A CITY PERFORMANCE

Considering the city as a conglomerate of processes producing data, the need for a monitoring dashboard emerged in numerous cases. Unsurprisingly, **the uncertainty surrounding the definition of "smart city" and "dashboard" deeply affects smart city dashboards too.**
Rob Kitchin (50) provides an insightful analysis of the definition and final purpose of a city dashboard. *"Dashboards act as cognitive tools that improve a user's 'span of control' over voluminous, varied and quickly transitioning data [...]. In essence, dashboards enable a user to understand what is happening in a city system at any point in time and to act on that data – to steer the city through a set of visualisations and data levers in much the same way as a driver is presented with data via a dashboard and reacts accordingly".*
In other words, **city dashboards perform the hard task of making people more aware of the wide framework they inhabit**: being inside an ever-changing system can make people blind to the bigger processes influencing it, and what would be needed is taking a look from a distance, as a dashboard can do. The physical vastness of the area to represent is not the only complex factor: in fact, **the dashboards presented in the previous section are often fed with one or few data formats**, like events, physical parameters, cash flows, and so forth.
On the other hand, **city dashboards have to combine different data formats coming from different sources**. The most widespread data source is possibly made by **sensors**, installed by public administration operators.

Sensors have with the city the same relationship a smart band has with the human body. The dashboard is the interface allowing users to take action to change a critical situation, or be reassured when everything is fine. A sensor is a module or subsystem which converts parameters of a physical nature to an electronic signal. Such signals can then be read by human operators or can be fed into other machines. Sensing possibilities are endless, considering for example that traffic flows can be measured with more than ten different hardware setup and approaches. Generally speaking, there has been a growing attempt to **integrate multiple sensors within the same device**. Among the most relevant examples there is the Array of Things (AoT) project in Chicago (2), namely devices capable of monitoring temperature, barometric pressure, light, vibration, carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, ambient sound intensity, pedestrian and vehicle traffic, and surface temperature. One pioneering work in Italy is the smart lamp posts' installations by Sharing Cities: the European-funded project, aimed at developing a smart district in 6 European cities (78), will install new smart poles with 20 sensors (measuring environmental, acoustic and meteorological data) and 3 cameras (counting vehicles). In Milan, the project will focus on Porta Romana area.
From this perspective, **smartphones can be considered as sensors clusters too** (GPS, gyroscopes, accelerometers and compasses), and their importance in city mapping is steadily growing. Moreover, **the physical information recorded by**

smartphone sensors can be combined with digital information produced through social media.
By relying on user-generated content, we can get a combination of a *technical data* (namely location, phone orientation, movement speed...) with *personal data* (the ones shared on social media) related to emotions, experiences, opinions...
Many of the datasets usually end up in an open data platform: apart from granting government's transparency, open data policy has the potential to generate significant economic benefits. The consulting firm McKinsey has estimated open data's economic potential at more than $3 trillion globally (59).
Nevertheless, these benefits come with a consistent start-up and maintenance cost. **In order to limit expenses, a careful analysis of which data should be provided must be carried out**, focusing on two aspects: the quality of the dataset (namely the data frequency, the rate with which it can be updated) and the degree with which it fulfils an existing need.
Experts and academics have struggled to agree on a common set of indicators to evaluate a city's performance. Recently, **ISO 37120** (Sustainable cities and communities - Indicators for city services and quality of life) tried to end the stalemate (86): it's the **first set of internationally standardized city indicators, providing a uniform approach for assessing smart cities' status**. It was first published in 2014 and a second edition came out in 2018.
The indicators are the following: **economy, education, energy, environment, finance, emergency response, governance, health, recreation, safety, shelter, solid waste, telecommunications, transportation, urban planning, wastewater, water & sanitation.**
These indicators set out a common ground for cities, allowing them to measure their performance on service delivery and quality of life. Hopefully, **having globally standardized, comparable parameters should also lead to a fruitful comparison between cities**, that will get a higher awareness about the international framework they are in and adapt their strategy to keep up with other municipalities with similar features. For these reasons, **such indicators must be central in a dashboard design process**, hoping they will be adopted by as many cities as possible, thus allowing a correct comparison.
The benefits and possible risks of employing dashboards were clearly described by Stephen Few on various occasions (32, 33). The following is a brief recollection of the main benefits:

Quickness
Dashboards allow different stakeholders to gain insights and promptly gain the same degree of knowledge, unlike usual reports, that may not be shared as quickly. This makes immediate reaction possible.

Transparency
Dashboards can grant absolute transparency over the issues affecting the city, and the possibility to look at details increases this sense of trust. In this way, both positive and negative trends can be identified, while government, people, and other actors can be held accountable for their actions.

Efficiency
Displaying relevant information on a dashboard can improve the efficiency of operations, resulting in better management of several situations, like the reduction of traffic congestion. Witnessing such positive outcomes makes people trust the platform, improving the effectiveness of operations in both the short and long term.
Diffusion
Municipalities can use the dashboard as a common ground for its department, but it can also serve as a tool to communicate with external institutions, such as infrastructure providers, technology partners, and media, like radio, TV, social channels, and so forth. All these actors can then use and spread the same information displayed on the dashboard, to make sure more people get to know about a particular event, thus increasing general coordination, especially in emergency situations.
Nevertheless, there are some risks that cannot be neglected and need to be carefully avoided or cautiously dealt with:
Low data quality
The data that are fed into the platform must be thoroughly analysed, in order to assess their quality and reliability. If the data has some faults in itself, it may convey untrue or imprecise information, so the dashboard itself gets useless if not dangerous, and the users' trust may be severely compromised.
Data privacy
If data is not properly anonymised, a process requiring adequate skills and investments to be done the right way, private details could be erroneously displayed or maliciously stolen. The safety of data is another fundamental pillar of users' trust, that must be safeguarded.
Little or wrong interpretation of the dashboard
This is possibly one of the most controversial risks, and it has only partially to do with the dashboard design, as political motivation may interfere. In fact, data quality and reliability are often not enough to grant the dashboard's efficiency. Raw data must be interpreted and visualised in a way that is not misleading. Citizens may be provided with made-up views or fake assumptions, set by those in charge to manipulate the public opinion.
Limited maintenance and further development
Managing dashboards is a complex job, making it a quite expensive and time-consuming endeavour. Nevertheless, dashboards are dynamic platforms, as dynamic as the city they refer to. If it's not taken care of, citizens will lose interest and will stop using it, dooming the whole project to failure.
Limited willingness to change
Even if they do get to a certain degree of knowledge derived by the dashboard, knowledge can be considered effective only when it leads to acting.
There are many barriers preventing city leaders to act. Knowledge can be ignored, not understood, or not believed to be true. Bearers of knowledge may lack the influence on people that are supposed to act accordingly, and lastly, there may be budget or resources issues. That's why data are potential power, but so is knowledge, as it loses all its meaning if people don't use it in the proper way.

CITY DASHBOARDS STATE-OF-THE-ART

After laying out the main benefits and risks, a selection of some dashboards will be analysed more in deep. Such analysis started with a research about the cities that supported the most effective smart initiatives.
London has been declared the smartest city in the world for the second year in a row, according to the IESE Cities in Motion Index 2019 (14).
The top-10 list is completed, in ranking order, by New York, Amsterdam, Paris, Reykjavik, Tokyo, Singapore, Copenhagen, Berlin, and Vienna. Starting from this ranking, **I wanted to investigate which of these cities have worked to develop some form of institutional dashboard**. In the final comparison, I considered only the dashboards that were developed as City Council's initiatives, and that featured more than one topic.
I evaluated them based on whether they are public or private platform, on the frequency of the updates, and on their development level, intended as the available functionalities and on the number of topics.
As shown in Figure 23, it emerges that **the majority of cities in the ranking worked on the development of a dashboard featuring institutional results and city performance.** Nevertheless, **a higher ranking position doesn't necessarily result in a more finely designed dashboard**: if the ranking was to be redefined based on the quality and refinement of each dashboard, it would be featuring Amsterdam and Berlin in leading positions.
As my research went on, I carried out a further analysis of the most prominent city dashboards available, including also other cities that were not featured in the IESE ranking. After analysing and testing them (Figure 30), I mapped which ISO parameters they included, highlighting the kind of real-time data they feature.
Afterwards, I felt the need to concentrate my attention on a more narrow set of platforms, in order to evaluate them in a more structured way. I opted for five prominent dashboards: **Amsterdam, Dublin, Florence, London, and Edmonton.**
I chose these five examples based on a few criteria: first of all, compared to the others, **they showed a better technical efficiency**, an aspect that should not be taken for granted, as the dashboards of many prominent cities, like Paris, are either not working at all or severely affected by updating issues.
Secondly, **I reckon these dashboards are effective examples because of the variety of indicators they display and the number of different topics they cover**. This is among the hardest aspects in dashboard development, and that's possibly the reason why the majority of dashboards focus on a particular topic (be it the air quality, the transportation state, touristic attractions...).
Thirdly, **each of these three examples stood out for a particular reason** (the quality of the design for Amsterdam, the infrastructure reliability for Florence, the variety of users for Dublin, the modular structure for London and the government transparency for Edmonton), and, all things considered, that's what made them worthy of a further analysis in the first place.

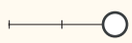
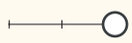
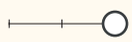
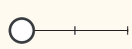
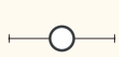
Ranking	City	Dashboard	Development	Type	Updated
1	London	✓		public	real time
2	New York	✓		private	/
3	Amsterdam	✓		public	weekly update
4	Paris	✓		public	annually
5	Reykjavik	✗			
6	Tokyo	✓		public	real time
7	Singapore	✗			
8	Copenhagen	✗			
9	Berlin	✓		public	annually
10	Vienna	✓		public	annually

FIG. 23 - IESE Index' ranking analysis

FIG. 24 -Paris Dashboard

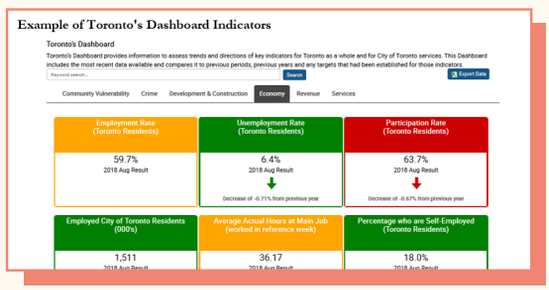


FIG. 25 - Tokyo dashboard

FIG. 26 - London dashboard

FIG. 27 - Seoul dashboard

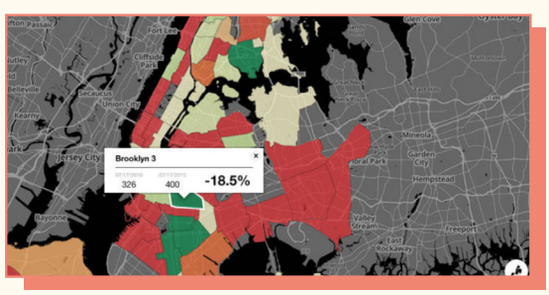


FIG. 28 - New York dashboard

FIG. 29 - Tokyo dashboard

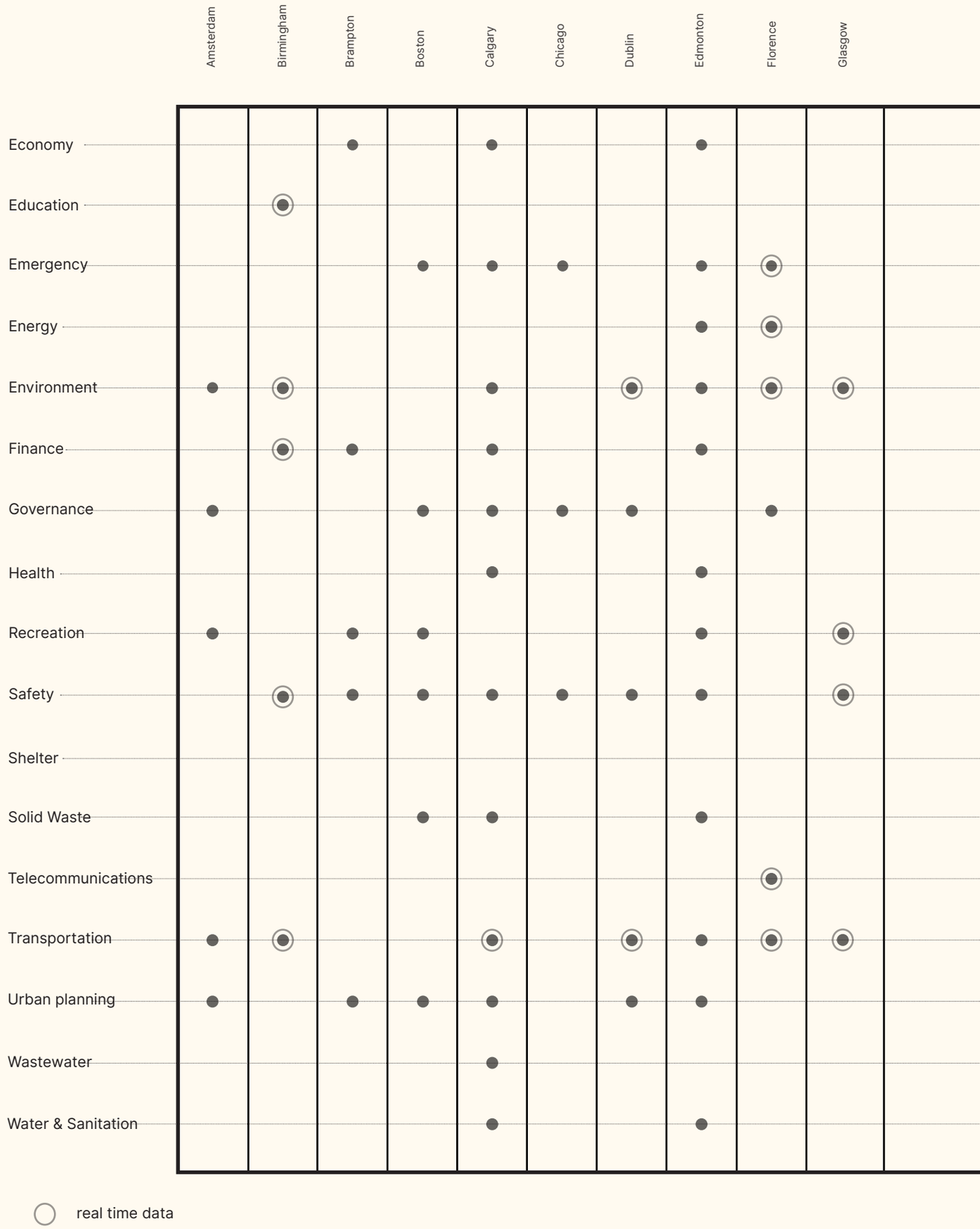
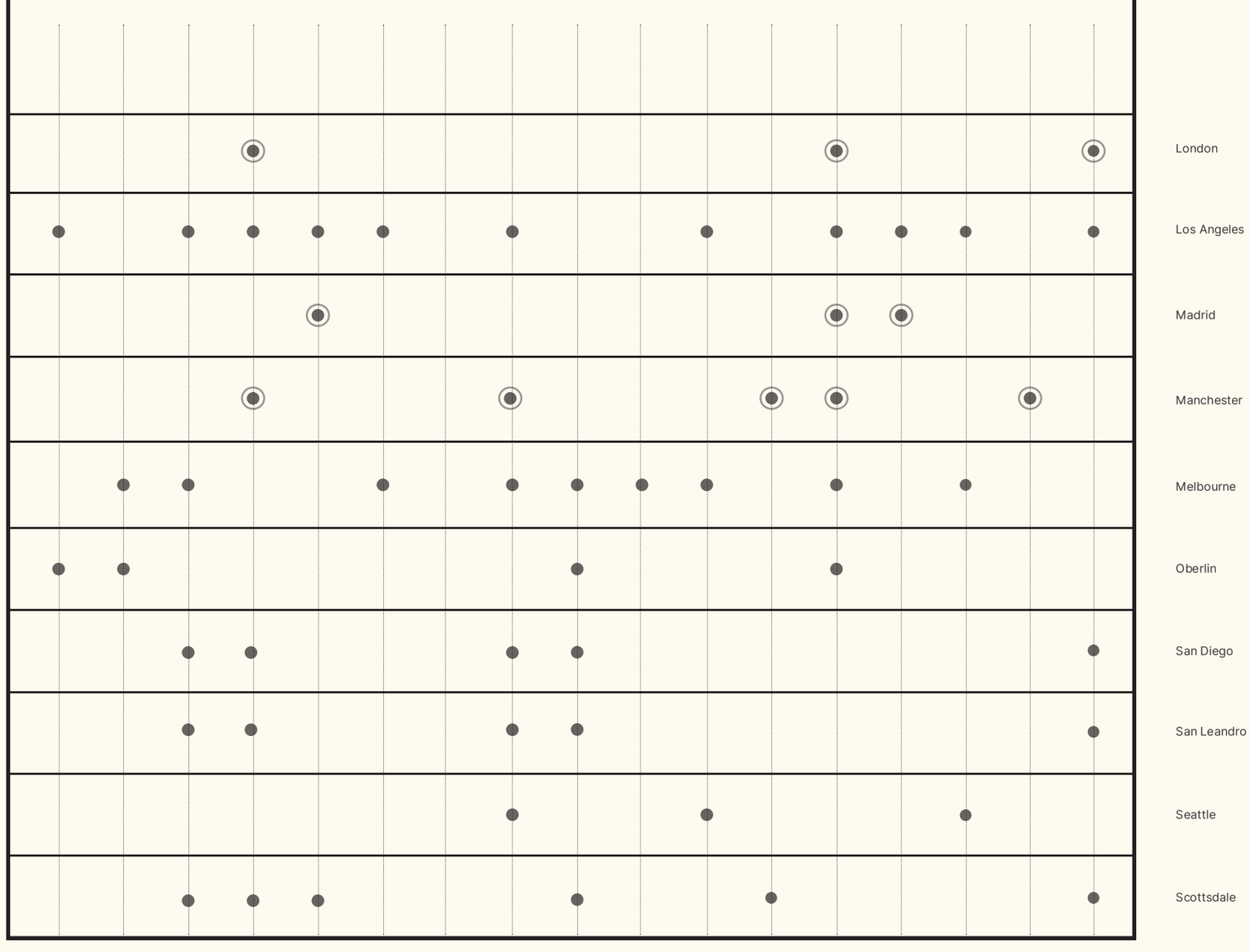


FIG. 30 - City dashboard topics


London
Los Angeles
Madrid
Manchester
Melbourne
Oberlin
San Diego
San Leandro
Seattle
Scottsdale

Km4city - Florence Smart City

According to ICityRate 2018, **Florence is the second "smartest" city in Italy** (35), showing positive results in the fields of sustainable mobility, economic stability, education, employment, civic participation and energy. Moreover, from Figure 30 analysis, Florence City Dashboard (51), named KM4City, resulted to be one of the most effective examples: in fact, **despite displaying less datasets than other dashboards, they are smoothly updated on a daily basis and displayed spatially and in real-time.** This puts it a step further than the other websites and platforms, as they are usually nothing more than universities' experiments or even municipal projects that in the final phase were stopped, while Florence dashboard is constantly updated and enriched since the moment it was launched for the first time, in 2013.

The web platform was developed by the Florence University (Information Engineering Department and DISIT, Distributed Systems and Internet Technologies Lab) and was defined by its creators as a "smart decision support system". In fact, data representation on the platform can be divided into two sections. **The private section, the so-called "control room", is an entire part available only to the dashboard creators and the municipality's representatives.** It gathers a series of Big Data Analytics tools aiding decision making, as they allow the analysis of statistical, historical and real-time data for the assessment of risk and vulnerabilities. This provides a stronger basis when embarking on city renewal or infrastructure transformation projects.

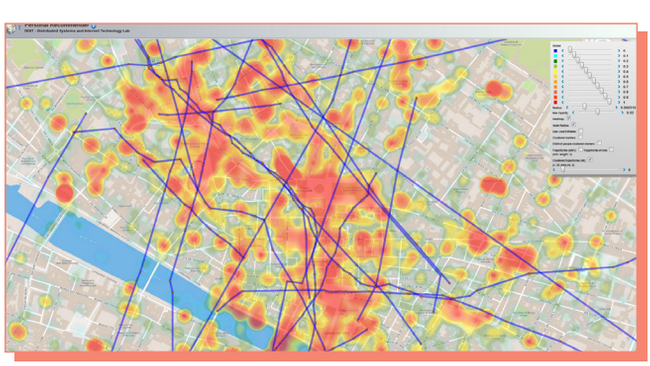


FIG. 31 - Km4City screenshot

On the other hand, public section could be accessed by any citizen, and it displays a considerable amount of real-time datasets, that can help them in their everyday lives: **mobility** traffic congestions, e-cars charge stations, ZTL gates state...); **environment** (weather data, air pollutants level, pollen monitoring...); **services** (wifi points, bins location, smart benches positions, first aid situation in different hospitals, Civil Protection alerts...); **energy** (public buildings energy consumption, photovoltaics plants trend...). Moreover, all these data is also arranged in a spatial representation of the city, thus allowing an easier recollection of the most useful information.

Maps For Amsterdam

The main directions along which the Amsterdam Smart City Initiative has been carried out are Smart Energy, Smart Mobility and Smart Building, all in line with the ultimate objective to cut the CO2 emissions by at least 75% by 2040, compared to the 1990 levels (1). To achieve this ambitious goal and to grant a higher efficiency on this matter, **data collection, management, visualisation has become one of the main pillars of the whole initiative since its conception**; a few years back, the city was gathering nearly 12.000 datasets to use (30), and the municipality, once a year, **evaluates the concerns of the people and create a set of social challenges for startups to solve using city data.** By doing this, they tap into the huge startup culture in Amsterdam and the talented application, platform and software developers they employ. These intents are perfectly embodied by Map for Amsterdam (16): unlike Km4City, **the website is clearly aimed at citizens and tourists, rather than decision-makers**, that instead use this platform to show what is being done and will be done to improve the city. Plus, all the data are spatially represented on a series of maps of the city. What really makes this dashboard stand out from the others is the **high degree of customization in the visualisation of data**: users are free to analyse Amsterdam from various points of view, filtering the data, zooming in and out, and being provided with additional information. Moreover, the platform features a functionality that really makes it stand out among the others: in fact, **users can select up to three spatial datasets and visualise them overlapping on the same map**. Dashboards like this could improve the way a city is perceived by its inhabitants and tourists. Even if this dashboard in particular was not actually designed for governance, it can still support some decisions, but simply not the ones by politicians: it is common people that rely on the dashboard to make everyday decisions. Looking at the information displayed, **there seems to be a substantial support especially for people willing to buy or rent a house in the city**. In particular, by overlapping different maps, users can easily understand which issues or positive aspects affect each neighbourhood, together with the housing prices, and take more informed decisions.

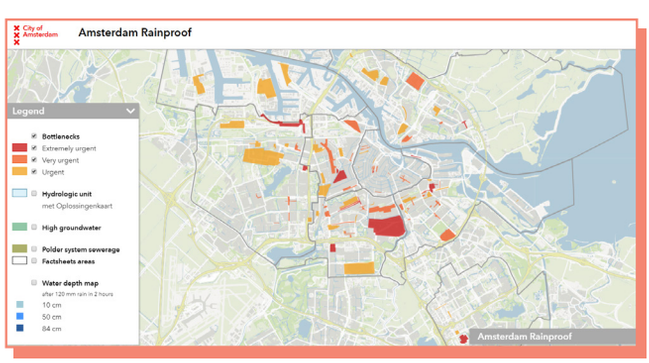


FIG. 32 - Maps for Amsterdam screenshot

Dublin Dashboard

In the last couple of years, Dublin Local Authorities tried to gather all the smart city initiatives flourishing in the city around a single platform, named Smart Dublin (80). The main purpose of this project is making sure demand meets offer: **authorities collect citizens' needs on a daily basis and set up "call for ideas" based on such necessities.** The ensuing proposals are then validated by the Smart Dublin committee, that grant support from the economic and technical point of view, aimed at the development and application of the idea in the city area.

One of the most tangible results was the **successful development of three new smart districts within the city areas**, among which DCU district features a new smart stadium, embedding technology to collect and analyse data about both the players and the audience. Also in this case, one of the main institutions advocating smart city solutions is an academic one: Maynooth University is among the actors that contributed to the initiative in the most thorough and holistic way, backing many of the projects proposed on the above-mentioned platform. Maynooth's research fellows at the National Institute of Regional and Spatial Analysis were particularly fond of the themes of geographical digitization and citizen's activities visualisations. This theoretical background kickstarted what grew to become the official Dublin Dashboard (25).

The platform's target seems to be quite varied, as it is aimed at citizens that want to be informed about the city status, council representatives, and also those companies that want to invest in the city.

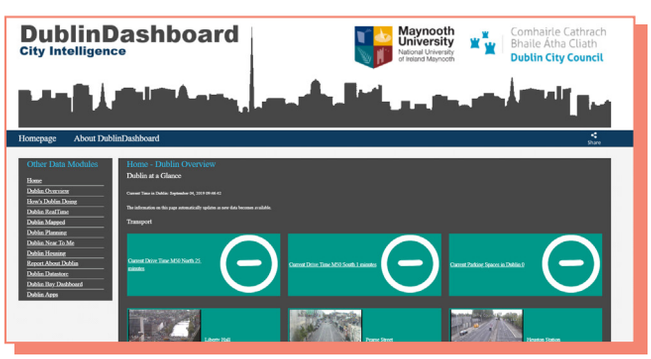


FIG. 33 - Dublin Dashboard screenshot

The website allows users to get more details about a wide range of different aspects of the whole Dublin city, providing real-time data, city mapping, and long-term performance indicators. In some cases, **the final results of the "call for ideas" that was promoted by Smart Dublin ended up in the dashboard**, thus contributing to an ever-changing platform, that evolves with the city it represents on a daily basis. The dashboard creators want it to motivate other people to embark on similar projects, considering that all the data sources embedded in the dashboard are publicly available, and can therefore be used freely to start new projects.

London Dashboard

According to a census held in January 2019, **London is currently the most populous city in Europe**, with more than 9 million inhabitants, which are likely to become 10 million by the end of 2030 (81). London is already a trailblazer city from the creative, industrial, and financial perspective, but it still needs to tackle a wide range of pressing issues. The rising number of inhabitants is putting city managers to the test, as services like healthcare, social welfare, and utilities struggle to keep up with requests. As for now, **one of the most urgent issues is undoubtedly about mobility management, both public and private**, as London citizens are now spending an estimated 70 hours in traffic every year. In order to face these issues in a more holistic way, the Major founded the Smart City London Board back in 2013 (81). The committee's final goal is to promote new technological paradigms for service delivery and fruition, like digital payments, intelligent roads, innovative means of transport and, lastly, the establishment of London datastore. The datasets that are here gathered became the core of **London City Dashboard, promoted by the University of Manchester in 2012** (66). The project represents a compelling example **both for the variety of datasets that are featured and for the fact that the project involves different cities in the United Kingdom**: the platform structure has been applied to London, Cardiff, Edinburgh, Glasgow, Manchester, Leeds, Birmingham, and Newcastle, and each of them featured different information, based on the cities' necessities and resources. I chose to analyse London because its web page resulted to be among the most complete examples, with a wide variety of topics.

FIG. 34 - London Dashboard screenshot

The platform is made by three main pages: **the *dashboard page***, that is also the landing one, has a modular layout with different widgets, that are visualising some datasets coming from other sources, from Twitter to TfL, from BBC news to London universities. On the other hand, **the *map page* combines the spatial datasets about mobility and weather**. Lastly, **the *grid page* features a treemap aggregating all the dashboard indicators in the same place**, to convey an at-a-glance view of the city performance, expressed through colour coding.

Edmonton Dashboard

Edmonton is among the most populous cities in Canada, and in the last few years **it gained recognition for its social, industrial, and cultural activity**. The city features a well-structured Smart City framework (82), trying to promote new directions for innovation starting from the local communities resources. First of all, **the whole city underwent a profound infrastructural renewal**, with the development of several technological solutions, like devices that can monitor pedestrians flows and also smart street lights. Citizens are involved on a regular basis, in order to cooperate with policy-makers to reach all their common goals. One of those primary goals is data analysis, confirmed by the fact that the city founded the Analytics Centre of Excellence (ACE) to deal with this topic (80). **The local government has worked out plenty of ways to gather as much data as possible**: for instance, in order to curb needle debris diffusion, citizens were asked to signal the riskiest zones around the city; secondly, city lights are also serving as air quality sensors; lastly, pedestrians counters are monitoring the number of people visiting one of the city's most busy junctions, River Valley Funicular. Moreover, in this context, Edmonton is advocating for transparency, claiming that if the City Government has access to a certain piece of information, citizens should have it too, so that everyone has the same degree of knowledge. **This focus on transparency and the need to value accountability is perfectly embodied by Edmonton City Dashboard**: the platform is completely in line with the city's government intent, as it tries to set up an interaction with citizens in the clearest way possible. Moreover, it was developed with the clear intention to gather datasets that would have been otherwise spread among various different channels. Even if Edmonton may not be as popular as the previous cities, its dashboard resulted to be very interesting, especially considering **it is the only example that is explicitly stating government's target objectives in different areas, and whether they were met or not.** The homepage features different topics divided into subcategories: each subcategory is summed up by a single indicator, referring to the annual performance from that standpoint.

FIG. 35 - Edmonton Dashboard screenshot

HEURISTIC EVALUATION

In order to gain a deeper knowledge of the above-mentioned dashboard, and to identify the issues that are hindering their usage, **I carried out a usability analysis of Dublin, Amsterdam, Florence, London, and Edmonton platforms based on the ten Nielsen heuristics** (64). Nielsen started working on some principles evaluating usability in 1990, and then released the final set in 1994. They were called heuristics to point out they are not proper guidelines, but more like "rules of thumb" aiding the usability assessment of an interface.
The principles are the following:

1. Visibility of system status
The system should always keep users informed about what is going on, through appropriate feedback within reasonable time

2. Match between system and the real world
The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

3. User Control and Freedom
Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

4. Consistency and standards
Users should not have to wonder whether different words, situations, or actions mean the same thing.

5. Error Prevention
Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

6. Recognition rather than recall
Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

7. Flexibility and Efficiency of use
Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

8. Aesthetic and minimalist design
Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

9. Help users recognize, diagnose, and recover from errors
Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

10. Help and Documentation
Even though it would be better if the system could be used without documentation, it may be necessary to provide it. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out.

While the complete usability evaluation can be found in the Appendix, here I will just illustrate the main insights of the analysis, that will be at the basis of the further steps of this thesis work.

Km4City appears to be extremely efficient from the data updates and infrastructure point of view. Nevertheless, **the visual models and maps included are more a "showcase" of possibilities rather than an answer to a need.** There are possibly too many data sources, and non-expert users may get lost while looking for meaningful information. In fact, in some cases **the language is too complex and could be misleading**.

Moreover, the graphical appearance doesn't support understanding, as sometimes it happens to be too cluttered with useless details, pure decorations that don't aid the comprehension of the information displayed.

Maps for Amsterdam is undoubtedly the most effective example from many points of view: first of all, the platform includes content that can generate a genuine interest also in non-expert users, like common citizens and tourists, who can rely on the dashboard to take their own everyday decisions or just satisfy their curiosity.

The website can give some interesting insights to decision-makers too, but the platform is clearly citizen-oriented.

The design is minimal and clear, giving total centrality to the visualisation. There are still some issues in the navigation and the colour coding, but the outcome is positive.

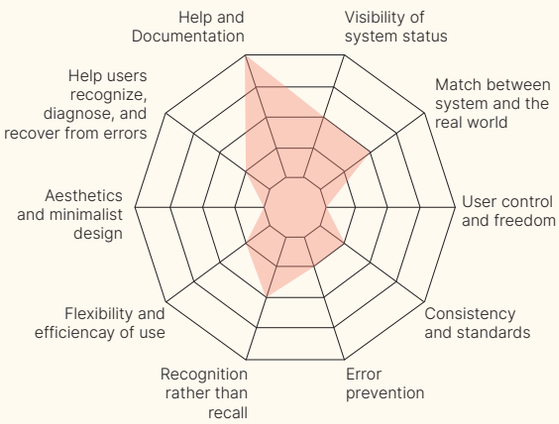
Dublin Dashboard's qualities make it a sort of "combination" of the first two examples: the data is efficiently fed into the dashboard and constantly updated, the language used makes it perfectly understandable to non-expert users, and the information is clustered properly. **Nevertheless, the data sources are still too numerous, and the user may get lost in looking for a piece of information.**

Although the design is clean and neat, it could be rendered even more minimal, in order to give more centrality to the maps and indicators.

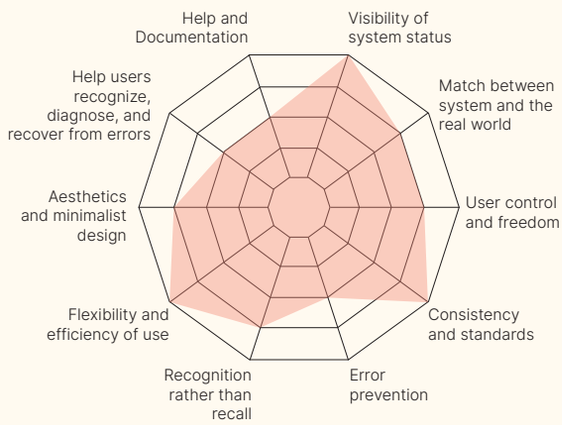
London Dashboard doesn't perform its own analysis, but **it's a rather effective recollection of external sources of information.** The colour coding is used efficiently, to quickly communicate the city status at a glance. Nevertheless, the platform has several weaknesses from the usability point of view: **the content is not clustered in any way**, and there is no hierarchy in the various pieces of information. Moreover, the project has some issues from the technical point of view, as some links are not updated correctly.

Edmonton Dashboard appears to respect several best practices from the usability point of view: each piece of information is clear and easy to understand, and **the fact that it is linked to its performance prediction radically increases trust in policy-makers**. Furthermore, the platform seems to answer different needs from the citizens perspective: first of all, the homepage appears to be very simple and straightforward, allowing users looking for general information to get to know more in no time. Nevertheless, users that are

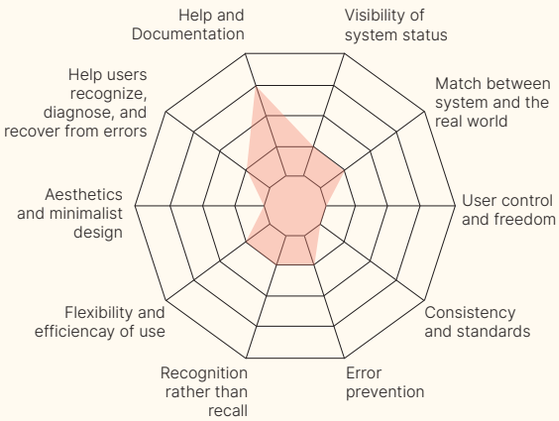
London Dashboard



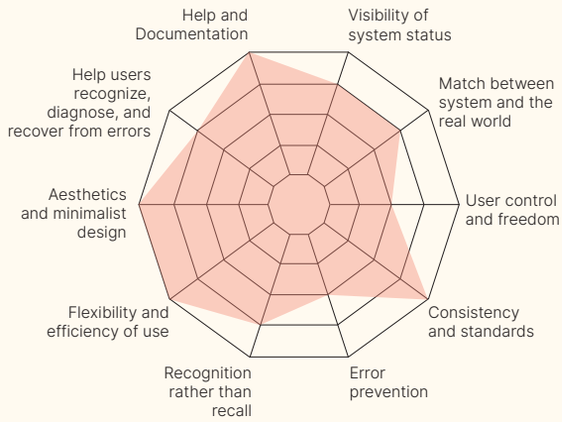
Edmonton Dashboard



Km4City



Maps for Amsterdam



Dublin Dashboard

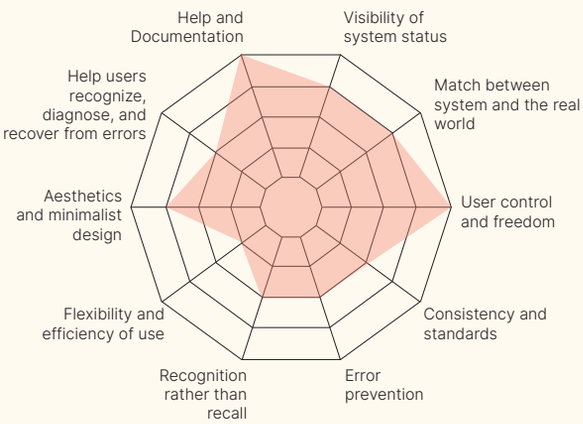


FIG. 36 - Heuristic evaluation results

looking for more detailed knowledge can drill down each topic and learn more about it. After evaluating these five case studies, I compared the analysis results and found some recurring features that may hinder the correct fruition of the dashboard.
The main problem is many of the publicly available platforms are the result of academic efforts, supported by professors or PhD fellows, or developed as thesis works. Consequently, **after these platforms went online for the first time, they often lacked further support and improvement**, that left them at a preliminary stage of development.
Secondly, **they are designed to be displayed mainly (or, in most cases, only) on desktop, rather than on a mobile screen**. This gets in contrast with a trend that has been growing since 2008, when, for the first time, there were more mobile than fixed broadband subscriptions (29). While a desktop view may be the most suitable for policy-makers, smartphones are the primary way with which citizens communicate and get the information they want: given the "frenzy" of contemporary urban lifestyle, it should be the channel with which they can get to know about the environment they inhabit.
Moreover, in the case of Dublin and Florence, **the principle of data-ink ratio is neglected**.
Such principle was introduced by **Edward Tufte**, one of the founding fathers of modern data visualisation, that used this concept to illustrate the best practices of information display (88). Tufte divides the content of each page in **data-ink** and **non-data-ink**. **The former is the set of graphical elements aimed at representing data**: if any of these elements are removed from the page, the data visualisation is no longer understandable. **Non-data-ink**, on the other hand, **is every element that's not related to the representation of data**. Therefore this latter category should be reduced as much as possible throughout the project. These visual elements of the page, being unrelated to data, don't give any contribution to understanding, and most of the times they are displayed only for the sake of aesthetics. **Although eliminating the superfluous should be at the basis of every design project, it becomes unavoidable when it comes to dashboard design**, as every redundant element, however harmless it might seem, could become a major source of distraction from the relevant pieces of information. Lastly, **a deeper analysis of the team members of the project was conducted**, in order to understand which skills were integrated to get to the final result. Every dashboard team was made by people with the same academic background, like geographers (Dublin Dashboard), architects (Maps for Amsterdam), computer engineers and data scientists (Km4City)...
An inevitable consequence is that each project honed only some aspects of the dashboard, like the spatial representation, the technical efficiency of data streams, the variety of the indicators...
A dashboard is a multi-faceted project, and its contributors must tap into different fields of knowledge so as to unfold its full potential: each of the above-mentioned professional roles are fundamental in shaping such a complex platform, but

they must be combined in order to reach an effective result. Lastly, I tapped into the documentation provided with the dashboards, in order to **shed a light on the process leading to the final platform**. What emerged is that, most of the times, **the whole project was technology-driven, rather than demand-pull**. Simply put, universities or other institutions utilised their technological resources and data analysis infrastructures to develop some possible applications, among which dashboards were featured. They put such platforms online, assuming that they may have resulted to be useful for some user categories. Nonetheless, it appears that **the final users were not involved in any of the project phases**, thus neglecting a session of needs setting.
Therefore, regarding existing dashboard, **while there may be little or no room for improvement from the technical and functional point of view** (and I would lack the experience to provide insights of these matters), **the overall user experience and the platform design could be radically enhanced.**

4 HYPOTHESIS DEFINITION

INTRODUCTION

This preliminary research shaped the main hypothesis of this work: now more than ever, **there is an abundance of digital tools that can aid decision-making, covering different topics and involving different channels and devices**. However good the intentions, not all platforms succeed in doing so: the information might be conveyed in an unclear way, or it might be delivered over too many channels at once. As a result, **workers spend up to 1.8 hours a day just looking for information** (90). This endeavour can't help getting even more demanding when the object of information retrieval is the city as a whole.

Local governments are often plagued by outdated processes, that most of the times fail to be innovated in a radical way. Therefore, **an incremental innovation is to be preferred, favouring new tools and practices that can support and facilitate the current way of working, without changing it**.
As stated in the previous sections, current platforms often lack attention to the final users needs and a true knowledge of the decision-making process *as is*. For this reason, they cannot replace an existing process, if they don't know what they are trying to replace or improve.

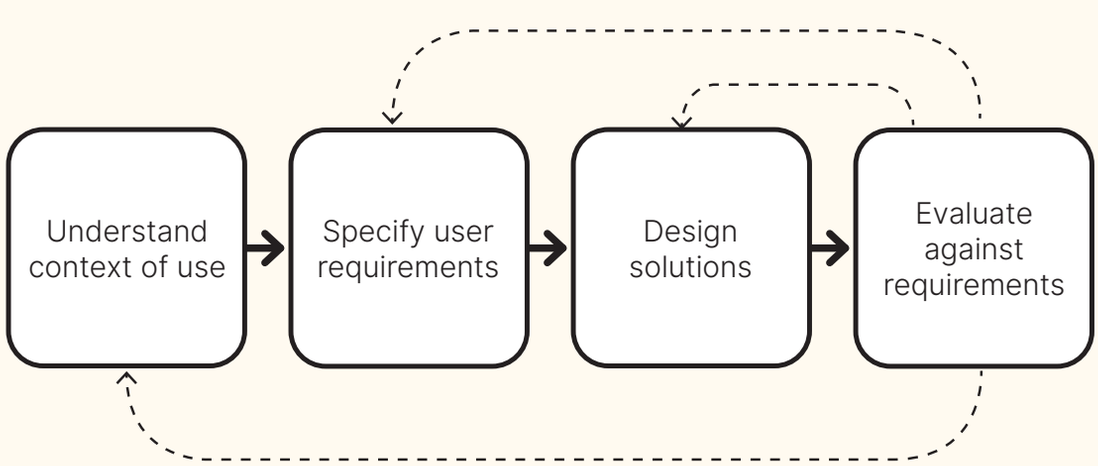


FIG. 37 - User-centred design approach, according to the Interaction Design Foundation

The idea underlying the whole thesis is **changing the way people interact with each other and with information in a city management framework, allowing smoother cooperation between different department and easier information retrieval and sharing.** In this context, **design can be the mediator of a co-creation process, allowing value creation thanks to the users' groups interactions.**
Considering the constraints and the vastity of the project, **I reckon a user-centred approach as the most appropriate one**, as it may ensure the correct definition of the final users' needs, in order to incorporate them within the platforms' requirements, and understand the way users take their everyday decisions regarding city management. **A platform designed following such methodology can become a fruitful and precious tool for users, and that's the starting point of the hypothesis this thesis is trying to advocate.** The definition for user-centred design such practice, provided by Interaction Design Foundation, is the following: *"User-centered design is an iterative design approach in which designers focus on the users and their needs in each phase of the design process. UCD calls for involving*

HYPOTHESIS

The project will explore the application of user centered design principles to dashboard design, **to improve the way people interact with each other and with information in a city management framework, thus enabling a smoother cooperation between the different department and an easier information retrieval and sharing.**
In this context, **design can be the mediator of a co-creation process, thus allowing value creation thanks to the users' groups interactions.**

users throughout the design process via a variety of research and design techniques so as to create highly usable and accessible products for them" (46). The term itself was coined in 1986 by **Donald Norman** and it got more popularity with the publication of his book *"User-Centered System Design: New Perspectives on Human-Computer Interaction"*.
But its definitive acceptance is related to the publication of another book, namely *"The Design of Everyday Things",* whose first edition came out in 1988. The main purpose of the book was **advocating the role of design as the mediator between object and user**, and therefore make users stop blaming themselves when they don't know how to use something, but blaming bad design instead (65). The book contains one of the most complete definitions of user-centred design and its principles, like **simplifying the structure of tasks, mapping functions in the proper way, exploiting the powers of constraint, designing for error prevention, and focusing on affordances**. User-centred design is often used as a synonym for human centered design, while in reality it is a subgroup of this wider practice (36). **Human centred design focuses on designing for people as a whole, regardless of their gender, age, social background, skills, etc.** Consequently, human needs and limitations that affect the vast majority of people (for example, visual perception in different environments, body characteristics...) get a higher priority throughout the whole design process. **User centred is**, instead, **taking into account all the characteristics and limitations of human centred design, but focusing more attentively on a certain section of the target audience.** In this case, specific personal factors like age, gender, education, social status, psychological condition, and personal skills get more important in designing a product or service. For this reason, a deeper analysis of the target is required, to "empathise" with them on a deeper level and understand their tastes, desires, and preferences. To sum up, human centred design principles are the core reason a product is useful and easy to interact with; user centred design is one step ahead, aimed at satisfying the needs of a particular target audience.
Regarding the scope of this thesis, and dashboard design in general, the **characteristics of the target audience are of paramount importance**: generally speaking, **it's a platform not everyone will use**, but it's aimed at people with a high interest in the city's condition and with basic technological skills. Therefore, **a user centred approach is to be preferred**. The next section will introduce the project starting point, the methodology and the involved partners.

FIELD OF APPLICATION

A useful occasion to put this research into practice arose while I was attending Alta Scuola Politecnica: it is a programme founded in 2004 by Politecnico di Milano and Politecnico di Torino. The programme is restricted to 150 students, among the applicants to the Laurea Magistrale programme in Engineering, Architecture and Design at the two universities.
I had the privilege to join ASP's XIV cycle, starting in February 2018 and ending in September 2019. The importance of this opportunity lies in two aspects: the possibility to cooperate with people from different backgrounds and the chance to work on a professional project with academic and industrial stakeholders, thus leading the project to a higher level of implementation.
The project proposed to our group was **designing a city dashboard for Milan**, with the following brief: *"The project aims at connecting sound analytics approaches to data visualization for the Smart City, in particular for what concerns the topic of energy and environment. The idea is to create a city dashboard/platform (accessible via apps, web, etc.) for the city of Milan, able to perform advanced analytics procedures and effective visualisations for various final users (e.g., citizens, technical decision-makers, political decision-makers, urban planners)."*
The project involves several stakeholders that gave a unique and precious contribution to the project:
The Municipality of Milan was the main data provider and evaluator of the final prototype. **AMAT (Agenzia Mobilità Ambiente e Territorio)**, via its technical staff, provided their expertise to clarify actual needs for the public authority and data characteristics and quality;
CEFRIEL provided technical support on data analytics, system interoperability and digital ecosystems integration..
The project started in July 2018 and has formally ended in July 2019, when a partially working prototype has been presented to Municipality's representatives.
During this timespan, I took care of the state of the art research, user analysis, platform design, and visual models definition.
The project for ASP ended with the delivery of a prototype, that can be accessed at **www.smartcitydiva.it**.
The platform encountered the praise of several stakeholders: it was **featured on the E015 platform** as a successful application of their APIs, it was **presented to Regione Lombardia**, and it was **backed by the Digital Transformation Council**.
After the final delivery, **I took charge of the whole project**, using the knowledge background I had gained in the previous months and **starting from scratch from the design standpoint**, as that phase hadn't received the attention and focus it required.
The main goal of this thesis is trying to **further develop the dashboard after the prototype delivery**, thus becoming an access point for citizens seeking information about the City Council's actions and a support for decision-makers in their everyday tasks.
During the thesis development, I got in touch with the main stakeholders again, namely the Municipality, AMAT, and Cefriel.

For what concerns the Municipality, **I managed to get in contact with Milan's Digital Transformation Councillor**, who expressed her appreciation in the work. This was an opportunity to **gain deeper insights about the Municipality's needs**, and leverage on their know-how on smart city projects.
I managed to spoke with **AMAT employees**, and on these occasions I managed to **clarify the way they work with data every day, the softwares and platforms they rely on, and their usual decision-making process**. Their help was of paramount importance in order to understand how to insert the dashboard in their daily workflow.
Cefriel support was fundamental from the design and technological point of view. They have a very clear idea of the digital framework of the Municipality, and they helped me **understand the limits and challenges of the technological solutions they support.**
The nature and results of all these interactions, and more details about each institution, will be laid out in the "User analysis" chapter.

Part II

Project development

5 CONTEXT ANALYSIS

MILAN AS A SMART CITY

On the 1st of January 2019, **Milan resulted to be the second most populous Metropolitan City in Italy**, with a population of more than 3 million people (15). The institution of metropolitan cities was a profound change for the Italian administrative structure, as provinces, the former geographical subdivision, had been used since the second half of the Nineteenth century. In 2015, the reform of local authorities (Law 142/1990) before and with the Law 56/2014 after, 10 metropolitan cities were established, and 4 more were to be added later. The main reason for such reform was reducing administrative costs, by giving more power to larger geographical areas and improve local management. The main aim was **allowing municipalities to coordinate themselves in a more efficient way**, and consequently improve the quality of services like transportation, education, and social programs. Managing such a wide territory is not an easy task, and it gets all the more difficult considering how distant and different each part appears to be. Milan is also subdivided within the range of its capital city, as the urban area is divided into 9 zones (that can be seen in Figure 38). Despite these premises, **Milan was proclaimed to be the first smart city in Italy, according to ICityRate, for the fourth year in a row** (35): the city scored the higher overall grade, and it's first in the ranking for 20% of the indicators. It has several characteristics that make it a fertile environment for the creation of effective smart city initiatives, along with some critical issues that must be addressed for future projects to find full success. Its strong points are mainly innovative urban development, shared administration, social innovation; 30 km/h zones, improved public transport, bike/car sharing; renewable energy; entrepreneurship, disposable income, knowledge-intensive companies, productivity, fablabs, corporate credit, coworking; touristic entrepreneurship, touristic occupation; home banking spreading, social PA, broadband penetration.

However, **Milan is still below the national average for rates like micro crime in the city, air pollution (NO2 and PM2,5), and green spaces availability.**

In order to tackle all these problems, various initiatives (see Area C, LTZs) were backed by the Municipality. Some of these solutions are aimed at the reduction of noise and air pollution, while many other tactical urbanism interventions, set up in neighbourhoods with a higher crime rate (like Piazza Dergano and Piazza Angilberto earlier this year) want to increase the living conditions in those urban areas. The development of car sharing and bike sharing services resulted in a significant improvement of the traffic and parking situation, and **one of the most pressing challenges is to make the sharing services even more pervasive and suitable for the**

"We want to be a model for all other italian cities. For this reason, we started a dialogue with them"

—R. Cocco

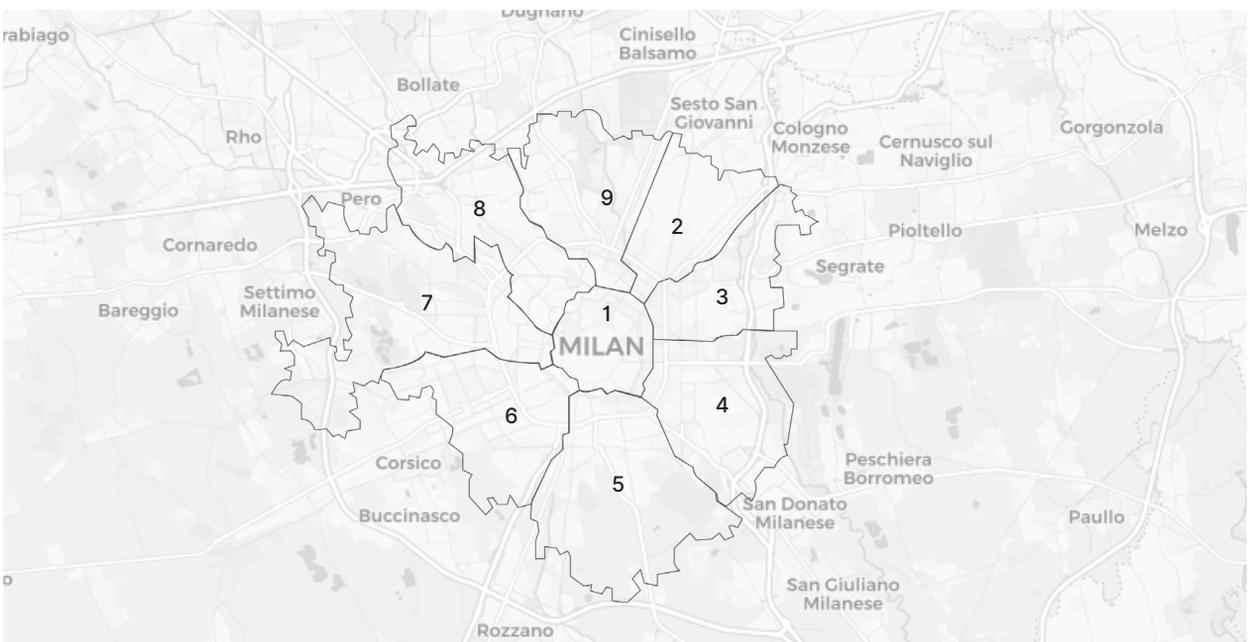


FIG. 38 -Milan 9 zones

lifestyle of citizens. In this regard, a smart parking service is being developed, with the main objective of providing constantly updated data on the state of occupation of parking lots and to systematically monitor irregular stops. Furthermore, Milan **aims at becoming a leader in the management of urban waste**, trying to have the highest rate of recycling among major European cities (right now, it holds the second place in the ranking, after Wien) and promoting energy efficiency plans to reduce carbon exhalation by combining intelligent buildings, innovative public lighting and smart metering. The municipality devotes attention also to the needs of the most marginalized members of society, stimulating local welfare to develop the idea of shared services and social interactions. Milan focuses also on simplifying bureaucracy and procedures, developing an efficient information system which allows citizens to access online services. This is the main focus of the Digital Transformation councillor, who explained to me all the effort poured into this advancement. Moreover, **all these services have to take into account not only citizens, but also the so-called *city users*** (estimated to be 1 million), a category including commuters, travellers for work or tourists. Lastly, Milan is involved in several supranational initiatives, that aim at building smart city networks pursuing objectives on a European scale

DIGITAL PLATFORMS FOR MILAN

Considering the high attention the Municipality gives to the theme of digital innovation, there have already been some attempts to use Milan's data in a fruitful way. **We can divide these efforts in the same categories mentioned into the previous section**, namely **top-down** and **bottom-up projects**. Some examples of bottom-up initiatives are listed below:

QuoliMi app (72)

The app won the first edition of App4Mi, a contest promoted by the Municipality for the development of innovative tools tapping into the Open Data resources.

The platform evaluates the quality of life of a particular city address by aggregating different data. With clear and simple graphics, it shows the district that best suits the needs of the user who does the research, by measuring green level, transportation, commercial establishments, services and entertainment.

BiciMi4Social app (6)

This platform aims at promoting the mobility of citizens of Milan using the bike-sharing service. The app allows, for example, to reach the stalls of the nearest bicycles, know the number of bicycles for each stall, share information with friends (on social networks, through messages, WhatsApp...), display on a map all the bicycles available in the city of Milan etc.

EcoMilano (27)

EcoMilano was developed with the aim of helping citizens to effortlessly find the best green places in Milan.

The various points of interest are divided into categories (parks, dog areas, car/bike-sharing services, parking, methane distributors...) and the lists are updated in real-time following the position of the user (the points of interest are rearranged from the closest to the furthest). For each point of interest, some basic information is displayed, obtained from the Open Data of the City of Milan (location, distance...) and the location on a map. For example, for parking lots, the total number of parking spaces is displayed, as well as the connections with public transport.

Spotlime (83)

Spotlime was founded in 2013 by a Milanese startup, and it's aimed at the best venues and event organizers in every city. For this reason, the app is divided into categories, so that the user can easily find the location that suits him best: discos, restaurants, cocktail bars, exhibitions, cinemas, and so forth.

All the above-mentioned tools were generated by citizens' efforts, but also Municipality operators advocate the importance of new digital solutions to improve the fruition of services.

Below are **some examples of online platform promoted by Milan's council and its cooperators.**

PULIamo App (70)

Created in collaboration with Azienda Milanese Servizi Ambientali (AMSA, Milan's environmental services company).

The app displays, for each address in the city, the nearest waste collection points and available delivery services, as well as data on the street washing program. It allows citizens to make their own reports. Moreover, it shows the latest updates in waste management and the results AMSA managed to achieve. This model could be a good start for the construction of a

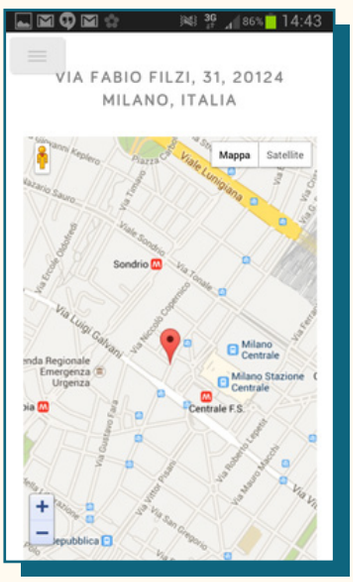


FIG. 39 - Quolimi app

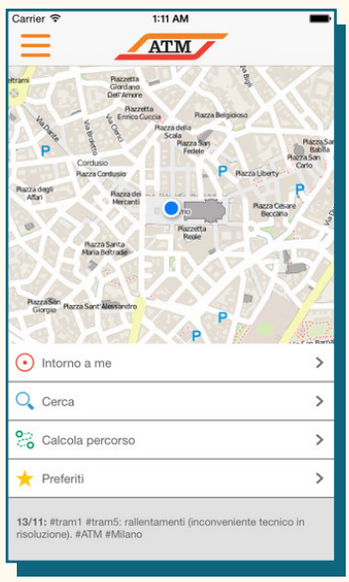


FIG. 40 - BiciMi4Social

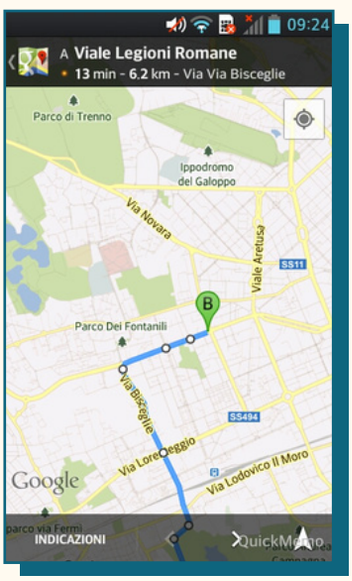


FIG. 41 - EcoMilano

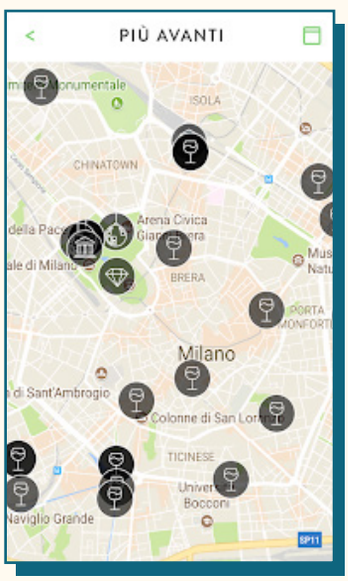


FIG. 42 - Spotlime

broader service, including not only data on waste collection services, and in which the current services could be merged and integrated.

Open Data (67)

Open Data is Milan's platform for public datasets publication and sharing. All datasets are divided into 13 categories and each of them features a short description, temporal and geographical coverage, and last modification date. Another interesting aspect of Open Data platform is the statement of mandate, with 12 KPIs focussed on government's actions and achievements. Nevertheless, at least during the development period of this thesis, s this section doesn't seem to be working.

E015 Digital Ecosystem (26)

One of the most prominent examples of this effort towards digitalization is the Digital Ecosystem E015, a platform on which various organizations (public transport companies, cultural heritage institutions, universities, event organizers, healthcare operators...) can share their data: such datasets are then turned into APIs , allowing an easier integration in websites, platforms, or physical touchpoints by other stakeholders. This favours the creation of digital relationships between different subjects, both public and private, interested in enhancing their digital heritage or in enriching their software solutions with the functions and information shared by other contributors. The whole project was developed by Cefriel and it was subsequently backed by Lombardy government, that wants to favour digitalization of the territory by asking for a "digital return" to the call for tenders' winners, that are required to share their own information inside E015.

Here's the complete text of the regional law:

"1. In order to create the conditions for the development of digital ecosystems, the Regional Council defines guidelines for public and private operators.

1a. The Regional Council promotes the Digital Ecosystem E015 as a tool for data exchange and integration between public and private information systems, also through the introduction of charges and rewards for operators participating in regional call for tenders for the provision of funding, when the conditions are met, even as an alternative, for sharing information with the public administration and for the accessibility to the public of general interest information." Below are reported three successful applications of E015 resources:

Muoversi Milano website (62)

Milan's transportation services are managed by different providers, ranging from metro lines, commuter rails, airlines, sharing mobility services and so forth. Each of these providers developed its own apps or websites, where it shares news and relevant information, thus making it hard for users to compare different mobility solutions. The Milan's Infomobility Portal provides a solution: users can now have access to all available information on Milan's mobility within the same page and can choose which mode of transport best suits their needs. The website also features a section where citizens can apply

for special passes or parking permissions.

Emergency dashboard (60)

As EXPO 2015 approached, there was a growing concern about how to grant the safety of visitors and how to coordinate the different rescue teams (ambulances, policemen, firefighters...)

The Emergency Dashboard was designed to overcome this issue: **the platform allows the georeferenced visualization of strategic locations, resources and situations of actual or potential danger**. The data are collected from the information platform of the Lombardy Region (in particular the one related to Civil Protection, from the Regional Agencies dedicated to Environmental Protection (ARPA), from health emergency management platforms (AREU) and other bodies (Law Enforcement, Fire Brigade, local police headquarters, municipalities, public transport operators, etc.). The dashboard favours a holistic vision of the city situation and **makes sure all the different bodies share the same level of knowledge**, in order to act and cooperate accordingly. The starting point is a series of scenarios: the institutional scenarios are more general, the modelled scenarios are based on the operators' experiences. When operators gain experience, they can create a modeled scenario on the platform, to keep it for later use.

L15 (55)

L15 wants to be **a tool to discover the riches of the Lombard territory**, but it's also a showcase of the main content shared through the digital ecosystem and, for this reason, is constantly evolving, following the developments of E015.

L15 is possibly the closest thing to a dashboard for citizens, despite not focusing only on Milan but on the whole Lombardy region: in fact, it was specially designed to showcase *"the beauty of the landscape, the variety of events, the opportunities of the territory, the offer of services at the click of a button".* The homepage offers a huge variety of information, ranging from events to healthcare facilities location, from student campuses to air quality. The pieces of information are wisely linked, meaning that, **when clicking on an event to get more details, we can easily learn how to get there, by being redirected on the page dedicated to mobility**. Nevertheless, from the usability point of view, the various pieces of information could have been clustered in a clearer way, in order to support non-expert users.

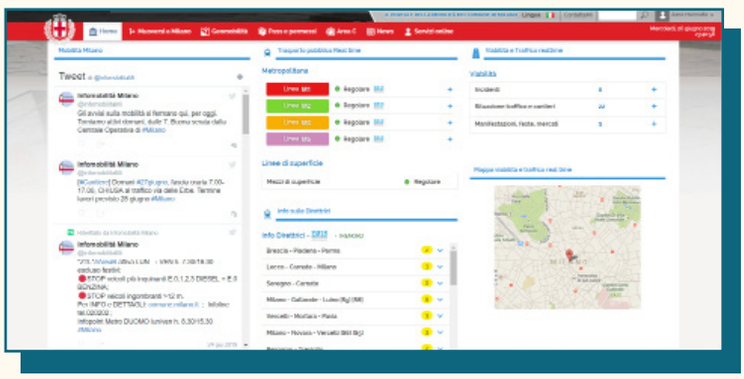


FIG. 43 - Muoversi Milano

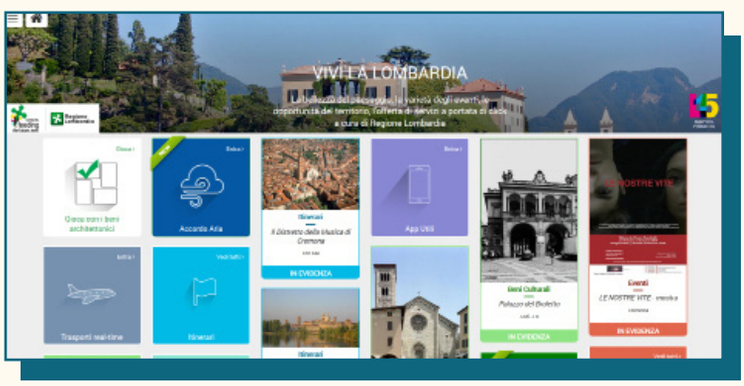


FIG. 44 - L15

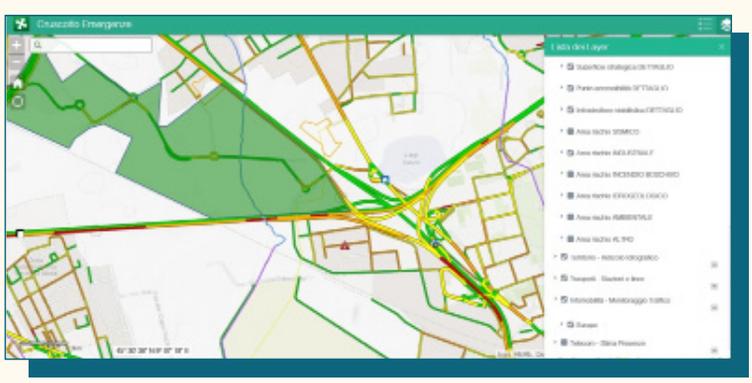


FIG. 45 - Emergency dashboard

6 USER ANALYSIS

USER CATEGORIES

Displaying the situation of Milan is a complex task, given the heterogeneity of the factors acting on the city. Such endeavour gets all the more difficult considering the platform's relationship with users, as the people using the dashboard come from different background and have, in some cases, opposite needs. Moreover, a review of the literature on information seeking showed how people experience this process in a non-linear and dynamic way, namely as a combination of intertwining thoughts and feelings (53).
Therefore, **the user flow in dashboard navigation is highly unpredictable and, most of the times, it cannot be funnelled by the designer in any way**.
A user flow is a series of steps a user takes to achieve a meaningful goal and, in the majority of cases, they should follow three fundamental laws (19): have a clear purpose, go in one direction, and present a complete task. A single user can perform different actions on the same website: for example, on Amazon, a user could want to buy something or verify the situation of his/her order. However, with most data-driven products, these three principles cannot be

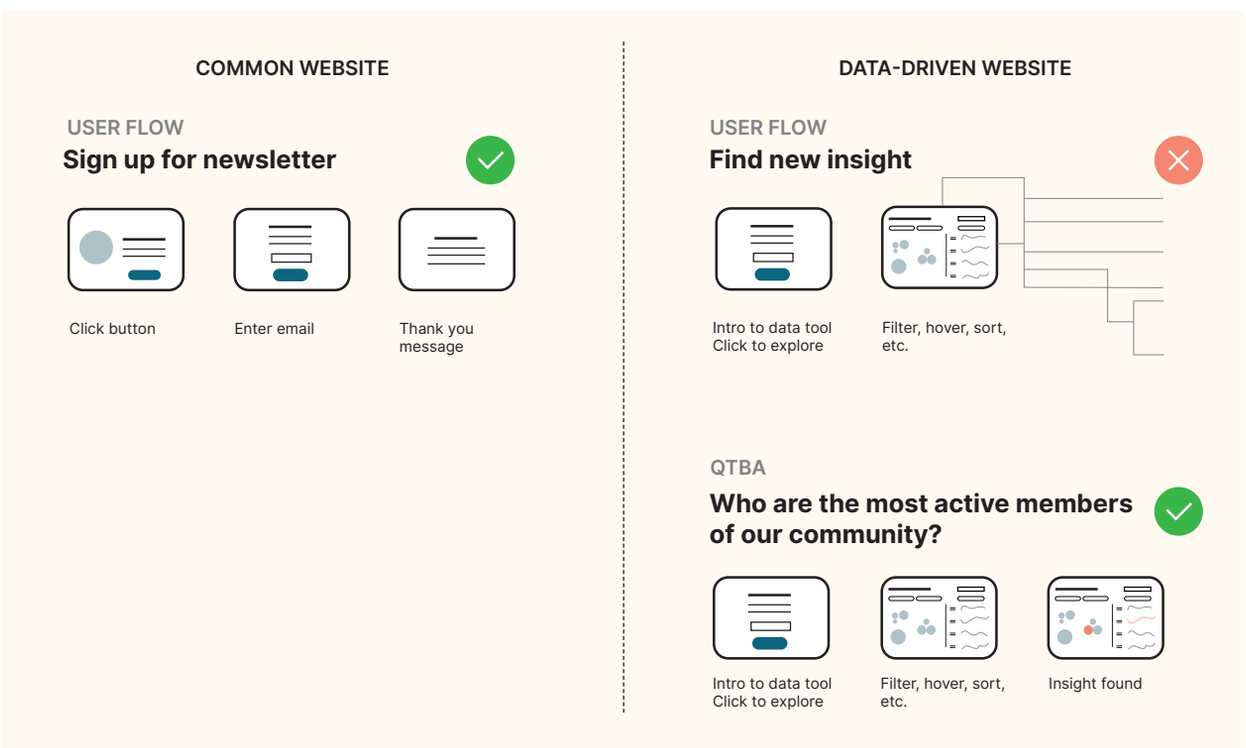


FIG. 46 - User flow and QTBA for different platforms (source: Benjamin Cooley)

	Decision-makers	Citizens
Number of users involved	6	74
Method	-Focus group (6) -Structured interviews (4)	-Survey (69) -Semistructured interviews (5)
Timespan	January-March 2019	March-April 2019

FIG. 47 - User analysis outline

respected: users navigate a dashboard to get new information about a certain topic, but then their attention may be caught by another detail, and they may want to deepen that aspect.
Consequently, **the user journey is highly unpredictable, as users receive inputs in each phase of the navigation, and such inputs could abruptly change their focus.**
Therefore, designers need to account for a branching journey instead.
As Benjamin Cooley (19) claims: *"Building a data visualisation product always starts with a list of questions from the people that will be using it. If someone is actively exploring and analyzing data, they will have a question in mind that they want to answer. Our job as data designers is to anticipate these questions and provide intuitive, user-friendly ways to find the answers in a dataset"*.
The only way to identify these sort of questions is by deeply analysing the categories of users and the need that drew them to use the dashboard.
For this reason, **the first phase of the project development was dedicated to user analysis:** considering the initial direction provided by the project partners, the dashboard should have ended up as a tool for decision-makers only. Nevertheless, I really wanted to include also citizens in this attempt to spread knowledge and reach a higher degree of participation. The reason for this can be traced back to the previous section, **proving how each successful smart city project require the active cooperation of both citizens and city government.**

Based on the preliminary research about Milan as a smart city, **I divided users into two main categories, according to their background and needs**, namely decision-makers and citizens. Setting the users' needs in a smart city environment is particularly challenging, as explained by the concept of ***goal variety*** (28): such theory claims that **urban categories (decision-makers, officeholders, citizens, private institutions...) demand things and changes that are *"inherently contradictory and competing each other"*.**

For this reason, creating a satisfactory requirements framework can be resource and time-intensive, but it's an unavoidable step that can jump-start the project's development.

Therefore, I drew a preliminary picture of what could be the needs of these two branches of the target, before deepening them through various user analysis' techniques.

In Figure 47 there is a brief recollection of the number of people involved, the techniques I applied, and the time required to complete the analysis phase.

While I managed to involve a higher number of citizens than I expected, I could not do the same for decision-makers: I managed to get in contact with only 6 people over the course of three months, after which I had to go on with the following phases, in order not to come to a standstill. Therefore, **I tried to make the best out of the interactions I managed to have, in order to draft a preliminary concept and then involve users again at a later stage.**

DECISION-MAKERS' ANALYSIS

Before going any further into the analysis, I felt the need to **clarify Milan's Municipality structure**, in order to have a more detailed idea about the possible fields of application of the platform.
In Figure 48, a schematic representation of such structure is displayed.
During the months spent on the development of the project, I managed to get in contact with people from three main institutions:
Municipality of Milan: it's the institution, overseen by the Major, administrating the Metropolitan Council, made by 24 majors of the other municipalities within this urban area, and the City Council. The purpose of the City Council is to **support the Mayor in decision-making on a regular basis and to ensure the guidelines of the Council are fully implemented.** The management function does not fall within its competence (apart from cases of exceptional delegation), therefore it has a role of guidance, supervision and political and administrative control.
AMAT: it is the Municipality Agency, and since its foundation in 2000 it carries out field analyses and monitoring, **it processes data and maps, it develops models, simulations, evaluations and feasibility studies**. Moreover, it's also focussed on the comparisons with international contexts, developing planning tools to keep up with other cities. Lastly, it provides the municipal administration with the necessary support in the implementation phase of their ideas.
Cefriel is a digital innovation centre founded in 1988 by Politecnico di Milano. Nowadays, it creates digital products, services and processes, it participates in national and international research programmes, and it develops digital skills support and culture.
The team has a strong multidisciplinary setting, as it's made by over 130 people with a mix of technical, business and design skills. **Cefriel is a consortium company, therefore it's totally independent from structural financing, both public and private.** Despite being more related to Lombardy's initiatives, they frequently cooperate with the single municipalities within the Region. In particular, **they strongly cooperated with Milan's Municipality and AMAT in the visitors flows management during EXPO 2015.**
After delineating the various institutions forming the decision-makers base, I asked myself something more about their possible needs. First of all, **this section of the project's target needs the platform as a basis for decision-making in various fields** (mobility, service delivery, citizens' satisfaction...). They may need access to both datasets and aggregated indicators: for example, an employee in charge of mobility may need a high level of granularity for his/her topic of interest, with very frequent updates and very specific information from the spatial point of view. Nevertheless, he/she may also need some general information about, for example, urban planning, but just through general KPIs, in order to combine them with mobility information and make more informed decisions. Nevertheless, **decision-makers may need the dashboard not only as a decision support, but also as a communication tool**: from this perspective, the platform's aim would be twofold, as **it**

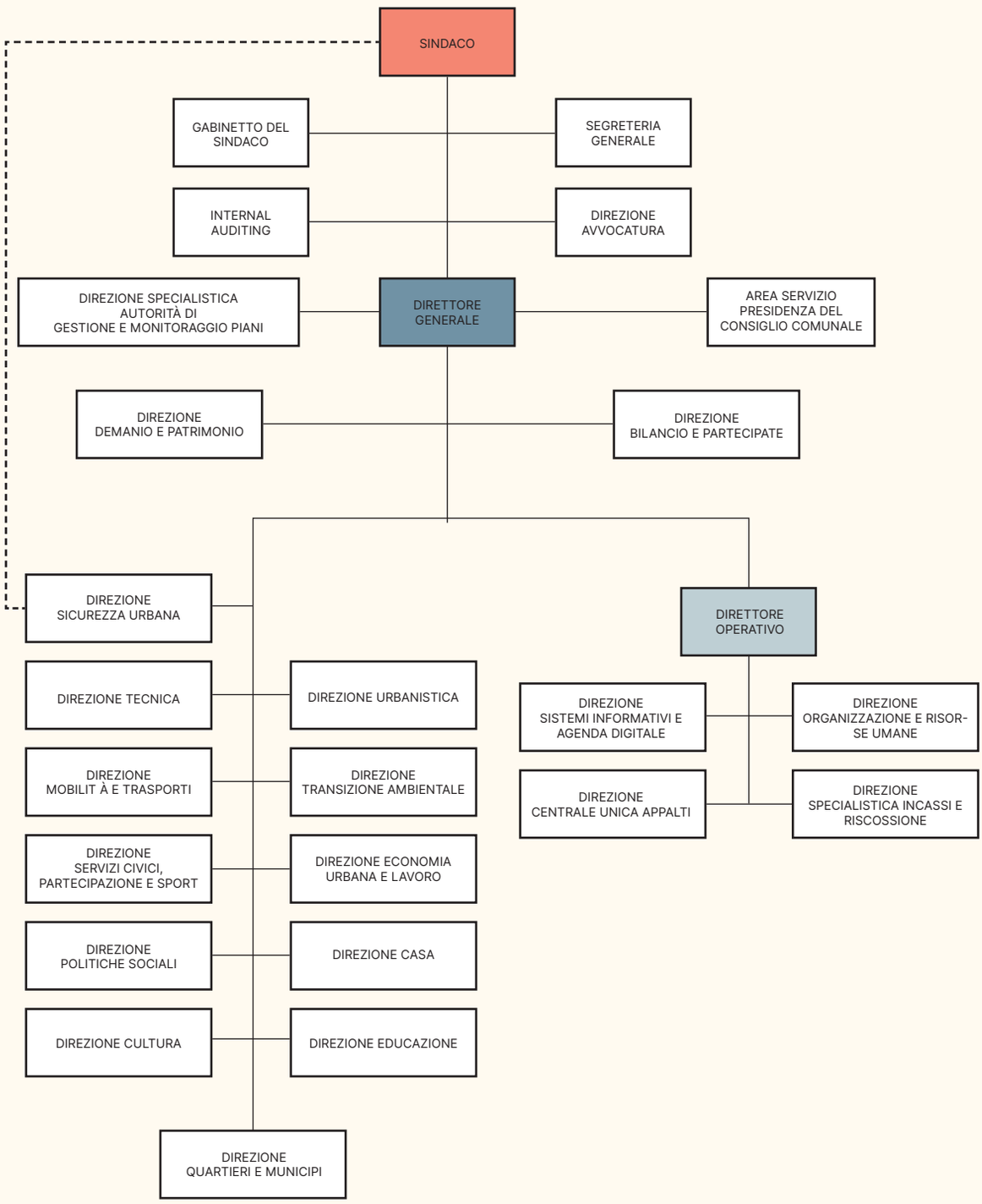


FIG. 48 - Organisational chart for Milan's Municipality

could favour connection with citizens but also aid internal communication within different governmental departments.
I was able to identify the needs of public administrators in three different ways: **one focus group**, that took place in March 2019; **six interviews** carried out between May and June 2019; **a meeting with the Digital Transformation Councillor**, Roberta Cocco, in July 2019.
I opted for a focus group because I needed to involve as many people as possible in the shortest time, since at the time I did not know how many more occasions to interact with them I would have had.
On this occasion, I was able to understand not only the needs of decision-makers, but also how the institutional partners (a2a and Cefriel) could give a contribution to the final result. Having all the stakeholders in the same room was **a precious occasion to understand the way they cooperate with each other**, and whether there are frictions or unsolved issues hindering such cooperation. **It was interesting to see how people coming from far-flung areas**, with completely different viewpoints and tasks, **share the same idea about the main problems** affecting their work inside the Municipality's structure, namely **the lack of timely communication, the struggle to find a common language, the lack of connection with citizens, and the fact that some monitoring activities are still time and resource-intensive.**
After delineating the most pressing issues, the focus shifted to understanding what users were expecting from the dashboard and **which features they would have valued the most.** The most helpful features were **combining information coming from different topics, comparing two or more datasets in order to identify patterns, and trying to bridge the gap with citizens.**
Luckily enough, **I was able to deepen the analysis through interviews, both in person and on the phone.**
The interviews involved five people that took part to the focus group and another person I had no previous contacts with. **I chose to carry out structured interviews** for a variety of reasons: first of all, **after the focus group, I had very specific doubts in mind**, and I needed to go straight to the point with each user. **Secondly, I needed to grant good time management in order to take advantage of every moment I was granted**. The interviews allowed me to dig deeper into these problems, **with the interviewees bringing their personal experience to the table**, and using it to talk about the issues they face every day, and how a dashboard might solve them. Some went as far as to suggest very specific functions for the platform, functions addressing some particularly relevant issues.
The interviews' integral transcription is available in the Appendix.
Lastly, the meeting with the Councillor was a useful occasion to enrich my previous findings: it was a mutual exchange of information, as I managed to lay out the results of my user analysis, while she provided me with some precious directions on how the project might have developed. She showed a particular interest in the project, as she always promoted initiatives pursuing processes digitization and technological solutions

aiding the city administration.
As a closing note I tried to gather the necessities emerged in this analysis phase: some of the needs were clearly expressed during the meetings, **like allowing the dashboard to combine different datasets** (also from different fields) in a fruitful way, in order to identify recurring patterns.
The platform must also highlight when there's a recurring abnormality in the recorded data, and trace when critical situations tend to happen in time. Moreover, it must **favour a more effective communication with citizens and allow the understanding of the information also in non-expert users.** Lastly, the people involved asked for a **deeper focus on the themes of mobility and environment**, that were signalled as the most interesting topics also by citizens.
After all these fruitful interactions, I also identified **some "latent" needs,** like the fact that **the smooth cooperation between different Municipality departments is still held up for many reasons, mainly because the interoperability of datasets is still not as effective as requested.** Besides, there isn't a clear and unique idea about the number and characteristics of the datasets at the disposal of the Municipality. **Moreover, some monitoring operations are still extremely burdensome.** Therefore, the need for physical checking of the city situation (like for parking) could be reduced with the dashboard introduction.

*"Reports drafting take a lot of time **when they should be ready as quickly as possible**."*

*"When it comes to information, it's like **operators are deep diving**, and **citizens are doing snorkeling**"*

*"People really need to **understand the limits of what they are leaving** before jumping into a whole new method."*

*"There are a lot of variables to be considered before making even a small decision [...] I think it would be useful to **combine these variables with other coming from other areas**, in order to identify interesting patterns."*

*"We have **a lot of different sources of information**, some of them I don't even remember if they are still online or not"*

FIG. 49 - Decision-makers' interviews quotes

CITIZENS' ANALYSIS

This is possibly the most difficult section to grasp, being very wide, numerous and heterogenous. In the past, Milan underwent a relevant decline in population, mainly caused by the financial crisis that plagued the industries of that urban area. Nevertheless, thanks to a revived industrial framework and national and international immigration, **Milan's population reached 1.4 million in September 2019** and is expected to grow up to 3.16 million by 2030 (98).
The number of inhabitants is not the only factor making citizens' analysis strenuous, as another fundamental aspect to bear in mind is the **heterogeneity and mobility of Milan's citizenship**, that changes its composition on a regular basis. First of all, **20% of Milan population is made by foreign inhabitants**, that on 1st of January 2019 were 268.215 people and the number is likely to increase in the near future. Secondly, another dynamic force is made by students: **Milan hosts new 174000 new students each year**, and it is also the second most visited destination by Erasmus students after Barcelona. Moreover, **470 thousand commuters move towards the city every day.** Consequently, framing the needs of this social group is extremely burdensome.
Citizens were not the primary target for this project, but they must be involved anyway, considering how decision-makers want to use the platform as a way to communicate with the city inhabitants. In order to cope

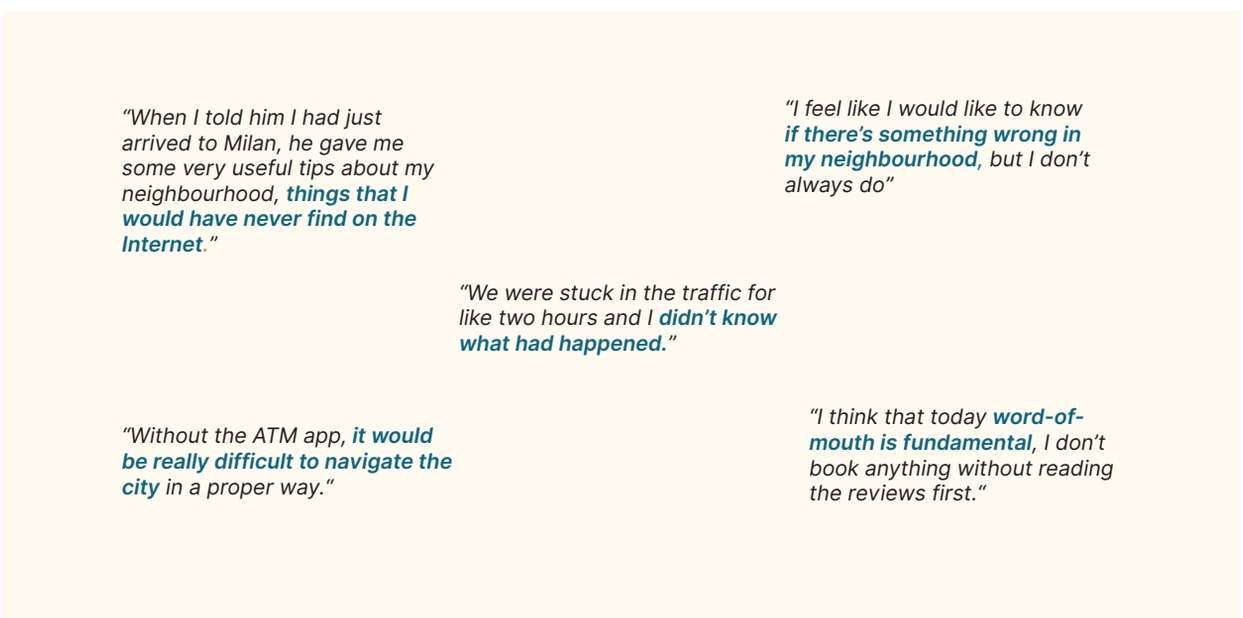


FIG. 50 - Citizens' interviews quotes

with my lack of knowledge about this target section, two different steps were followed: the first one was a **quantitative research, based on an online survey**, that reached **69 people from far-flung backgrounds, but all living/working in Milan**. Participants were asked questions on the main topics they research information about, and on the platforms they use to keep up with the city's updates. In order to understand whether Milan's open data policy matches citizens' needs, **participants were also asked about the perceived utility of datasets that aren't in Milan's databases, but are displayed in other cities** (first aid situation, free parking spaces...).

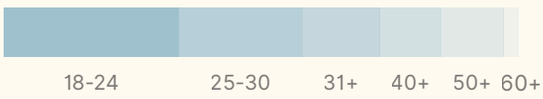
The second one was a qualitative research, based on **semistructured interviews (age range 14-58) to 5 people**: after some general questions about their background and their relationship with Milan, interviewees were asked to **identify the information categories they are more interested in** and, after that, they were asked to signal the different aspects of that topic they would like to be informed about. Moreover, they were asked to what extent they would prefer to be involved in the platform creation.

The interviews' integral transcription and the survey results are available in the Appendix.

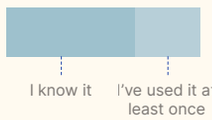
What emerged from this analysis were a series of expressed needs: for example, in the citizens' eyes, **some Municipality's decisions could be made clearer**, as sometimes people see changes in the city that they cannot trace back to any specific reason. **Moreover, helping other people is also perceived as a very important aspect of everyday life**: sharing information with other citizens is seen as a way to cope with uncertainty, and as a strategy to reassure each other when a problem arises. **Lastly, mobility is perceived as the most interesting theme** when it comes to updates and real-time information. Nevertheless, **this analysis phase was useful to identify latent needs too.** First of all, I understood how **difficult it is to start using a new platform, as there must be a profound motivation to do so**. Moreover, not everyone wants to feed content into the platform and play an active role in it. **Sometimes users just want to get informed, without giving any significant contribution to the overall project.**

Regarding the way they feel about Milan, I reckon the perception of the city is generally positive, with some issues still to be solved.

How old are you?

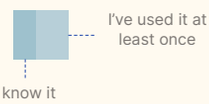


% of people that know/have used Open Data website



% of people having experience with data analysis or programming

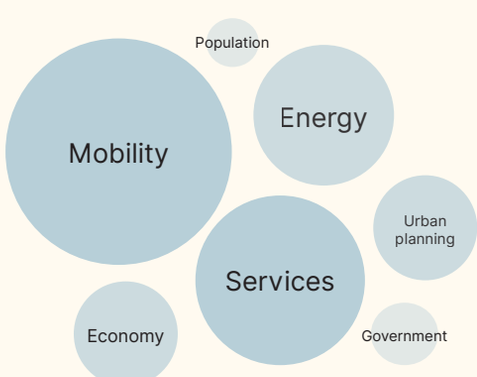
% of people that know/have used E015 website



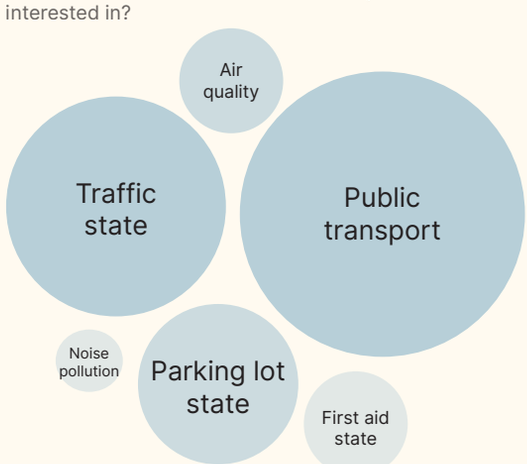
Which devices do you usually use to read the news?

42% 31% 13% 13% 13%

If there was a website that could inform you about Milan, what would be your interest in these topics?



Which of this real-time information are you most interested in?



Would you actively take part in the development of the website? For example, by sending reports about accidents, road conditions, public transport situation... through your smartphone?

Have you ever made any reports to the City of Milan? If not, would you know how to communicate with the Municipality?

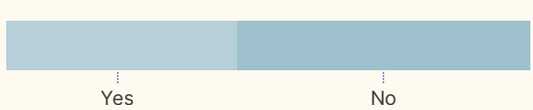


FIG. 51- Citizens' survey results

USER ANALYSIS OUTPUT

The user research phase was extremely useful to fuel the preliminary part of the project, and it gave me the main insights at the core of further advancements.
Nevertheless, I found myself dealing with extremely heterogeneous needs, and figuring out how to combine them all was a complex task. I really felt the urgency to sum up the research in a more structured way, in order to visualise the main results more clearly. I used the matrix in Figure 52 to place the people I interviewed according to their technological skills and level of granularity needed while navigating an informative platform. This phase made me understand that the target I had to consider was made by more than two groups (decision-makers and citizens), but instead were belonging to four different categories.
The **first category** is made by those I called **decision-makers**, namely people with higher administrative roles, like the Major, the Councillors, and their collaborators.

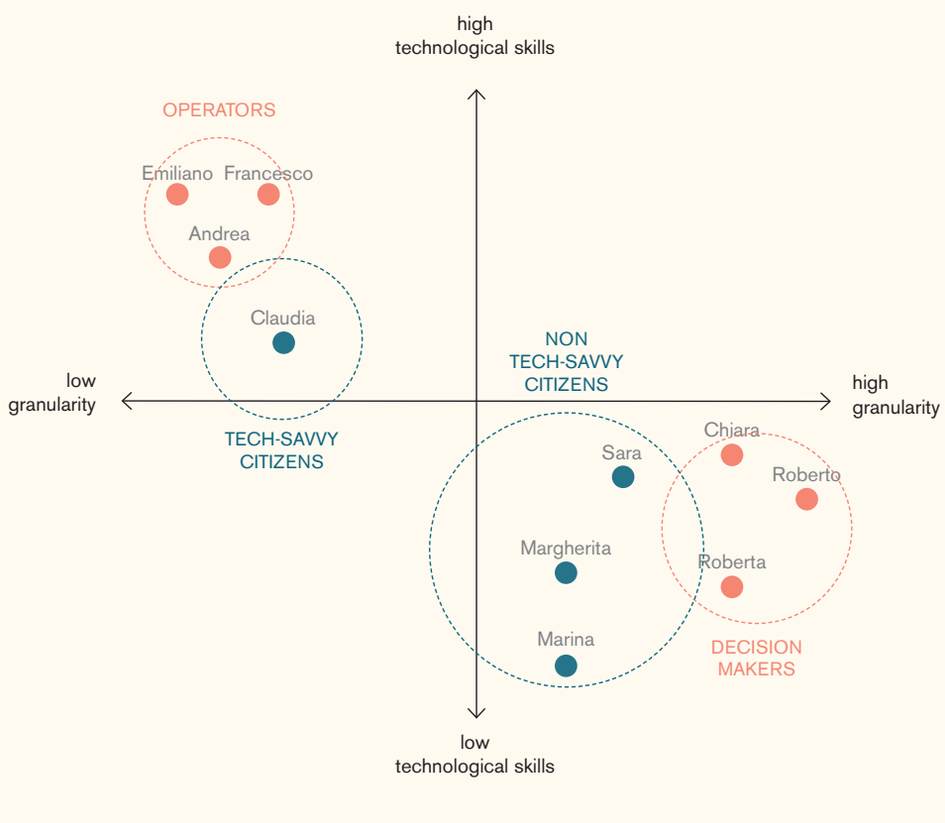


FIG. 52 - Interviewees mapping

They are the ones in charge of the real decisions affecting the city.
The **second category** is called **operators**, made by all people, from AMAT, Cefriel, or Siad, that work in the field field and analyse data to work out the main issues affecting the city. They are in charge of monitoring, but they cannot take proper decisions. They have to keep decision-makers informed, so that they can act accordingly.
The third category could be summed up as made by "tech-savvy" citizens. In other words, all the people belonging to this category are not properly involved in any governmental activity, but nurture some kind of professional or personal interest for Milan's datasets. Examples could be data journalists, researchers, professors, data scientists, and so forth. They have high technological skills, therefore they often want to create their own visualisations. That is the reason why they need access to the datasets behind the graphs.
The **last category** is made by **"non-tech-savvy" citizens**, namely all people that simply want to gain an idea about the city's status, maybe out of necessity or to understand a problem affecting their area. They lack the technical skills to work with data, so they need clear visualisations on the website.
Given the scope and the final aim of this thesis, I decided to **dedicate particular attention to the informative needs of the users, to understand the situation "as is" to better define the situation "to be".** This was an aspect of their everyday life that was more clearly expressed during the user analysis phase, and I really felt the need to give it more centrality in order to better structure the future solution.
Therefore, **I mapped all the informative touchpoints with which citizens and decision-makers interact in their everyday life and the information they draw from them.** Figure 53 displays all the touchpoints I identified during the research, while Figure 54 maps all the topics that are featured in each platform. Mapping all the informative touchpoints supporting the Municipality operators was a time-consuming effort: to begin with, **not all the sources are spread among all departments**; although some tools were deprecated by the majority of operators, they are still used occasionally; **the introduction of new platforms is tiresome and often ineffective**. Citizens, on the other hand, can refer to a huge variety of touchpoints, but also in this case the information is fragmented, as different operators rely on different channels, thus making comparison quite difficult for users. Regarding more expert and tech-savvy users, the platforms they may be interested in, like Open Data or E015, don't provide any kind of default visualisation, thus denying novice users any form of onboarding.
By focussing on the users' informative needs, it was easier to understand which needs remained unmet.
At this stage, **based on the pain points emerged during the needs setting phase, I set up the basis for the Objectives and Key Results (OKR) definition.**
OKR make up a methodological framework attributed to Andy Grove (38), who introduced it after becoming Intel's CEO. He perfectly explained its purpose by claiming: *"The key result has to be measurable. But at the end you can look, and without any*

	Decision-makers	Citizens
Digital touchpoints	• Open Data; • E015; • Polis; • Simulation ADS; • Emergency dashboard; • Qlik	• Services providers applications (ATM app, Trenord app...); • Municipality's website • Open Data; • E015
Physical touchpoints	• Periodic reports • Paper newsletters	• Public transport stop screens; • Informative posters • Informative leaflets
Human actors	• Colleagues; • Partner institutions' employees; • City Council; • Private actors; • Citizens	• Municipality's offices operators; • Other citizens

FIG. 53 - Informative touchpoints

arguments: Did I do that or did I not do it? Yes? No? Simple. No judgments in it."

The methodology starts from an objective, namely a high-level goal, and 3-5 key results, specific values that can be measured on a 0-100% scale. The percentage represents the degree with which the objective has been met.

Particularly complex projects can be assessed with more than one objective, and more numerous key results.

I followed the standard process and inferred the key results from the pain points highlighted in the user analysis.

The main objective is providing the Municipality operators with the prototype of a dashboard. The effectiveness of the solution will be evaluated based on the following key results:

time needed to share a visualisation with colleagues and collaborators;

time needed to compare two different spatial datasets onto the same map;

time needed to compare the performance of two different zones in Milan.

This is due to the fact that the time-consuming nature of many governmental activities was a recurring theme in many of the interviews and, as stated above, information retrieval is still one of the longest activities involving workers on a daily basis. **Information must not only be reliable but, in order to be as effective as possible, and must be delivered in a timely manner.**

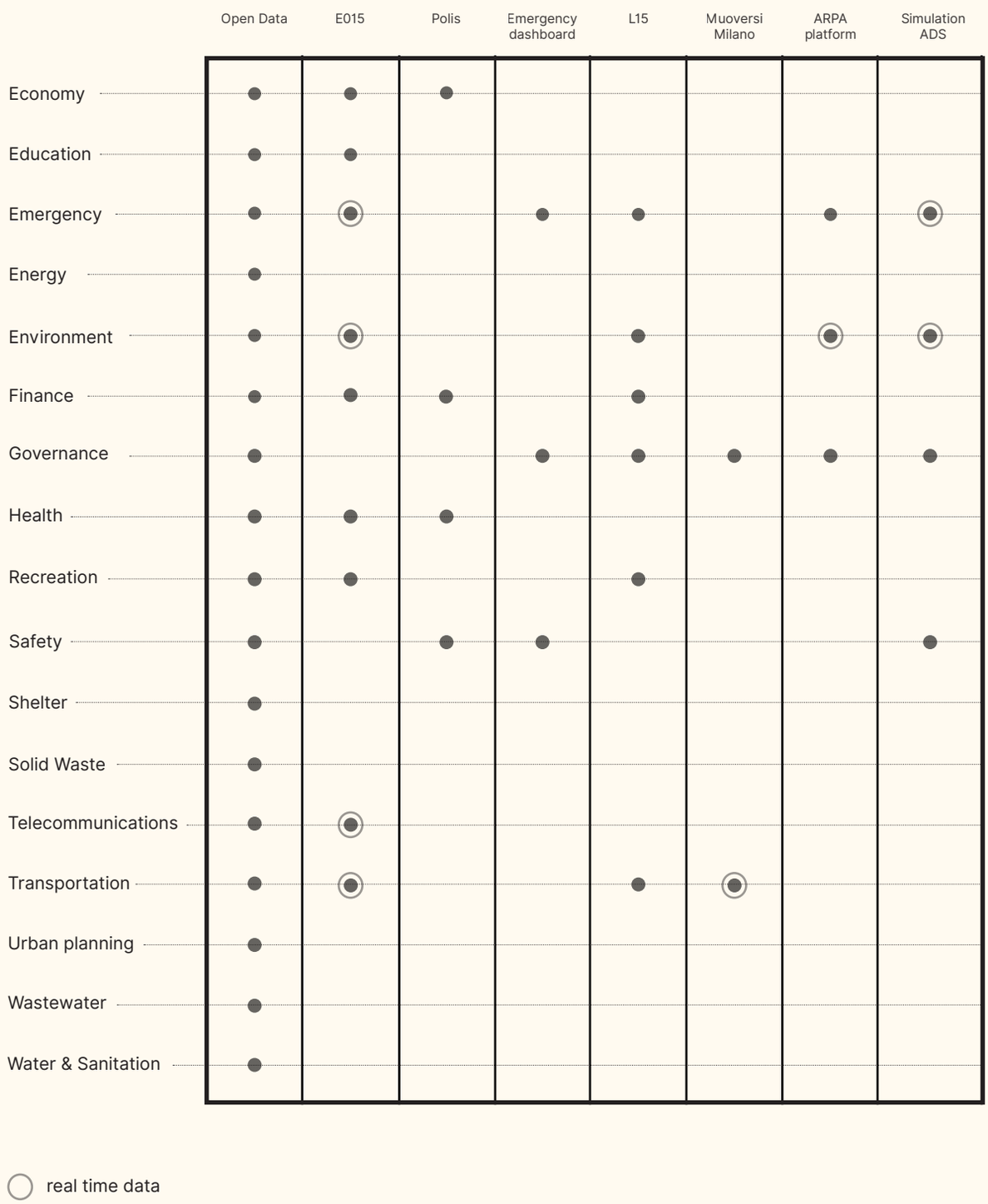


FIG. 54 - Informative touchpoints topics

7 SOLUTION DEVELOPMENT

MATCHING NEEDS WITH REQUIREMENTS

Given the heterogeneity of the target' needs, and before going any further in the project development, **I felt the need to sum up the main features of the future solutions, to ensure they all matched existing needs**.
I took into account three aspects: the **data visualisation**, the **interface structure**, and the **infrastructure characteristics**.
First of all, the data visualisation should allow two different fruition ways, **exploratory** and **explanatory**: in this way, each user could adapt the visualisation to his/her current necessities, avoiding to get too much or too little information. Moreover, I do believe that **each dataset will provide more relevant information when compared with other datasets in a meaningful way**. For example, signalling previous results and future objectives of a Municipality effort will give a general understanding of the path leading to that result. The importance of this aspect was also confirmed during the user analysis. Lastly, real-time visualisation should be visually highlighted, as it has been identified as one of the main sources of value by both sections of target.
Secondly, **the interface structure must be as customisable as possible**, in order to answer to the ever-changing necessities of the Municipality. Moreover, **each page structure should be easy to update, and should not be disrupted when new content is uploaded**. Therefore, a modular layout is to be preferred. Moreover, all the users involved in the project have a double need, namely **the access to datasets and the possibility to visualise high-level indicators**. For this reason, the platform should involve different layers for different users. In order to deliver a higher level of trustworthiness, **users should be able to reach the origin datasets starting from the single visualisations**, which is a feature the majority of dashboards are lacking. Lastly, the possibility for decision-makers to add new datasets should be placed within reach and visually highlighted.
Lastly, I tried to draft some guidelines for the infrastructure development, although I did not involve this aspect within the thesis work: as claimed in the previous section, **citizens and decision-makers will be able to access different information**, since some datasets must be kept private and displayed only to authorised users, like Municipality and AMAT's employees.
For this reason, the website may be divided into **a public part** and **a private area**. People working for the Municipality can require access to the admin of the website, that will generate the credentials that will authorize the new user.
As a closing note, I tried to **set up the platform as a common ground**, trying to bridge the gap between the four different user groups. As it can be seen in Figure 55, **the platform is not to replace the tools that are already employed**, but it will **serve as an alternative, as a quicker way to communicate in an efficient way.** Therefore, **in order to be understood by each and every user, it will rely on a simpler visual language**, while more thorough analyses could be performed on technical tools.

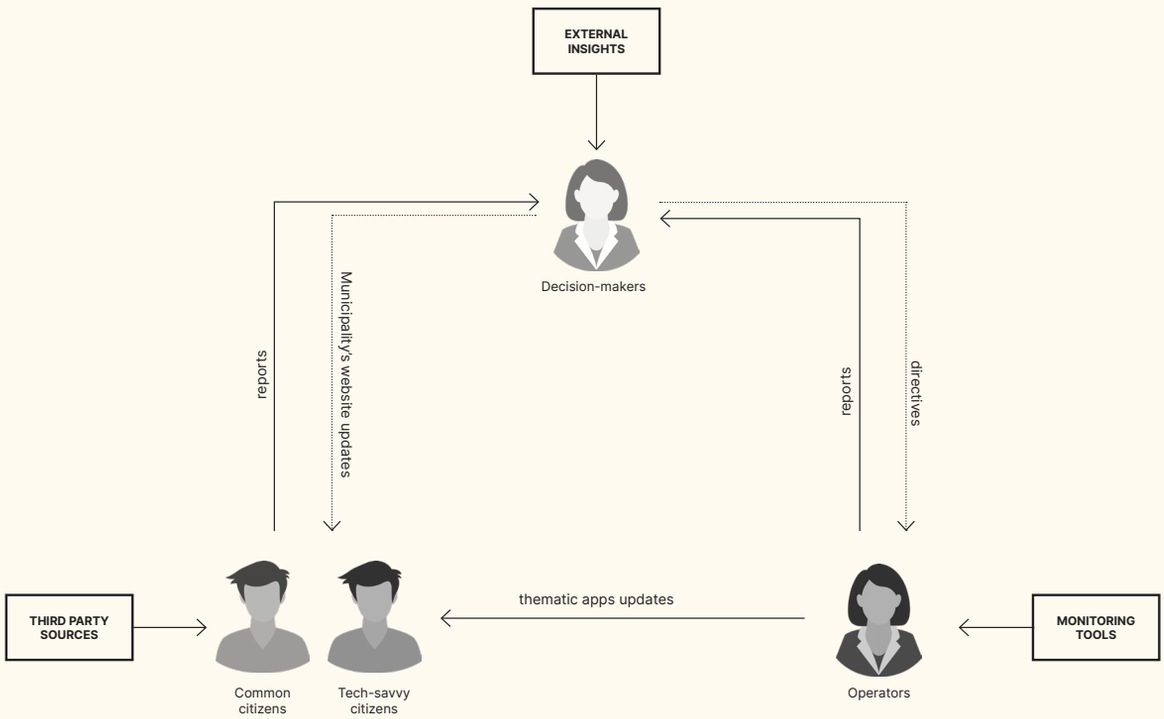


FIG.49 - Informative system (as is)

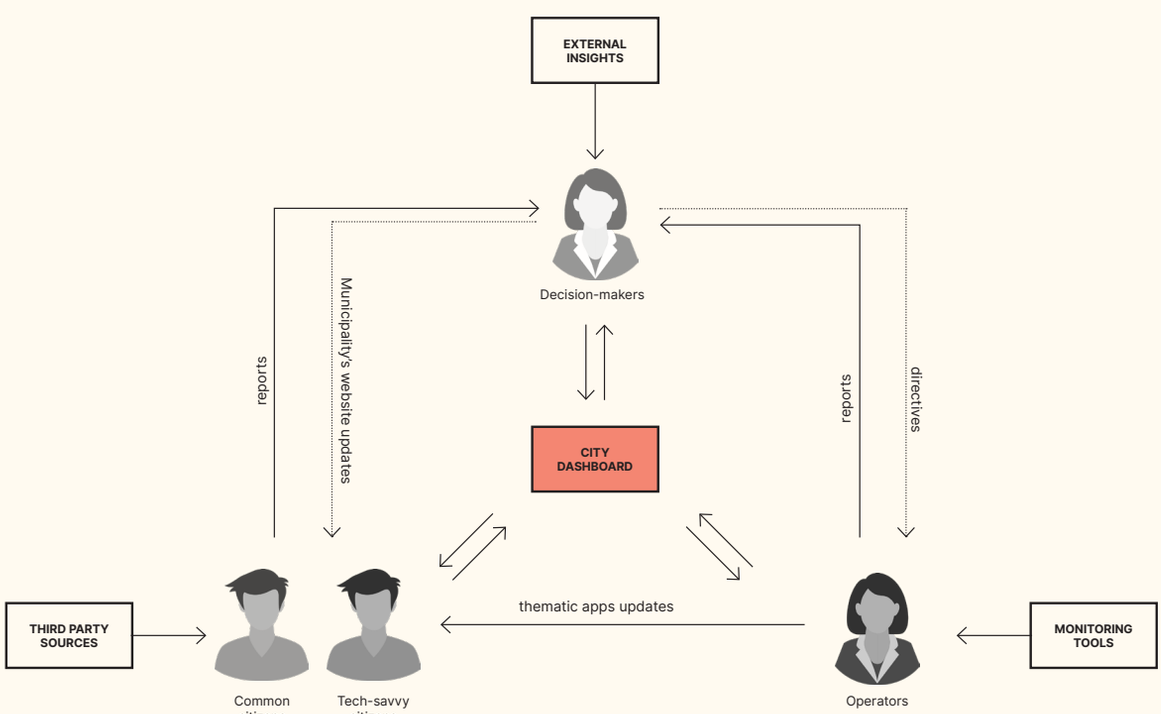


FIG. 55 - Informative system (to be)

INFORMATION ARCHITECTURE

The flow of value originating from the user analysis must be kept throughout the following phases of the design process: in order to effectively answer to the users' needs, the platform's information architecture must be developed accordingly.

I had the chance to deepen the subject during my internship at Fifth Beat: during their 6 years of experience as a design studio, they worked out a well-structured process to define information architecture, thoroughly following consequential steps in order to reach an effective result.

The basic unit of the IA structure is the so-called content type. For example, the content types featured in a news website may be "Article", "Gallery", "Podcast", "User", "Comment", and so forth.

Nevertheless, **the true potential of a content type can be traced back to its metadata, namely the attributes defining it**. Going back to the news website, we may say that the "Article" metadata are "Author", "Date", "Reading Time", and so forth.

Splitting each content type into its metadata makes them more flexible and reusable, in addition to creating potential relationships between different elements: **such relationships can then grow to become part of the website, and be used to group or navigate content**. For example, it can be used to show all the articles written by the same author. Although it may seem more natural to say it is the final product that must answer to the users' needs, **it is of primary importance that the platform's content types and their related metadata are structured according to those needs**, in order to deliver a meaningful experience in every detail of the interaction. For this reason, information architecture must find its roots into three different elements (84):

People: as claimed before, information architecture must stem from the user analysis' result. If the user studies phase is not structured in the proper way, this will directly influence the information architecture's quality. What people need to do with the platform must be taken into account. This means analysing the words they use and their jargon, understanding how they might search content and clearing the steps they follow while navigating the website.

Content: as the name may suggest, the ultimate goal of information architecture is to structure the platform content so that it can be reached in the most fruitful and time-effective way possible. Consequently, designers must have a clear and complete idea of the content that will populate the website. One of the best methodical ways to organise content is site mapping, that was developed in the following section.

Context: this is to bear in mind that the constraints given by the users' framework will shape the information architecture too. Considering the city dashboard, I developed the following content types, detailed in the following pages.

After defining the IA, I moved on to site mapping. **One of the main issues hindering the navigation of other dashboards is the absence of a proper clustering structure.** Given the amount of information provided by the website, turning data into effective indicators or visualisations is not enough. **Although information architecture partially tackles this problem, by**

providing a structure to content, a further step must be taken, and all these pieces of information must be gathered around topics or themes, that are familiar for users.
I started with the categories featured in Open Data Milano, that proposes a wide range of topics, and noticed that some of them contained very few datasets, and so they could have been merged with other ones, without standing as independent categories. Moreover, the Science and Technology category appears to be empty. In order to come up with a new clustering, **I merged the Open Data categories with ISO37120, namely the indicators for city services and quality of life, with a particular focus on smart cities' needs.**
Figure X shows the categories that emerged during this process: **this content subdivision was approved by the Municipality operators in June 2019 and was at the core of the next steps of the project.**
For what concerns the content definition for each category, I checked all the datasets on Open Data platform, and combined them with some E015 APIs. In this way, I started identifying some that could have been integrated into the platform, with particular attention to the ones that resulted more interesting to the decision-makers (namely the ones related to mobility and environment).
For the sake of this thesis, I decided to focus on a narrow set of data, that could be further expanded. **The general idea is that users should feed content into the platform based on their current necessities.**

After defining the eight categories pages, I started from the choreography framework to define the other ones and their related content. Figure 57 shows the resulting sitemap for the first prototype.

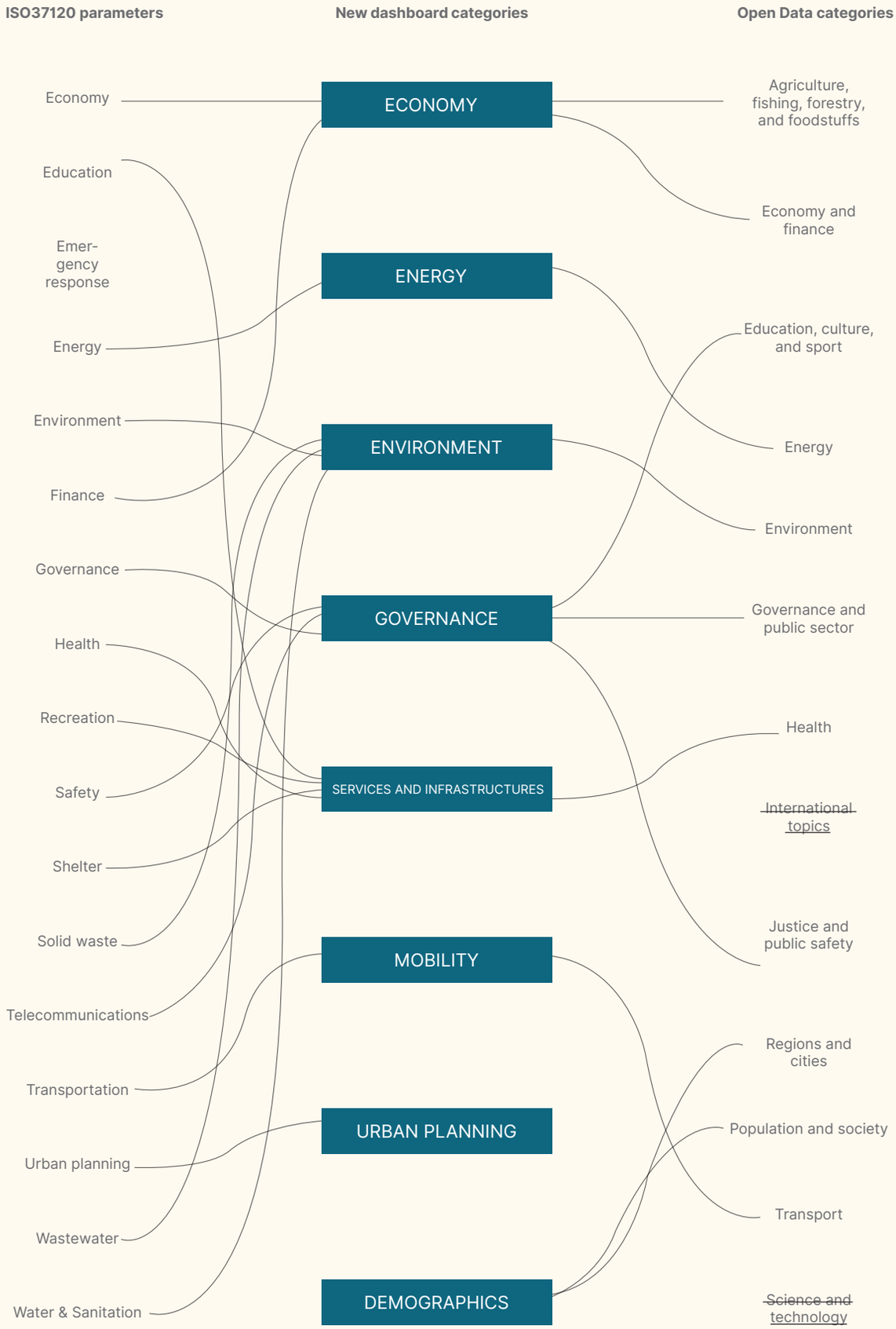


FIG. 56 - Clustering structure

TAXONOMY

Content Type	Description	Metadata
VISUAL MODEL	The graphical representation of the datasets featured in the platform	• Title • Last update • Related topic • Related dataset • Related user
COLLECTION	A user-generated group of visual models, that can be shared with colleagues	• Title • Creation date • Related topic • Section
USER	The platforms target, that can have different level of allowance	• Name • Surname • Role • Permission status
COMPARISON	A user-generated comparison between a maximum of three visual models	• Name • Related visual models • Related user
TOPIC	One of the eight themes around which the datasets are gathered	• Name • Related visual models • Related sections • State of performance
ZONE	One of the nine municipalities in which Milan is divided from the administrative standpoint	• Name • Related visual models • Related topics • State of performance
TAG	User generated denominations for datasets	• Name • Related visual models

ONTHOLOGY

Content Type	Relationship	Content Type
○ VISUAL MODEL	∞ to ∞	○ COLLECTION
	1 to ∞	○ USER
	∞ to ∞	○ COMPARISON
	1 to ∞	○ TOPIC
	1 to ∞	○ ZONE
	∞ to ∞	○ TAG
○ COLLECTION	∞ to ∞	○ USER
	∞ to ∞	○ COMPARISON
	∞ to ∞	○ TAG
	∞ to ∞	○ VISUAL MODEL
○ USER	∞ to ∞	○ COLLECTION
	1 to ∞	○ COMPARISON
	∞ to ∞	○ TAG
	1 to ∞	○ VISUAL MODEL
○ COMPARISON	∞ to ∞	○ COLLECTION
	1 to ∞	○ COMPARISON
	∞ to ∞	○ TAG
	∞ to ∞	○ VISUAL MODEL

ONTHOLOGY

Content Type	Relationship	Content Type
○ TOPIC	∞ to ∞	○ VISUAL MODEL
	∞ to ∞	○ ZONE
○ ZONE	∞ to ∞	○ VISUAL MODEL
	∞ to ∞	○ TOPIC
○ TAG	∞ to ∞	○ VISUAL MODEL
	1 to ∞	○ COMPARISON
	∞ to ∞	○ USER

CHOREOGRAPHY

Page	Content type
HOMEPAGE	TOPIC ZONE
TOPIC PAGE	VISUAL MODEL TAG
COLLECTIONS PAGE	VISUAL MODEL COMPARISON
ZONE PAGE	TOPIC
USER PROFILE	COLLECTION TAG

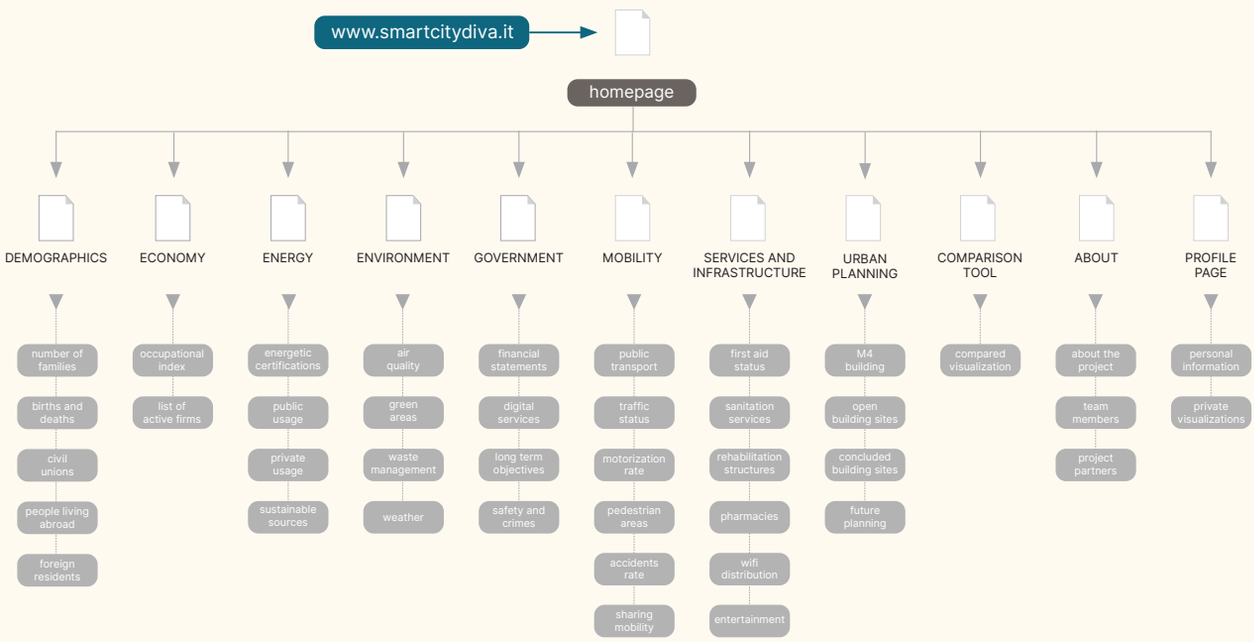


FIG. 57 - Content mapping

WIREFRAMING AND VISUAL MODELS

After defining the content and the main pages featured in the platform, I started structuring the various steps of the experience. I **adopted an activity-based approach, starting from the main functions the website should feature, namely** downloading the dataset, comparing different visual models, accessing private visualisations (for decision-makers only).
Afterwards, I moved to the wireframe development: in this phase, I took into account only the most basic functions, waiting for more insights from the stakeholders after seeing the prototype. Therefore, together with the eight thematic pages, **I added a comparison page** (where two datasets can be visualised and compared), **an *About* section**, and **a profile page** to check the private visualisations, accessible only to decision-makers.
Moving from the sitemap to the wireframe was a difficult endeavour: after a while, **I realised I couldn't proceed in the interaction definition without clarifying the way information was displayed.**
In fact, while designing a website or app, the actual content can be added at a later stage, after the interaction has been drafted on a low-fidelity prototype. Nevertheless, unlikely other digital platforms, dashboard design process can't proceed following the same path: as a matter of fact, **the user experience and the visual models that are featured in each stage of the interaction are seamlessly tied together, and neither of them can be developed before the other.**
For this reason, I changed approach and tried to follow an iterative process, in which drafts of the wireframes were followed by drafts of the visual models, and these steps were repeated until the whole interaction and data visualisation were clear enough to be further refined.
The first step was a very rough draft of the wireframe, that was trying to envision the structure of the homepage and thematic page.
Afterwards, I moved on to the visual models definition: from this standpoint, the literature review and **my internship experience at Accurat**, a data visualisation company, **helped me comprehend the significance of this task.** I tried to **reduce the range of visualisations, in order to keep cognitive and technological load at bay**: as claimed in Chapter 2, employing different visual models just for the sake of variation is detrimental to the user's understanding, and it could seriously slow down the flow of information.
I tried to perform a further clustering of the datasets, in order to understand if some of them could be visualised in the same way.
I then chose among the visual models proposed by Stephen Few in his *Information Dashboard Design* (33): in the book, Few follows two principles while selecting the graphs for information display: first of all, it must be the best means to display a type of quantitative information; secondly, it must be able to convey its meaning even when sized to fit into a small space;
After analysing the datasets I needed to represent, **I decided to include three different visual models**, displayed in Figure 59.
Once the visual models were partially defined, a further refinement of the

wireframe was needed: I recalled the interface requirements, defined in the previous phase, and one of the most important ones resulted to be the **modularity of the page**. Therefore, I tried to understand how the different visual models could fit within the same page, and how their structure could avoid the need to rearrange the page every time new content was added. For this reason, I opted for a modular structure made by different elements with only two fixed-width measures.
Afterwards, I added more details to the visual models, tying together the visualisation and its dataset within the same page element. For this reason, I designed each visual model as a sort of "folder", in which the visualisation and the related datasets are "sheets" that can be consulted by the user.
The resulting solution is displayed in Figure 60.

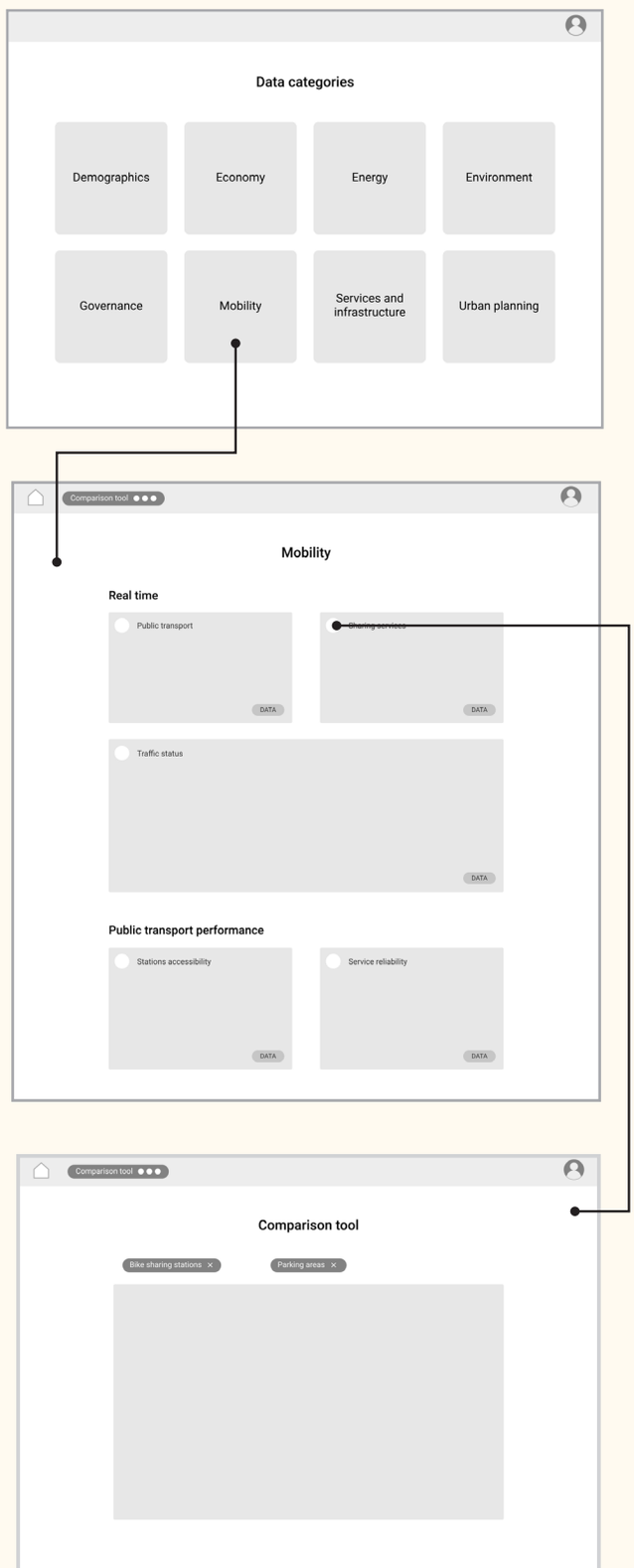
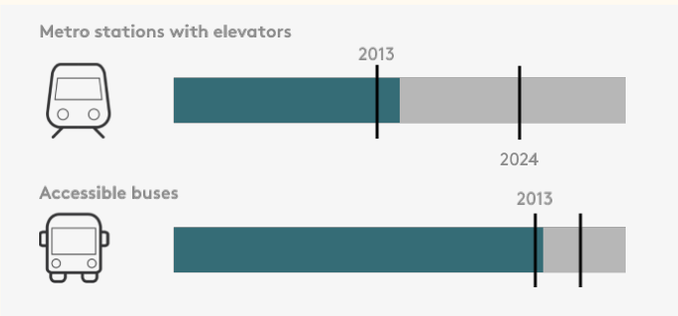
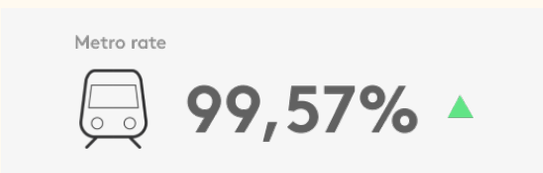


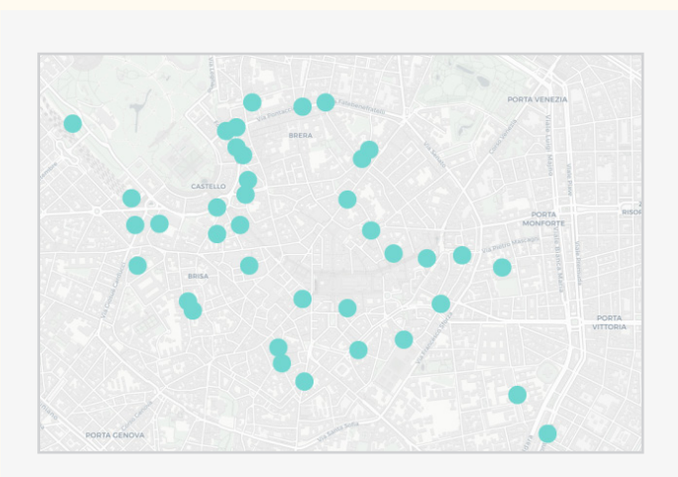
FIG. 58 - Wireframe



Bar graph



Numerical indicator and performance trend



Spatial data

FIG. 59 - Visual models

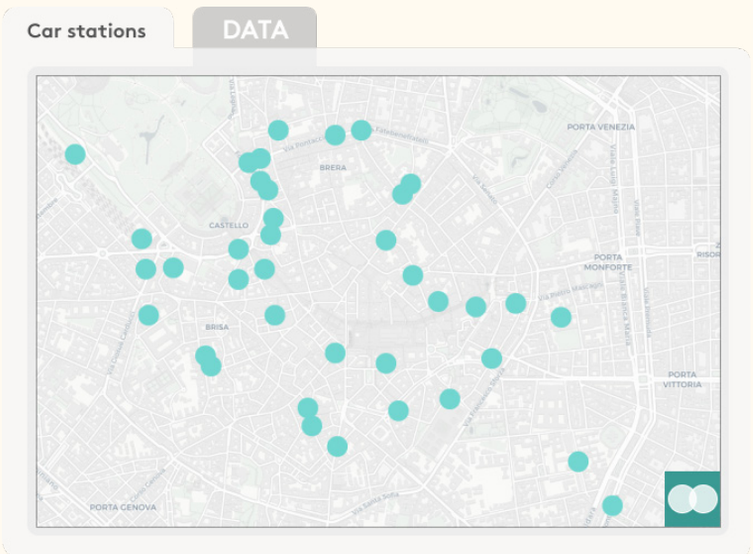


FIG. 60 - Visualisation module

FIRST PROTOTYPE

At this point, I could tie together all the different details and start working on a more detailed version of all the pages, that would become the basis for the development of the first prototype.
After the wireframe and visualisation definition, **I needed to set up a way to get as many feedbacks as possible by final users. For this reason, I reckoned a prototype as the safest and most effective option** from this standpoint.
Prototypes can trigger substantial improvement in the interface development process, as their usefulness is twofold: first of all, **it helped me**, the designer, **understand some aspects of my concept that weren't clear enough** when it was still on paper or, although digitalised, was still not interactive. In this way, I managed to identify some aspects that were still unclear or bottlenecks that were hindering the smoothness of navigation.
Secondly, the prototype helped me engage users in a more efficient and timely manner as, for people that are not accustomed to give design feedbacks, reviewing sketches or wireframes can be quite difficult and confusing.
Since I needed feedbacks in the shortest time possible, I started working on a first interactive prototype as early as July 2019.
I began by honing the user interface, in order to reach a higher level of fidelity and accuracy, and give users the feel of what would have been the final platform. In this way, I wanted to make them feel at ease, like they were using a full-fledged website, rather than a simple prototype.
From the structural point of view, I eventually integrated the "About us" information on the homepage, but users can reach them only by scrolling down, so that **more visual importance is given to the eight datasets categories**, featured in the upper part of the homepage.
Once users click on one of the categories, **the page will display all the visual models, starting from the ones featuring real-time data.**
The navigation sidebar allows users to come back to the homepage and, while users are in a topic page, it also helps them reach the subcategories of each topic in a faster way. I decided to insert this additional navigation system since topic pages, in the long term, may host a considerable number of visual models, and browsing them just by scrolling may be time-consuming and frustrating.
Since the first prototype was developed during the Alta Scuola Politecnica time span, it was successfully implemented and for this reason **it will be functioning and accessible until the end of December 2019 at www.smartcitydiva.com.**

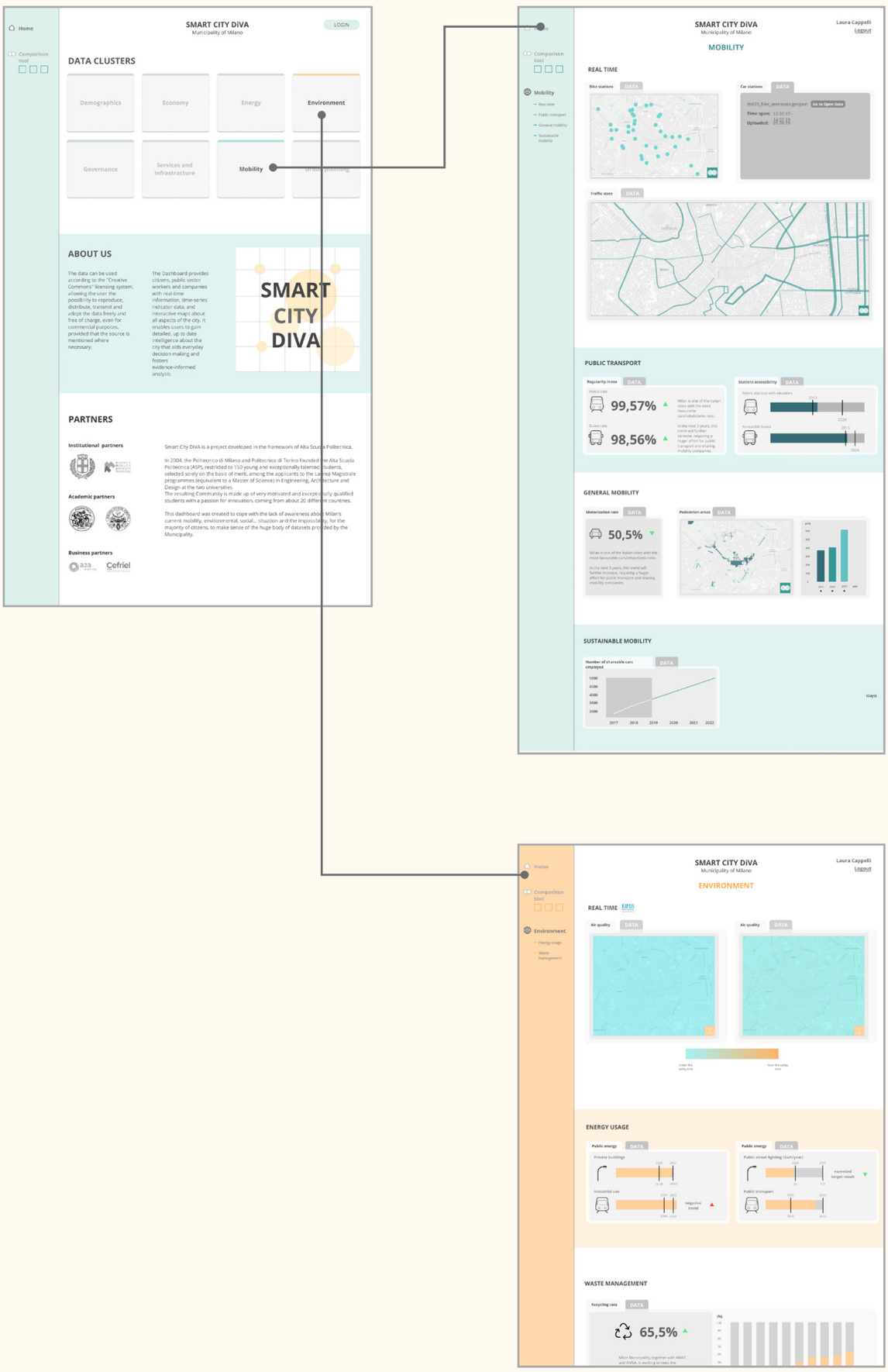


FIG. 61 - Homepage and thematic pages (Environment, Mobility)

8 TESTING AND VALIDATION

FIRST ROUND OF TESTING

The prototype was then shown to representatives of the Municipality, AMAT and Cefriel on the 1st of July 2019, during a meeting that took place in Politecnico di Milano, Department of Energy. It was then shown to the Digital Transformation Councillor, Roberta Cocco, on the 8th of July 2019. Reactions were generally positive on both occasions, but **a few critical aspects emerged** anyway.

First of all, during the Politecnico meeting, **the homepage was considered to be lacking information**: this remark came from Cefriel, who claimed users might want to see a general performance indicator for each of the eight categories, before clicking on one category in particular for further details and granularity.

Furthermore, **the "About the project" section was required to be moved to a separate page**, in order not to clutter the homepage with secondary information.

Lastly, **the buttons linked to the Mobility and Environment categories needed to be highlighted in some way**, as these were the only two working pages in the prototype, while the other buttons are greyed out in a way that makes them look unaccessible.

On the other hand, the thematic pages generally had more positive feedbacks, as the page structure resulted to be clear and effective.

Nevertheless, one important adjustment that was requested was to **allow the use of the comparison tool not only on spatial data, but also on temporal data**.

Lastly, a higher attention to the spatial aspects of the city, like the situation of the different neighbourhoods, was required by some of the stakeholders.

A summary of the feedbacks emerged during this session is shown in Figure 62 and 63.

Regarding the meeting with Roberta Cocco, some different aspects emerged: she and her team were more interested in long term performance, so they would have wanted to **highlight the results or failures over time, in order to gain a better perspective about what the Major and the Council had been doing during their mandate.**

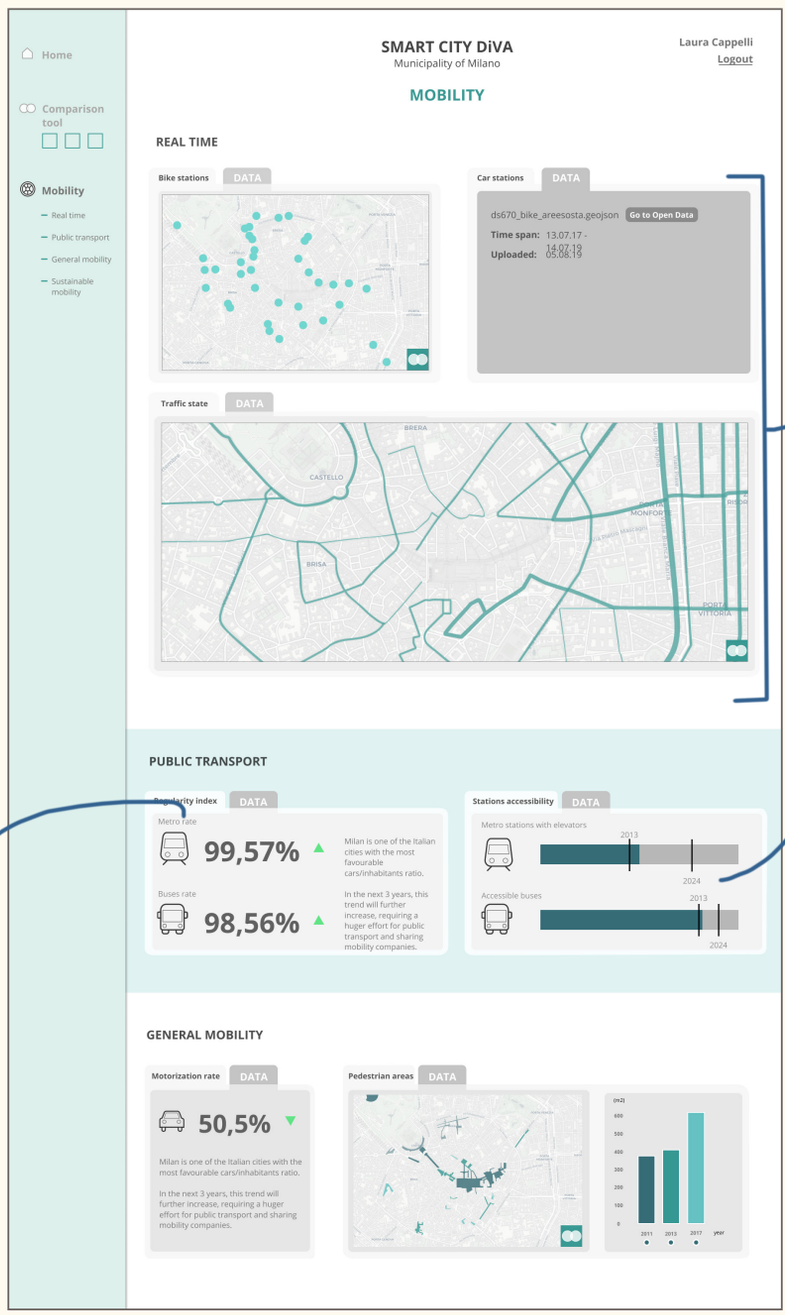
Moreover, they evaluated the possible development of a further platform, that would have been dedicated only to citizens, with filtered information at hand and through which they could have sent feedbacks or reports about the city issues.

"Before clicking on any category, I already need to have some sort of indicator about the performance of such category"

"I would concentrate just on environment and mobility in this phase. So it must be made clear that they are the only functioning

"I would dedicate a separate page to the acknowledgements, partners, and description of the project"

FIG. 62 - Homepage with stakeholders corrections



"When possible, I want to compare current performance with past results"

"It's of paramount importance that the page structure is not disrupted with every new addiction"

"What if I want to use the comparison tool also on the bar graphs?"

FIG. 63 - Mobility page with stakeholders corrections

FINAL SOLUTION REDEFINITION

The preliminary research set the foundation to understand the process behind decision-making in local government, while literature focussed on the importance of shared knowledge and communication in this kind of environment, as the lack of effective communication was also among the pain points emerged during the user analysis. For this reason, the plaftorm should not put information delivery at its core, but information sharing: it should not be simply intended as an informative dashboard, but **more like a toolbox, supporting the communication and cooperation between different categories of users.** The reason for this is that there must be an online space for cooperation as there is in real life. Granting the communication between different departments requires the use of a common language, **renouncing to a further level of detail for the sake of clarity** and using simple visualisations and aggregated indicators everyone can understand. Moreover, **operators will keep relying on their specific softwares and tools for more advanced analyses**, while they may **employ the dashboard to share the insights they get from deeper simulations and studies.** Consequently, the thesis will propose some of the datasets that may be included in the website. Nevertheless, **the aim of the project is to provide a "framework", a structure in which content is added and managed by users themselves on a regular basis,** based on the current necessities. The majority of dashboards are static, while value is fully unlocked whenever platforms start learning from users. Considering the specialised nature of the project, I didn't go as far as to impose the body of content in full detail: **the most appropriate choice would be trusting the expertise of operators, and try not to replace their skills by putting default content that could grow useless in time.**

Another interesting theme is the international breadth the topic might get. In fact, the main aim of the ISO37120 is supporting comparison between city governments all over the world. **This is in line with a broader trend trying to standardise the portals for Public Administration, trying to develop frameworks not depending on the single cities, like the Identità Comuni project** (23). Furthermore, Milan is part of numerous supranational networks (like the Sharing Cities project) that manage to join effort to reach a higher degree of innovation. **Monitoring and comparing the performance of all the cities in the network could be easy through this platform, given that a certain degree of interoperability is reached.** The platform is an experiment allowing cities to come closer, as by now they don't have a digital common ground. Here are the pages making up the final version of the prototype, through which I tested the initial hypothesis and verified the OKRs. Regarding the **homepage** (Figure 64), a deeper attention to data-ink ratio was required, and this resulted in giving less space to the eight categories buttons in the homepage and filling it with more meaningful content. The homepage must serve as an onboarding support for users, who need to gather as much knowledge as possible about Milan's performance as soon as they land on the website. Moreover, **a more preminent role was given to the**

geographical areas of the city, in line with the latest feedbacks. Considering that zones are the building blocks of the city, and they deeply influence AMAT's work, the map on the homepage will allow operators to quickly locate the issue and then, by simply checking on the zones page, the nature of such issue (Figure 65). The colour palette was minimised as much as possible, so that the information can be delivered in the fastest and most efficient way possible: **the largest part of the interface is in greyscale, while the only two colours, red and blue, are used to convey the state of performance of the various models**. The evaluation scale is the following: **dark red** means that critical issues are severely affecting the performance of one of the indicators; **light red** signals when the performance is below average; **grey** means the various indicators have average values; **light blue** is used when the indicators' values are slightly above average; **dark blue** means the indicators showed outstanding results
Thematic pages (Figure 66 and 67) is where the customisation possibilities start to unfold for users: **every aspect of the pages**, from the layout of the page itself to the content of the visual models, **can be changed and updated anytime by authorised users like decision-makers.** Citizens and other unauthorised users won't have this possibility of changing the website content.
In order to avoid the lack of wayfinding of other dashboards, each thematic page is divided in further categories, to support information retrieval. Each visual model features different functions: in order not to overwhelm the user, some of such functions will be displayed only when the user is hovering on one of the visual models. Moreover, each of the visual models is coupled with its relative dataset: the button *Dataset link* will redirect users to the external websites (Open Data, E015...) from which they can download the raw dataset. **Zone pages** (Figure 71) provide a further level of detail in the various city areas: in fact, the homepage features just a high level of granularity regarding the city's performance, but this information can then be deepened by clicking on the single zone. Each zone page recalls the structure seen in the thematic pages, but **the menu in the upper part support an easier comparison between the different areas.** Moreover, as it will be further discussed in the *Conclusions* section, each of these pages is also a first way to access citizens-generated content, as users will be able to send reports on their neighbourhood, and such reports may populate a specific section of these pages. **Collections page** (Figure 68) is where cooperation finds its place: users can gather datasets based on their own clustering of interest, so as to answer to their current necessities. **Other users can be added to the single collections, to make sure every person involved in a project shares the same level of knowledge of any other colleague**. Moreover, datasets' value is fully unlocked as **users are allowed to compare different spatial datasets onto the same map**, thus facilitating all monitoring activities aimed at identifying patterns between services and phenomena. One of the main aims of the dashboard is creating a common ground

not only for citizens and decision-makers, but also between tech-savvy and non-tech-savvy Municipality's operators. The platform must empower also non-expert users in content management, providing them some guidance while adding, deleting, and updating new content. The **New visual model page** (Figure 72) tries to bridge this gap: **the interface tries to simplify the process of uploading new visual models on the platform**, by simply requiring the user to perform a few actions: select a dataset by attaching a file or pasting it, rename it, tagging it when appropriate. Afterwards, users have to choose a visual model and give some information about it, like linking the model dimension with the dataset's ones. Moreover, users can also indicate the limits over which and under which the performance may be judged as satisfactory or poor. Lastly, users select the most appropriate thematic page of the datasets and decide whether it should be kept private or open also to unauthorised users. Lastly, the **User profile page** (Figure 70) provides a general glimpse about the users' professional background, tags of interests and actions performed on the platform, as well as details about the permissions he/she has received to navigate the dashboard.

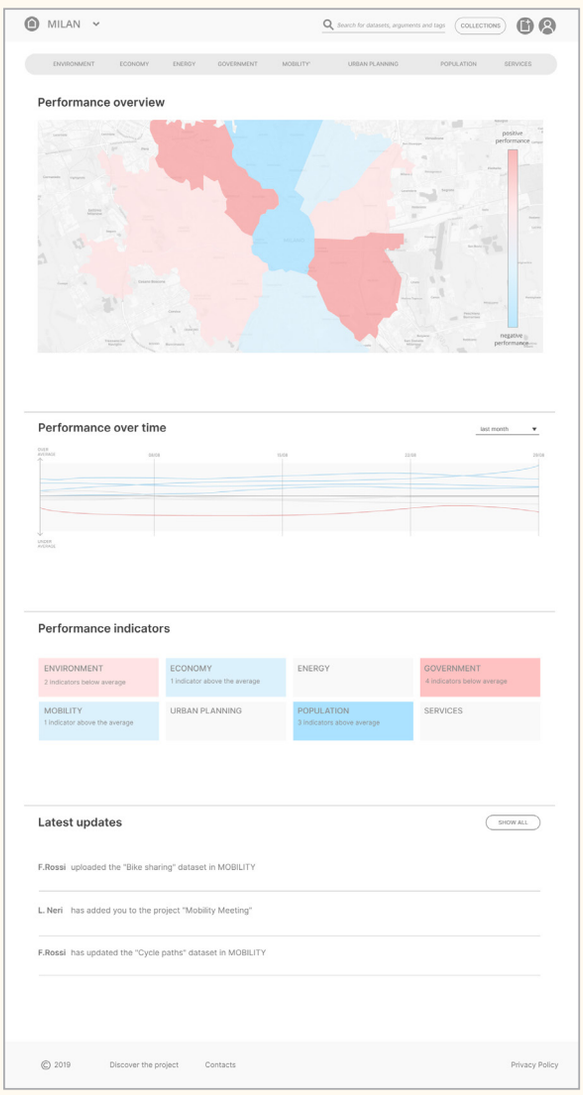


FIG. 64 - Homepage

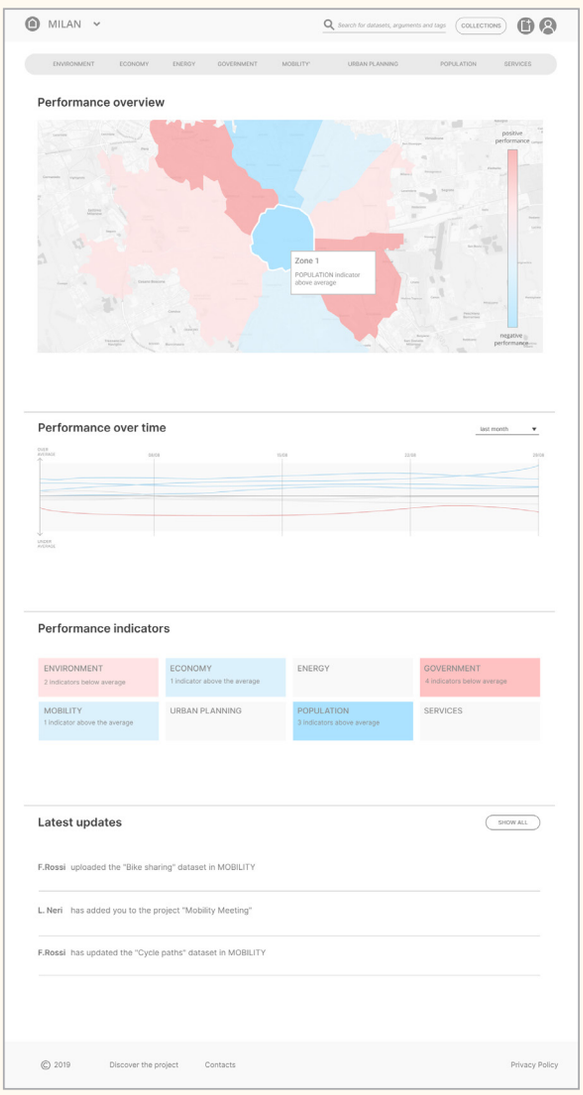


FIG. 65 - Homepage (zone hovering)

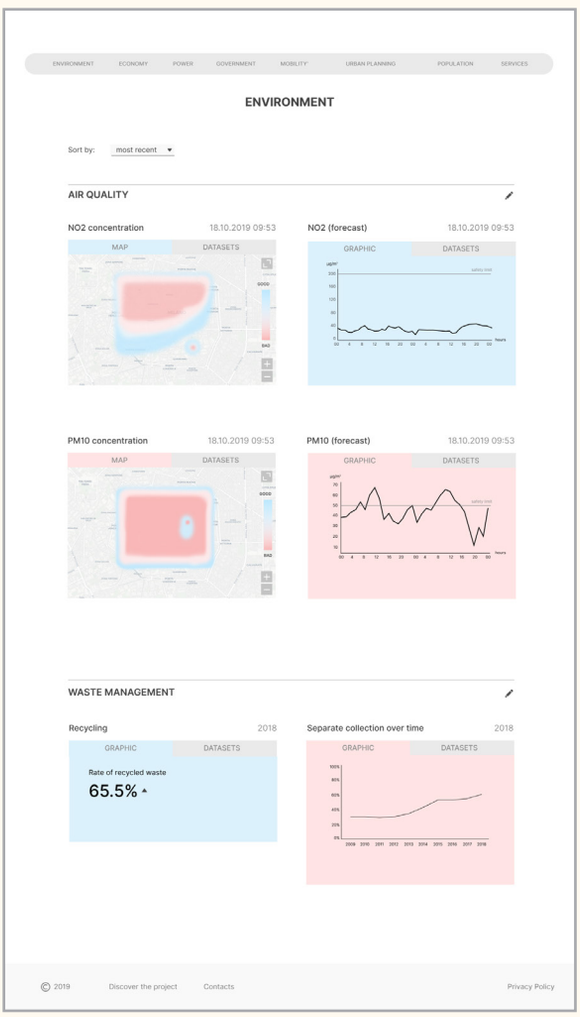


FIG. 66 - Environment page

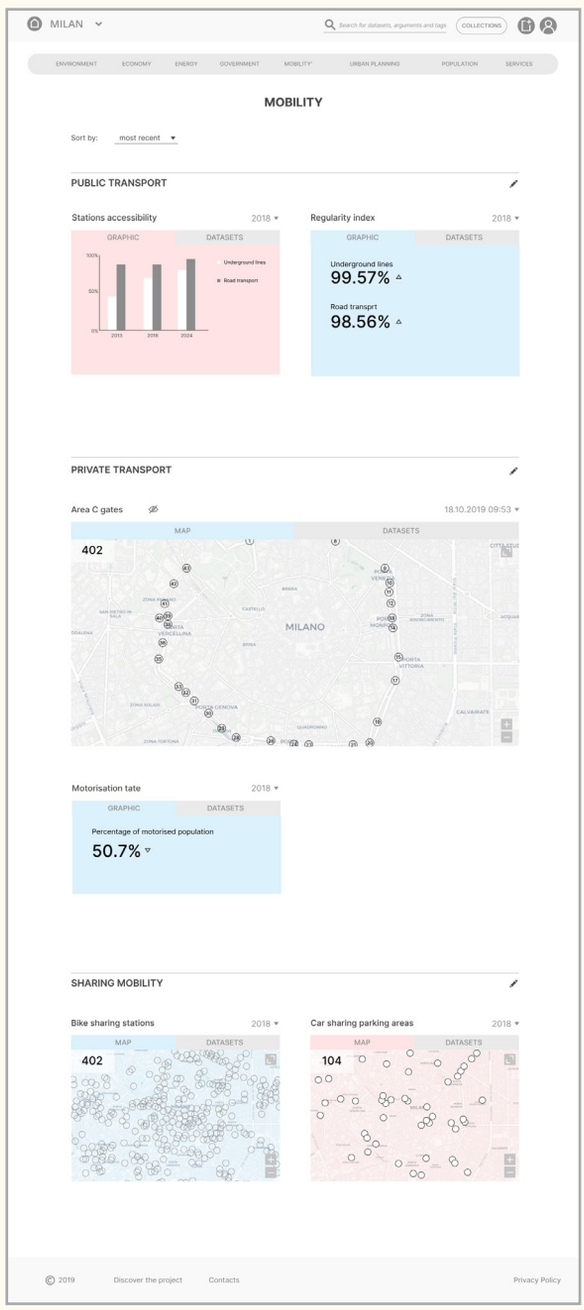


FIG. 67 - Mobility page

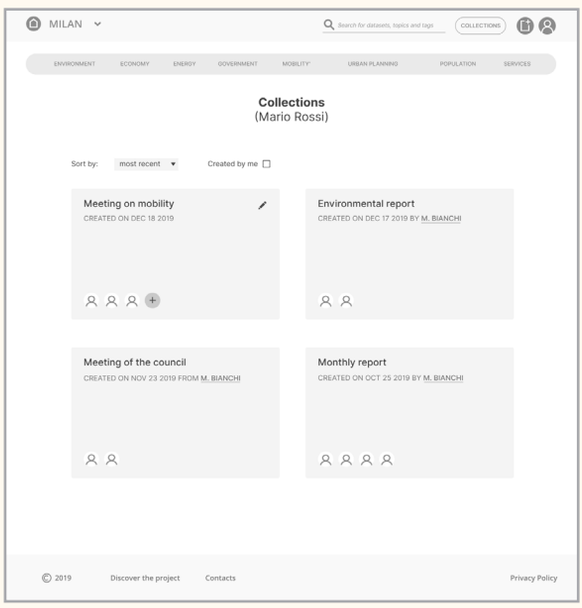


FIG. 68 - All Collections page

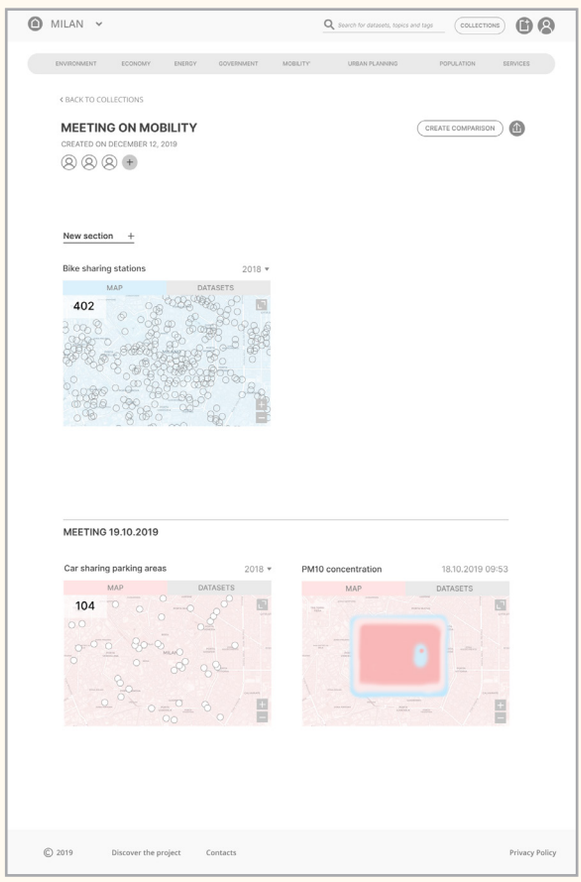


FIG. 69 - Single collection page

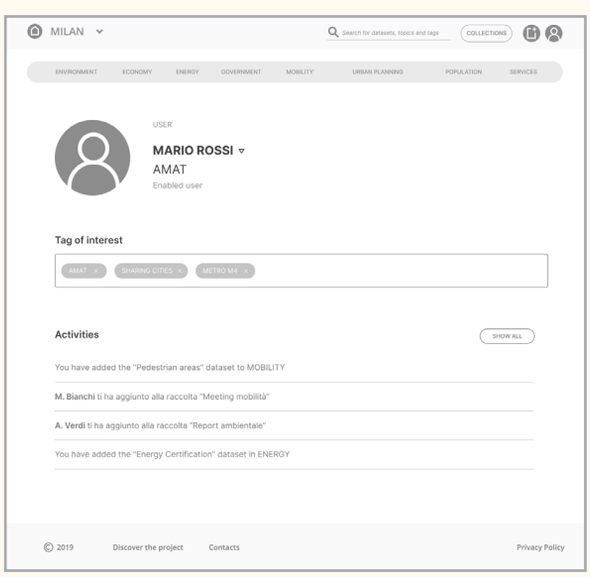


FIG. 70 - Single collection page

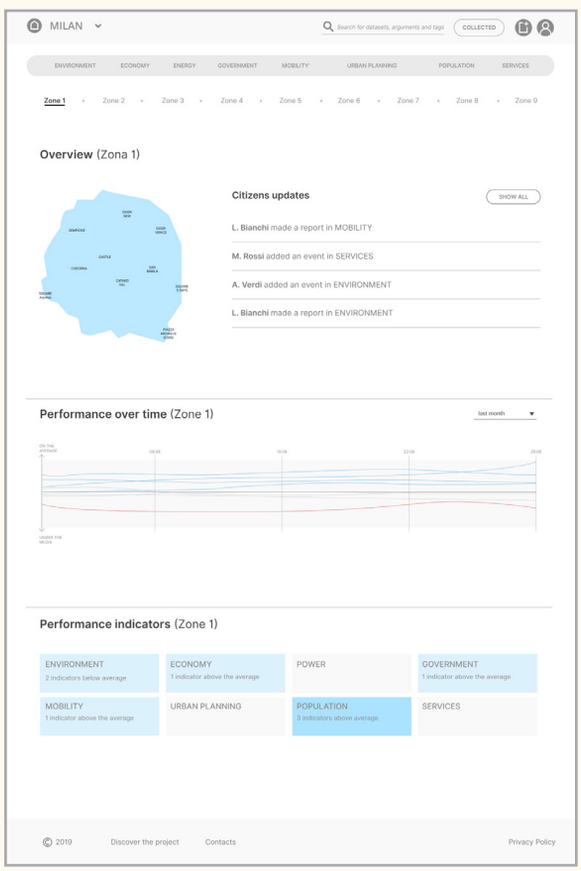


FIG. 71 - Zone overview page

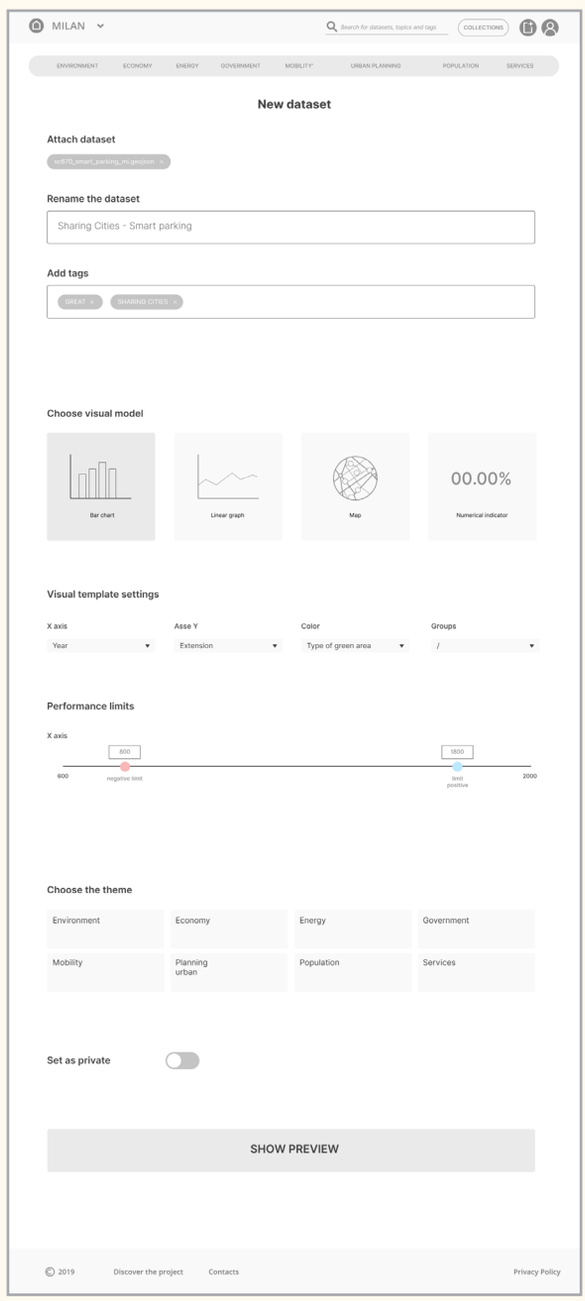


FIG. 72 - New visual model page

USER STORIES

In this section, I outlined the interaction in a more detailed way. I structured the steps of the users actions based on the need that brought them to the website in the first place.

Scenario #1 - AMAT consultant

The user has recently gathered some data about the vehicles entering the B Area in Milan. After checking the reliability of the datasets from an exernal software, he gets to the dashboard homepage and clicks on the New visual model button. Here he can insert the link to the new datasets. He then chooses the appropriate visual model and tag the content of the dataset.

Scenario #2 - Mobility Councillor advisor

The user needs to quickly gain knowledge about the mobility situation in the last year. He checks the general trend in the homepage, before clicking on the Mobility trendline and being redirected to the Mobility page. Here he can see which indicators have been registering the worst performance. He clicks on the Share button related to the worst performing visual model and sends it to one of his colleagues.

Scenario #3 - Sharing Cities cooperator

The user has just come back from a session of user analysis in the cities involved in the network. He needs to check the follow-up of the projects that were kick-started during the previous months. He gets to the homepage and searches for the “Sharing Cities” tag in the searchbar. In this way he gets all the visual models that were tagged in that way, so that he can quickly monitor the other cities involved in the project and easily compare them through the dropdown menu on the upper left.

Scenario #4 - Citizens’ association president

The user got to know about the next meeting with the Councillor. He wants to know more about the crime rate in her neighbourhood. She gets to the website’s homepage and she clicks on Zone 8. Here she scrolls the page and clicks on the “Government” topic. Here she can get an idea about the latest trend in safety in Zone 8 and quickly compare it with the other zones by toggling the top menu.

Scenario #5 - Data journalist

The user is interested into the way air quality changes in the different neighbourhoods. She can click on a particular zone from the Homepage and take a look at its general performance. She clicks on the air quality map and adds it to a new collection. She does the same with the other zones she’s interested to. She then looks at the collection while she drafts her article about the topic.

Scenario #6 - PhD student

The user wants to find the datasets related to the energy usage in Milan. He goes to the Homepage and clicks on the topic Energy. Here he finds the visual model for public and private energy usages. He clicks on the “Dataset” tab and he’s redirected to the Open Data website, where he can download the datasets. He can then feed the datasets into a new platform he developed, to perform a further analysis.

1.

As: a data journalist
I want: to learn more about the rise in the number of students in Milan
So that: I can gather all the information upon which I can structure my article

2.

As: an AMAT consultant
I want to: gather some indicators
So that: I can quickly generate a report with and share it during an international conference

3.

As: a Sharing Cities cooperator
I want to: rely on the dashboard functions
So that: I can have an at-a-glance view of the situation in the different cities

4.

As: a Mobility Councillor advisor
I want to: learn more about the latest improvements in the mobility planning
So that: I can use this know-how during the next meeting

5.

As: a PhD student
I want to: gather datasets about the quality of Milan's air
So that: I can set up a dashboard with some aggregated indicators

6.

As: a citizens' association president
I want to: know more about the crime rate in my zone
So that: I can share the problem during the next meeting

FINAL VALIDATION

The final platform was **a slightly more refined version of a wireframe**, as I wanted to convey a more complete idea about the experience delivered by the platform. As one of AMAT's employees claimed during one of the interviews, **people really need to understand the benefits of a new platform, in order to find it engaging and convenient enough to be learned from scratch**. At this point, I needed to use the prototype to verify the hypothesis, namely whether the dashboard introduction could make information retrieval faster for users. At this point, I adapted the hypothesis to the nature of the target: **for "technical" users**, namely operators and tech-savvy citizens, **I verified how much time they saved by using the dashboard and their general satisfaction. For the remaining categories,** namely decision-makers and non-tech-savvy citizens, **I carried out a qualitative analysis**, focussing on their satisfaction towards the platform. **I made this shift because these latter categories don't embark on time-consuming activities, like technical users do.**

I started my validation from operators, as **I managed to get in contact with some Cefriel employees**, with different roles within the company, but that are currently cooperating with urban or regional decision-makers, on various levels.

Sessions were held at Cefriel headquarters, and involved four different people coming from various operative departments.

I recorded their actions and comments by capturing the laptop screen and by using the vocal recorder on my smartphone.

The following list is a series of additional details about the people involved in the testing, who agreed on me attaching their names to the thesis work: Alberto Radice, Comune di Milano and Cefriel's cooperator. He deals with emergency management and mainly relies on Emergency Dashboard and Simulator-ADS. Luca Mastrangelo, artificial intelligence and machine learning specialist at Cefriel; Federico Piccinini, design practice manager at Cefriel; Emiliano Sergio Verga, Digital Ecosystem manager for E015 at Lombardy Region.

After a brief introduction, in which I tried to understand the tester's background, I introduced the platform's features. At this point, **users were asked to perform three actions on the prototype**, namely sharing a visual model with a colleague, comparing two different datasets onto the same map, and evaluate the performance of two different Milan's zones. Afterwards, **I asked users how they would have performed the same actions through the tools and platforms they currently employ, and how long these tasks would have taken**.

What emerged is that **the dashboard could significantly reduce the time needed to perform two of the tasks**: this happens because having all the visual models in the same place, and keeping them there in the long term, can avoid the need to recap knowledge every time there is the need to update decision-makers.

Moreover, **the comparison between different zones could be aided too**: this could be easily done also through their current tools, like Qlik, but **the added value**, according to one user, **is having the same set of indicators**.

On the other, **there were no significant changes in the way users can compare**

different datasets on the same map: this feature was considered to be quite valuable by users, but **the time needed for the comparison on the dashboard is not radically different from the situation "as is".** All things considered, **the most appreciated features were the Comparison tool and the possibility to create collections.** Two users **mentioned the comparison between cities** as another precious feature as, at municipality level, **there is this continuous effort to chase trailblazers, in order to improve their own performance.** Therefore, keeping other cities' indicators at hand can be a useful input for decision-makers to pursue constant innovation.

For tech-savvy citizens, I managed to involve three users, **two data journalists and one urban development operator.**

In this case, I replaced the first task with one that was most suitable to their role, namely gathering information about a specific topic (like, for instance, sharing mobility). Also in this case, the dashboard was evaluated as a good technical support and a way to avoid longer research sessions. **Another meaningful aspect**, that didn't emerge in the operators analysis phase, **is the reliability of datasets**: one of the most pressing issues of people looking for datasets, while being out of a governmental structure, is understanding whether to trust a specific dataset or not. For this reason, **promoting the dashboard as a Municipality initiative will definitely increase trust and reduce verification time for tech-savvy citizens.**

Regarding decision-makers, I had a precious meeting with **two consultants at Lombardy Region**. On this occasion, they resulted to be the target section with the highest satisfaction rate. They especially appreciated the mediator nature of the project, claiming it could **bridge the gap between the different institutions** with which they cooperate on a daily basis. This testing session was particularly useful not only to verify my initial hypothesis, but also to gather more feedbacks about the final version of the platform and on its future applications. Decision-makers appeared to be particularly eager to test the platform's capabilities outside its primary scope, adapting its structure to a whole range of new project: one of the most interesting options was **applying the dashboard to the management of the 2026 Olympic Games**, that are to be held between Milan and Cortina d'Ampezzo. **The supervision of a huge event**, in that case EXPO 2015, **triggered the development of another fundamental platform like E015**. Such digital tools can simplify operators and decision-makers work, both while planning the activities before the event and while monitoring the involved resources after its beginning.

Lastly, I got in contact with **people falling into the "non-tech-savvy category"**. It was possibly the target branch that felt more unsure about the dashboard value, as **the majority of functions they featured were related to actions they don't usually perform on a regular basis**. Moreover, one of them felt like some information were far more reachable on other channels, rather than the dashboard itself.

OPERATORS (4 users)

TASK	CURRENT METHOD		DASHBOARD	
TASK NAMES	TIME NEEDED	SATISFACTION	TIME NEEDED	SATISFACTION
#1 Share a visual model with your colleagues	5h-6h	3/5	1h-2h ▼	4.75/5 ▲
#2 Compare two or more datasets onto the same map	20’	4.25/5	15’ =	4/5 ▲
#3 Compare one Milan’s zone performance with that of another one	1h	2.75/5	10’ ▼	4/5 ▲

DECISION MAKERS (2 users)

TASK	CURRENT METHOD	DASHBOARD
TASK NAMES	SATISFACTION	SATISFACTION
#1 Get an idea about the whole city performance	3/5	5/5 ▲
#2 Get an idea about a single zone’s performance	4.25/5	5/5 ▲

FIG. 73 - Decision-makers’ testing results

TECH-SAVVY CITIZENS (6 users)

TASK	CURRENT METHOD		DASHBOARD	
TASK NAMES	TIME NEEDED	SATISFACTION	TIME NEEDED	SATISFACTION
#1 Gather reliable information about sharing mobility efficiency	2h	3/5	30’ ▼	4.25/5 ▲
#2 Compare two or more datasets onto the same map	30’	4/5	15’ =	5/5 ▲
#3 Compare one Milan’s zone performance with that of another one	2h	2.25/5	15’ ▼	3/5 ▲

NON-TECH-SAVVY CITIZENS (6 users)

TASK	CURRENT METHOD	DASHBOARD
TASK NAMES	SATISFACTION	SATISFACTION
#1 Get an idea about the whole city performance	3/5	3/5 =
#2 Get an idea about a single zone’s performance	3.75/5	3.25/5 ▼

FIG. 74 - Citizens’ testing results

CONCLUSIONS

This experience featured various levels of complexity, which caused some aspects of the thesis to lack the right amount of detailing.
First of all, **the data visualisation system would need additional work and analysis**. Working out the best way to represent city data would have been a project of its own, given the heterogeneity of datasets and the range of their possible declinations. Moreover, the set of visual models that are available on the platform could be extended, in order to fit the needs of as many datasets as possible.
Secondly, **setting this platform as a cross-national meeting point would require additional work on the dashboard structure**, as it should be completely detached from any reference to the single city's needs. This would be a difficult endeavour, considering the whole platform was based exclusively on Milan's administrators and citizens' needs. A new user analysis phase should be set up, in order to shape the features around cross-national necessities.
Moreover, together with the effort poured into the platform cross-national adaptation, **an even harder work on interoperability is required from all the Municipalities involved**. Comparison between the cities must be as quick and reliable as possible, and the only way to grant data authenticity and accuracy is to map all the different sources and verify their current status. Otherwise, the work would be rendered useless in no time.
Lastly, **the dashboard should bridge the gap with citizens, by giving information and by receiving feedbacks from them.** This aspect would have been out of the primary scope of this thesis, but it is a point that strongly emerged during the testing session. All users expressed their interest in setting up a conversation with citizens, as this kind of communication would benefit both parties in different ways.
Nevertheless, **the most controversial aspect** of the whole experience **was undoubtedly the context in which the whole project took place.**
As stated in the previous sections, between July 2019 and November 2019, the project was discussed with the main stakeholders at various levels. **The last meeting with the Digital Transformation Councillor ended with the intention to further develop the project.** Moreover, the Lombardy region representatives I spoke with were interested in a specific version of the dashboard, aimed at monitoring the various activities related to the **2026 Winter Olympic Games**. In both cases, the project would have been entrusted to students, rather than to professionals. This can possibly mean that **the true potential of these sort of platforms is still unclear or underestimated by the most powerful stakeholders**, the ones that could really shift the project and develop it in the most efficient way.
Therefore, there are still some aspects that need to be clarified before going through a more structured development process, because this whole effort is trying to **advocate for a change in the mindset, rather than an update in the tools.**
All things considered, **the project is not simply about the introduction of a new digital platform, but it implies a change in**

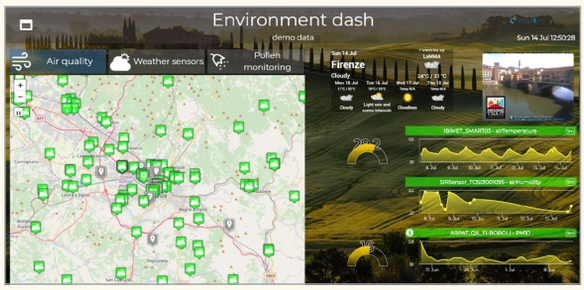
the way people interact with each other in the city environment, thus requiring a shift in the communication paradigm.
First of all, the regultating principle in communication should be **accountability**, in order to grant a homogeneous participation. **There should be an active exchange of information from both sides, policy-makers and citizens**: by keeping this conversation going, and by keeping track of the ensuing knowledge, users that appear to be far from each other will be drawn together towards a common goal.
Therefore, **this project was just an attempt to employ design practices and methodologies in an unusual context**, trying to advocate the importance of some themes (involving users, setting the needs before starting the development, iterative cycles of prototyping and feedbacks, and so forth) and **trying to highlight the value and the competitive advantage design can bring about**, if applied in the proper way. All things considered, a dashboard is the kind of project that makes sense **only if a consistent number of people use it** on a regular basis: if there are any **political or social motivations hindering its full potential**, the whole effort would have been done to no avail.

APPENDIX

HEURISTIC EVALUATION - KM4CITY

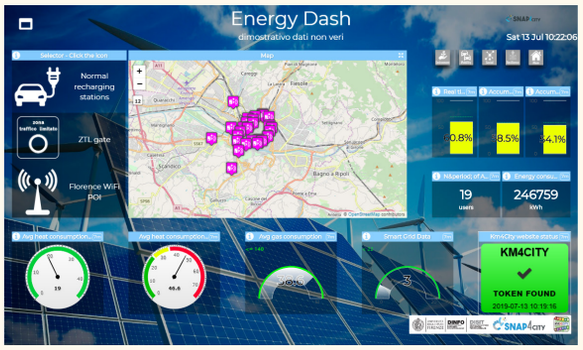
1. Visibility of system status

The section the user is navigation is not signalled in any way. Moreover, many visualizations just show data, without an indication of whether it is a good or bad result.



2. Match between system and the real world

In the Energy dashboard, gauges are used to signal the state of the system, and this may be a clear and straightforward visual model. Nevertheless, this is combined with some words taken from the energy engineering jargon (N&period, token...) and they may be meaningless for a common user.



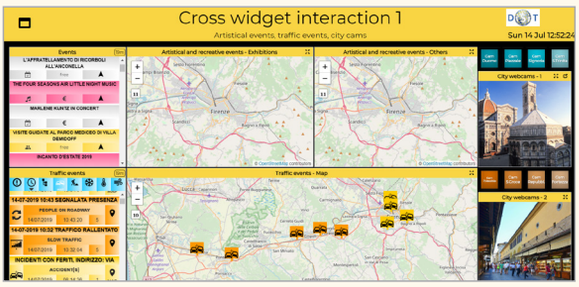
3. User control and freedom

Once the user clicks on a section on the main page, there are no clear links that can bring him/her back to the homepage.

HEURISTIC EVALUATION - KM4CITY

4. Consistency and standards

Every page has its own standards, layout, and visual language. This may result in great confusion for the user.



5. Error prevention

The way the sections are titled don't help the user understand what they are going to see once they click. At least the homepage shows a small preview of the content, and this may lead the user to choose the right section of the website.

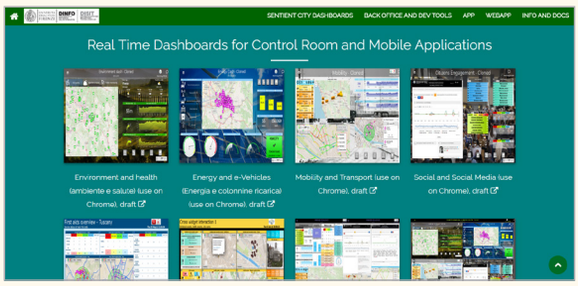
6. Recognition rather than recall

Each and every section of the website has its own layout, rules, and arrangement, as said at Point 4. Nevertheless, the colour coding, being quite standard, is the same in every section, and it's used in the same way to indicate a bad or good performance.

HEURISTIC EVALUATION - KM4CITY

7. Flexibility and efficiency of use

There is no such thing as an expert user and novice user pattern: the experience provided is the same for everyone, and there's no way to speed up some operations.

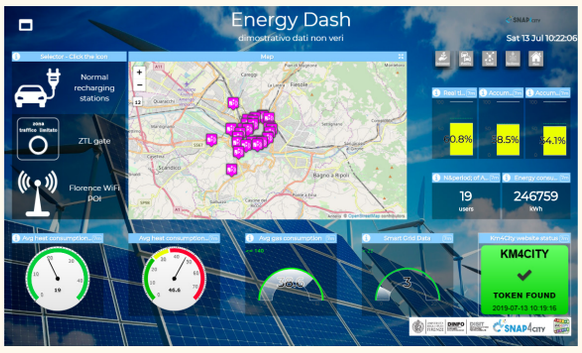


8. Aesthetic and minimalist design

Pages background often display an image that play against the clarity of graphs and indicators. This is a purely aesthetical choice that doesn't aid comprehension in any way.

9. Help users recognize, diagnose, and recover from errors

The user should not occur in fatal functional errors, but they may want to come back quickly to the homepage once they get to a section they're not interested in. Unfortunately, the CTAs around visualisations redirect to external links, and not to the homepage



HEURISTIC EVALUATION - KM4CITY

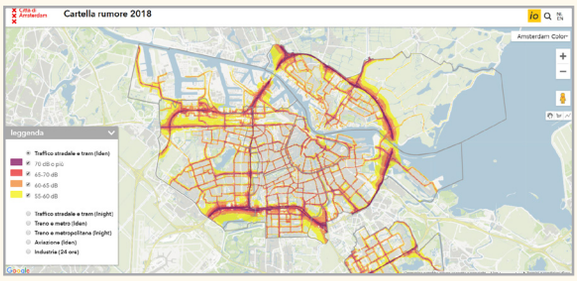
10. Help and documentation

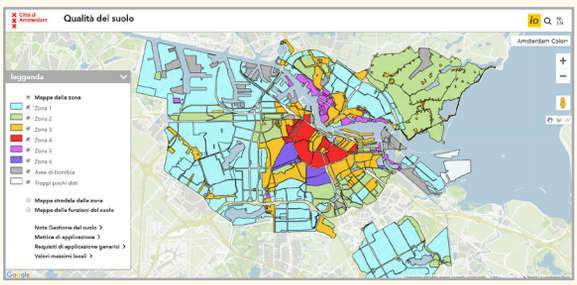
Being an academic research project, the website provides plenty of documentation both on the current dashboard and on the work lying behind it.

HEURISTIC EVALUATION - MAPS FOR AMSTERDAM

1. Visibility of system status

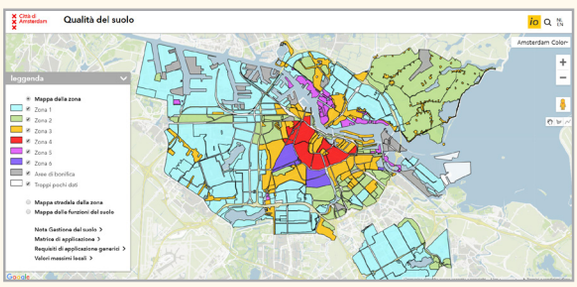
Colour coding is not used in a clear way, since colours that are linked with a negative result (like red or orange) are unrelated to the value. Nevertheless, a navigation aid (navbar, breadcrumb...) is missing, so users don't always know the section they are navigating.





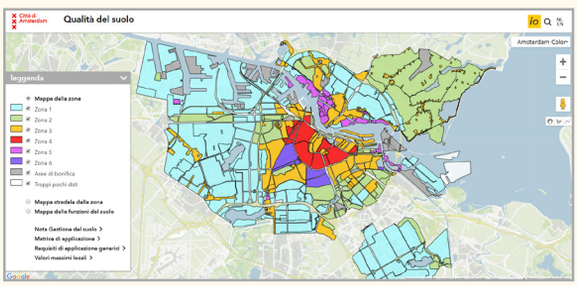
2. Match between system and the real world

The general use of words in the website is clear and straightforward, while the links to more complex information are called in a technical way.



3. User control and freedom

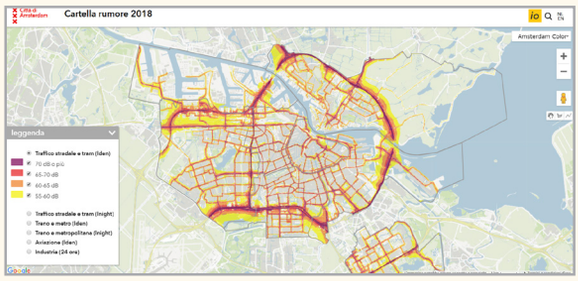
In some pages, there's a clear call to action to come back to the index. In others, such link is not present: the most natural way should be by clicking on the logo in the top left part of the navigation bar, but instead it takes the user to the Amsterdam website.

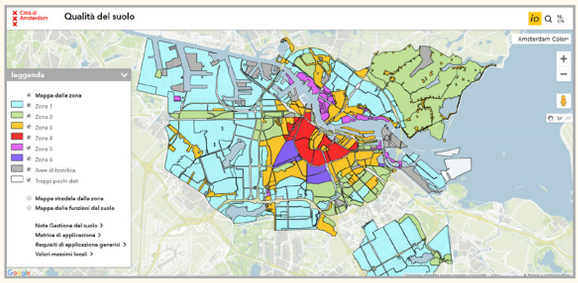


HEURISTIC EVALUATION - MAPS FOR AMSTERDAM

4. Consistency and standards

The page layout is the same throughout the whole website: this reduces the cognitive load in the user, that doesn't have to process the page structure and can just concentrate on the map visualization.



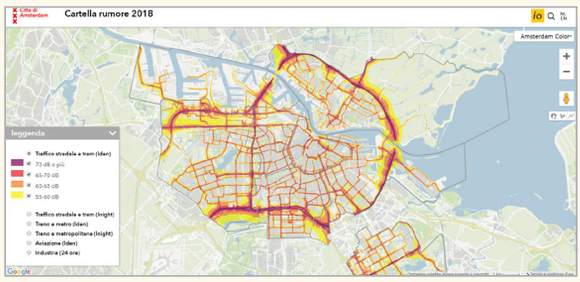


5. Error prevention

The way the sections are titled don't help the user understand what they are going to see once they click. At least the homepage shows a small preview of the content, and this may lead the user to choose the right section of the website.

6. Recognition rather than recall

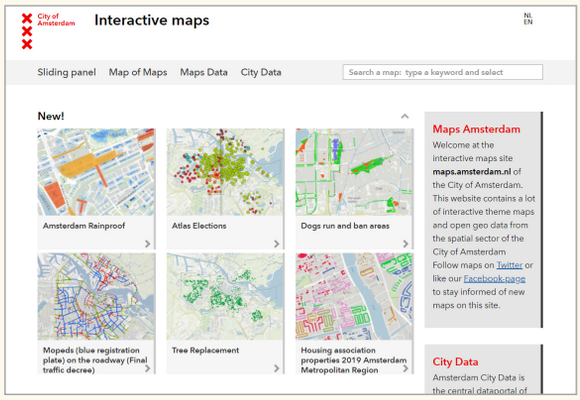
As previously stated, both colours and words are used in a consistent way throughout the whole website, so the user doesn't have to get accustomed to a new visual language everytime he/she opens a new page.



HEURISTIC EVALUATION - MAPS FOR AMSTERDAM

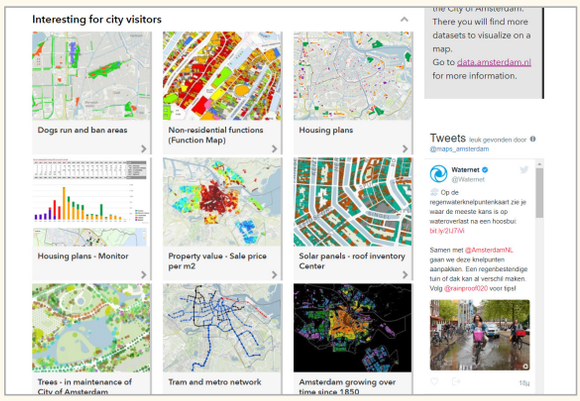
7. Flexibility and efficiency of use

There are various CTAs, and the user can follow different patters to get to the same map visualization. In this way, the experience is tailored around the user's level of experience.



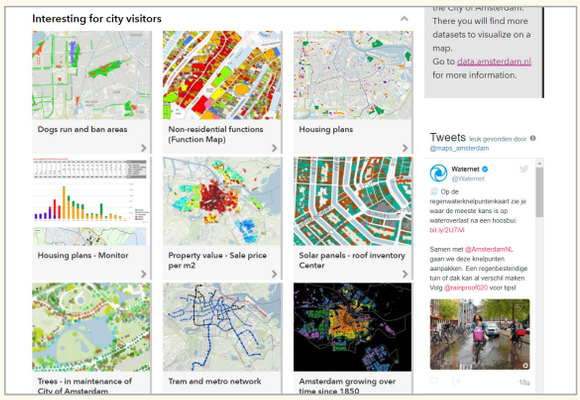
8. Aesthetic and minimalist design

The page appearance is designed so that the visualization really "pops out" and become the center of the overall experience: the background is neutral, the only strong colours are the ones used in the maps, and the text is reduced at a minimum.



9. Help users recognize, diagnose, and recover from errors

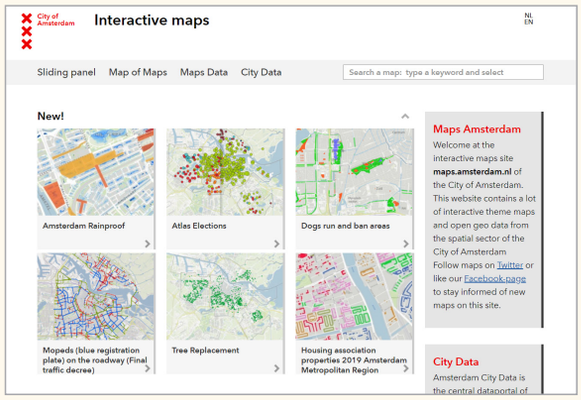
Being an exploratory website, the user should not occur in fatal functional errors, but they may want to come back quickly to the homepage once they get to a section they're not interested in. Unfortunately, there is no way to do so, as all the CTAs around the visualization redirect to external links, and not to the homepage



HEURISTIC EVALUATION - MAPS FOR AMSTERDAM

10. Help and documentation

The website provides plenty of documentation and external links, for those users that want to deepen some aspects of the dashboard.



HEURISTIC EVALUATION - DUBLIN DASHBOARD

1. Visibility of system status

●●●○○

Performance is described through very simple indicators, but sometimes the nature of the performance is not clear, as there's no colour coding referring to a good or bad situation in the city

2. Match between system and the real world

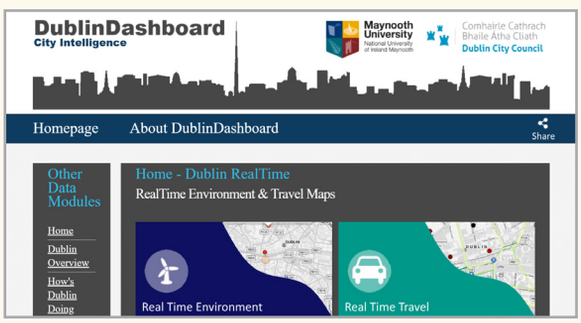
●●●●●

The language used is truly conversational, and it really draws the user to learn more in a clear and simple way.

3. User control and freedom

●●●○○

The navigation between sections is smooth thanks to the navigation bar on the top and the side menu.
Nevertheless, many times the maps redirect users to external links, in which this navigational aid is not present anymore.

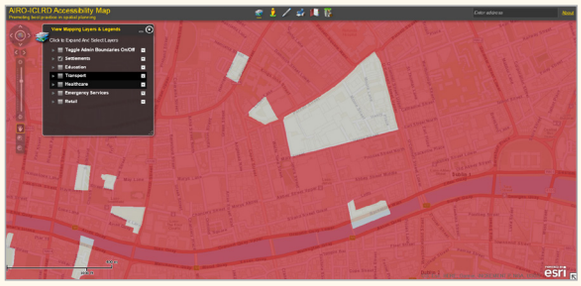


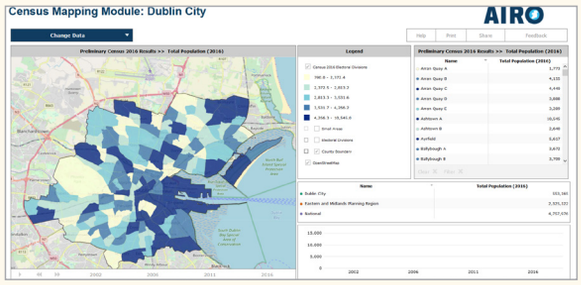
HEURISTIC EVALUATION - DUBLIN DASHBOARD

4. Consistency and standards

●●●○○

Also in this case, like shown in KM4City, each visualization is quite different from the others. This results in a lack of consistency that may confuse the user and distract him/her.





5. Error prevention

●●○○○

Errors are prevented by the simplicity with which each visualization is titled, and thanks to the small previews that guide the users towards the right one.

6. Recognition rather than recall

●●●○○

The layout is effective, as it shows a small preview of the single visualizations. Nevertheless, each has its own layout, style, and section arrangements, and this may not aid immediate comprehension.

HEURISTIC EVALUATION - DUBLIN DASHBOARD

7. Flexibility and efficiency of use

There are not many shortcuts, as also expert users, in order to get to a particular visualization, have to pass through several sections.

8. Aesthetic and minimalist design

The indicators are given enough visual importance, and the layout is not cluttered with useless information.

9. Help users recognize, diagnose, and recover from errors

As stated in Point 3, the user can easily change section if he/she makes a mistake, thanks to the navigation bar and the side menu

HEURISTIC EVALUATION - DUBLIN DASHBOARD

10. Help and documentation

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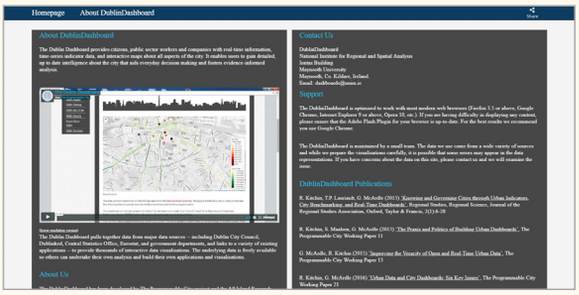
The Programmable City (the research group that designed the dashboard) provides plenty of information about the process, the platform and the aim of this experience.



HEURISTIC EVALUATION - LONDON DASHBOARD

1. Visibility of system status

The colour coding is used in an effective way, so that users can get an at-a-glance rendition of the city situation.

2. Match between system and the real world

The language is colloquial and easy to understand, and users can click on the links in each tile to get more information about each piece of information.

3. User control and freedom

The platforms offers few possibilities for users' interaction. The only thing they are enabled to do is switching to a different visualisation of the city's performance, choosing between the dashboard, the grid, and the map.

HEURISTIC EVALUATION - LONDON DASHBOARD

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4. Consistency and standards

The colours and text styles are the same throughout the three pages, and within the different tiles. Nevertheless, the layout is radically different in the map and grid page.

---

5. Error prevention

The three links in the upper right part of the page are the only navigational aid provided to the user. They are visible and clear enough to support users in the navigation.

---

6. Recognition rather than recall

All the tiles have some traits in common, meaning that once the user decodes one of them, they can easily grasp the meaning of all the other tiles featured in the homepage.

HEURISTIC EVALUATION - LONDON DASHBOARD

7. Flexibility and efficiency of use

The platform is undoubtedly plagued by several technical issues, considering that, most of the times, some of the tiles are either not working or not updating properly. Moreover, the page layout is not adapted in any way on a mobile device.

8. Aesthetic and minimalist design

The data-ink ratio could have been preserved in a more efficient way, as the homepage is quite cluttered with different elements. There is no visual hierarchy, as each tile tries to attract the user's attention with bright colours.

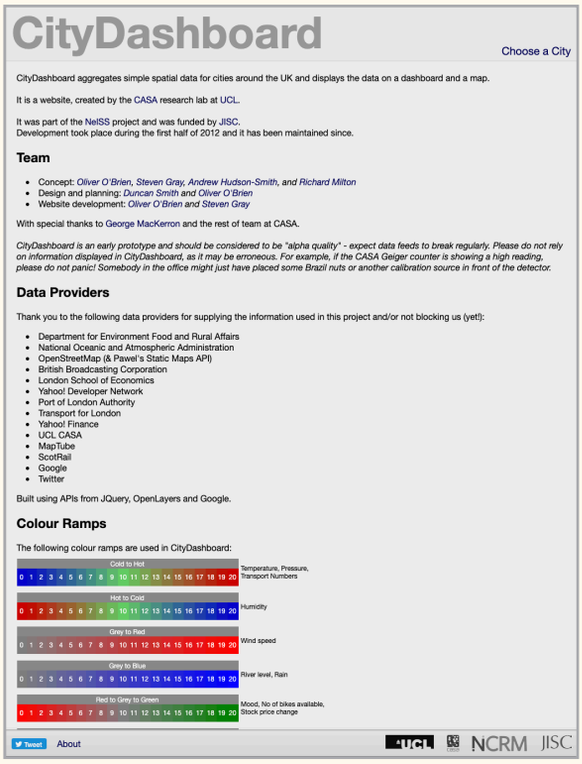
9. Help users recognize, diagnose, and recover from errors

As stated in Point 5, the three links in the upper right part of the page are the only navigational aid provided to the user. They allow users to come back in a quick way if they want to visit another page.

HEURISTIC EVALUATION - LONDON DASHBOARD

10. Help and documentation

The Centre for Advanced Spatial Analysis (CASA) was the main project stakeholder, and therefore it provided plenty of documentation detailing the platform's background.



CityDashboard

Choose a City

CityDashboard aggregates simple spatial data for cities around the UK and displays the data on a dashboard and a map.

It is a website, created by the CASA research lab at UCL.

It was part of the NeISS project and was funded by JISC.
Development took place during the first half of 2012 and it has been maintained since.

Team

- Concept: *Oliver O'Brien, Steven Gray, Andrew Hudson-Smith, and Richard Milton*
- Design and planning: *Duncan Smith and Oliver O'Brien*
- Website development: *Oliver O'Brien and Steven Gray*

With special thanks to George MacKerron and the rest of team at CASA.

CityDashboard is an early prototype and should be considered to be "alpha quality" - expect data feeds to break regularly. Please do not rely on information displayed in CityDashboard, as it may be erroneous. For example, if the CASA Geiger counter is showing a high reading, please do not panic! Somebody in the office might just have placed some Brazil nuts or another calibration source in front of the detector.

Data Providers

Thank you to the following data providers for supplying the information used in this project and/or not blocking us (yet!):

- Department for Environment Food and Rural Affairs
- National Oceanic and Atmospheric Administration
- OpenStreetMap (& Pawel's Static Maps API)
- British Broadcasting Corporation
- London School of Economics
- Yahoo! Developer Network
- Port of London Authority
- Transport for London
- Yahoo! Finance
- UCL CASA
- MapTube
- ScotRail
- Google
- Twitter

Built using APIs from JQuery, OpenLayers and Google.

Colour Ramps

The following colour ramps are used in CityDashboard:

Cold to Hot 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 — Temperature, Pressure, Transport Numbers

Hot to Cold 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 — Humidity

Grey to Red 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 — Wind speed

Grey to Blue 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 — River level, Rain

Red to Grey to Green 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 — Mood, No of bikes available, Stock price change

Tweet About

UCL NCRM JISC

HEURISTIC EVALUATION - EDMONTON DASHBOARD

1. Visibility of system status

The colour coding is used in an effective way, so that users can get an at-a-glance rendition of the city situation.

2. Match between system and the real world

The language is extremely simple, and each category name is coupled with a descriptive icon.

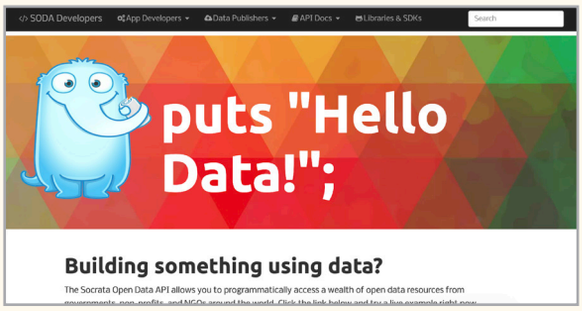
3. User control and freedom

Users' navigation between different pages is supported by the top navigation bar, while users can see the different indicators sections by clicking on the icons on top.

HEURISTIC EVALUATION - EDMONTON DASHBOARD

4. Consistency and standards

The top navigation bar elements are looking the same. Nevertheless, some of these are actually redirecting the user to a different website, rather than on a different section of the dashboard website.

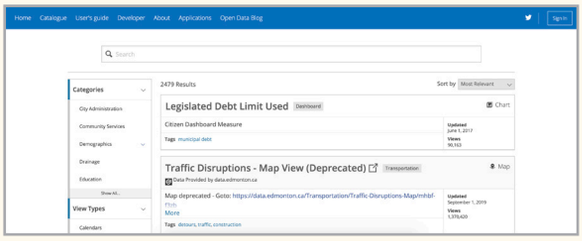


5. Error prevention

If the user ends up in one of the external pages described in Point 4, there is no link that can redirect him or her to the dashboard page.

6. Recognition rather than recall

This aspect could have been set up in a more efficient way, as the other pages have a completely different layout.



HEURISTIC EVALUATION - EDMONTON DASHBOARD

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7. Flexibility and efficiency of use

The platform allows less expert users to easily visualise the indicators, and have a general idea about the city performance. On the other hand, more expert users can consult the Catalogue to find specific datasets.

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8. Aesthetic and minimalist design

The data-ink ratio could have been preserved in a more efficient way, as the homepage is quite cluttered with different elements. There is no visual hierarchy, as each tile tries to attract the user's attention with bright colours.

---

9. Help users recognize, diagnose, and recover from errors

As stated in Point 5, If the user ends up in one of the external pages, there is no link that can redirect him or her to the dashboard page.

HEURISTIC EVALUATION - EDMONTON DASHBOARD

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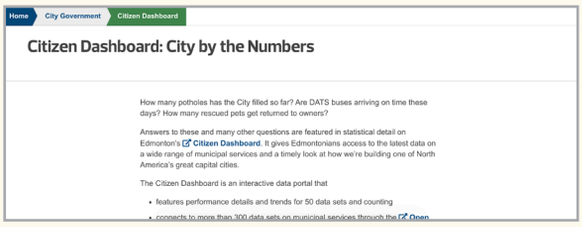
10. Help and documentation

The project background is not fully detailed. Nevertheless, users can consult the About page to get an idea about the project's purpouse.



EXPERTS' TAKE

In the preliminary phase of the research, I tried to speak with expert professionals and take part to smart city conferences, in order to enrich my background knowledge. First of all, I got in contact with Laura De Prato, a former ERVET employee in Bologna: since her work was focused on ranking Italian provinces based on some performance indicators, I asked her some advices regarding the project.

Tell me a little bit more about your former job.
I worked at ERVET (Emilia-Romagna Valorizzazione Economica Territorio SpA) from 2004 to 2006.
It is the "in house" company of the Emilia-Romagna Region that operates as an agency for territorial development in support of the Region itself.
It tries to favour the cooperation between the Region and local authorities, the consultation with economic and social forces, the support of the Emilia-Romagna Region to promote sustainable economic development and qualification of the regional territory.

What was your duty?
In addition to other office functions, my task was to draw up, annually, a ranking of the Italian provinces based on various indices, such as liveability, economic activity, social stability, and legal situation.

What kind of data did you collect?
I took the data from various institutes, like ISTAT, Eurostat or some regional institutions.
Our aim was to propose a different classification from the one drawn up, for example, by Il Sole 24 Ore: in fact, while the newspaper is now expanding the variety of evaluated data, at the time, it was based on purely economic indicators (GDP per capita, pensions amount, registered companies...)
In order to amplify the number of factors contributing to the province

performance, I also inserted some other indicators, that were not included in other rankings, like the number of social services, volunteering associations, measures for the weakest citizens (handicapped people, immigrants…) or the number of companies that obtained SA8000, a certification standard that encourages organizations to develop socially acceptable practices in the workplace. Emilia Romagna has always been a paramount example of all these values, that's why I wanted to highlight them; although these indicators are not strictly related to an economic return, they can deeply influence how a city is perceived and how citizens live in it, and they could have brought Emilia Romagna far ahead of other richer Regions in the rankings.

What was your workflow?
First of all, I had to understand ERVET's mindset, namely the message they wanted to convey with this analysis: their aim was mainly showing the effects of investments in the Region from an industrial, economical, and social point of view, compared to other provinces.
Then I started analysing the rankings that were already available (like the one by Il Sole 24 Ore) to see how they were set up, which kind of data were included and how they were displayed.
Afterwards, I started to list the data sets I recognized as useful: I have a master's degree in Political, Social and International Sciences, so I listed all the data sets that could contribute in evaluating a city's performance.
Then I had to reduce the list based on the quality of the available data: this was the most basic condition for me, as before inserting an indicator in the overall analysis, I had to make sure the data were not only available, but also coming from a reliable source.
Afterwards, I clustered the data sets that were showing some analogies between each other, so as to create a real performance indicator: for example, by combining the number of young kids per province and the number of vacancies in kindergartens, we can get an indicator about the condition of daycare services. More broadly, by combining all the data sets about kindergartens, playgrounds, paediatric structures, we can have a complete indicator of children services offered by the Region.
Where were these results published?

It was mainly published on ERVET channels?
It was mainly published on ER report, like a sort of regional newspaper, so unfortunately the visibility was not very high at that time, especially from the citizens' side.
However, the report was more institution-oriented than citizen-

oriented, and regional authorities often used the ranking results to successfully obtain funding, since ERVET analysis showed how Emilia Romagna used regional and national funds.

What would be your advices about the design of a city performance dashboard?

The main limitation at that time was the total absence of real-time data, while these can be quite easily found today. And I do believe they make a great part of a dashboard success, since it's what makes the difference between a dashboard and a simple report.

Secondly, through this report, ERVET was also trying to convey a sense of transparency regarding the government choices. But this probably never happened, because the number of citizens consulting our report was too low.

Today this goal should be reconsidered, as it can really increase citizens' trust in their own institutions, as in the future the e-government features will grow more and more important.

The greatest result, although this may be an utopia, is that, for example, Milan would set a sort of standard for transparency, that would inevitably spread to other cities, that would lose trustworthiness if they don't adapt.

I got in contact with Paolo Nesi, professor at the University of Florence, working at DINFO, Department of Information Engineering, and chair of DISIT Lab. He's one of the scholars that gave the major contribution to Florence's dashboard (called Km4City). As said in the related chapter, Km4City was one of the biggest references throughout this project, especially in the preliminary part: it was one of the first examples of dashboard I got to know, and the only relevant example for an Italian city. Moreover, it really helped me process the complexity of the project I was undertaking, considering the remarkable result he and his collaborators achieved.
For this reason, I felt the need to hear from him, as I wanted to know more about the project and the phases that led to the final platform.
During our brief mail exchange, I got to know that his department is currently working on other cities. For this reason, what was called Km4City is now referred to as Snap4City, a broader project, involving more cities all over Europe, that managed to gain international resonance. In fact, in the last few months, the project was involved in several smart cities conferences all over the world.
At the moment, the newest cities to be involved are Helsinki and Antwerp: in both cases, the cooperation stemmed from the relationship between DISIT Lab (University of Florence) and the local

institutes (UAntwerp and University of Helsinki) that mediated the process allowing DISIT to work on the local data. In each city the team tried to develop both private control dashboards, accessible only to operators, and citizen dashboards, that instead deliver informative services to city dwellers and tourists.
Nevertheless, during the platform further development, they felt the need to combine the web-based platform with apps, that could answer to the ever-changing needs of citizens.

ICITYLAB - Florence

On October 17, 2019 I had the opportunity to take part to ICityLab, taking place in Florence.
The two main themes of this edition were digital transformation and smart city governance, two topics that are deeply linked to the scope of this thesis. What should have been simply an occasion of deepening certain themes became a fundamental aspect of my research work. The most insightful intervention was the one by Renato Galliano, Head of the Urban Economy and Labour Department, Municipality of Milan, named “Smart city and strategic planning”.
His talk really shed a light on Milan’s current and future strategy to pursuit continuous innovation and value creation. Also the name “strategic planning” indicates an attention both to short term (planning) and long term (strategic) issues. Moreover, the overall approach of the Municipality has been defined “in permanent beta”, always ready to be rearranged and adapted. He further defined the role of Milan, not as a city, but as a “platform at citizens, city users, and industry’s disposal”, in which technology (in the forms of fiber, free wifi, 5g…) is a fundamental basis, but reducing Milan’s value to technology would be reductive. In fact, some of the measures applied in the city have little to do with technology: for example, the effort to employ abandoned places (like BASE, a former industrial building

that has been turned in one of the most active cultural spots of the city) and innovative ways of financing projects (if citizens crowdfund half of the money needed for a project, the Municipality will provide the remaining half). He closed his intervention by focusing on some critical points and issues that are still lingering in the city administratioin, namely the uncertainty about norms, the timing differences between politics and market, and the lack of cooperation between certain municipality’s department. Another insightful intervention was the one by Simone

D'Antonio, an expert from URBACT, that instead was more narrowly focused on citizens' engagement and participation through social media. One of the latest projects by URBACT is Interactive Cities, a network of cities around Europe (Genoa and Palermo are the Italian participants). The aim of Interactive cities is exploring new ways of using social media in the framework of public administration. This is not a simple endeavour, given the continuously evolving nature of such social platforms: nevertheless, their potential is still considerable, and Interactive Cities proposed several ways of using them, both to inform citizens (e.g. to explain the aim of some building sites) and to engage citizens in the city's development (e.g. to propose new urban projects or create a storytelling around the city through social media). The wrap up session, that closed the event, focused on the current situation in Italy: 58 out of 107 Municipalities are actually sharing Open Data, and there's still a gap between the available e-government services and the actual use. There's still the need to spread data literacy and interoperability, but new initiatives are spreading on a daily basis. All these insights were integrated in the thesis work, that tries to become a platform for multiple actors.

SHARING CITIES MEETING

In September 2019 I had the opportunity to get in contact with some of the most preminent stakeholders in the Smart City DiVA project (in particular AMAT and A2A). This opportunity gave me some insights about the features to be included in the dashboard. In particular, I took part to the meeting between AMAT, A2A, and Future Cities Catapult (FCC), a company working on the development of Sharing Cities: this initiative focuses on the development, by 2020, of a zero-emissions smart neighbourhood in some European cities. In Milan, the smart area will be in Porta Romana/Chiaravalle area. This document is a short summary of this experience, where FCC tried to obtain from the stakeholders as much information about the current smart solutions in Milan.

Bike sharing

Milan Municipality offers two different bike sharing modalities: station-based (Bikemi, owned by the Municipality itself) and free-floating (managed by Ofo and Mobike, two private companies).

Despite being part of the same services, there is a huge different in data availability between municipal and private companies: Milan Municipality is constantly monitoring Bikemi activity, in particular the state of the stations, the customer satisfaction, and the origin-destination matrix for each trip. This doesn't happen for Ofo and Mobike, that are not providing the Municipality enough data about their activity. Even the number of bikes is not totally confirmed. Given that, the bike sharing section of the dashboard should provide users enough information about the position of the stations and the availability of the service; moreover, it could be include to combine weather data in the visualization, so as to favour the bikes' usage in case of good weather, in order to reduce traffic.

On the other hand, the dashboard should provide the Municipality as much information as possible on bike sharing trends, namely gender/age of the users, origin-destination matrices and areas where more bikes are needed.

Condominium car sharing (EV)

This is another unprecedented initiative for Milan, that will be implemented within Sharing Cities. It will involve the Municipality for regulations, and AMAT for the organization, aided by private companies. This field is quite challenging, as there is no long-term plan: the solution will be tested in a 600 families condominium (2000 people), and the idea is that, from that, other condominiums could join the initiative independently.

The initiave will be mapped in every aspect, as the data that will be gathered include starting point, duration, battery usage, gender/age, frequency of use (both per car and per user), whether the user is a resident or not, and customer satisfaction.

A dashboard including this service

should show also updates about weather and events (e.g. strikes...)
In the long term, Municipality could benefit from the visualization of changes in the apartments price and in residents habits.

Smart parking

Smart parking is one of the solutions Sharing Cities could adopt to optimize traffic management: at the moment, the service is still in an implementation phase, but the Municipality has some data about already existing parking that could come in handy in the smart parking diffusion.
AMAT and AMAT has data about both street and structured parkings, that include demand/offer comparison, payment machines informations and parking irregularities. These data, combined with smart parking sensors, should show real-time occupation of the area, in order to reduce the operators' work, and also display night parking data (to check how many people actually live in the area). As the operators suggested, one added value could be analyzing how the state of a parking area changes in various moments of the day, or using historical data in order to recognize recurring anomalies.
In this way parking planning and checking operations would become easier, and irregular parkings could be tackled in a more efficient way.

Smart lamp posts

LED lamps were installed in Milan before the EXPO 2015: starting from this, one of our main stakeholders, A2A, wants to install new smart poles with ~20 sensors (measuring environmental, acoustic and meteorological data) and 3 cameras (counting vehicles). The biggest challenge, together with turning data into meaningful information, is understanding if this network of sensors is really able to outperform more expensive weather stations. In this case, data related to traffic could be compared with air quality/sound level data in different areas of the city, to see how these measures influence each other.

Traffic monitoring

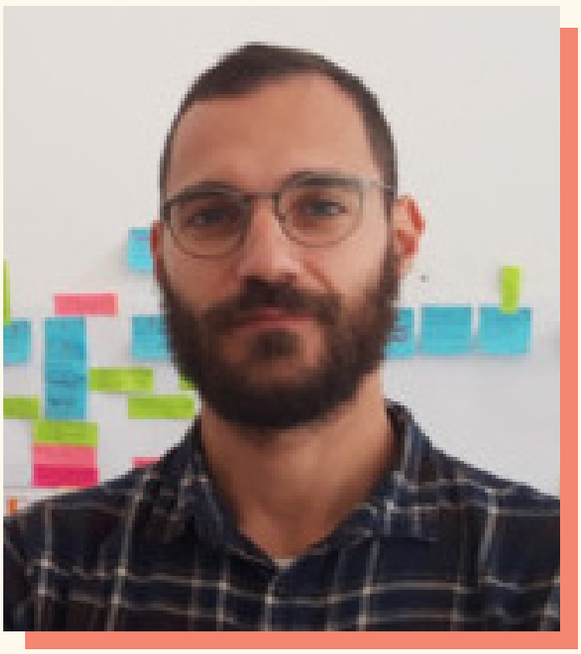
At the moment, cars are counted 3/4 times a week, in some selected intersections, through mobile cameras or coils in the asphalt: the resulting videos are analyzed by an external company that provides the count; such count is then fed into a simulation model, that's able to simulate the micro and the macro state of the traffic. These models are useful when it comes to deciding traffic lights timing and roads direction).

DECISION-MAKERS' INTERVIEWS

What's your current role? And how it interrelates with the Municipality?
I'm the project manager of Sharing Cities Milan: it's a EU-funded project aiming at building zero-emissions
neighbourhood in six European cities. And Milan is among them. Right now I'm managing the relationship between the Municipality (that's involved) and the Sharing Cities headquarters in London.

What are the main issues in designing a dashboard for Milan's municipality?
One fundamental aspect is the cost, as it's a project in which revenues may be at minimum, while it may need a lot of investment. A second aspect is data management, given the recent
novelties introduced by GDPR, this matter is more sensible than ever.

What criteria should the dashboard respect? And which issues could it tackle?
I'm more into the communication and the public relationship part of each project, so I see the dashboard as a very useful communicative tool, but not only towards citizens. Sometimes I see things that get "lost in translation" also between different areas of the Council. The platform would be a way to make sure everyone speaks the same language, in order to take
common decisions. For this reason, I think the most important criterium is clarity and accessibility to everyone: the dashboard shouldn't reflect the mindset of just a part of the
council, but should be understandable by everyone.



Name: Roberto Nocerino
Works at: Comune di Milano
Role: Sharing Cities project manager

What strategy would be useful to draw citizens into using the dashboard?
That's a problem we've been coping with for a long time, and we still haven't worked out how to solve it.
The point is that citizens are accustomed to a way of using information that's different from the decisors'. Just to use a metaphor, it's as if citizens are surfing, and decisors are diving. What's hard is getting citizens interested in the long term performance of the city.

What's your current role? And how it interrelates with the Municipality?
I'm the project manager of Sharing Cities, head of the London team: in particular, I took care of the coordination between the six cities, and this year I also followed the user analysis part. I work closely with Milan institutions, especially AMAT, in order to understand the potential of the datasets they have access to.

What are the main issues in designing a dashboard for Milan's municipality?
The hardest obstacle I've come across is possibly interoperability: I spoke with government agencies in all the involved cities, and each of them works in an extremely different way. But from what I saw in Milan, there are some issues hindering the cooperation between different agencies, like AMAT, ATM, or Lombardy Region. This may prevent datasets to be exchanged effectively.

What criteria should the dashboard respect? And which issues could it tackle?
From what I saw, datasets have a particular potential especially when it comes to environmental sustainability and money saving features: I think their true potential is still unfolding, and it should be done in the fastest way possible.

What strategy would be useful to draw citizens into using the dashboard?
While working on UPS we evaluated different strategies, and the one we implemented relies on the principles of gamification, to reward citizens adopting sustainable and environmentally-friendly behaviours in their everyday life. I think citizens must feel part of something bigger in order to understand the importance of what they can do on their own.

Name: Francesco Marchet
Works at: Future Cities Catapult
Role: Sharing Cities project manager

What's your current role? And how it interrelates with the Municipality?
Over the last three years, I've been working as a consultant for the Digital Transformation Councillor. The main aim of this mandate is simplifying the bureaucratic procedures, which is something we haven't fully achieved yet.

What are the main issues in designing a dashboard for Milan's municipality?
As far as Councillor Roberta Cocco claims, the Municipality has been thinking about developing a dashboard for a long time, almost two years. The main issue is not knowing where to get the datasets, as there are too many players involved. And not all of them are willing to share.

What criteria should the dashboard respect? And which issues could it tackle?
I think the most important criteria are the active involvement of all urban actors together with their complete transparency. It's such a wide endeavour the Comune cannot face it by itself.

What strategy would be useful to draw citizens into using the dashboard?
I think the government is doing an effective job in involving citizens, especially during the Meetings with neighobourhoods. But there is still quite a lot of work to do. I think citizens will really start to feel involved when they will see the practical effects of new policies. There were undeniable improvements in the last years, but the dashboard could be a way to make them more tangible.

Name: Chiara Daneo
Works at: Comune di Milano
Role: Digital Transformation advisor

What's your current role? And how it interrelates with the Municipality?
I mainly deal with API Economy and Digital Ecosystem, but my main role is following the technical-scientific coordination of the Digital Ecosystem E015. We've been working with the Municipality for several years, but this relationship has been made stronger in 2012, when a regional law promoted E105 by asking tender winners to share data on the platform. This made the data stream richer than it ever was, and this means a lot of opportunities may arise for us.

What are the main issues in designing a dashboard for Milan's municipality?
Well, Milan's municipality is striving towards innovation and digitalization, but still there are some obstacles in internal communication and, especially. interoperability. This last theme is particularly important, and despite the steps made in the last few years, there's still plenty of work to do.

What criteria should the dashboard respect? And which issues could it tackle?
I think that E015 API may be quite useful in the development, as they would grant efficiency and cut time needed to get to data. What I would suggest for now is a T approach, first showing all the potential of the platform and then focusing on a single topic, agreed among all the stakeholders.

What strategy would be useful to draw citizens into using the dashboard?
This is a matter of digital strategy. The most ideal solution, although it may be too resource-intensive, would be tailoring the experience around the single clusters of citizens or, better, around each and every citizen. Most importantly, we must undestand which are the drivers of these citizens, and how and when they may need the dashboard.

Name: Emiliano Sergio Verga
Works at: Cefriel
Role: E015 Digital Manager

What's your current role? And how it interrelates with the Municipality?
I'm an architect working for AMAT, therefore my work cannot be separated from the Municipality's.
I took part to many projects that changed the way Milan "works", both permanently or temporarily, like City Life area and EXPO 2015. During these projects, I actually focussed on their impact on mobility, and I tried to reduce the negative effects on the city and to allow users of the site and other citizens to keep moving smoothly.

What are the main issues in designing a dashboard for Milan's municipality?
I think the main obstacle is that, at least inside AMAT, there are some decision-making patterns that stayed unchanged for many years. They work, for sure, but they also have large margins for improvements. Still, people really need to undestand the limits of what they are leaving before jumping into a whole new method.

What criteria should the dashboard respect? And which issues could it tackle?
Mobility management is the most resource intensive activity we deal with. There are a lot of variables to be considered before making even a small decision, and while I do believe we already consider them in the proper way, I think it would be useful to combine these variables with other coming from other areas, in order to identify interesting patterns that may drive decisions towards another unexpected direction.

Name: Andrea Canevazzi
Works at: AMAT
Role: Mobility consultant

What strategy would be useful to draw citizens into using the dashboard?
Many successful projects rely on gamification and rewarding system, in order to engage citizens in an unusual way. That's the strategy me and my team used for another app funded by Regione Lombardia. I think it could be interesting given that such dashboard wouldn't visualize data that are interesting for citizens. It would be also useful to insert a feedback section in the website, in order to really make people heard.

What's your current role? And how it interrelates with the Municipality?
I've been cooperating with AMAT on the Emergency side for 5 years. We communicate emergencies to the decision-makers, that then needs to act accordingly.

What are the main issues in designing a dashboard for Milan's municipality?
One fundamental aspect is the cost, as it's a project in which revenues may be at minimum, while it may need a lot of investment. A second aspect is data management, given the recent novelties introduced by GDPR, this matter is more sensible than ever.

What criteria should the dashboard respect? And which issues could it tackle?
I'm more into the communication and the public relationship part of each project, so I see the dashboard as a very useful communicative tool, but not only towards citizens. Sometimes I see things that get "lost in translation" also between different areas of the Council. The platform would be a way to make sure everyone speaks the same language, in order to take common decisions. For this reason, I think the most important criterium is clarity and accessibility to everyone: the dashboard shouldn't reflect the mindset of just a part of the council, but should be understandable by everyone.

phone interview

Name: Alberto Radice
Works at: Cefriel
Role: Emergency consultant

What strategy would be useful to draw citizens into using the dashboard?
That's a problem we've been coping with for a long time, and we still haven't worked out how to solve it.
The point is that citizens are accustomed to a way of using information that's different from the decisors'. Just to use a metaphor, it's as if citizens are surfing, and decisors are diving. What's hard is getting citizens interested in the long term performance of the city.

CITIZENS' INTERVIEWS

What kind of information about Milan do you usually look for?
Well, me and my friends look for events basically. Not only, for example, book signing... but also events that promotes new cafés, shops, or restaurants. This is something I'm really interested in.

How often do you use public transport in Milan?
Not very often, my parents drive me almost everywhere. But sometimes I use the metro to go to volley training or to take a walk near Duomo.

Have you ever had problems with public transport due to the lack of information?
Since I don't use public transport very often, sometimes I get confused. I take metros and buses in the wrong direction, maybe because I'm not an expert, but I also think that sometimes the information is not very clear.

Do you use apps or websites related to Milan?
No I don't really use anything like that... some friends of mine, that live a little far from Milan, get informed through apps like ATM, Trenord or Trenitalia.

Would you like to give information to other people through an app or website? Or would you prefer an app that informs you without requiring your involvement?
I like to talk to people and give information. Sometimes my friends tell me something I don't know... well, even if I knew it I like the fact that they were thinking about me and wanted me to know

Name: Sara Bonfiglio
Age: 14
Born in: Milan
Lives in: Milan
Job: student

something, to help me. Or for example, I know that a friend of mine attends a course in a certain gym. And if I see something new or strange around that gym I always tell her.

If you were to describe Milan with just one word, what would it be?
The words is innovation. There's always something new coming up on a daily basis.

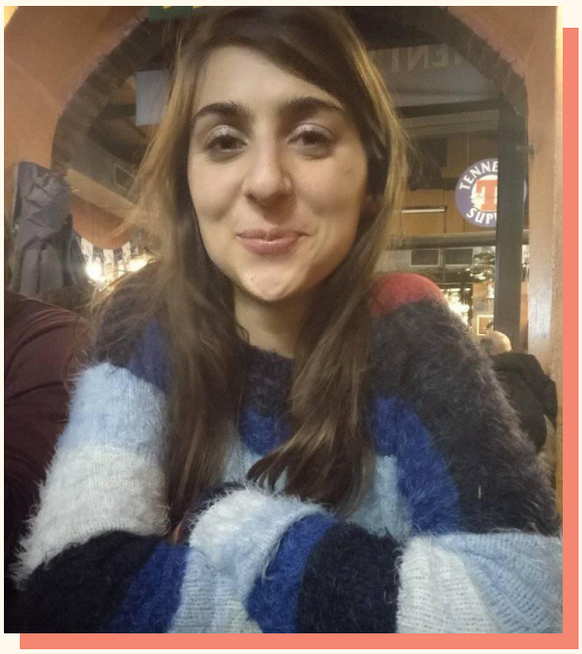
What kind of information about Milan do you usually look for?
I've just moved to Milan, so actually I need quite a lot of information, starting from ruotes on Google Maps, reviews on Tripadvisor, events on Facebook... I try to get as much information as possible from people that have lived in Milan for longer tha I did.

How often do you use public transport in Milan?
I use it everyday because I live in Milan but I work in San Donato Milanese. Right now I'm still "exploring" the city, so I try to reach as many places as possible also during the weekend.

Have you ever had problems with public transport due to the lack of information?
No actually, the point is that I just need more time to get used to it. The positive thing is that the public transport here makes me feel safe and relaxed, because transportation gets stuck or has problems very rarely.

Do you use apps or websites related to Milan?
I use BikeMi quite a lot, because it's such a functional service and it's really funny to explore the city in that way. Apart from that, I haven't used any other apps.

Would you like to give information to other people through an app or website? Or would you prefer an app that informs you without requiring your involvement?
Well, that would be very helpful for me. Maybe I'm a little bit "old-fashioned", but for example... The first day I came here I couldn't find a supermarket. I tried to figure it out on Google Maps for a bit, then I asked a man in my neighbourhood. Not only he explained to me where the supermarket was but, when I told him I had just arrived to Milan, he gave me some very useful tips about my neighbourhood, things that I would have never find on the Internet. So I would be happy to help someone else.



Name: Claudia Di Felice
Age: 24
Born in: Teramo
Lives in: Milan
Job: intern

If you were to describe Milan with just one word, what would it be?
The only word that comes to my mind is beautiful. I do believe people criticizing Milan never bothered to explore it in a proper way.

What kind of information about Milan do you usually look for?
I use channels like ATM, Eventi Milano or other online magazines. One event that comes to mind is that, for example, there are markets in almost every neighbourhood, but many areas of Milan are not treated in the same way. I noticed that in Piazzale Lagosta is like streets are cleaned better than here, so I asked AMSA why. It would have been better for a citizen to know that through the website they can send complaints or reports.

How often do you use public transport in Milan?
I use the yellow line everyday to go to work. On the evenings and weekends I usually move by car.

Have you ever had problems with public transport due to the lack of information?
There was this one time when I had to take mu daughter to the hospital, and we were stuck in the traffic for like two hours and I didn't know what had happened. Some operators told me it was just due to the traffic jam, then that a truck had an incident.

Do you use apps or websites related to Milan?
Well I'm not a big fan of the website of the City of Milan, I had to use it for registration at schools or summer camps. And I don't use many apps in general.

Would you like to give information to other people through an app or website?

Name: Margherita Prusciano
Age: 50
Born in: Brindisi
Lives in: Milan
Job: consultant

Or would you prefer an app that informs you without requiring your involvement?
No, that would be very helpful. For example, I have to take the yellow line and I realize it's stuck, so I send a message to my office group. But on WhatsApp it's useful only for me, it's not a 360 degrees information for all citizens.

If you were to describe Milan with just one word, what would it be?
The words are beautiful and European.

phone interview

Name: Marina Ripamonti
Age: 57
Born in: Milan
Lives in: Milan
Job: secretary

What kind of information about Milan do you usually look for?
Be warned, you're talking to a 58-year-old person, who's used to read information on paper. Paper is no longer used, so now the only platforms I rely on are the ATM app and Comune di Milano website: there you can find anything you want.

How often do you use public transport in Milan?
I don't have a driving license, so public transport is my "third leg". At the metro stops you get all the information you need, about when the trains are arriving, their delay... but without the ATM app, it would be really difficult to navigate the city in a proper way. I know Milan by heart, because I've always lived here, but the ATM app gives me validation when I need to give directions.

Have you ever had problems with public transport due to the lack of information?
No, I think the information is provided quite effectively. I was born in '61, and back then we moved around anyway, but now life is better.

Do you use apps or websites related to Milan?
As I said, I just need the ATM app and the Municipality website.

Would you like to give information to other people through an app or website? Or would you prefer an app that informs you without requiring your involvement?
Of course I would! For example, I get a lot of tips on Facebook (the only social media I use). If I hadn't read on Facebook that in the San Siro area (where I live) people were leaving poisoned meatballs around, I would have walked my dog there, completely unaware. But you can also give a lot of other information, for example opinions about an area, like Quarto Oggiaro, that's terrible. I think that today word-of-mouth is fundamental, I don't book anything without reading the reviews first.

If you were to describe Milan with just one word, what would it be?
Productivity. The things they say about Milan, that we work a lot, it's true. Many other things are not true, like that Milan it's dirty: you can find careless people in every city, and Milan is no worse or better than the others.

DATA SOURCES

Topic	Datasets features	Property of	Possible applications
Traffic	number of cars passing through a certain intersection. Update every 2/3 weeks	AMAT	For decision-makers -traffic forecasts based on historical data
Parking spots	-comparison of supply and demand -parking meter data -irregularity of parking	AMAT	For decision-makers -analyse irregularities and verify their repetition over time;
Bike sharing	/	AMAT	For decision-makers -Analyse usage data to meet demand by providing more bikes in the most frequented areas. For citizens -Combining bike availability data with weather data to encourage use when possible
Vehicles entering in Area B/Area C		AMAT	For decision-makers -traffic forecasts based on historical data

Topic	Datasets features	Property of	Possible applications
Air quality	hourly percentage of NO2, PM2.5 and PM10	E015	For decision-makers -combine the level of air quality with other data, to track down any correlations For citizens -plan their own route (especially for cyclists) depending on air quality
Weather	-weather -level of pollutants -heat discomfort -UV radiation	ARPA (via E015)	For decision-makers -denoting how change the modes of transport according to the weather conditions; -to encourage the use of the bike sharing services in case of good weather For citizens -to get traffic forecasts based on the weather
Events	-date -site -description	Local authorities (via E015)	For decision-makers -Strengthen lines of transport during events For citizens -combine events with mode of transport, to verify which are more easily reachable

Topic	Datasets features	Property of	Possible applications
Condominium car sharing service	-starting point -longevity -battery use -gender/age/status of driver's residence -frequency of use (both for cars and for user), -user satisfaction	Sharing Cities	For decision-makers -to study changes in the price of apartments and users behaviour after the introduction For citizens -combine the data on the availability of car with weather data and information on events nearby
Smart parking	-typology (standard, for disabled, unloading of goods, public transport) -usage data during daily/nighlty hours	Sharing Cities	For decision-makers -verify the number of residents of an area through the night usage data; For citizens -Book a parking space beforehand -combine information about events nearby with related data from parking
Smart lampposts	-weather -noise pollution -air quality -vehicles counting through cameras	Sharing Cities	For decision-makers -combine the data of noise pollution/ atmospheric with the traffic information, to understand how they could influence each other

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