

# SMART CITIES AND INTEGRATED MOBILITY

## A WHITE PAPER



JUNE 2018

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Driving Smart Cities  
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## **FOREWORD**

In the last 15 years, the concept of a Smart City has become a focus of public attention as an answer to emerging needs and challenges of urban areas. Fueled by the potential of ICT (information and communication technologies), cities around the world are adopting a variety of strategies to improve economic competitiveness, sustainability, social and capital attractiveness and most importantly quality of life for everyone. There is a wide spectrum of strategies that cities can put forward to become smarter but it is not always that obvious to select those that fit their specific needs and ambitions. Decisions are often the results of important trade-offs and identifying the right balance requires cities to be fully aware of their forces and weaknesses.

There seems to be an agreement that additional literature is still welcome with respect to Smart City processes and strategies, namely to provide more guidance to cities in-search for answers in their complex task of developing their smart mobility strategy. This White Paper builds on existing literature by providing insights on the development of smart cities collected through in-depth interviews with 5 key smart cities highlighted at the Montreal ITS World Congress 2017: Columbus (USA), Singapore, Copenhagen (Denmark), Christchurch (New Zealand) and Montreal (Canada).

It also relies on two additional sources of information: (1) an online survey shared through the regional and national ITS Associations networks and (2) an in-session survey conducted during the Network of ITS Associations' executive session at the ITS World Congress 2017 in October. The research team thank Ertico, ITS Asia-Pacific, ITS America and ITS Canada for providing them with this valuable opportunity. They also wish to acknowledge the contributions of representatives of the ITS Associations namely David Cummins, Michael de Santis and Eric Sampson. The participants of the In-session Interactive Survey and the Web Survey are also to be thanked: they provided relevant information on the Smart City concept and processes.

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# 1 INTRODUCTION

In the last 15 years, the concept of Smart City has become a focus of public attention as an answer to emerging needs and challenges in urban areas. Fueled by the potential of ICT (information and communication technologies), cities around the world have adopted a variety of strategies to improve economic competitiveness, sustainability, social and capital attractiveness and most importantly quality of life for everyone. There exists a wide spectrum of strategies for cities to become smarter, but it is not always obvious which are most suited to their specific needs and ambitions. Decisions are often made based on trade-offs, and identifying the right balance requires cities to be fully aware of their strengths and weaknesses.

While the concept of Smart City refers to a variety of dimensions (smart economy, smart governance, smart environment, smart living, smart people and smart mobility)<sup>1</sup>, this white paper focuses on the transportation component. Modern and sustainable transportation systems, supported by a wide array of technological innovations and initiatives, enable the efficient mobility of people and goods within a city while connecting it with the rest of the world. While considering the most promising technology-based strategies, it is important to keep in mind that relying on technology will only get cities so far<sup>2</sup>. In the larger context of smart cities, developing smart mobility relies on a good understanding of the interrelationship and synergy with other dimensions of Smart City development.

There seems to be an agreement that further literature is required with respect to Smart City processes and strategies, namely to provide more guidance for cities in search for answers to their complex task of developing their smart mobility strategy. This white paper builds on existing literature by providing insight on the development of smart cities collected through in-depth interviews with 5 key smart cities highlighted at the Montreal ITS World Congress 2017: Columbus (USA), Singapore, Copenhagen (Denmark), Christchurch (New Zealand) and Montreal (Canada)<sup>3</sup>. It also relies on two additional sources of information: (1) an online survey shared through the regional and national ITS Associations networks and (2) an in-session survey conducted during the annual ITS association's executive session at ITS World Congress 2017 in October.

The document first describes the methodology behind the construction of this White Paper. It then presents an overview of what a Smart City is with respect to transportation components and gathers the most common elements from the literature. The following section focuses on the 5 case studies and discusses their

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<sup>1</sup> Giffinger, Fertner, Kramar, & Meijers, 2007; Manville et al., 2014

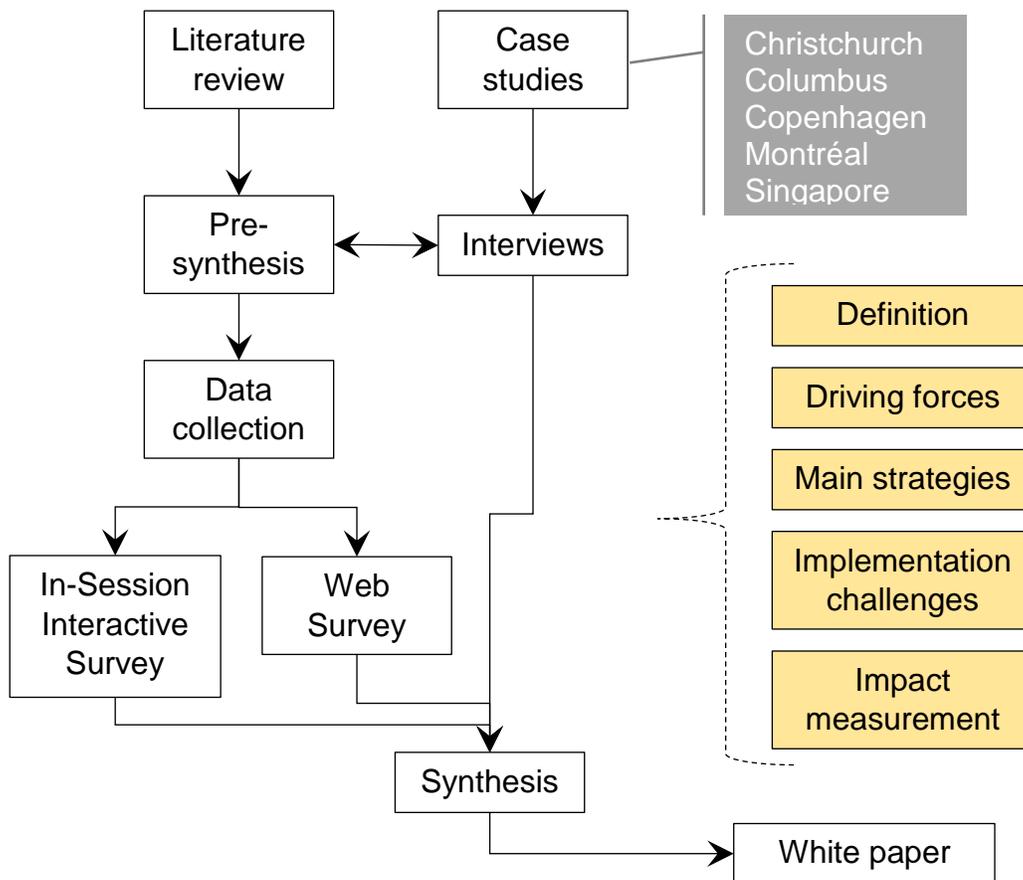
<sup>2</sup> Banister, 2011

<sup>3</sup> Thanks to Ryan Cooney (Christchurch), Mandy K. Bishop (Columbus), Stéphane Guidoin (Montreal), Alan Quek (Singapore) and Mads Gaml (Copenhagen) for their contributions

overall characteristics and key components. This paves the way for discussions on driving forces behind Smart City initiatives as well as for the main strategies underpinning smart mobility. In section 5, implementation challenges and obstacles are discussed. Section 6 presents an often-overlooked component of Smart City strategies: impact measurements. The white paper concludes with some prospective elements.

## 1.1 GENERAL METHODOLOGY

This white paper is the result of a series of steps and events. The various questions surrounding the concept of smart cities were initially documented through a review of the literature and interviews with representatives from the 5 case studies. This led to the identification of the key perspectives to be addressed such as the definition, driving forces, main strategies, implementation challenges and impact measurement of smart cities. These two threads of information were used to articulate a first synthesis and develop a data collection method including an In-Session Interactive Survey among ITS representatives (36 respondents), during the 2017 ITS World Congress in Montreal, and a Web Survey (15 respondents). All these elements contributed to the development of this white paper. A more detailed view of the process leading to the development of the white paper is available in the appendix section.



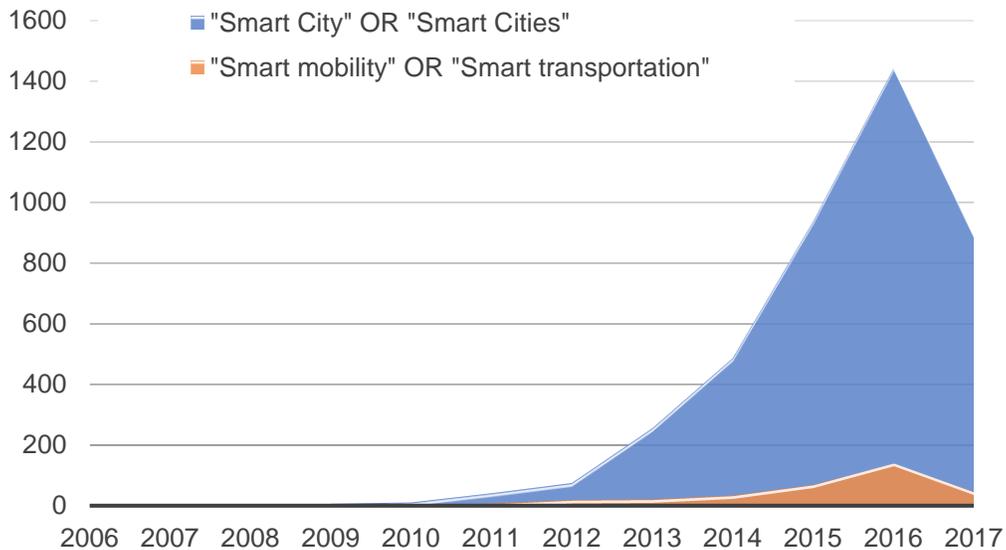
**FIGURE 1.1 : MAIN STEPS IN THE DEVELOPMENT OF THE WHITE PAPER**

## 1.2 WHAT IS A SMART CITY?

Being labelled as a Smart City has definitely become a current trend among public organisations. However, a relevant question to ask is whether this labelling has the same meaning for all those organisations and cities around the world. The literature review and study of the 5 case studies are used to define the components of a Smart City.

### 1.2.1 LITERATURE PERSPECTIVE

In the last 20 years, the interest in the concept of Smart City has grown rapidly as observed by the rising number of scientific publications as well as government, NGO, research institute and consulting firm reports on the topic. To show the extent of this trend, FIGURE 1 illustrates the number of scientific papers and Conference proceedings found on the Web of Science using the key words “Smart City/Cities” and “Smart Mobility/Transportation”.



**FIGURE 1.2 : NUMBER OF PUBLISHED AND PROCEEDING PAPERS ON SMART CITIES AND SMART MOBILITY<sup>4</sup>**

In their conceptual paper, Nam and Pardo (2011) propose three dimensions of smart cities: (1) technology (digital, intelligent, ubiquitous, wired, hybrid and information cities), (2) people (creative, learning, humane and knowledge cities) and (3) community (smart community). These three dimensions are supported respectively by technological, human and institutional factors. This conceptual framework supports the idea that a Smart City goes beyond the more traditional technologically driven concept. In such, it is the addition of people and institutions that transform a city to become more inclusive and broader than its counterpart ‘intelligent city’, defined<sup>5</sup> as a top-down concept centered on technology.

There are also many discussions about the meaning and legitimacy of both the concept and the presumption of smart cities. Some authors<sup>6</sup> argue that the large variety of needs and contexts (developed versus developing countries for instance) that drive the adoption of Smart City explain the current absence of a shared definition at a global scale. Other authors<sup>7</sup> argue that the Smart City label is a fuzzy and imprecise concept, with unspoken assumptions, that may lead cities to proclaim themselves as being ‘Smart’ while at the same time self-congratulating their initiatives and achievements in this regard.

Ramaprasad et al. (2017) propose a relevant point of view around the idea of developing a unified definition of a Smart City. They propose to define a Smart City using “a high-level ontology” including concepts defining both the smart and the

<sup>4</sup> Web of Science, 2018

<sup>5</sup> Ben Letaifa (2015)

<sup>6</sup> Neirotti, De Marco, Cagliano, Mangano, and Scorrano (2014)

<sup>7</sup> Nam and Pardo (2011), Hollands, (2008)

city components. They use four components to describe the smart aspect (structure – infrastructure or services for instance -, functions – monitor or communicate for instance -, focus – cultural or environmental for instance- and semiotics – data or information for instance) and two components to define the city aspect (stakeholders – citizens and professionals for instance- and outcomes – sustainability or equity for instance). Their definition is the combination of all these components and aims to be fully inclusive.

Other definitions of both Smart City and smart mobility have been proposed:

*“A smart city is a framework, predominantly composed of Information and Communication Technologies (ICT), to develop, deploy and promote sustainable development practices to address growing urbanization challenges”<sup>8</sup>*

*“A Smart City is a city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership. These solutions are developed and refined through Smart City initiatives, either as discrete projects or (more usually) as a network of overlapping activities.”<sup>9</sup>*

*“A city may be called ‘Smart’ ‘when investments in human and social capital and a high quality of life, with a wise management of natural resources, through participatory governance.”<sup>10</sup>*

*«Generally, a smart city is a high-tech intensive city that connects people, information, and city elements using new technologies and infrastructure to create a sustainable, greener city, competitive and innovative economy, and an enhanced life quality. »<sup>11</sup>*

*«Smart Mobility is largely permeated by ICT, used in both backward and forward applications, to support the optimization of traffic fluxes, but also to collect citizens’ opinions about liveability in cities or quality of local public transport services ».*

<sup>12</sup>

*«Smart mobility refers to local and supra-local accessibility, availability of ICT, modern, sustainable, and safe transport systems»<sup>13</sup>*

Several authors have provided definitions of a Smart City, aiming to advance knowledge on the dimensions, key components and strategies that underpin this label. Various definitions have been proposed in the literature, relying on important key words such as: technology, information, efficient, sustainable, equitable, livable, critical infrastructure, monitoring, intelligent, interconnected, data

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<sup>8</sup> <https://www.gemalto.com/companyinfo>

<sup>9</sup> European Parliament (2014)

<sup>10</sup> Schaffers et al. (2011)

<sup>11</sup> Tahir and Abdul Malek (2016)

<sup>12</sup> Benevolo et al. (2016)

<sup>13</sup> Monfaredzadeh and Berardi (2015)

acquisition, knowledge, freedom, accessibility, modelling, optimisation, quality of life, and so forth, as reflected in the word cloud below (FIGURE 1.3). We find definitions focusing on the technological aspects, the instrumented citizens or global optimisation goals.



FIGURE 1.3 : KEYWORDS REFLECTED IN SMART CITY DEFINITIONS

### 1.2.2 FIVE RELEVANT POINTS OF VIEW

At the center of this white paper stand five cities that have accepted to contribute to the development of a grounded understanding of smart cities through their own understanding and process. Their points of view are echoed at various points of the document, including here with respect to the definition of a Smart City. Officials from these cities were interviewed and asked two questions: “What is a Smart City?” and “Why is your city smart?” Not that surprisingly, they all provided different answers. Furthermore, there is a discrepancy between the theoretical definition of a Smart City they provide and their understanding of how it is embodied in their own city. The answers provided by these cities are reported below.

## **WHAT IS A SMART CITY?**

### **Christchurch**

*"A Smart City is one who is responsive to his community needs in real time, engages with the community and enables the community to engage with it."*

### **Columbus**

*"A Smart City is a city that makes data driven decisions to enhance its residents and visitors' life."*

### **Copenhagen**

*"A Smart City is a city which is very good in using data but a Smart City is also a city which is using the infrastructure that they always added. So, this is not only about the 0 and 1 but it is also about the physical structure of a city."*

### **Montreal**

*"A Smart City is a community that uses technologies and social innovations to improve the life quality of all his citizens."*

### **Singapore**

*"A smart nation is one that honors the technologies to improve the lives of the people."*

## 2 CASE STUDIES – 5 INSPIRING SMART CITIES

As mentioned previously, this document puts forward the experience of five cities that were highlighted during the Montreal ITS World Conference due to their exemplary advancement as smart cities. While theory and definition help conceptualise what smart cities are and what their common features should be, case studies pragmatically expose what it takes to move forward and illustrate the diversity of paths that can be taken to move forward. Below are fact sheets describing the experience and perspectives of these cities<sup>14</sup>.

The content was constructed both using publicly available information and elements from discussions and survey answers for the five cities. Quick facts represent the best assessment from our research team according to the available information.

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<sup>14</sup> Icons used in the factsheets: *Star* by Benjamin Sommerlad, *dollar* by Adrien Coquet, *electric* by Landan Lloyd, *Bus* by i cons from, *Integrated Management* by Becris, *group* by Setyo Ari Wibowo, *Share* by Gregor Cresna, *Bike* by logan, *Traffic Light* by andriwidodo from the *Noun Project* (thenounproject.com)



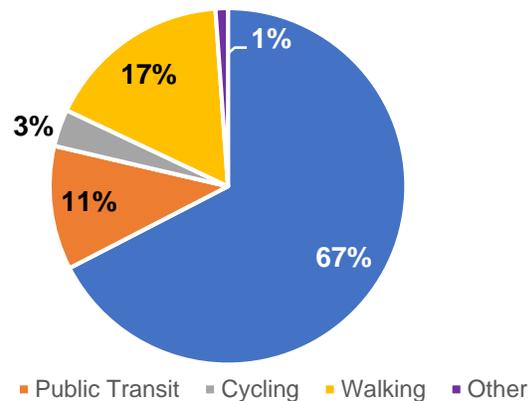
# CHRISTCHURCH NEW ZEALAND

**“Christchurch is becoming a Smart City because we are looking at new ways of solving problems and we are bringing technology to the table. We are also looking at opportunities to do things differently.”**

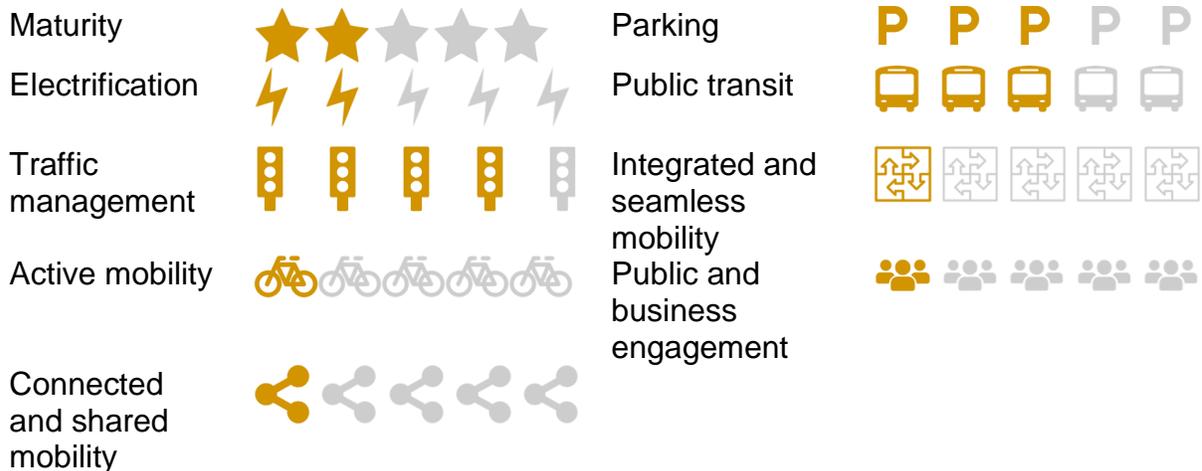
– *Ryan Cooney, Manager, Transport Operations Center, Christchurch City Council*

Population (metropolitan area)<sup>1</sup>  
341,469  
Area (metropolitan area)<sup>2</sup>  
608 km<sup>2</sup>  
Population density<sup>2</sup>  
270/km<sup>2</sup>  
GDP (New Zealand, 2016)<sup>3</sup>  
G\$185  
GDP (Per Capita, 2016)<sup>3</sup>  
\$36,842

Modal Share in 2011  
Canterbury Province<sup>4</sup>



## QUICK FACTS ABOUT SMART CITY INITIATIVES



## TRIGGERS

The genesis was the 2011 earthquake by which the city of Christchurch and its infrastructure were badly affected. Following the two devastating earthquakes of 2010 and 2011, where around 1500 commercial buildings in the central business district of Christchurch were destroyed, and the city began to rebuild; this time using sensors and smart technologies.

According to Ryan Cooney, Manager of Transport Operations Center at Christchurch City Council: *“Following the earthquakes, Christchurch found itself in a situation with relatively low resources in terms of funding, personnel, and equipment. We were forced to think very differently about how to overcome the challenges that we were facing and to efficiently solve our problems.”*

Christchurch took these devastating crises and transformed them into an opportunity to rebuild the city using a carpet of sensors, data collection devices and smart technologies, to monitor the slew of environmental factors that impact urban life and improve the functionality of the city and the life of its citizens.

## PRIORITIES AND APPLICATION FIELDS



The priority for Christchurch was to improve the city’s traffic problems and minimize delay. Hence, the travel information channel is developed to inform travelers about construction sites and to suggest the fastest possible routes to their destinations. Also, the city has introduced a smart rubbish collection system in which bins are equipped with sensors that can detect when they are almost full and send an alert to the contractors to empty them. Another priority of Christchurch was to prepare the ground for the introduction of autonomous vehicles. The main application of such technology in Christchurch is to provide autonomous shuttles and bus services.

## FOCUS ON: TRAFFIC MANAGEMENT

The destructive series of earthquakes in 2010 and 2011 caused significant disruption and damage to a large portion of the central business district of Christchurch. Much of the infrastructure, including pipelines, roads, and buildings had been impacted. Apart from numerous buildings and other infrastructure, around 45% of Christchurch roads were damaged and up to 50,000 repairs were needed. Major roads to the Port had been closed, which greatly affected freight movement, businesses were relocated and land uses were changed. As a result, travel patterns were changed and traffic congestion increased. Major roads were closed and the movement of people and goods became a major issue<sup>5</sup>.



*Fitzgerald Avenue (Christchurch) after the February 2011 earthquake (left) and in December 2012 after extensive roadwork (right)*

To facilitate traffic flow, a management center has been developed to centralize all the available information about road closures and construction affecting the traffic flow. An online website has also been developed so that travellers could easily find the fastest route to their destinations, and would have access to information such as planned events on the road network, delays and road closures, and weight restrictions on bridges.

## CHALLENGES

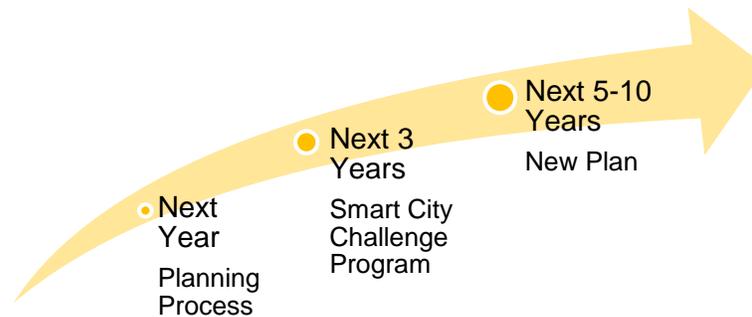
Christchurch is facing three main challenges in its path to becoming a Smart City. The first challenge that was brought up was the adaptation of the population with the rapidly changing face of Christchurch. Since many new technologies have been implemented in Christchurch in a short period of time, people have had less time to prepare themselves and get used to them. Second, securing the funding needed for changing the existing infrastructure where needed, was mentioned as a big challenge. Also, legislative issues and bureaucracies make the adoption and implementation of some new technologies, such as autonomous vehicles, more challenging and time consuming.

## IMPACT MEASUREMENT

Several measures have been adopted to evaluate the impact of the implemented strategies. For instance, customer feedback is collected through communication channels, such as the travel information channel and its Facebook page. Responsive measures are taken accordingly if required.

Moreover, Bluetooth devices have been implemented on the road network to verify road counts and track the travel time and its variations. Also, real-time bus tracking systems were implemented and the real-time traffic flow on freight and public transport routes is monitored.

## VISION OF THE FUTURE



## HOW TO BECOME A SMART CITY

The Smart City of the future will be:

### RESPONSIVE      ENGAGING      ENERGETIC

*“Most cities in New Zealand follow the traditional path to become a Smart City. In other words, they exhaustively evaluate the existing needs of the city and study different strategies and technologies to address those needs and prepare detailed implementation plans and strategic documents, which then undergoes complicated legislative processes to be approved.*

*In Christchurch, because of the special circumstances following the earthquakes, we did not have the time, budget or the human resources to follow the traditional path. We needed to act quickly and efficiently. Our strategy was to grab opportunities, react to it efficiently and satisfy our needs!*

*In my opinion a city needs a fair share of both of these strategies to become a Smart City. On one side, if you put too much legislation and regulations you will eventually discourage people and kill the positive vibe, which is needed when you are moving towards a Smart City. On the other side, lack of control always results in chaos and too much entropy. Therefore, we need to have a combination of both.”*

– **Ryan Cooney**, Manager, Transport Operations Center, Christchurch City Council



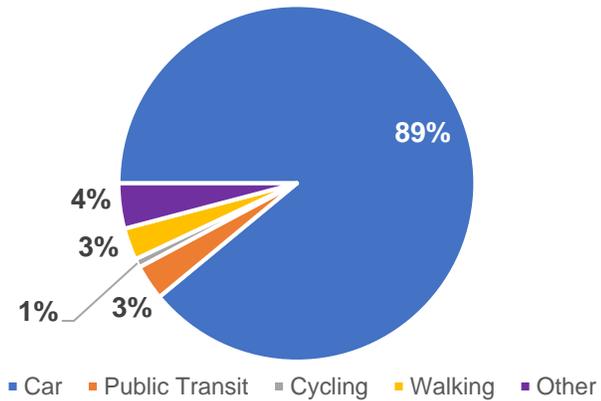
# COLUMBUS OHIO, UNITED STATES

**“Columbus is a Smart City because we are trying to solve some of the social issues in our community using data.”**

– Mandy Bishop, Smart Columbus Program Manager

Population (metropolitan area)<sup>6</sup>  
1,901,974  
Area (metropolitan area)<sup>7</sup>  
8,208 km<sup>2</sup>  
Population density  
231,7/km<sup>2</sup>  
GDP (Total, 2016)<sup>8</sup>  
M\$130,758  
GDP (Per Capita, 2016)<sup>8</sup>  
\$56,082

Modal Share in 2013  
City of Columbus<sup>9</sup>



## QUICK FACTS ABOUT SMART CITY INITIATIVES

Maturity



Parking



Electrification



Public transit



Traffic management



Integrated and seamless mobility



Active mobility



Public and business engagement



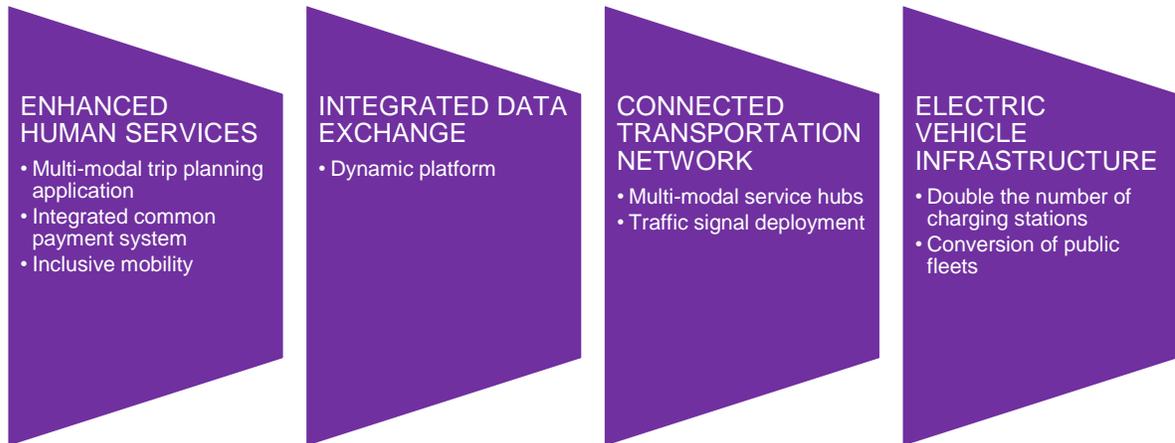
Connected and shared mobility



## TRIGGERS

For the representatives of Columbus' Smart City project, mobility is the great equalizer, i.e. giving access to transportation could help solve social issues. They also believe that technology can help. It began with the need to improve security, health, access to job and education in some districts of Columbus, and was helped by the Smart City Challenge in the USA which has been the catalyst for the region of Columbus to launch into the Smart City project.

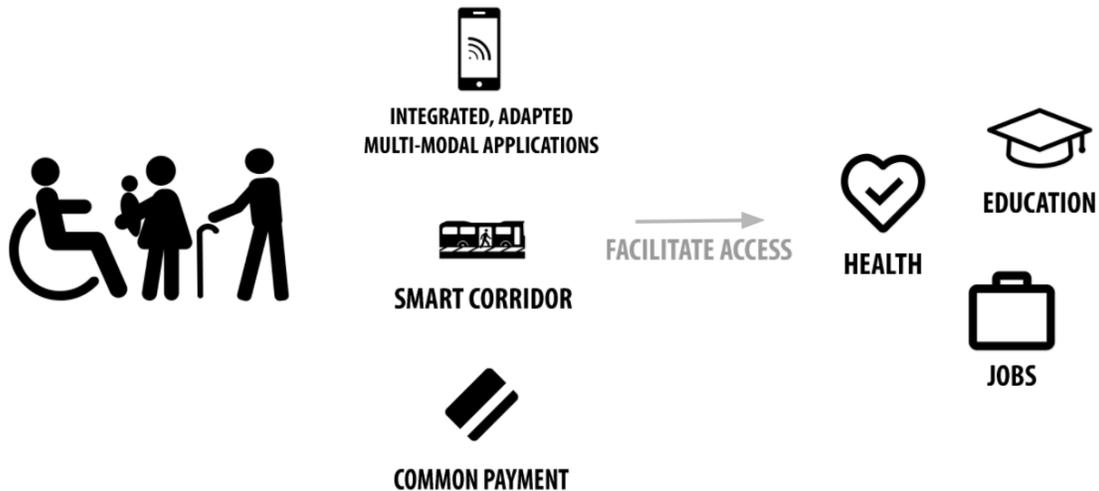
## PRIORITIES AND APPLICATION FIELDS



The city of Columbus plans to set up and apply four elements, required for a Smart City, to meet urban challenges<sup>10</sup>. These are the ones cited above: a connected transportation network, an integrated data exchange network, systems to support enhanced human services and infrastructure elements to support smart grid and vehicle electrification solutions.

## FOCUS ON: ENHANCED HUMAN SERVICES

The city of Columbus chose to put the emphasis on citizens, particularly the disadvantaged ones who live in isolated districts. In those districts, citizens have a very poor access to education, jobs and health services. To improve accessibility, the city of Columbus has set up several actions, mainly in the form of Mobile Apps<sup>11</sup>. For example, a mobile application was developed for cognitively impaired people allowing them to use their device to access public transport instead of on-demand services. A common payment application has also been created to help unbanked people, numerous in those isolated districts, to improve their access to public transportation. Aside from these applications, they also created a smart corridor with a bus rapid transit (BRT) line, upgraded transit stops, more frequent bus service, faster travel times and enhanced services such as pedestrian detectors, Wi-Fi and information hubs.



Another application was designed to improve access to maternity care for low income pregnant women<sup>11</sup> in areas with a high infant mortality rate. In those areas, it is common for pregnant women or new mothers to miss their medical appointments due to unreliable bus services to health centers, clinics and hospitals. As a result, they do not get to see a doctor often enough during and after giving birth, which is the cause of a lot of new born deaths. That is why Columbus, in partnership with the county of Franklin and the program “Celebrate 1” are trying to set up this application. The application allows a pregnant woman to book a flexible trip to the doctor, so that if an unforeseen delay happens on her trip to her appointment, she can reschedule very quickly. The application would also be linked to doctors’ timetables so that if there is traffic and the woman is late to her appointment, the doctor is informed and the appointment can be rescheduled so that the pregnant/young mother still gets to see the doctor.



## CHALLENGES

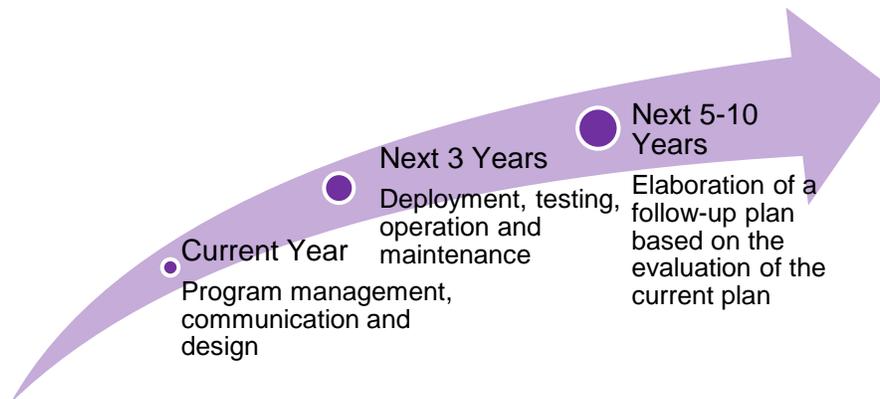
According to the representatives of the smart Columbus project, the main challenges they must face is centered around the mind shift necessary for civil engineers who are used to detail. But now they need to accept and try to provide more informal propositions because the projects are more informal too. It is also a question of learning new technologies, a completely new glossary and to work with IT engineers who are used to working in a more traditional way.

## IMPACT MEASUREMENT

Columbus has put in place several measures and methods through which performance will be evaluated to determine the effectiveness of the Smart Columbus deployments<sup>12</sup>. Each performance measure was established through collaboration between the City of Columbus and the USDOT. Performance measures for Smart Columbus were designed to measure the impact of the projects on the region of Columbus and to provide a framework for the remaining tasks of data collection, evaluation, and reporting.

A document identifies the measures for 15 main projects of Smart Columbus. Various indicators will be analyzed using specific methodologies. The type of methodology that each indicator is evaluated with is based on data availability and interpretation by evaluators. For example, concerning the project Mobile Assistance for cognitive disabilities, which aims at moving certain paratransit riders to fixed bus routes, the number of customer trips moved from paratransit to fixed routes will be measured, the method applied is a before-after analysis using data from the Central Ohio Transit Authority.

## VISION OF THE FUTURE



## HOW TO BECOME A SMART CITY

The Smart City of the future will be:

**CREATIVE      INNOVATIVE      DATA-DRIVEN**

*“The best start to build the roadmap to become a Smart City is first to is to define the problem which needs to be solved and then get the right people working on it.”*

*– Mandy Bishop, Smart Columbus Program Manager*



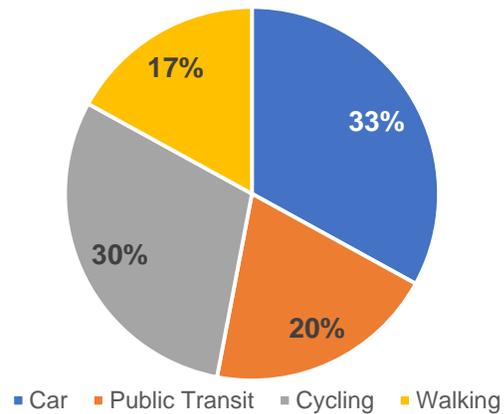
# COPENHAGEN DENMARK

**“Copenhagen is a Smart City because we are trying to incorporate data, incorporating solutions which are built upon a good market dialogue and about user needs.”**

– Mads Gaml, ITS Program Manager, City of Copenhagen

Population (metropolitan area)<sup>13</sup>  
2,025,171  
Area (metropolitan area)<sup>14</sup>  
2,768.6 km<sup>2</sup>  
Population density  
731/km<sup>2</sup>  
GDP (Total, 2012)<sup>13</sup>  
98,832.25M US\$  
GDP (Per Capita)  
48,801 US\$

Modal Share in 2014  
City of Copenhagen<sup>15</sup>



## QUICK FACTS ABOUT SMART CITY INITIATIVES

Maturity



Electrification



Traffic management



Active mobility



Connected and shared mobility



Parking



Public transit



Integrated and seamless mobility



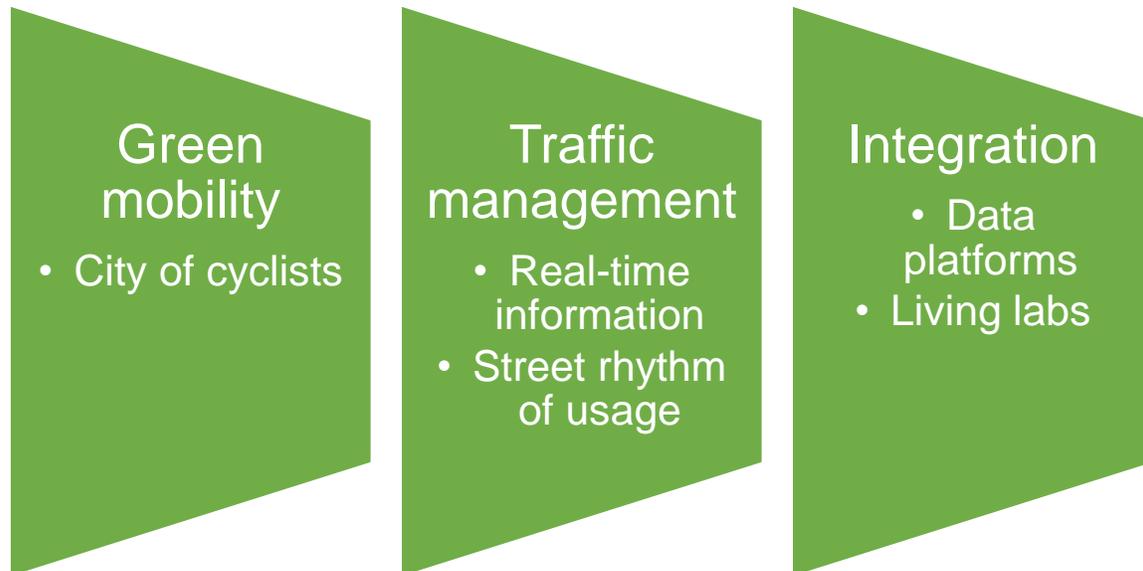
Public and business engagement



## TRIGGERS

One of the main triggers behind Copenhagen's Smart City strategy is their ambitious project to become the world's first carbon-neutral city by 2025 (CPH 2025 climate plan<sup>16</sup>). This, coupled with a strong political focus and an extensive plan to promote the use of bicycle, would induce sustainable Smart City initiatives.

## PRIORITIES AND APPLICATION FIELDS



Copenhagen articulates its Smart City plan across various axes. Its ITS Action Plan 2015-2016<sup>17</sup> states five main development categories as Mobility & Green driving, Traffic safety, Street rhythm of usage, Data & Traffic management and Information & Services. These ITS strategies are in support to the CPH 2025 Action Plan, which also states a City of Cyclist<sup>18</sup> development to substantially promote the use of the bicycle. Copenhagen's Solutions Lab<sup>19</sup> in part of the "Integration" strategy, where open-data and data exchange initiatives are made available to stimulate innovation, and real test areas are created to put new technologies into practice.

## FOCUS ON: GREEN MOBILITY

CPH 2025 set a goal to Copenhageners to make 75% of their journeys either on foot, bike, or by public transportation. Also, half of work and school related trips would be done using a bicycle. This is a serious goal for a city to achieve, even for one with an already substantial bike modal share. The green mobility strategy integrates both technology and a sustainable ideology.

A full biking strategy (2011-2025)<sup>20</sup> for the city is described. With respect to travel time, the city looks to increase its network of bicycle lanes with dedicated infrastructure like “Superhighways” or short cuts to decrease the average time travel (reduction of 15% in 2025 from 2010 level). ITS are applied to create “green wave” routes, meaning more fluid trips with less stops. Implementation of a new bike-sharing service and e-bike solutions are also considered. Real-time information dedicated to cyclists for travel time estimation are already established, but some real-time mitigation routes for bike users would be proposed with the eventual integration of a traffic management system.

With respect to safety, traffic policies and intersection redesigns are considered. A smart lighting system may be integrated to help cyclists and pedestrians at night while reducing energy consumption. Cargo bikes would also be promoted as a better replacement for conventional vehicles and dedicated parking spaces are planned to accommodate them.

The city has a project called “street rhythm of usage” to dynamically assign street space. Streets would be dynamically transformed during rush hour or other events to prioritize public transit and bicycles.

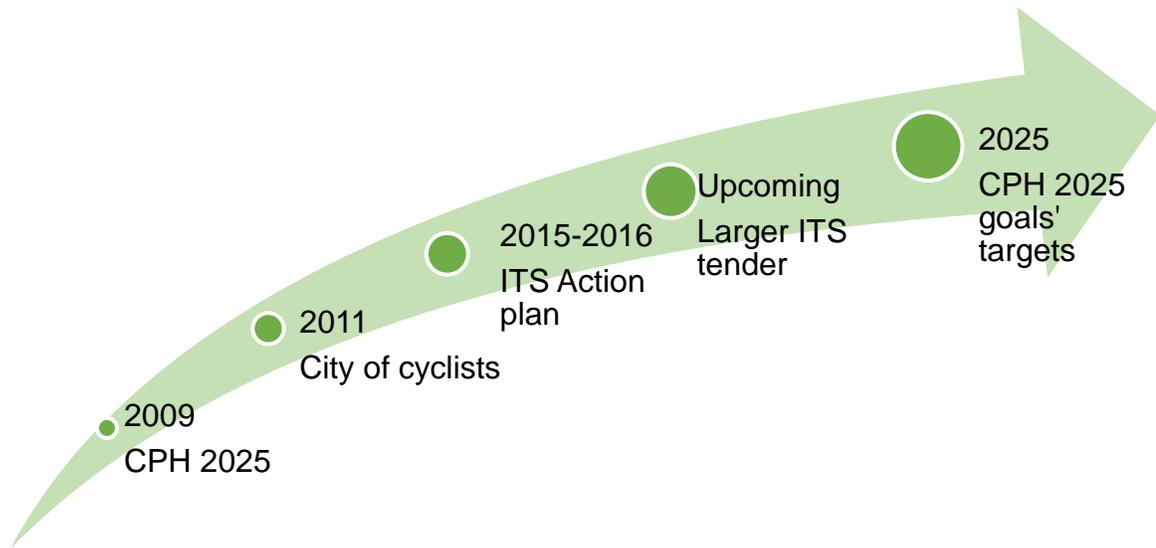
## CHALLENGES

One of the identified challenges is how the classic market is being confronted by Smart City initiatives. This currently challenges the way organizations and the city work together. There is a need for more openness between them, and an understanding that Smart City initiatives are about integration and collaboration. While Copenhagen has a substantial start-up community (more agile)<sup>21</sup>, those may be limited in large-scale deployment. Privacy is also brought up as a major concern. With more ways to easily capture passive data streams, the storage and use of these sensible data is something to be looked at closely. Finally, citizens’ needs must be addressed, not the technology itself.

## IMPACT MEASUREMENT

Numerous passive data streams are collected to track the city’s performance on mobility. Aside from the more traditional journeys by car, public transit, walk or bike that are captured in some street segments, Copenhagen’s Solution Labs integrates a test area to assess the performance of new initiatives. What they call “Street Lab” has been part of the award winning “Connecting Copenhagen” project<sup>22</sup>. Different initiatives would be tested, smart parking for example, to validate the use of the right technology or process to respond accurately to the problem.

## VISION OF THE FUTURE



## HOW TO BECOME A SMART CITY

The Smart City of the future will be:

**CREATIVE      INNOVATIVE      DATA-DRIVEN**

While no single roadmap is applicable for each city in their Smart City process, an awareness exercise should be undertaken by each city: How they want to be smart? When they want to be smart? About what they want to be smart? These are questions cities should ask themselves, because they are in the best position to understand their needs and prioritize actions. In that sense, it is important not to put too much focus on technology, but rather on the needs of the citizens.



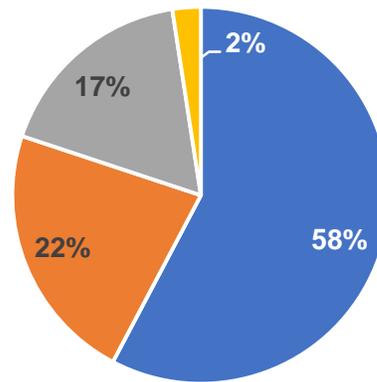
# MONTREAL CANADA

**“Montreal is a Smart City because we use citizen input and what they need in order to build a better city for them.”**

– *Stéphane Guidoin, Head of the Smart and Digital City Office (BVIN), City of Montréal*

Population (agglomeration)<sup>23</sup>  
2,033,189  
Area (agglomeration)<sup>23</sup>  
498 km<sup>2</sup>  
Population density<sup>23</sup>  
4,082/km<sup>2</sup>  
GDP (Total, 2015)<sup>24</sup>  
123,686 M\$CAN  
GDP (Per Capita, 2015)<sup>23</sup>  
62,135 \$CAN

Modal Share in 2013  
Montréal Urban Agglomeration<sup>25</sup>



■ Car ■ Public Transit ■ Active Transportation ■ Other

## QUICK FACTS ABOUT SMART CITY INITIATIVES

Maturity



Electrification



Traffic management



Active mobility



Connected and shared mobility



Parking



Public transit



Integrated and seamless mobility



Public and business engagement



## TRIGGERS

The principal reason that pushed the city of Montreal to enroll in a Smart City plan is the international vision from the mayor Mr. Coderre, to highlight Montreal as a different city, where it is good to live, where a lot of services are offered and easily accessible by citizens. The economic development is another incentive because Montreal as a Smart City wants to promote technological development.

## PRIORITIES AND APPLICATION FIELDS

### PARTICIPATORY DEMOCRACY

- View of performance indicators
- Online right of initiative for public consultations

### PUBLIC WI-FI

- MtlWiFi - Free public Wi-Fi harmonized experience
- Deployment of public Wi-Fi in Montreal's Underground City

### ULTRA HIGH-SPEED NETWORK

- Fibre optic to the home (FTTH)
- Inclusion of fibre infrastructure in the list of major projects

### DIGITAL PUBLIC SERVICES

- Online/mobile payment functionalities for public services
- Digital citizens ID

### SMART MOBILITY

- Collection of incomplete and missing mobility data
- Traffic light synchronization

### SMART ECONOMIC DEVELOPMENT

- Modification of procurement rules
- Montreal Technological Showcase initiative

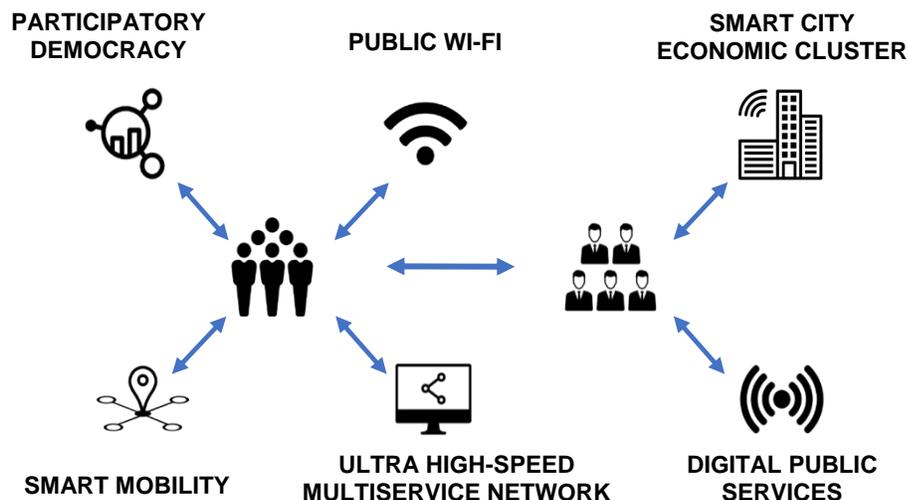
There are 9 projects in the Smart City Economic Cluster, 14 projects in the Participatory Democracy, 14 projects in the Smart Mobility, 5 projects in the Ultra High-Speed Multiservice Network, 11 projects in the Digital public services and 14 projects in the Wi-Fi public, for a total of 67 projects between 2015 and 2017 <sup>27</sup>.

## FOCUS ON: CITIZEN ENGAGEMENT

Citizen engagement is central in the Montreal process. The interim director of BVIN discusses about meetings with citizens:

*“We did it in different places, mainly in libraries, to make sure that really everybody felt that it was accessible. The thing that we understand now is that even by mentioning Smart City, it might make some people uncomfortable because they would think it is about technology. So now we are moving more and more to not say Smart City, just say we want to do some engagement, we want to get the needs and I say it's probably the next phase of what we are doing which is just completely forget about the fact that we are discussing about Smart City and really just discussing about the needs and think about innovation and transformation to improve quality of life.”*

– *Stéphane Guidoin, Head of BVIN, City of Montréal*



The key feature of public engagement is a Web platform, [www.fairemtl.ca](http://www.fairemtl.ca), to encourage citizen mobilization about the many projects taking place as part of the “Montreal, Smart and Digital City”. The platform keeps its citizens informed on the progress of the projects and allows them to participate in its development. Above is a framework of the 6 main programs selected from the ideas submitted by citizens, the business community and public partners. As presented in the framework, 4 of these projects have been selected in collaboration with the citizens.

## CHALLENGES

*“The main difficulty is to constantly get the input from citizens while trying to deliver some solutions. It is very easy to get focused on delivering and then we tend to forget the needs, so there this real need to constantly check for what’s the input and what citizens want even when we are delivering”*

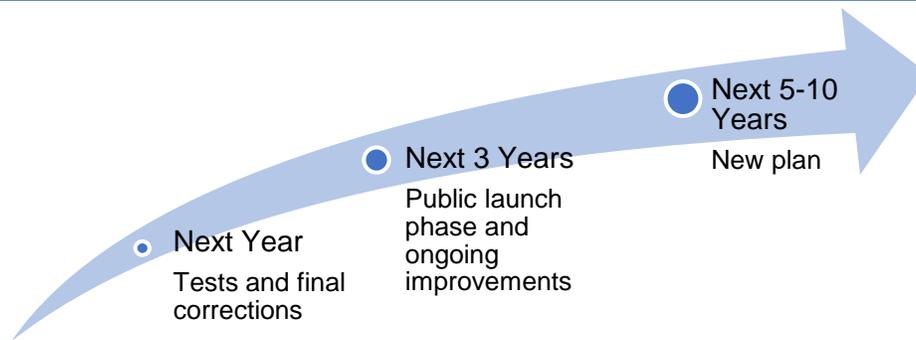
– *Stéphane Guidoin, Head of BVIN, City of Montréal*

## IMPACT MEASUREMENT

There are 13 proposed performance indicators in the Montreal Smart and Digital City 2015-2017 Action Plan:

1- Number of businesses and jobs in the Smart City cluster	8- Ultra-high-speed internet connection on the territory
2- Total venture capital investing in the community for Smart City	9- Connection to public Wi-Fi on the territory of Montreal
3- Number of small industries in the Smart City cluster and the value of their contracts	10- Access to real-time data on people and freight mobility
4- Part of numeric activities in range of municipal services	11- Use of real-time data on people and freight mobility
5- Percentage of citizens who take part in numeric participatory democracy	12- Behavior changes through the use of mobility data
6- Feeling of closeness from the citizens with instances and elected representative because of numeric	13- Number of projects implemented by «Plan d'action ville intelligente et numérique»
7- Citizens' participatory to democracy life by numeric	

## VISION OF THE FUTURE



## HOW TO BECOME A SMART CITY

Social and ethical dimensions are key to becoming a Smart City. Real-time data, and the internet of things, raise issues of privacy, consent and human dignity. They may lead to issues of segregation and discrimination, for instance for those not or less connected with technology. It is important to examine problems from a different point of view: understand the vulnerability and the ethical challenges we face and then identify solutions and ways to improve the situation and make sure the needs of all population segments, including vulnerable people, are accounted for.

The Smart City of the future will be:

**OPEN**

**RESILIENT**

**LIVING  
TOGETHER**



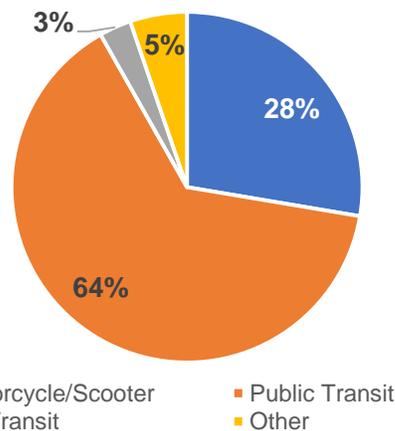
# SINGAPORE

**“Singapore is a Smart Nation because we make use of innovations and technologies to enhance the lives of people.”**

– Alan Quek, Senior Manager, Cooperative and Quality ITS, ITS Development Division, Land Transportation Authority

Population<sup>27</sup>  
5,607,300  
Area<sup>27</sup>  
720 km<sup>2</sup>  
Population density<sup>27</sup>  
7,797/km<sup>2</sup>  
GDP (Total)<sup>28</sup>  
G\$311  
GDP (Per Capita)<sup>28</sup>  
\$55,252

Modal Share in 2015  
Singapore<sup>29</sup>



## QUICK FACTS ABOUT SMART CITY INITIATIVES

Maturity	★★★★★	Parking	P P P P P
Electrification	⚡ ⚡ ⚡ ⚡ ⚡	Public transit	🚊 🚊 🚊 🚊 🚊
Traffic management	🚦 🚦 🚦 🚦 🚦	Integrated and seamless mobility	🗺️ 🗺️ 🗺️ 🗺️ 🗺️
Active mobility	🚲 🚲 🚲 🚲 🚲	Public and business engagement	👥 👥 👥 👥 👥
Connected and shared mobility	🔗 🔗 🔗 🔗 🔗		

## TRIGGERS

Singapore is a nation of 5.6 million people living on a 716 square kilometer island. They do not have any natural resources and their main resource is human capital. In order to grow and stay competitive in a globalized economy, Singapore has had to put restrictions on spatial development and to leverage technology from very early on in order to have the most efficient transportation system possible. Technology has always been a method for improving productivity of this very small country, to do more with less people and resources.

Singapore does not want to become a Smart Nation for the sake of it, but rather to solve the challenges inherent to its unique situation. Transportation is a lever to enable a better quality of life in the three components of people's lives: Live, Work and Play. Singapore's Smart Nation initiative comes from local challenges and not from an external push. The initiative is piloted by the Prime Minister's office and thus benefits from important political support.

## PRIORITIES AND APPLICATION FIELDS

### SMART TRAFFIC MANAGEMENT AND SMART TOLLS

- New generation toll system
- Adaptive, real-time traffic light optimization

### DATA COLLECTION

- Integrated data platform
- V2I and GPS-based data collection

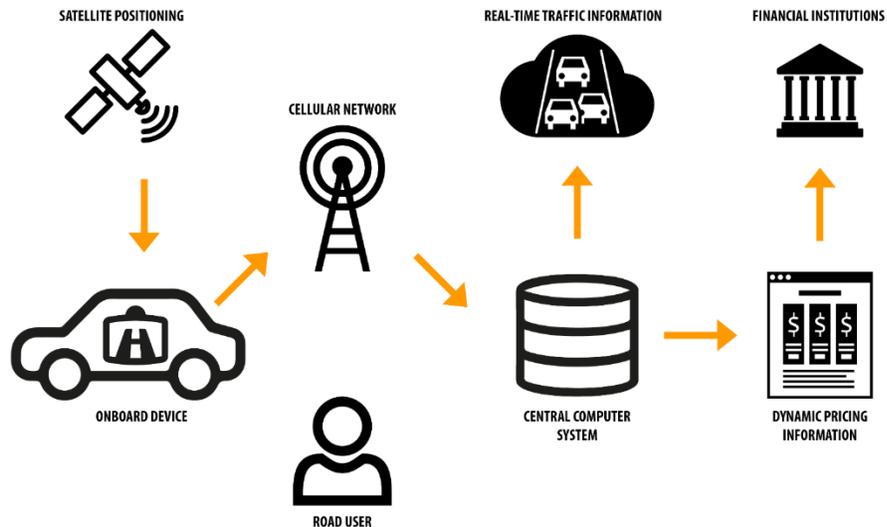
### INTEGRATED MOBILITY ECOSYSTEM

- Microtransit & shared mobility pilots
- Integrated, real-time traveler information

The use of big data and analytics is crucial to improve the management of the transportation system. For instance, real-time data on the bus system helps diagnose the quality, comfort and reliability of the bus system in order to improve the service. Making public transportation the first choice for transportation in Singapore and reducing the number and individual vehicles in the city is the key goal for the LTA.

## FOCUS ON: NEW GENERATION ROAD PRICING

The new Electronic Road Pricing (ERP) system is a dynamic tolling system under development. It will replace the current ERP system, which was implemented in 1998 and was the first system of its type in the world. The current system is based on gantries («doorways») at specific entry points on the system and uses a dedicated short-range communication (DSRC) infrastructure.



The new system, planned for 2020, should be more flexible and equitable, as it is designed to manage congestion by collecting dynamic fare tolls across main road infrastructure (highways, main roads, tunnels...) using onboard GPS devices. Onboard devices will be mandatory in Singapore and will display information on pricing as well as real-time traffic information, to replace variable message signs on the highways.

The onboard device will communicate every vehicle's position to a central computer system using satellite positioning. Real-time traffic information will be extracted from this data stream and pushed back to the onboard device to inform the traveler. Tolls will be adjusted dynamically according to congestion and, eventually, based on the distance travelled by the vehicle on the network.

## CHALLENGES

Technology readiness is a big issue. Sometimes the technology works at a prototype level but is not yet ready to be implemented in a stable form or at a large scale, which leads to delays in its implementation. Autonomous vehicles, for example, still have issues with real-world navigation, liability management and cybersecurity. Good infrastructure availability is also important, but comes with significant costs.

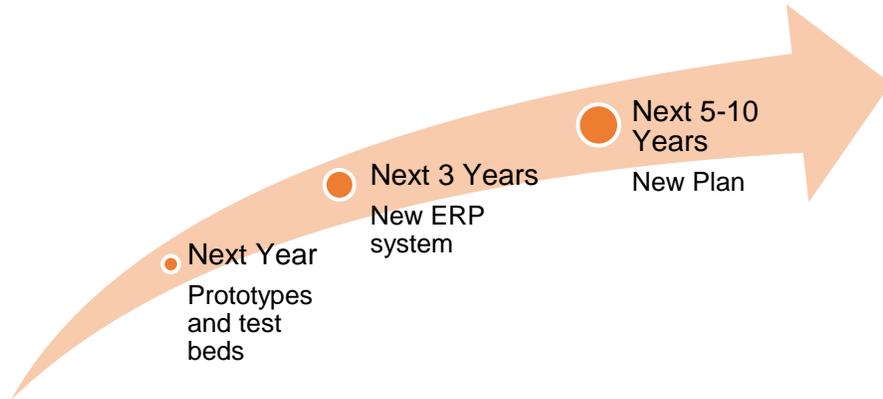
The question of a critical mass of users is also a challenge, like with electrical vehicles: it is hard to determine if authorities should wait until there is enough EV users before investing in a large-scale charging network, or if the government should develop the network beforehand in order to encourage a faster adoption of EVs.

The principal societal issue is the acceptance of new technologies or disruptive business models for the population. For example, Uber has gained a wide acceptance in the population because commuters can see an advantage in the system and it fosters competition in private companies.

## IMPACT MEASUREMENT

Each time a new technology is implemented, the LTA carries out pre- and post-implementation studies to evaluate the impact of the measure. International benchmarking is also carried out to compare the context and/or outcome of the project with comparable contexts. For example, for the bus network, data is collected on the punctuality of buses to establish a level of quality of service for each public transit operator.

## VISION OF THE FUTURE



## HOW TO BECOME A SMART CITY

The Smart City of the future will be:

**CONNECTED**

**ANALYTIC**

**PREDICTIVE**

According to Alan Quek, the most important dimension is to have world-class infrastructure, since infrastructure is the foundation of a Smart City. Once a solid infrastructure is laid out, you can decide on the different layers that you can implement on top in order to leverage the data collected by the infrastructure.

The community and the citizens should be informed in an ongoing manner on the projects that are being planned. Thus, when the projects are implemented, the public is aware. Focus groups and community engagement is also important to get end-user feedback and improve the projects.

### 3 MAIN DRIVING FORCES

Cities are being pushed or encouraged to become Smart Cities based on a variety of triggers or goals. This section discusses the key findings from the literature, presents the results of the surveys and recaps on the driving forces of the five highlighted cities.

#### 3.1 KEY FINDINGS FROM THE LITERATURE

The quantity of triggers and goals is practically limitless and there are various reasons why a city may want to become a Smart City. Most of the literature on the topic relies on a classification of the most recurring triggers into broad categories. Each source has a slightly different way of categorizing the triggers; however, they generally follow the same themes.

In general, a city wishes to become “smart” for the ability to<sup>15</sup>:

- Save costs and increase revenues;
- Make better use and deal with inadequate and deteriorating infrastructure;
- Manage scarce resources;
- Mitigate climate change;
- Deal with energy shortage and price instabilities;
- Become more environmentally friendly (“greener”);
- Deal with health and safety issues;
- Increase social inclusiveness; and
- Become more attractive for its residents and businesses.

Many existing and potential triggers fall within these broad categories. In some cases, cities target one or more broad categories in their mission to become a Smart City. However, in many cases, cities are pushed by more specific and urgent needs in response to specific challenges they are facing such as: managing population growth and ensuring liveable conditions, controlling urban sprawl, dealing with congestion, reducing the dependence on cars, improving physical activity, reducing exposure to air pollution, shrinking the gap between rich and poor as well as addressing racial inequalities, among others.

Hence, one of the main triggers for cities to engage in a Smart City process is the need to mitigate the negative impacts of large population growth concentrated in urban areas<sup>16</sup>. This scale of population growth and its concentration in cities has already led to serious social, technological and political problems as well as others<sup>17</sup>. Urban areas are also responsible for high energy consumption and energy-related greenhouse gas emissions. According to ISO, only “smart cities” can overcome these negative impacts. Therefore, one of the goals of utmost

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<sup>15</sup> Swisscom and IMD report, 2016

<sup>16</sup> Angelidou, 2015

<sup>17</sup> Tokody and Schuster, 2016

importance for smart cities is providing a solution capable of curbing the negative impacts of a large surge of people migrating into cities.

In addition, Angelidou (2015) identifies two main forces driving the global movement of cities to transform into “smart cities”:

- Technology push;
- Demand pull.

Technology has been advancing at a fast pace, has become cheaper and with higher performance than ever before. Smart cities are being pushed by advances in science and technology. The demand pull refers to the need for smart cities to use this technology to respond to the needs and demands of its citizens. One demand pull mentioned by Angelidou (2015) is the competition between cities. Cities are competing to attract new citizens, skilled workers, investors, tourists, international events and so on.

The symbolic value of the Smart City concept is also identified as a possible driver: “The idea that the different types of values reinforce one another was confirmed and symbolic value was identified as an early driver of legitimacy for the innovation process”<sup>18</sup>.

### 3.2 RESULTS AND ANALYSIS OF THE WEB SURVEY AND IN-SESSION INTERACTIVE SURVEY

For the In-Session Interactive Survey, the triggers were grouped into the following four large categories: 1) support economic competitiveness, 2) enhance social cohesion and increase quality of life, 3) enhance or support environmental sustainability and 4) benefit from the occurrence of an event.

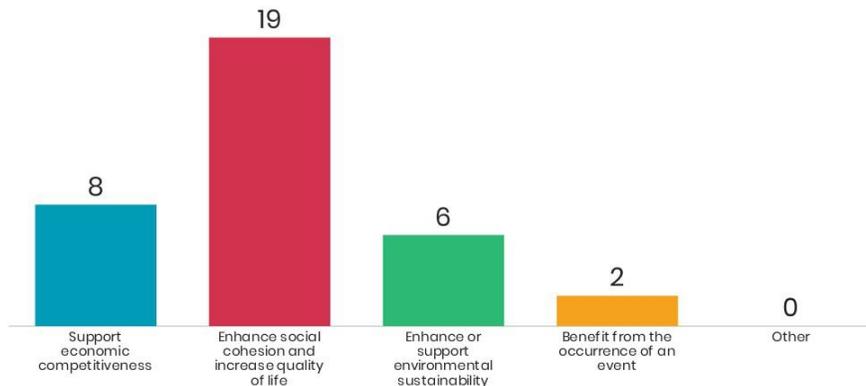
About 55% of the respondents who participated in the In-Session Interactive Survey chose “enhance social cohesion and increase the quality of life” as being the most important trigger for their cities. Interestingly, no respondent selected “other”, suggesting that the proposed categories were covering what they felt were the most important triggers. Supporting economic development and enhance or support environmental sustainability received almost an equal number of respondents whereas very few respondents selected benefiting from the occurrence of an event as their city’s main trigger.

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<sup>18</sup> Meijer & Thaens, 2016

**Q1: What is (was) the most important trigger/goal in your city's process of becoming a "Smart City"?**

Mentimeter



35

**FIGURE 3.1 : MOST IMPORTANT TRIGGERS / GOALS – RESULTS FROM THE INTERACTIVE IN-SESSION SURVEY HELD DURING THE 2017 ITS NATIONAL ASSOCIATIONS MEETING**

The categories were further refined for use in the online survey. Respondents were asked to indicate the level of importance their city gives to seven categories of triggers:

- Manage traffic congestion;
- Improve road safety;
- Reduce health risks linked to transportation;
- Improve accessibility;
- Reduce economic inequalities;
- Manage population growth;
- Manage urban sprawl.

Firstly, it is worth mentioning that only one respondent selected “not important at all” to one category (“Manage population growth”). Otherwise, no category received any “not important at all”.

The need to improve road safety and manage traffic congestion both received the most replies as being “very important”.

Manage traffic congestion, improve road safety, improve accessibility and manage urban sprawl all received the same number of respondents identifying them as being very important.

Respondents were also invited to identify triggers they felt were left out of the list. This question provided the following answers:

- Increase quality of life in cities;

- Increase citizen engagement with services;
- Productivity of people and freight movement;
- Reduce personal car use and enhance public transit efficiency;
- Reduce greenhouse gas emissions;
- Drive economic growth.

### 3.3 INCENTIVES

Aside from requiring a lot of work, becoming a Smart City is often dependent on the availability of government funding. In many cities or countries, the governments are initiating national competitions where the winners are awarded funding towards the implementation of their Smart City. At the end of 2015, the United States Department of Transportation (U.S. DOT) launched a Smart City Challenge where they invited mid-sized cities across the country to develop a Smart City plan linked to transportation that uses data, applications and technology to move people and goods in a quick, cheap and efficient manner. 78 cities applied and the finalists were awarded by being given the opportunity to work with the U.S. DOT to further develop their ideas as well as with grants to put their plans into action. The government of Canada also launched, in early 2018, a Smart City challenge where the winners will be awarded millions of dollars to put towards their Smart City plans. Smart City challenges are in no way unique to North America. For instance, the European Commission launched a Digital Cities Challenge in October 2017. Federal support, not only with respect to providing funding, is vital for smart cities to succeed but also can help ensure interoperability between cities in the same country.

Aside from competitions, some governments provide incentives for the population for example for the purchase of electric vehicles.

### 3.4 KEY ASPECTS FROM THE 5 CASE STUDIES

There is no finite number of reasons that drive cities to achieve a certain level of Smart City; every city seeks to achieve different goals. Returning to the 5 showcased cities: Christchurch (New Zealand), Columbus (USA), Copenhagen (Denmark), Montreal (Canada) and Singapore; each one of these cities was driven by different needs to become a Smart City.

- **Christchurch** was driven by the urgent need to rebuild the city resulting from the destruction of two massive earthquakes. Christchurch took this crisis and instead of just rebuilding, decided that this was an opportunity to move towards becoming a Smart City.
- **Columbus** was driven by the need to support an isolated and neglected population with a very high infant mortality rate among a specific group of people.
- **Copenhagen** was driven by their desire to be CO<sub>2</sub> neutral by 2025 and reduce congestion by prioritizing cycling and walking over buses and cars.

- **Montreal** was driven by political reasons to make Montreal stand out on an international stage.
- **Singapore** was driven by their desire to grow and stay competitive in an international economy.

## 4 MAIN STRATEGIES

This section presents a general overview of the main Smart Mobility strategies adopted by cities around the world in the process towards becoming a Smart City. First, findings from the existing literature are briefly presented. Then, subcategories of each strategy and examples of adopted measures are presented to provide more detail. Finally, results and analysis of the In-Session Interactive Survey and Web Surveys are presented and discussed.

### 4.1 KEY FINDINGS FROM THE LITERATURE

Even though there may not be a universally accepted definition of Smart Cities, there seem to be similar leading strategies on how to promote Smart Mobility as one of the main pillars of the Smart City concept. This section presents a succinct synthesis of the existing strategies and their subcategories.

#### 4.1.1 MAIN STRATEGIES

Based on the literature, strategies defining Smart Mobility have been identified and grouped into eight (8) broad categories: 1) Transportation electrification, 2) Smart parking, 3) Smart vehicular traffic management, 4) Smart transit, 5) Smart active mobility, 6) Integrated and seamless mobility, 7) Connected & shared mobility, and 8) Public & business engagement. These categories are discussed below and examples are provided.

#### **TRANSPORTATION ELECTRIFICATION**

Transport electrification refers to the use of electricity as the main power source for transportation means (e.g. personal vehicles, taxis, buses, trains, boats, etc.) in urbanized areas to reduce the principal sources of air pollution and greenhouse gas emissions. This is achieved by discouraging the use of vehicles with internal combustion engines and by promoting the market penetration of electric vehicles. For instance, Denmark's heavy taxation on the sale of new vehicles with internal combustion engines aims to increase the adoption of electric vehicles<sup>19</sup>. Also, in Canada, the provincial government of Quebec proposed a comprehensive plan (released in 2015) to promote the electrification of transportation systems<sup>20</sup>.

#### **SMART PARKING**

Smart parking initiatives form an important component of the Smart City framework. Car parking space management is a major problem in dense urban areas, and routinely searching for a parking space is a common challenge faced by people driving in these areas. Smart parking strategies can be defined as the use of a combination of real-time data and advanced technologies to improve the operation and management of parking systems by continuously monitoring parking

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<sup>19</sup> Danish Ecological Council, 2016

<sup>20</sup> Government of Québec, 2016

spots and helping drivers to find an available parking space, reserve and pay for it more efficiently in a seamless system. For instance, cities such as San Francisco, USA, collect accurate data using different types of sensors to detect the availability of a parking spot and provide real-time parking information<sup>21</sup>. A different approach has been adopted by Copenhagen<sup>22</sup>, Denmark, in which parking information is communicated to drivers through a smartphone application, which maps the location of the best parking spaces at any given time<sup>23</sup>.

## **SMART VEHICULAR TRAFFIC MANAGEMENT**

Smart traffic management systems can be defined as a centrally-controlled network of signals and sensors to monitor, operate, manage, and regulate traffic flow using a combination of real-time and historical data. Although this strategy includes several subcategories (described in more detail in the next section), the overall goal is to optimize traffic-related components of the transportation system by acquiring and processing accurate real-time information.

## **SMART TRANSIT**

Today's transit systems face numerous challenges, such as the gap between demand and supply, unreliable travel times, unreliable stop times, safety, etc. Smart transit strategies regroup all the measures that make use of real-time and historical data as well as new technologies to make transit more accessible, reliable, safe, demand oriented and sustainable as well as less pollutant. Real-time bus tracking systems, smart card fare collection technologies, bus prioritization measures and emerging forms of microtransit are instances of smart transit strategies.

## **SMART ACTIVE MOBILITY**

Another main strategy of smart cities is to make cities more liveable by promoting physical activity through sustainable transportation approaches, such as walking and cycling. Promoting active mobility can eventually lead to a shift from car to biking and walking, consequently contributing to reduce greenhouse gas emissions, air and noise pollution, boost individuals' health, and reduce traffic congestion. Copenhagen, Denmark, is renowned for its pioneering efforts in promoting bicycle use and its extensive cycling infrastructure, yielding a 41% modal share for commuting trips<sup>24</sup>, the highest compared to all the other modes. Another example of a measure to promote active mobility is bicycle sharing systems that aim to encourage individuals to use bikes for their trips.

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<sup>21</sup> Gordon, R., 2010

<sup>22</sup> Copenhagen Capacity, 2015

<sup>23</sup> City of Copenhagen, 2017

<sup>24</sup> City of Copenhagen, 2017

## **INTEGRATED AND SEAMLESS MOBILITY**

Integrated and seamless mobility focuses on measures related to the multi-modal integration of the cities' mobility cocktail. Mobility as a Service (MaaS) is an emerging concept where users can enjoy a seamless integration of all modes in exchange of a subscription. It is part of the wider concept of sharing economy in which people choose services instead of acquiring products. Multiple measures may be incorporated, as a multi-modal trip planner, payment integration, multi-modal infrastructure and gamification. In Germany, the city of Hannover launched the second phase of its MaaS project in 2016<sup>25</sup>, centralizing the subscription, routing, booking and billing processes.

## **CONNECTED AND SHARED MOBILITY**

Connected and shared mobility strategy distinguished itself from the previous two strategies by targeting autonomous vehicles, shared mobility options as carsharing and ride-hailing, and the integration of the Internet of things with infrastructure and communication protocols. Hence, legislations about autonomous vehicles is amongst the listed measures in this category. In the United States, as of 2017, 33 states incorporated legislations about autonomous and self-driving vehicles<sup>26</sup>. Also, carsharing has seen an important increase in popularity in the last decade with car manufacturers storming the market with their free-floating solutions<sup>27</sup>. Such system allows members to drop-in and drop-off a vehicle anywhere within the operating area.

## **PUBLIC AND BUSINESS ENGAGEMENT**

Public and business engagement focus on elements dealing with the interactions between various actors in a city: public sector, private sector, citizens, and academics. One of the main measures found in this strategy is related to data collaboration: data-exchange and open-data platforms. Other examples include the development of a collaborative platform, with citizens to collect their needs. This is the case of the city of Montreal<sup>28</sup>, Canada, where citizen input is a central part of the strategy to develop the city. Another measure is the creation of smaller scale test areas or innovation areas. In Copenhagen<sup>29</sup>, Denmark, the Street Lab was created to test innovative technologies and collect user feedback before scaling a successful solution city-wide.

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<sup>25</sup> UITP, 2016

<sup>26</sup> National Conference of State Legislatures, 2018

<sup>27</sup> Shaheen et al., 2018

<sup>28</sup> Ville de Montréal, personal communication, 2017.

<sup>29</sup> Copenhagen Solutions Lab, personal communication, 2017.

#### 4.1.2 TYPOLOGY OF SMART CITY STRATEGIES

A typology of the main strategies is created based on the previous findings. The 8 broader strategies are further segmented into 25 sub-categories providing more detailed measures (62) within each strategy. The typology is presented below.

**TABLE 4-1. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – TRANSPORTATION ELECTRIFICATION**

Strategy	Sub-Category	Measure
Transportation Electrification	Infrastructure	Network of public charging stations
		Vehicle-to-grid system
	Vehicle fleet	Measures to encourage vehicle electrification for private / shared / corporate / institutional fleet Electric buses
	Policies	Limit or ban the use of emission vehicles

**TABLE 4-2. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – SMART PARKING**

Smart Parking	Parking space information	Parking space locations (no information on availability)
		Real-time information for off-street parking
Real-time information for on-street parking zones (availability is estimated based on predictive models)		
Real-time information for on-street parking (exact availability based on sensors)		
	Pricing related	Dynamic parking pricing based on demand
		Ability to pay via a smartphone application or online
		Ability to reserve an off-street parking space ahead of time
		Ability to reserve an on-street parking space ahead of time

**TABLE 4-3. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – SMART VEHICULAR TRAFFIC MANAGEMENT**

Smart Vehicular Traffic Management	Data collection and basic information	Basic data collection (vehicle counts, speed, CCTV, etc.)
		Variable message signs
		Dynamic speed signs
	Traffic management	Lane management (change lane configuration) Traffic light management (prioritize and synchronize traffic flow)
	Toll management	Fast/easy payment technology Dynamic pricing Measures to track distances traveled by car (charged based on distance)
	Real-time information	Real-time congestion information for drivers Real-time traffic rerouting
	Support	Smart operation and traffic management center
	Simulation	Demand forecasting traffic simulation

**TABLE 4-4. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – SMART PUBLIC TRANSIT**

Smart Transit	Public	Data collection and basic information	<p>GPS-equipped buses</p> <p>Real-time transit information at bus stops and train stations</p> <p>Smart card system for payment and data collection</p> <p>Real-time transit information through transit &amp; map applications</p>
		Traffic Management Innovative form of PT	<p>Traffic light management - Bus, LRT, Tram prioritization</p> <p>Microtransit / Demand-based public transit</p>

**TABLE 4-5. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – SMART ACTIVE MOBILITY**

Smart Mobility	Active	Data Collection	<p>Collect bicycle and pedestrian trips through applications</p>
		Traffic Management and Routing	<p>Traffic light management - Bicycle prioritization</p> <p>Traffic light management - Pedestrian prioritization</p> <p>Cyclist variable signs</p> <p>Applications recommending the safest/fastest/most used bicycle routes</p> <p>Applications recommending safe/historical/specific walking routes</p>
		Bikesharing	<p>Regular bikesharing network</p> <p>Electric bikesharing</p> <p>Cargo bikesharing</p>

**TABLE 4-6. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – INTEGRATED AND SEAMLESS MOBILITY**

Integrated and Seamless Mobility	and	MaaS	<p>Multimodal trip planning</p> <p>Integrated payment through smart cards</p> <p>Integrated membership to multiple mobility providers through an application</p> <p>Integrated access to mobility solutions through an application</p> <p>Integrated multimodal stations/links</p> <p>Gamification of mobility (reward system, good mobility behaviour credits, etc.)</p>
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**TABLE 4-7. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – CONNECTED AND SHARED MOBILITY**

Connected and Shared Mobility	Autonomous vehicles	Autonomous Vehicles (AVs): regulations and policies AV testing facilities or zones Autonomous bus testing
	Shared mobility	Application-based carsharing solutions Application-based ride-hailing solutions Innovative taxi solutions Application-based carpooling solutions
	Internet of things	Infrastructure and communication protocols for vehicle to vehicle or vehicle to infrastructure communications

**TABLE 4-8. MAIN MEASURES OF A SMART CITY ACCORDING TO 8 STRATEGIES – PUBLIC AND BUSINESS ENGAGEMENT**

Public and Business Engagement	Data infrastructure	Open-data platform Data exchange platform
	Communication	Open Wi-Fi coverage
	Public engagement	Digital citizen platform to collect citizen needs Hackathon competitions Electronic voting service
	Others	Innovation labs / incubators Small-scale test areas

This typology was used in the in-depth survey to allow respondents to rank the various measures according to their level of realisation within their city.

## 4.2 RESULTS AND ANALYSIS OF THE IN-SESSION INTERACTIVE SURVEY AND WEB SURVEY

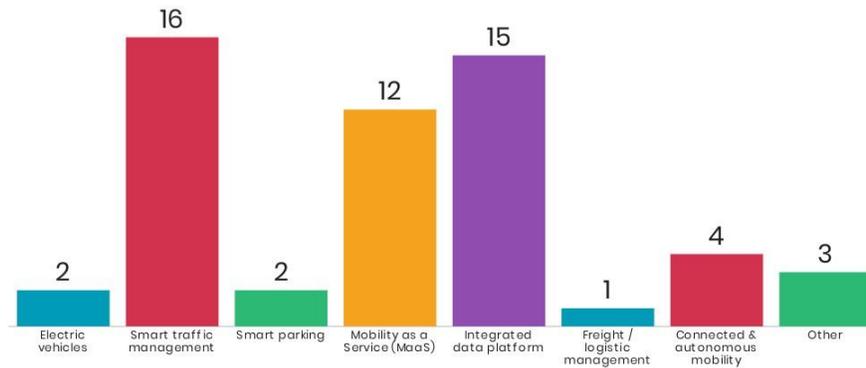
In the In-Session Interactive Survey, the second question (Q2) asked the audience about the main strategies a city should focus on embarking on a Smart City initiative. Seven different categories of strategies were presented in addition to an “Other” option.

1. Electric vehicles
2. Smart traffic management
3. Smart parking
4. Mobility as a Service (MaaS)
5. Integrated data platform
6. Freight logistic/management
7. Connected and autonomous mobility

Each member of the audience could choose up to two elements. In total, 31 people responded to this question and their results are revealed in the figure below.

**Q2: What are (were) the two main strategies for your city in its "Smart City" process?**

Mentimeter



31

**FIGURE 4.1. MAIN SMART CITY STRATEGIES – RESULTS FROM THE INTERACTIVE IN-SESSION SURVEY HELD DURING THE 2017 ITS NATIONAL ASSOCIATIONS MEETING**

Results show that the strategies are concentrated around three main topics: traffic-related (16/31), data-related (15/31) and personal mobility-related (12/31). While traffic and mobility issues are intrinsically related to citizens' mobility, data initiatives are an important supporting feature in a Smart City initiative process to leverage traffic and mobility strategies. Vehicle electrification, parking management, freight management and autonomous mobility were seldom selected as the main strategies. This does not imply that these strategies are left out of Smart City plans, but rather that they are not the main focus of these cities. Only three responses identified "Other" as being a main strategy, showing that the presented strategies potentially encompass the essential parts of cities' Smart City strategies.

#### 4.2.1 IN-DEPTH SURVEY RESULTS

In the Web Survey, respondents were asked to qualify the progress of the measures presented in the previous table using the following options.

1. Not planned
2. Planned
3. Pilot/Currently testing
4. Being implemented
5. Fully implemented
6. Unknown

In addition, measures were grouped according to main strategies, and at the end of each section, respondents were asked to quantify how important this strategy was for their city and to mention any measure not listed in the survey that would be relevant.

## TRANSPORTATION ELECTRIFICATION

For transportation electrification, respondents provided an average importance level of 3.6/5. Table 4-9 presents the results.

**TABLE 4-9. IN-DEPTH SURVEY RESULTS ABOUT TRANSPORTATION ELECTRIFICATION**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Network of public charging stations	0	3	2	6	0	2
Vehicle-to-grid system	6	2	2	0	0	3
Measures to encourage vehicle electrification for private / shared / corporate / institutional fleet	1	2	3	5	1	1
Electric buses	2	3	3	5	0	0
Limit or ban the use of emission vehicles	7	1	0	3	0	2

The results show that charging station networks, vehicle electrification measures and electric buses are among the most popular measures. A vehicle-to-grid system and policies around the limitation or ban of emission vehicles are mostly “Not planned”. One respondent mentioned that the freight component of the electrification strategy is missing among the listed features.

## SMART PARKING

An average importance of 4.2/5 was given to smart parking measures. Table 4-10 presents the results.

**TABLE 4-10. IN-DEPTH SURVEY RESULTS ABOUT SMART PARKING**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Parking space locations (no information on actual availability)	0	1	3	3	6	0
Real-time information for off-street parking	0	4	1	2	5	1
Real-time information for on-street parking zones (availability is estimated based on predictive models)	2	5	2	2	1	1
Real-time information for on-street parking (exact availability based on sensor(s))	5	1	2	3	2	0
Dynamic parking pricing based on demand	6	0	1	1	2	3
Ability to pay via a smartphone application or online	1	2	0	3	6	1
Ability to reserve an off-street parking space ahead of time	4	1	3	3	0	2
Ability to reserve an on-street parking space ahead of time	6	2	1	1	0	3

Regarding information on parking spaces, nearly all cities reported being able (or in the process) to present the location of parking spots. If the real-time component is incorporated, off-street parking information is more available than on-street parking due to its more controlled environment. Cities seem to prioritize on-street information based on predictive models rather than the measurement of actual sensors that could potentially give accurate information at the parking space level.

With respect to pricing, dynamic pricing does not seem to have much traction, but the ability to pay remotely is more established. None of the surveyed cities offer the option to reserve parking spaces ahead of time, but some of them are in the process of implementing this option.

Additional measures suggested by respondents are the ability to reserve temporary on-street spaces for deliveries and disabled parking accessibility.

### SMART VEHICULAR TRAFFIC MANAGEMENT

For smart vehicular traffic management measures, respondents gave an average importance of 4.6/5. Table 4-11 presents the results.

**TABLE 4-11. IN-DEPTH SURVEY RESULTS ABOUT VEHICULAR TRAFFIC MANAGEMENT**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Basic data collection (vehicle count, speed, CCTV, etc.)	0	2	0	4	7	0
Variable message signs	0	1	2	4	6	0
Dynamic speed signs	3	0	1	3	6	0
Lane management (change lane configuration)	4	2	0	1	5	1
Traffic light management (prioritize and synchronize traffic flow)	0	0	2	4	7	0
Fast/easy payment technology	5	1	1	0	5	1
Dynamic pricing	7	3	0	1	1	1
Measures to track distances traveled by car (charged based on distance)	4	3	2	0	3	1
Real-time congestion information for drivers	0	1	2	3	6	1
Real-time traffic rerouting	3	2	1	2	4	1
Smart operation and traffic management center	0	1	1	3	8	0
Demand forecasting traffic simulation	1	3	3	2	4	0

Data collection measures to gather vehicle trips are fairly well implemented with 11 cities replying by a “Being implemented” status. This high level of maturity shows the availability of variable message and dynamic speed signs, the latter still showing 3 cities with no intention to implement such measures. Traffic management features such as lane management are more polarized: 6 cities mention having either “Not planned” or “Planned” this measure, while 6 others mention “Being implemented” or “Fully implemented”. Traffic light management seems to be more accessible than lane management. Toll management provides similar findings to lane management measure: results show either “Not planned” or “Fully implemented”. Dynamic pricing is still not planned for the majority of the

surveyed cities (7). Real-time information on congestion is quite mature, while actual traffic rerouting will need some time before reaching the same level of maturity. Cities seem to incorporate traffic management centers in all of them (or in the process to) while the actual traffic forecasting simulation is in progress.

### SMART TRANSIT

The respondents gave smart transit measures an average importance of 4.7/5. Table 4-12 presents the results.

**TABLE 4-12. IN-DEPTH SURVEY RESULTS ABOUT SMART TRANSIT**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
GPS-equipped buses	0	1	0	3	9	0
Real-time transit information at bus stops and train stations	0	1	1	4	6	1
Smart card system for payment and data collection	0	0	1	3	9	0
Real-time transit information through transit and map applications	0	1	0	4	6	2
Traffic light management - Bus, LRT, Tram prioritization	0	1	0	6	6	0
Microtransit / Demand-based public transit	2	2	2	4	1	2

The results show a high degree of maturity for measures related to this strategy. With respect to data collection and basic information, nearly all cities mention “Being implemented” or have “Fully implemented” (12), providing valuable information to its users and transit authorities. While the data is theoretically there, the real-time information is less fully implemented. Smart card system shows the highest implementation maturity. Traffic prioritization for public transit is also well implemented for 12 cities, and the others are in the “Planned phase”. Finally, innovative public transit mobility options such as microtransit, has the lowest implementation level among this strategy’s measures.

### SMART ACTIVE MOBILITY

For smart active measures, respondents gave an average importance level of 4.2/5. Table 4-13 presents the results.

**TABLE 4-13. IN-DEPTH SURVEY RESULTS ABOUT ACTIVE MOBILITY**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Collect bicycle and pedestrian trips through applications	2	1	2	5	1	2
Traffic light management - Bicycle prioritization	4	1	4	1	1	2
Traffic light management - Pedestrian prioritization	3	0	3	4	2	1
Cyclist variable signs	5	1	0	3	1	3
Applications recommending the safest/fastest/most used bicycle routes	1	1	2	4	3	2
Applications recommending safe/historical/specific walking routes	4	0	3	3	2	1
Regular bikesharing network	2	2	1	4	4	0
Electric bikesharing	3	3	3	1	1	2
Cargo bikesharing	7	1	1	1	0	3

The results for data collection show that most cities (8) are at least testing a way to collect data on active mobility trips. This data collection is essential for any integrated strategy to promote these transportation modes. With respect to traffic management and routing, cities are either at least “Currently testing” measures or they are simply “Not planned”. Bicycle route recommendations seem to be more implemented than walking ones. Finally, for bikesharing measures, logic is respected regarding the various degrees of implementation: regular bikesharing is more present than electric bikesharing, which in turn is more implemented than cargo bikesharing with the majority (7) of cities providing a “Not planned” status.

### **INTEGRATED AND SEAMLESS MOBILITY**

For integrated and seamless mobility measures, respondents gave an average importance of 4.1/5. Table 4-14 presents the results.

**TABLE 4-14. IN-DEPTH SURVEY RESULTS ABOUT SEAMLESS MOBILITY**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Multimodal trip planning	0	2	1	3	7	0
Integrated payment through smart cards	1	1	1	5	5	0
Integrated membership to multiple mobility providers through an application	3	3	1	5	0	1
Integrated access to mobility solutions through an application	1	3	1	6	1	1
Integrated multimodal stations/links	0	2	3	6	1	1
Gamification of mobility (reward system, good mobility behaviour credits, etc.)	4	3	2	1	0	3

While seamless mobility transportation options are important, access to the information is equally as important for users willing to optimize their journey. All respondents mentioned multimodal trip planning is either “Fully implemented” or in “Being implemented”. The maturity level of integrated payment is nearly as high and the previous measure with only one respondent replying “Not planned”. The payment process, however, is still not integrated. Multimodal stations or links seem

to be important according to the respondents with most cities in the “Being implemented” phase. Finally, a gamification system where users would be rewarded for using shared or active mobility are not planned for a good portion of the cities (4), while 6 of them are at the “Planned”, “Currently testing” and “Being implemented” levels.

One respondent mentioned that a “Smartphone payment” measure is missing for the list of measure.

## CONNECTED AND SHARED MOBILITY STRATEGY

For connected and shared mobility measures, respondents provided an average importance of 3.7/5. Table 4-15 presents the results.

**TABLE 4-15. IN-DEPTH SURVEY RESULTS ABOUT CONNECTED AND SHARED MOBILITY**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Autonomous Vehicles (AVs): regulations and policies	3	2	4	3	0	1
AV testing facilities or zones	2	2	6	1	1	1
Autonomous bus testing	4	3	3	2	0	1
Application-based carsharing solutions	1	0	2	3	5	2
Application-based ride-hailing solutions	2	0	2	3	3	3
Innovative taxi solutions	1	1	3	6	1	1
Application-based carpooling solutions	3	0	2	4	1	3
Infrastructure and communication protocols for vehicle to vehicle or vehicle to infrastructure communications	1	2	4	4	2	0

About autonomous vehicles, respondents mainly affirm being in the “Planned” and “Pilot” phases. Shared mobility solutions as carsharing seem to be well implemented as well as ride-hailing. Taxi and carpooling solutions seem to be one implementation step behind the previous two mobility options.

## PUBLIC AND BUSINESS ENGAGEMENT STRATEGY

Regarding public and business engagement measures, respondents gave an average importance of 3.8/5. Table 4-16 presents the results.

**TABLE 4-16. IN-DEPTH SURVEY RESULTS ABOUT PUBLIC AND BUSINESS ENGAGEMENT**

Measure	Not planned	Planned	Pilot/ Currently testing	Being implemented	Fully implemented	Unknown
Open-data platform	1	2	2	3	4	1
Data exchange platform	1	2	3	3	2	2
Open Wi-Fi coverage	2	1	2	3	1	4
Digital citizen platform to collect citizen needs	3	2	4	0	0	4
Hackathon competitions	2	1	3	4	2	1
Electronic voting service	5	2	1	0	0	5
Innovation labs / incubators	2	0	3	4	3	1
Small-scale test areas	2	2	1	3	4	1

The results show a relative maturity level for data platforms with a high rate of implementation, and only one city (in each measure) where it is not planned at all. Also, innovation-centric measures as incubators or smaller scale areas attract a fair share of interest. Population-related platforms, such as electronic voting services and platform to collect citizens' needs are still not implemented or planned. Respondents raised the issue of a legal framework for open-data which is essential in a data abundant Smart City.

Of the eight surveyed strategies, respondents selected public transit and vehicular traffic management as their top priorities, while public and business engagement, connected and shared mobility, as well as transportation electrification received the lowest values:

1. Smart Public Transit:	4.7 / 5
2. Smart Vehicular Traffic Management:	4.6 / 5
3. Smart Active Mobility:	4.2 / 5
4. Smart Parking:	4.2 / 5
5. Integrated and Seamless Mobility:	4.1 / 5
6. Public and Business Engagement:	3.8 / 5
7. Connected and Shared Mobility:	3.7 / 5
8. Transportation Electrification:	3.6 / 5

The results are in accordance with those from the interactive session survey, where vehicular traffic management, MaaS and integrated data platforms were predominantly chosen. With respect to public and business engagement, 6 cities confirmed being only at the planning or pilot phase of an integrated platform to collect citizen needs. While public transit and car use in a city may be seen as central pillars in a mobility strategy, Smart City strategies must be developed around the needs of its citizens. While the measure may have been perceived differently by the various respondents, the technical challenge of this measure may be more accessible than other technology-oriented measures already implemented.

## 5 IMPLEMENTATION CHALLENGES AND OBSTACLES

As described in the previous sections, cities around the world are implementing a wide array of Smart City strategies. In doing so, policy makers and stakeholders in these cities are faced with the need to address a variety of social, economic and technological challenges. This section provides a brief overview of these challenges as identified in the scientific literature and as communicated by stakeholders in cities around the globe.

### 5.1 KEY FINDINGS FROM THE LITERATURE

The challenges faced by Smart Cities can be classified into 3 categories:

1. Social challenges
2. Technological challenges
3. Governance challenges

The following subsections expand on each of these categories, providing a summary of the recent research on Smart Cities.

#### 5.1.1 SOCIAL CHALLENGES

Smart City strategies are not implemented in a void. Rather, most of these strategies – save cases like Masdar City, UAE, and Songdo, South Korea – are put into well-established urban environments. The changes brought to the cities by these initiatives have decisive impacts on citizens, who are, as noted by Moiser & Uffer (2016), “*the ultimate stakeholders in the city*”. One of the challenges of implementing a Smart City strategy is to work with the public, in one way or another, to ensure its acceptability.

By engaging the public, cities are able to implement comprehensive Smart City strategies, but are also able to encourage citizen participation in their projects. This is essential since, in many cases, smart systems are built upon data provided by citizens. Explaining the purpose of the different data collection efforts and enabling citizens to understand the benefits of their participation in the system, along with providing incentives for participation, strengthens the initiatives<sup>30</sup>.

Another challenge Smart Cities around the world are facing is keeping in touch with the needs of their population. A great number of current Smart City initiatives are supply-driven, i.e. emerge from the “push” of a vendor and the will to put in place a certain set of systems. However, successful Smart Cities select and implement systems based on the “pull” of public needs, and thus answer actual problems<sup>31</sup>. As stated by Nam & Pardo (2011), “*Technological innovation is a means to Smart City, not an end*”.

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<sup>30</sup> Arasteh (2016)

<sup>31</sup> Angelidou (2015)

Even when there is sufficient public involvement in every step of the implementation of a Smart City strategy, the very nature of many Smart City systems means that a part of the population, usually those with limited access to information and communication technologies (ICT), might be excluded from certain aspects of the Smart City. As illustrated by Moiser & Uffer (2016), decisions based on systems requiring citizen input – platforms that allow citizens to report traffic issues, for instance – might overlook the needs of segments of the population who do not participate in the system for whatever reason.

### 5.1.2 TECHNOLOGICAL CHALLENGES

Smart Cities are, first and foremost, technological enterprises. Therefore, cities implementing Smart City strategies face several challenges related to the implementation of diverse technological solutions, as highlighted by many researchers. The main challenges faced are: the heterogeneity of systems and data, the dependence on physical and connected devices to feed the systems and the security issues associated with large digital systems<sup>32</sup>.

The main technological challenge faced by Smart Cities today is the integration of heterogeneous systems into a single, overarching infrastructure. For half a century now, cities have been implementing digital tools and systems in order to respond to the specific needs of departments, agencies, utility providers, etc. Each system was often conceived with a single purpose in mind by multiple vendors and most of them were never meant to be integrated together. Cities are now confronted with the challenge of upgrading these systems to better enable their integration, which can be a significant task as it implies developing a global scheme of data needs and interactions for the entire Smart City<sup>33</sup>.

Even when the individual systems can be adapted to communicate together, the heterogeneity of data they produce can be an obstacle for the users. Data collection methods, for instance, can vary between departments within the same city, complicating their integration. The implementation of data standards is an essential step to allow the use of different datasets, for internal use within a city or to benchmark across cities around the world<sup>34</sup>.

As Smart Cities increasingly rely on a constant influx of real-time data, more and more sensors and smart infrastructure need to be put in place. This comes with a major increase in infrastructure installation and maintenance costs for cities and renders the provision of services dependent on this smart infrastructure. Dependence on smart devices can incur unreliability in the system and the

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<sup>32</sup> Paskaleva (2017)

<sup>33</sup> Petrolo (2015), Arasteh (2016)

<sup>34</sup> Angelidou (2012), Moiser & Uffer (2016), Paskaleva (2017)

decision process in case of failures, which emphasizes the need for a backup system<sup>35</sup>.

As mentioned earlier, the implementation of a variety of systems that collect large amounts of data, including sensitive data, heightens the need for secure digital platforms and networks. Varying levels of training and technological proficiency among users within the city administration and different security standards across system vendors can open vulnerabilities in the system that can lead to sensitive data being leaked<sup>36</sup>.

### 5.1.3 GOVERNANCE CHALLENGES

In addition to societal and technical challenges, cities face a great number of challenges related to the governance of a Smart City. Administrations must rethink their regulatory environment, foster cooperation within departments and overcome the limits of political mandates and timeframes, all while constantly reminding decision makers of the added value of a Smart City strategy.

The arrival of Smart Cities brought along several regulatory needs. Cities now must reflect on the protection of citizens' privacy, the ownership of data collected by systems and the issues related to potential breaches in digital security mechanisms when implementing Smart City initiatives so as to adapt the bylaws and regulations accordingly. Moiser and Uffer (2016) underline that in addition to being responsible for a suitable regulatory environment for working systems, cities should also consider the legal implications of eventual failures of these systems: *"If an automated vehicle drives into a parking lot based on geospatial data, but crashes into another car, responsibility could be with the manufacturer of the automated vehicle, the software producer, or the data provider"*. Until courts have ruled in a consistent matter over these issues, they remain a factor of uncertainty and could be an obstacle to the large-scale implementation of Smart Cities initiatives.

As mentioned previously, municipal administrations are made of numerous departments, utility providers and agencies that must cooperate to achieve the implementation of complex systems. Even when Smart City strategies have been implemented, the existing habits and the organizational structure of cities can create obstacles to their operation<sup>37</sup>. This vertical layering is concurrent to a horizontal fragmentation incurred by the structure of contemporary metropolitan areas. In most cases, a metropolitan region contains not only one, but many different cities, each with their elected officials, political agendas and administrative layers. This can make the application of a Smart City initiative at the level of an

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<sup>35</sup> Holgersson (2017), Arasteh (2016)

<sup>36</sup> Arasteh (2016), Moiser & Uffer (2016), Chourabi (2012)

<sup>37</sup> Nam & Pardo (2011)

entire metropolitan area – i.e. the city as experienced every day by mobile citizens – very complex<sup>38</sup>.

Strong political leadership can be a way to attenuate administrative resistance and to bridge organizational divides. Chourabi et al. (2012) stress the importance of having a political “champion” that leads the Smart City initiative and ensures that all departments and stakeholders work together. However, the timeframe within which politicians envision their action and expect returns is quite short, usually the length of their mandate, which can conflict with the timeframe necessary to finance, test and implement complex digital systems<sup>39</sup>.

In addition to these time limits, the budget allocated by decision makers to Smart City initiatives can be restricting, forcing the administration to develop large systems with limited resources<sup>40</sup>. With every political change, staff and project managers must make the case anew for Smart City programs. While even the most complex systems are usually far less expensive than traditional infrastructure investments (roads, utilities, mass transit, public works, etc.), the added value of Smart City initiatives can be hard to sell, especially in cases where the link between public needs and technological solutions has not been thoroughly documented<sup>41</sup>.

## 5.2 RESULTS AND ANALYSIS OF THE WEB SURVEY AND IN-SESSION INTERACTIVE SURVEY

Smart City project managers mention challenges, obstacles and barriers that echo the scientific literature. Figure 5-1 and Figure 5-2 show that the lack of funding and the challenge of inter-agency coordination are among the most cited obstacles in the implementation of a Smart City initiative. However, ITS representatives attending the 2017 ITS National Associations Meeting cited resistance to change from political actors as the main barrier to their activities. This suggests that not every decision maker is a Smart City champion and it highlights the importance of building a strong case for Smart City strategies within the administration.

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<sup>38</sup> Moiser & Uffer (2016)

<sup>39</sup> Holgersson et al. (2017)

<sup>40</sup> Holgersson et al. (2017)

<sup>41</sup> Moiser & Uffer (2016), Meijer & Thaens (2016)

## What are the largest obstacles and barriers your city is facing in implementing its Smart City strategies and measures ?

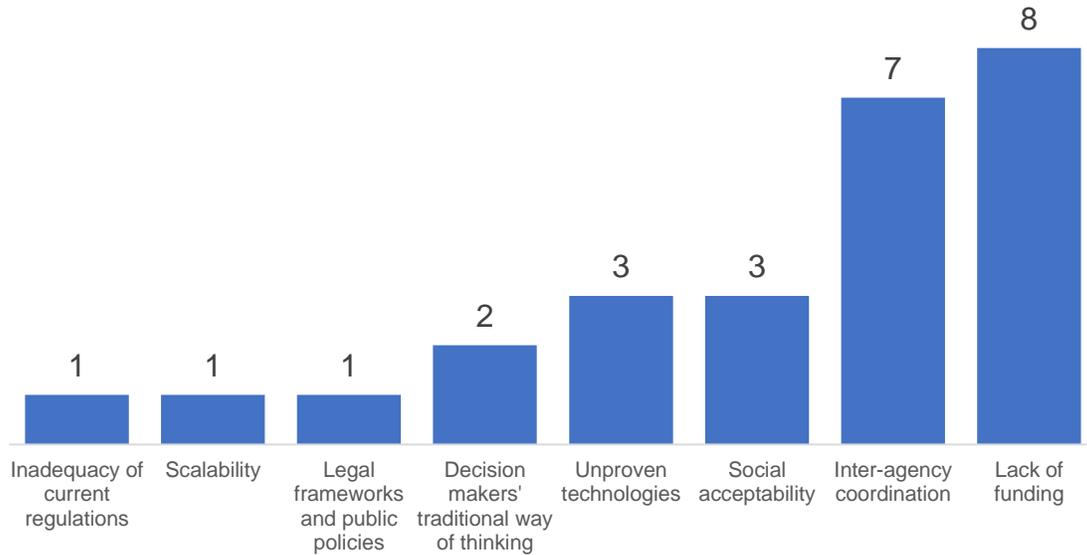
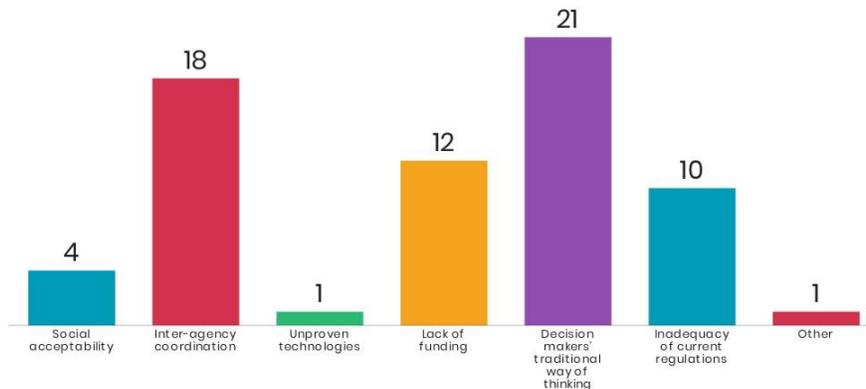


FIGURE 5-1 : CHALLENGES FACED – RESULTS FROM THE ONLINE SURVEY

Mentimeter

### Q3: What are the TWO main challenges your city is facing in the implementation of a “Smart City” strategy?



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FIGURE 5-2 : CHALLENGES FACED – RESULTS FROM THE INTERACTIVE IN-SESSION SURVEY HELD DURING THE 2017 ITS NATIONAL ASSOCIATIONS MEETING

To overcome the aforementioned obstacles, many survey respondents highlight the importance of explaining and promoting Smart City initiatives to stakeholders, thus building support among agencies, departments and the civil society. Benefits and eventual successes of Smart City strategies should be publicized to spark the interest of the public and stakeholders. Pilot projects and incremental implementation are cited as being well suited for this kind of approach.

Focusing on strategies that directly benefit the public can be a fruitful approach towards building support in the community. Open data portals, for example, are cited as an effective way to engage citizens and community groups, driving the demand for a larger implementation of Smart City strategies. Conducting benchmarking of key indicators is also mentioned as a way to build internal support in the administration.

### 5.3 KEY ASPECTS FROM THE 5 CASE STUDIES

Representatives from the 5 cities featured at the 2017 ITS World Congress Smart Cities Pavilion echoed the aforementioned challenges: technology readiness and scalability, maturity of the regulatory environment and social acceptability were regularly underscored in the interviews. Many new points were also brought to light.

For instance, one of the main challenges in Montréal is to maintain the balance between engaging the public and carrying out the implementation of Smart City strategies. Based on the experience of the *Bureau de la ville intelligente et numérique*, a constant contact with the public is necessary to stay connected to the needs of the citizens, but a small team can get overwhelmed by such an effort and fall behind on implementation schedules. As far as inter-department coordination goes, Montréal's open data portal has enabled the creation of efficient communication channels and has had a systemic impact on the inner workings of the administration.

In Christchurch, the Smart City initiative was cited as an efficient way to change mentalities related to transportation. For instance, when dynamic traffic management strategies were brought to the table, they enabled a shift from the traditional roadway expansion solution. Smart City initiative can thus be a tool for change and help focus different professionals towards sustainable goals and methods.

As a precursor of the Smart City movement with its Smart Nation initiative, Singapore is now facing scalability issues. Even when technological readiness of a system has been reached and the vendor can ensure its deployment at the national scale, decision makers must make sure that users are ready for the system in order to justify the investment. A critical mass of users, either citizens for public-facing systems or government employees for internal tools, is essential for the success and continuing support of the initiative.

In Columbus, the main challenge was the learning curve of Smart City strategies and the associated project management structures. Traditional infrastructure projects are usually thoroughly detailed and follow rigid schedules and procedures, while Smart City initiatives are based on agile development and prototyping. This has proven challenging for long-time employees and engineers, who are used to more traditional project management techniques.

Implementation of the Smart City initiative in Copenhagen has emphasized the need for the city, but also businesses and stakeholders, to be open to collaboration and change. New communication channels have been put into place to ensure open collaboration and that they stay focused on user needs. This makes it easier to resist the urge to implement every new technology. Instead, the city can pause, look back, consult stakeholders and determine if projects bring added value to the community before prototyping and eventually implementing the projects.

## 6 IMPACT MEASUREMENT

### 6.1 KEY FINDINGS FROM THE LITERATURE

The literature contains a lot of information regarding the benefits of measuring the impacts of strategies put into place. In the article "Measuring Success in the Development of Smart and Sustainable Cities", four benefits are listed:

- *"A common definition of terms so that everyone involved, from department heads, to the mayor, to citizen groups, to technology suppliers, is speaking the same language when discussing complex topics.*
- *The ability for cities to take a baseline, define where they want to go, and understand the gap between the two.*
- *To be able to quantify goals and outcomes. For example, how is sustainability as a goal measured? Once a measurement is determined, like a reduction in CO<sup>2</sup> emissions or harmful particulates in the air, then success or failure can be measured.*
- *Assessment and measurement allow cities to benchmark and compare themselves against their peers, or even from department to department within one city. This helps cities reduce their investment risk as they can follow the best practices and measures of other successful city initiatives".<sup>42</sup>*

#### 6.1.1 MEASURES

There are many ways to measure the impact of implemented strategies. Columbus' performance measures plan<sup>43</sup> provides many methods which are presented below.

##### **BEFORE-AFTER ANALYSIS**

When the data before the implementation of the project are available, it is possible, by continuing to collect data, to understand the impact of a project.

##### **WITH-WITHOUT ANALYSIS**

When the technology's infrastructure is installed and begins to operate and collect data before the implementation is announced to the user. This is useful to understand the shift in the behavior of the user.

##### **TREND ANALYSIS**

If the data were not collected before implementing the project, a trend analysis method can be used to understand the evolution of the impact of the project.

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<sup>42</sup> Clarke (2017)

<sup>43</sup> USDOT (2017)

## **SURVEY ANALYSIS**

Surveys make it possible to obtain a lot of information on the users' assessment of the implementation of a project.

It is possible to understand that in order to properly assess the impact of projects, an informed vision and a structured measurement strategy are needed well before the implementation of the project. This implies that impact measurement is often difficult to set up and even more complex to establish guidelines to compare projects to one another.<sup>44</sup>

### **6.1.2 OBSTACLES**

Obstacles arise even when it comes to measuring the impact of specific measures. Some of these obstacles are identified below.

#### **DIFFICULTY IN DEFINING AND ESTIMATING RELEVANT INDICATORS**

To measure the impact, it is necessary to define indicators. Carli et al. (2013) highlight that indicators can either be objective or subjective. First of all, objective indicators can be framed by the SMART principles (Specific, Measurable, Achievable, Relevant, Time-bound), while subjective indicators are more difficult to define. These authors include indicators such as the well-being of citizens, their satisfaction with governance or the perception of risks.

They also propose a framework to model indicators relevant to the development of the Smart City. They propose to define indicators according to two classes of tools: traditional and innovative, according to their degree of objectivity. Traditional tools are based on long-term collected data, census and statistics, while innovative indicators are divided into two classes: 1) tools that monitor the physical infrastructure, and 2) tools that monitor the social infrastructure.

Dameri (2017) suggests that quantitative indicators are not able to measure complex goals such as quality of life.

The framework proposal by Carli et al. (2013) makes it possible to understand the objective and subjective portion of the indicators considered to measure Smart City impacts. The authors point out, however, that there are no national or international rules defining the indicators accepted and used by several cities.

In parallel, there seem to be many available indicators. This diversity, where no one indicator is preferred over the rest, can slow down the decision-making process of each municipality in the choice of indicators to use. Monfaredzadeh & Berardi (2015) identify more than ten indicators in their system. Despite the large number of measures, these authors explain that, regarding sustainability,

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<sup>44</sup> Carli et al. (2013)

smartness or competitiveness, there are not a lot of indicators focusing on smart mobility.

Lastly, it is important to note that, according to Dameri et al. (2016), citizens are not really informed of the complete set of smart initiatives that are available in their region making it harder to correlate behaviours with initiatives.

### **UNAVAILABILITY OF BASELINE SCENARIOS (OBSERVED CURRENT BEHAVIOURS)**

As previously explained, impact assessment methods are often based on baseline scenarios. Unfortunately, data is rarely available prior to the project. To construct a baseline measure, Columbus (2017) collects data around one year before the project is completed in order to be able to assess its impacts.

### **NO PROPER DATA COLLECTION METHODS/ NO DATA MONITORING TOOLS**

Another issue in measuring the impact of the strategies put in place is the lack of data collection methods or non-existence of monitoring tools. Data is necessary to compare and see the evolution of the city.

According to Dameri (2017), several factors can favor setting up of a monitoring dashboard:

- Data already available on a digital platform;
- Long-time data series available;
- Comparability of data at the national or international level;
- Wide set of data available;
- Simple anonymization of the necessary data;
- Data easily adaptable to the dashboard's needs.

These elements clearly show the importance of having a long-term vision about the development of a Smart City.

### **NO CLEAR MANDATE (NO FUNDING) RELATED TO IMPACT MEASUREMENT**

To measure impacts, indicators must be defined and consistent data must be collected. The design of data collection strategies requires resources in terms of time, work and money<sup>45</sup>.

According to Clarke (2017), few cities have a specific budget set aside for Smart City investments. The allocation of resources to Smart City projects is therefore complicated. One can then imagine that the expenses specifically incurred to measure impacts are even more difficult to justify.

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<sup>45</sup> Dameri (2017)

## **SHORT TERM VISION**

Putting in place a Smart City can take a lot of time and unfortunately, most of the time a short-term vision is preferred to a long-term one. In his article "*Measuring Success in the Development of Smart and Sustainable Cities*", Clarke (2017) suggests:

*«Processes Can Take Longer than Elected Officials Have in Office: Cities do not necessarily move quickly and require time to procure, pilot, and adopt new strategies and initiatives. »*

Indeed, political terms are shorter compared to the time needed to implement a Smart City. Thus, continuity in political vision is necessary to ensure a long-term vision.

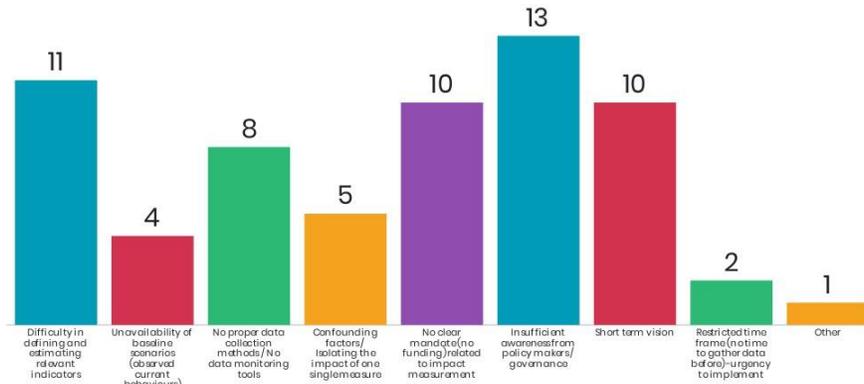
## **IMMATURE THINKING OF SMART CITY CONCEPTS**

The Smart City project needs to be conceived in a long-term perspective. Dameri et al. (2016) explain: *«If in the pioneer phase a spontaneous, bottom-up wave has been useful to stimulate innovative and original initiatives, now the Smart City needs comprehensive, integrated strategies to support long-term, profitable and effective smart projects. »* To be able to create a smart environment for the citizen, a reflection work seems to be necessary before implementing any project. Clarke (2017) shows that it can be possible to understand the maturity of a Smart City using a combination of three self-reported models: BSI Smart City Maturity Assessment, ISO City services and quality of life and IDC Smart Cities MaturityScape.

## **6.2 RESULTS AND ANALYSIS OF THE WEB SURVEY AND IN-SESSION INTERACTIVE SURVEY**

A question about impact measurement was also addressed during the in-session survey. The purpose of the question was to understand the main factors that prevent cities from assessing the impacts of implemented measures. The results are provided in Figure 6.1.

**Q4: What are the TWO main factors that prevent your city from assessing the impacts of implemented measures?**



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**FIGURE 6.1 : MAIN OBSTACLES TO THE ASSESSMENT OF SMART CITY INITIATIVES IMPACT ASSESSMENT – RESULTS FROM THE INTERACTIVE IN-SESSION SURVEY HELD DURING THE 2017 ITS NATIONAL ASSOCIATIONS MEETING**

In Figure 6.1, it is possible to see a clear difference between the top five answers and other four. The five-predominant factors that prevent a city from assessing the impacts of implemented measures are:

- Insufficient awareness from policymakers or governance;
- Estimating relevant indicators;
- No clear mandate related to impact measurement;
- Short-term vision;
- No proper data collection method or no data monitoring tools.

These answers seem to be consistent with the literature. Furthermore, these answers show that impact measurement is complex to operationalize. Indeed, the lack of a clear mandate coupled with the lack of relevant indicators and a short-term view by decision makers slow down the development of clear and community-accepted standards for measuring impacts.

Also, the respondents strongly raised the lack of awareness of policymakers in the measurement of impacts.

On the other hand, it may be suspected that data collection technologies may not be sufficiently developed to effectively measure the impacts generated by a project. It would be interesting to understand if it is the technological solutions which are deficient or if it is the costs associated with the use of these solutions that slow down their appropriation by municipalities.

### 6.3 SYNTHESIS

All in all, the scientific literature provides insight on the challenges of measuring the impact of projects implemented to make a city smarter. Several indicators do exist, as well as methods to understand the level of maturity of a city. However, a bridge between the literature and Smart City stakeholders seems to be missing. The survey results show that influential players consider a short-term vision and governance as the main barriers slowing down the implementation of an impact measurement protocol. In parallel, the literature explains that users do not feel aware of the different projects that their city deploys.

Perhaps more open management of data and projects would allow users to better understand the impact of them in their daily lives and thus make them more sensitive to the importance of getting involved in the development of the city.

Hence, Montréal, by setting up the Smart City office, is to some extent becoming less vulnerable to the power rotation between the different political parties. Such an office, as raised by Dameri (2016), academics, public administrators and companies working in the development of the Smart City, could thus make it possible to put forward the importance of measuring the impact of different projects.

If projects contribute to improve the efficiency of the city, why not reinvest the resulting gains in tools to monitor the impacts of these projects?

## 7 SMART CITIES OF THE FUTURE: PROSPECTIVE

Various components of Smart Cities have been presented in this document. To move forward, it is also relevant to consider what a Smart City will represent in the future. This section discusses the key findings from the literature, presents the results of the In-Session Interactive Survey and Web Survey and sums up on what is the future mobility for the five highlighted cities.

### 7.1 KEY FINDINGS FROM THE LITERATURE

There seems to be an agreement that Smart Cities should use technology to solve existing problems. While problems are numerous in urban areas, it is often stated that the most important problem needing to be addressed in a city is transportation. Thus, good transportation management is the core of an efficient city. That is why mobility has been ranked second, after environment, in the most important criterion for the future development of a Smart City<sup>46</sup>. Investments in transport resources would “*raise the level of the economy, social well-being and competitiveness, these being prerequisites of a successful and integrated Smart City*”. Hence, mobility is a recurrent topic in the literature regarding Smart Cities of the future.

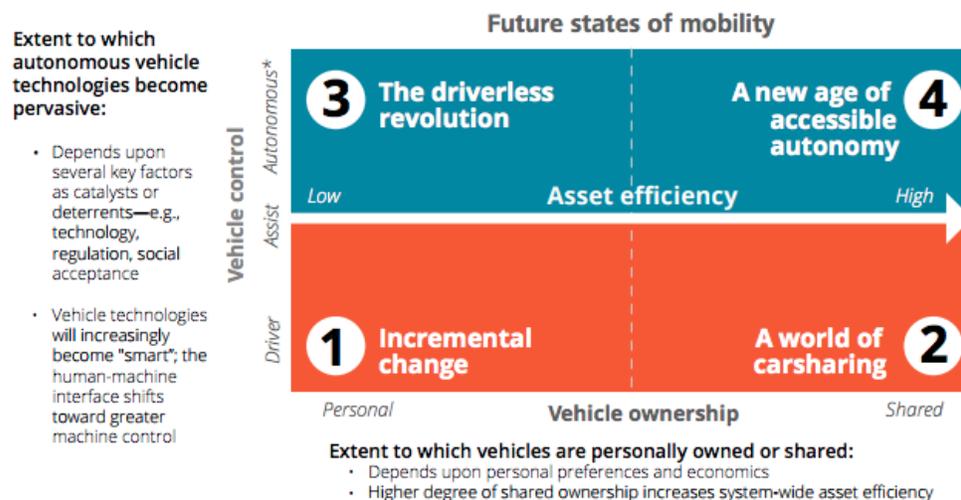
At the view of the various initiatives and the blooming and diversified literature on Smart Cities, it is clear that many cities are moving forward with such vision. Still, there is an important unbalance with respect to the level of maturity of cities as well as with respect to the means and support they received in their process. This means that the future of one city may look like the current state of another. Nevertheless, it is relevant to envision what smart cities may look like in the near and far future.

Relating to the far future, the most frequent keywords are shared and autonomous. It is very likely that a change will occur concerning who owns, operates and uses the vehicle. Four states of mobility could emerge depending on several key factors such as technology, economics, social acceptance as well as others<sup>47</sup>. These four states are described in the following figure.

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<sup>46</sup> Tahir (2016)

<sup>47</sup> Corwin (2016)



**FIGURE 7.1 : THE FUTURE STATES OF MOBILITY. SOURCE: DELOITTE ANALYSES**

If future mobility is to be the “*new age of accessible autonomy*”, the whole mobility ecosystem must change. Indeed, autonomous vehicles can be accompanied by various improvements to the road environment, such as reduction of curbside parking, intelligent traffic signals and the arrival of seamless intermodal transportation choices.

However, even if some people proclaim the arrival of the autonomous vehicle in the coming years, it seems to depend on the definition given to an autonomous vehicle. As of 2018, the totally driverless vehicle may not be a mainstream reality for a few decades<sup>48</sup>.

Until the “*new age of accessible autonomy*”, several points, mentioned in the literature concerning a closer future of mobility, still need to be reached. First, one mainstream objective of the mobility of tomorrow, as well as of the cities of the future, is to rely solely on clean energy. In transportation, this is mainly related to two distinct fields, in addition to the inevitable and important role that active modes should play in this respect: the electrification of public transit systems and the development of hybrid and electric vehicles, which are now being studied extensively by the international scientific community<sup>49</sup>. The spread of electric and hybrid vehicles is strongly related to the availability of charging infrastructure. In several cities, an important role is expected to be played by public transport. Indeed, the public procurement of electric and hybrid fleets of vehicles could be a way to accelerate the setup of charging infrastructure which could then be made available for private customers. Hence, the development of electric vehicles relies a lot on public fleets. Also, according to Sassi (2014), “*the future of energy will*

<sup>48</sup> Kessler (2017)

<sup>49</sup> Brenna (2012)

increasingly rely on digital intelligence and the use of data analysis which will serve to produce a more efficient use of resources”. Also, digital intelligence will not only serve the use of clean energy: it is definitely a crucial component of future mobility, as well as the “internet of things”. The internet of things is the network of physical devices that enables objects to connect and exchange data; it actually embodies the concept of Smart cities in itself. Hence, in the future, all technologies enabling the internet of things will have to develop quickly enough to follow the evolution of Smart Cities. This concerns the DeviceToDevice (D2D) communication, the 5G operation as well as the efficient management of big data and its related security challenges. Finally, before the integration of driverless vehicles, connecting vehicles using smartphones, users’ interactions and social networking is probably a key in the process of achieving smart mobility. This is important for users’ interactions and shared mobility and it will encourage a shift from smart mobility services to smart social mobility services (SSMS). The latest is defined as “The basic idea of SSMS is to dynamically sense the specific mobility needs of users and dynamically check them against not only the set of actual mobility services (for example, public buses), but also against potential mobility capabilities (such as a private vehicle going to a specific place) that could be turned into mobility services (by having the private vehicle offer a ride).”<sup>50</sup> Beyond evolution and endless technological improvements, it is comforting to see that the will to satisfy human needs remains central.

## 7.2 RESULTS AND ANALYSIS OF THE WEB SURVEY AND IN-SESSION INTERACTIVE SURVEY

In the Web Survey, the following question was asked: « What do you think will drive the next generation of Smart Cities? ». The answers are presented in the following figure.

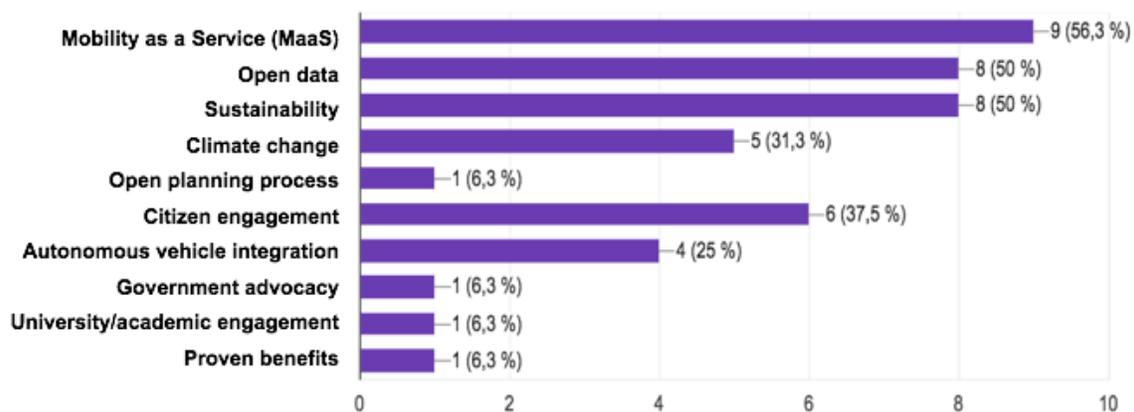


FIGURE 7.2 : RESULTS FROM THE IN-DEPTH SURVEY ABOUT NEXT GENERATION OF SMART CITIES DRIVERS<sup>7</sup>

<sup>50</sup> Ismail (2016)

The most popular answer was Mobility as a Service (MaaS), with 56.3% of the votes. The aim of MaaS is to provide people with the tools to optimize their trips, whether done by private or public transportation. MaaS improves quality of life through a new way of travel planning. The answers ranking in second place, with equal votes, are Open data and Sustainability. These results fit very well with the answers obtained from the in-session survey, where participants were asked to provide three words describing the Smart City of the future. Connected, Livable, Sustainable, Safe, Citizen Based and Open were the most popular answers. Connected was predominant, it was named by 17% of the participants, while Sustainable and Open were the third and sixth most chosen words. The word cloud generated from the in-session survey results is depicted in the following figure.



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**FIGURE 7.3 : RESULTS FROM THE INTERACTIVE IN-SESSION SURVEY HELD DURING THE 2017 ITS NATIONAL ASSOCIATIONS MEETING – WORDS DEFINING THE SMART CITY OF THE FUTURE**

There is consensus that technological advances are a pillar for future mobility. A city should be connected, the data open, but one should not forget that a city must also be livable and safe.

### 7.3 KEY ASPECTS FROM THE 5 CASE STUDIES

According to the 5 cities highlighted throughout this study, the trend for the future of mobility is nearly the same. For Singapore, autonomous vehicles and big data will lead the way to a smarter mobility and Columbus agrees by saying that there will be more artificial intelligence in the next decades. In Montréal, the impact of the internet of things, big data and so on, will be significant. However, for its representatives, there is a true need to reverse the trend which prioritizes the development of new technologies instead of ethics. Indeed, advanced technologies can present some problems such as violation of private life or segregation of people in need (who do not have access to the internet for example)

and Montréal thinks that technologies should not override the importance of human vulnerabilities. Christchurch case showed the importance to develop agile reflexes by seizing opportunities as they present. Empowerment and enthusiasm should drive future innovation, without being buried behind legislation and process barriers: a balance of organic and traditional growth should coexist. Finally, in Copenhagen, they are thinking larger than the city itself and saying that for a smart mobility, there is a need to find solutions across the border, suggesting that cities must work together to become smarter.

## 8 CONCLUSION

### 8.1 REVIEW OF CONTEXT AND OBJECTIVES

As cities become the focus of a sustainable tomorrow, the concept of Smart City, as fueled by ICT (information and communication technologies), has gained tremendous popularity across the world. Benefitting from a rare window of opportunity that was the Montreal ITS World Congress 2017, this white paper initiative was launched by the Regional ITS Associations in collaboration with Polytechnique Montreal as a mean to address current gaps in knowledge regarding the concept of Smart City. Its goal was to provide cities and ITS organizations some guidance with respect to key components of the development of Smart City strategies regarding mobility and transportation.

Focusing on five themes related to Smart City development, Definition, Driving Forces, Main strategies, Implementation challenges and Impact measurement, the paper presented a methodology that allows for the comparison of key scientific literature elements with the reality as experienced by 5 cities leading the way in Smart City strategies: Christchurch, Columbus, Copenhagen, Montréal and Singapore. Additional results obtained from two data collection processes, (1) an online survey shared through the regional and national ITS Associations networks and (2) an in-session survey conducted during the annual ITS associations executive session at ITS World Congress 2017 in October, were also used to provide additional insights on the 5 themes explored.

### 8.2 FIVE THEMES TO EXPLORE

Since the popularity of the Smart City concept has grown rapidly, the scientific community has come up with a wide array of definitions in a view of proposing a coherent and unified framework to encompass the large variety of strategies, goals and components of this concept. A key finding of this paper is the discrepancy between the theoretical definition found in scientific and grey literature and the more practical definitions proposed by the 5 highlighted cities. Each city had a different definition, tinted by their respective priorities, which echoed the challenge mentioned by several authors of developing a global definition of the Smart City concept.

Following the comparison of theoretical and practical definitions of a Smart City, the next step was to explore what drives a city to launch a Smart City initiative. The literature explored broad categories of triggers: do more with less/optimize what's already built, tackle the output of cities by reducing carbon footprints and environmental impacts and improve quality of life to increase attractiveness. One main trigger stands out: the need to mitigate the impacts of large population growth in urban areas. Some authors also defined two types of triggers: technology push and demand pull, including international competition between cities. The In-The In

Session interactive Survey revealed that enhancing social cohesion and quality of life as well as supporting economic development in a sustainable way were the most popular triggers of a Smart City initiative. Transportation wise, the Web Survey marked the need to improve road safety and manage traffic congestion as important drivers of smart mobility schemes. Furthermore, while Smart City program were initiated for different purposes around the world, several government launched some form of challenges among cities to award financial support to foster the development of a Smart City program. The five highlighted cities were all driven by different reasons, with Christchurch standing out from the others and from the literature as being driven by the urgent need to rebuild the city after two unfortunate earthquake destructions, demonstrating how such events can be turned into opportunities.

Based on literature findings and on the knowledge provided by Christchurch, Copenhagen, Columbus, Montreal and Singapore, smart mobility strategies were classified in 8 categories: 1) Transportation electrification, 2) Smart parking, 3) Smart vehicular traffic management, 4) Smart transit, 5) Smart active mobility, 6) Integrated and seamless mobility, 7) Connected & shared mobility, and 8) Public & business engagement. These categories were further divided into 25 sub-categories with details on 62 specific measures. The results from the In-Session survey indicates that Smart Traffic Management, Mobility as a Service (MaaS) and integrated data platform were the most common strategies among the 31 respondents. The Web Survey results highlighted similar findings: Smart Traffic management and Smart Transit as the most important strategies while Connected/Shared Mobility and Transportation electrification were given the least priorities.

Having the right framework of strategies does not however guarantees success. As such, several challenges await a city on its journey to become smart. The challenges are grouped in three main categories. First, the literature highlighted the social challenge of engaging the public as a key aspect of Smart City development as it fosters citizens' participation in the Smart initiatives and serves as a crucial step towards establishing the right set of strategies. Second, the heterogeneity of systems and data, the collection of data through physical and connected device and the level of security needed to protect and back-up such systems composed the technological challenges. And third, the challenge of developing the right regulatory framework in the complex administrative structure of today's metropolitan area while dealing with the short-term vision resulting from political cycles could be categorised as governance challenges. The In-Session Interactive Survey and Web Survey both returned results in accordance with the scientific literature. Inter-Agency cooperation and decision's maker traditional ways of thinking were the most important barriers to a Smart City approach in addition to a lack of funding. Promoting and explaining the motives and purposes of Smart City initiatives to stakeholders, government agencies and decision

makers is viewed as a good way to overcome some of those barriers. Engaging the public by promoting strategies that directly benefits them is also a fruitful approach for a successful Smart City implementation.

Finally, the last theme explored in this paper is the measurement of impacts resulting from Smart City initiatives. Properly measuring impacts may bring many benefits to a city but the literature shows that an informed vision and a structured measurement strategy are needed well before the implementation of the project to unlock those benefits. While often overlooked, a proper impact measurement strategy is not trivial as several obstacles are documented: defining and estimating relevant indicators, dealing with the unavailability of data before the implementation, the absence of proper data collection method and tools, the lack of funding for impact measurements and the short-term vision that often lead Smart City development. The In-Session Interactive Survey revealed that the five predominant factors that prevent a city from assessing the impacts of implemented measures are in-line with the obstacles identified in the literature.

### 8.3 PERSPECTIVE ELEMENTS

Looking forward, mobility and transportation are referred to as core components of the Smart Cities of the future. The literature shows that in the far future, mobility will be shared and autonomous, and thus an important shift will occur from individual ownership models to mobility as a service models relying on the shared use of fleets of vehicles in support of mass transit. One key component of future mobility regardless of its level of automation is its requirement to rely almost exclusively on clean energy. In such, two paths need to be followed simultaneously: the path of vehicular and transit electrification and the path of motorised travelled reduction.

The future of Smart Mobility will also rely on the concept of Internet of Things, i.e. the use of a network of connected devices allowing communications between vehicles (V2V), infrastructures (V2X) and personal devices. This will facilitate seamless mobility by tailoring supply of mobility services more closely with user's demand, an idea referred to as Smart Social Mobility Services (SSMS). This echoes partially the results on the In-Session Survey where Mobility as a Service (MaaS), Open Data and sustainability were identified as the keywords of the next generation of smart cities.

Finally, there is a consensus that technological advances are a pillar for future mobility, but must remain a mean to an end, not an end on itself. A city should be connected, the data open, but one should not forget that a city must aim for improving quality of life for its constituents while fostering all spheres of sustainability. Thus, the development of a smart city strategy must rely on the right balance between citizens and business engagement, stakeholder's collaboration, technological and social innovation and international openness and collaboration. In their quest for the right strategy, cities must also keep in mind their strengths,

weaknesses, challenges and other contextual elements allowing them to design their own optimal recipe for a Smarter city as no one size fits all approach will ever exist.

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CITY OF COPENHAGEN

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# 11 APPENDICES

## 11.1 WHITE PAPER DEVELOPMENT PROCESS

