Using Traditional and New Digital Technology Tools to Promote Sustainable Mobility: Current Trends in the Evolving Transformation of the Smart City

Efthimios Bakogiannis, Maria Siti, Charalampos Kyriakidis and Avgi Vassi

Abstract Sustainable mobility is one of the most emerging challenges in the contemporary car-oriented city, where congestion and lawlessness grow, while funds continue to decline. Greece, so far, remains far behind the European and international innovative channels for transportation and mobility technology-assisted applications, having indeed a considerable increase in recent research and business projects. This paper aims at showcasing a collection of practices that focuses on enabling sustainable mobility policies and measures as well as hard infrastructure projects, both ICT and non ICT-enabled, in order to reach the smart city in mobility terms. The concept of a smart city does not always require the support of web technology tools, but rather integrates their use in a holistic approach to cope with the growing pressure of traffic situation and the existing travel behavior patterns. The study presents five (5) grouped sets of policy interventions and measures consisting of more than twenty five (25) indicative actions to be applied in cities and/or regions, ranging from common traffic calming solutions to smart traffic lights, car-sharing, and innovative parking schemes. The suggested sets of actions focus at the regional level, exploring at first the case of Athens and Attica Prefecture, however they can be applied in several other cases in urban and regional scale accordingly. Actions aim to tackle traffic safety, travel behavior dynamics and patterns, local mobility cultures and mobility and environmental awareness issues, considering the widespread use of information and communication technologies.

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1 Introducing Smart City in Mobility Terms

A smart city is defined by its efficiency and livability as well as by the use of innovative operational and information technology. One of the key issues determining the new era of cities, is the ability of gathering, using and leveraging a meaningful amount of data (stored or real-time) in order to improve services directed to their citizens, decrease costs in energy consumption etc. According to the European Commission, a Smart City is a city that is well performing in six (6) key fields of urban development, built on the "smart" combination of endowments and activities of self-decisive, independent and aware citizens. These fields are smart economy, smart governance, smart living, smart people, smart environment and smart mobility. There are plenty of ranking systems, such as the Smart City ranking by Boyd Cohen, the European Smart Cities, the Juniper's Smart City Rankings, the Intelligent Community Forum assessment as well as panels including global and European stakeholders (i.e. the World Bank, universities, United Nations Habitat representatives etc.), listing cities that perform well in one or more of the afore-mentioned sectors. These rankings can directly assist cities in global and regional recognition as they draw public attention as well as attract several investment and development funding. More and more projects are being implemented within the concept of smart cities with the formulation of partnerships and other entities participating in programs such as Interreg, URBACT, Horizon 2020, Civitas, etc.

Traditional urban and transport planning have dealt so far with practices that tend to meet demands by improving capacity through car-centric approaches, especially in cities where urbanization is rapidly growing. Typical solutions have led to car-oriented development patterns, which also drive the land use patterns in unsustainable city forms. Numerous researchers and studies consider transport to be among the three most energy consuming activities, with the other two being the sectors of housing and food production.

Recent transportation research and studies regarding the sustainable and compact city form have highlighted the importance of altering daily commuting habits and introducing sustainable urban mobility practices along with the redesign of streetscape. Sustainable urban mobility is an emerging field in transportation and environmental studies—especially in the European transport Agenda—introducing policies and practices to face problems such as road safety, air and noise pollution, congestion etc. The need for sustainable urban mobility has been distinctly described only after 2001, with a Green Paper from the European Commission being finalized and issued in mid-2007 entitled "Green Paper—Towards a new culture for urban mobility". 2006 and 2007 were the years that the Commission had largely discussed the issue, launching the debate on mobility through several

conferences, workshops, internet consultations and meetings. Later on, in 2011 the European Commission, via the White Paper "Roadmap to a Single European Transport Area—Towards a competitive and resource efficient transport system" adopted a roadmap of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, according to the European Commission (2011), the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. This comprehensive strategy (called Transport 2050) puts innovation and smart solutions at the core of future development and recognizes the importance of technology-assisted mobility applications towards the success of a new sustainable transportation environment.

Greek cities, being formally obliged to follow European strategies, have implemented several, however abstract, practices related to transportation. European Funds (Horizon 2020, Interreg etc.) have allowed the development of a number of strategies, projects, mobility practices and services related to the smart city concept in cities such as Athens, Piraeus, Thessaloniki, Thermi, Trikala, Heraklion and others. Innovations in smart mobility are more profound in Thessaloniki (project Intelligent Thessaloniki) as well as in the city of Trikala (project CityMobil2), where the first autonomous bus has completed its pilot application and was tested in real traffic conditions; in Piraeus (project Cyclecities and Smile), which has participated in innovative mobility projects etc. Although several projects regarding mobility have been implemented, development has mostly focused on pilot services and the output data are not integrated in the future strategic municipal or regional planning. Similarly, the tools and innovative services developed by these projects do not seem to be upgraded in following schemes or applied in future technologies. Moreover, public-private partnerships in Greece do not follow the European norms, and thus it is difficult to promote the concept of sustainable competitiveness as a driver of prosperity and long-term growth in terms of sustainable mobility. Initiatives are driven either by public entities (universities and research centers) or by business and project consultants, whose interests are limited to the end of each program.

2 The Transition to a Holistic Approach: Introducing a Methodology on Smart Mobility

2.1 Transition to a Smart Mobility Context

It is profound that the city layout determines the way people move, which if combined with each country's transportation culture, shapes the daily mobility environment. Smart or so called "intelligent" transportation services are changing the way cities move (Arup 2016); while at the same time "smart infrastructure"

projects are becoming commonplace (Fishman 2012). More and more cities are implementing practices and policies related to intelligent transport systems (ITS) and many of them are investing in infrastructure that can assist in the transition to an up-to-dated 21st century urban mobility agenda. Common problems include travel delays, congestion, increased travel costs, environmental degradation and the need for public spaces' regeneration. Smart solutions in mobility terms consist of systems, applications, implementation of policies, designs and plans, indicator systems for assessing performance and many more. Addressing issues in different environments with various implications in culture and planning sets requires an overall approach with a set of tools and a robust methodology to explore, analyze, select, and combine the suitable methods and practices to "tackle" the identified issues, while keeping intact any particular place identities. This is to avoid homogenization that calls cities to only adopt central European-like public space and road designs; and suggests that proper integrated solutions are driven by people-centered and participatory procedures. Understanding the attitudes and behavior of urban residents in relation to their daily travel needs and using this knowledge to assess the potential for behavioral change is at the core of current urban mobility studies, as it was recently supported by the London School of Economics and Political Science (LSE) Cities Report (Rode et al. 2015). Some solutions can only be adopted by cities that have already implemented progressive transport planning embedding walking, cycling and public transport parameters; while other solutions can support cities that are at a critical point in terms of tech industry revolution. The overall approach however targets cities that deal with socio-economic pressure, congested public spaces and downgraded urban environment.

Changing travel patterns implies a critical intervention in the culture of daily commuting that aims at sustaining a transition from traditional car users to green travelers and/or technology focused individualists and innovative access-oriented users (groups user identification from Rode et al. 2015); while it requires integrated approaches in both planning and policy implementation.

The smart mobility agenda should include different technology-assisted services, alternative use of vehicles, introduction of the "sharing" culture, innovative integration of traditional traffic calming tools, implementation of customized solutions and a communicative participatory approach for information and awareness raising. This report collects the basic concepts of smart mobility as implemented in numerous cities around the world and groups the key categories of traditional and innovative approaches to assist in the development of an integrated *smart and sustainable approach*. The conceptual diagram presented in Fig. 1 depicts the summary of available services and new developments on smart mobility patterns.

Data collected from smartphones, sensors and other communicative channels (see graphic in Fig. 2) can form new type of services and mainly introduce smart solutions to the current transit users, drivers, walkers and cyclists. Real time traffic management; real-time traveler information; route planning; car, ride and bike sharing systems; multi-modal transportation management; etc. can be some of the

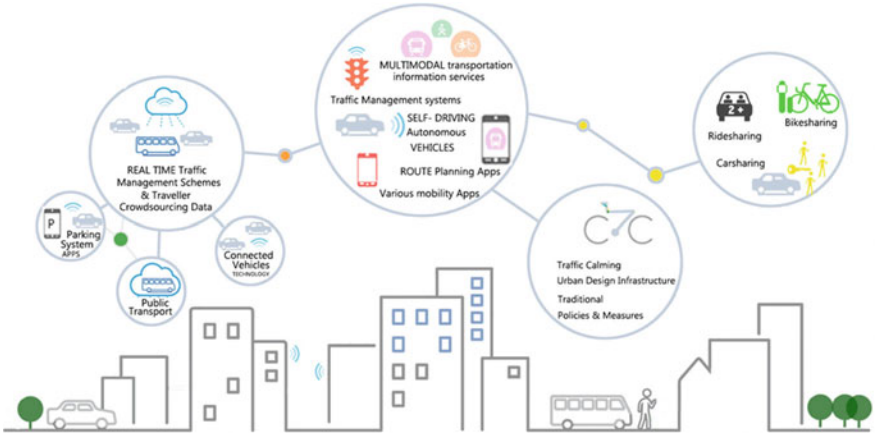

Fig. 1 Overall diagram of smart mobility tools, policies and services

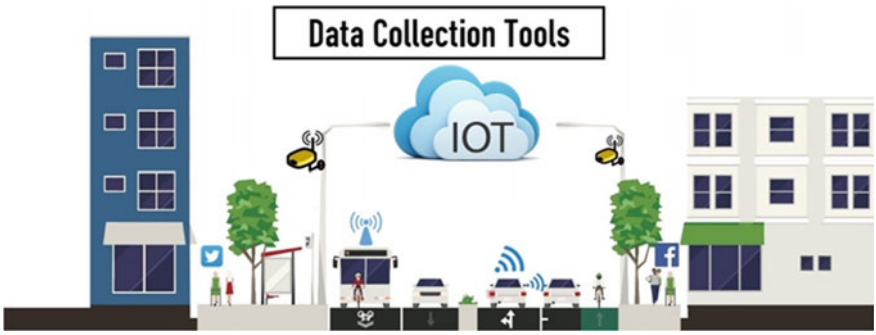

Fig. 2 Data collection tools including sensors, social networks, connected and autonomous vehicles

many services that highly rely on data gathering, crowdsourcing and technology to assist urban mobility alternatives. If the transportation related professions take full advantage of the technological and operational cutting-edge advances, traffic management can gain critical new tools to measure and understand commuting behavior and habits, leaving behind the traditional origin-destination and traffic volume studies. This can imply a highly promising professional revolution, embedding numerous changes in both the analysis and the policy formulation of sustainable mobility studies. The data can be gathered and provided either real-time or on demand according to the overall planning; and this can allow the flourishing of new types of services, letting the user of the transportation network become both the provider and the consumer of mobility information.

Fig. 3 Mobility services including ridesharing and multimodal management systems

Services generated in this new era of data acquisition and processing can significantly alter the way people choose to interact with their daily travels. Based on the new data availability and management, cities can develop dynamic tools to support reduction of traffic and carbon emissions; improve daily commuting pattern; decrease travel and maintenance costs; organize and sustain a viable on and off street parking system; impose fair congestion charging; and, most importantly, engage residents in urban and transportation management issues. Services may include congestion schemes, car sharing schemes, on demand car services, smart parking systems, real-time traffic control (see Fig. 3). Technologies allowing data collection from the wider environment (e.g. sensors or smartphones) can be used by local authorities to detect and solve problems, while complementary services can provide incentives to smart-users that decrease their environmental footprint and go multimodal. More common services deal with integrated public transport fare management or journey planning and travel assisting applications for improving individual travelers.

Automobile applications are on the rise and the rapid electrification of vehicles rushes to keep up with smart solutions. *Connected vehicles* can access, consume and produce information and share it with drivers, passengers, public infrastructure and machines, including other cars (Koslowski 2012). These next-generation vehicles can integrate a huge amount of the new services, such as ridesharing; while they can largely support smart parking services and assist in the development of new forms of private-public transportation. Connected vehicles can support integrated safety systems, evaluate weather and traffic conditions as well as act as sensors themselves and redistribute the data they gather in real time. The automotive industry is evolving in a rapid pace, presenting cooperative systems that deliver almost any kind of road data requested. Moreover, these vehicles can open the discussion on car ownership and help car-oriented cities to not consider abandoning their key gadget of travelling, but rather invest on it and leverage from its capabilities.

Traditional approaches in smart mobility are related to common traffic-calmed infrastructure and different planning hierarchies than previous transportation studies. Interventions should be followed by relevant policies and monitoring of their outcomes. Concise pedestrian networks, sidewalk widenings, bike lanes, road diet schemes, typical traffic calming solutions for traffic control (speed humps, speed tables, raised crosswalks, raised intersections, textured pavements, traffic circles, roundabouts, chicanes, re-aligned intersections, neckdowns, center-island narrowings and chokers), traffic calming solutions for volume control (full closures, half closures, diagonal diverters, median barriers, conversion to one-way streets) can accordingly be selected to fit in each case (see graphic representation of traffic calming techniques in Fig. 4). A crucial element in traditional approaches includes horizontal and vertical signaling that are constantly maintained, contributing to a tidy street environment.

Fig. 4 Traditional approaches in smart mobility (Reproduced from Traffic Calming 2016)

2.2 Developing a Methodological Framework for Planning Smart Mobility Solutions

The overall methodology of introducing smart mobility solutions should: consider current transport plans, existing inefficiencies, previous interventions in the smart city concept; explore willingness of citizens to support such systems; indicate priorities that need to be fixed; and conclude to potential policies, measures and tools that can contribute to street and overall transportation upgrade (see Fig. 5). Considering the potential policies and measures to be applied in each city, these should assess the technical effort needed and existing or future funding; while exploring political willingness to support small or big changes in infrastructure. Travel behavior reflects societal norms and the traditional urban culture of citizens; hence changes should be also largely supported with information and awareness

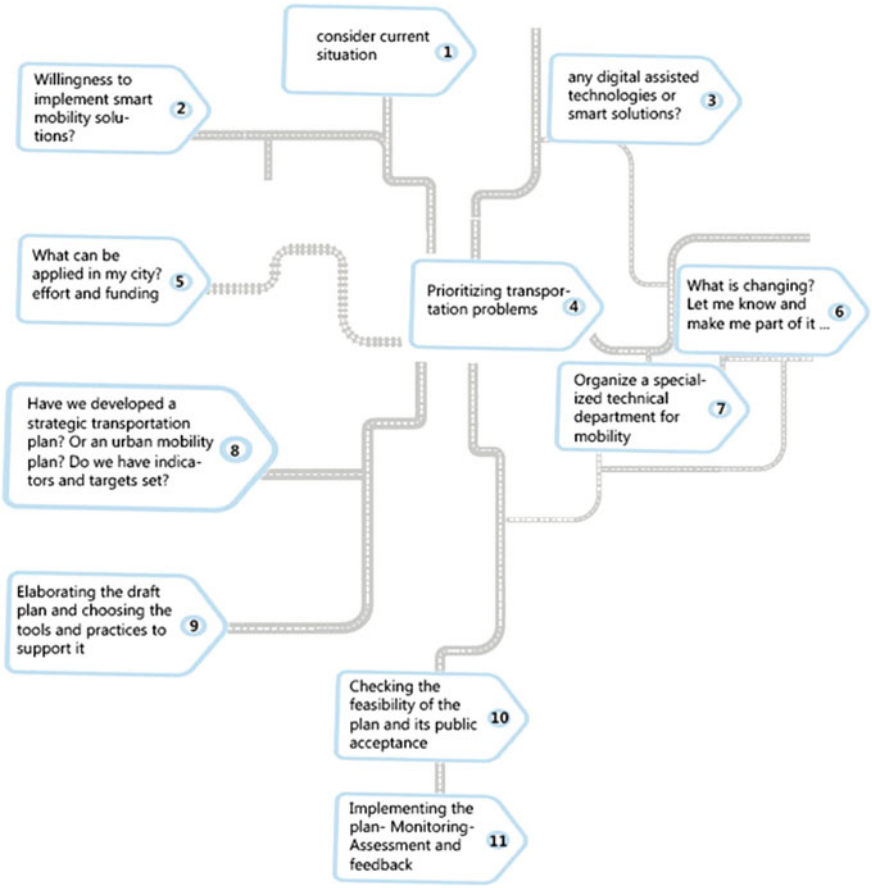

Fig. 5 Methodology on selecting city-specific smart mobility applications

raising campaigns. Adopting new policies and measures demands prior awareness raising steps in order to increase understanding of the needs and ease the acceptance and implementation of the planned interventions. Analyzing, assessing and selecting tools that best fit a specific city presupposes integrated management capabilities from specialized personnel and the development of a *strategic transportation plan*. If not existed, transport officials should elaborate a plan and choose the practices, measures and tools that can support it. Following, a technical feasibility study should check the ability of the city to implement such a plan; and ensure its public acceptance, with the last stage being the implementation. Implementation should be followed by constant monitoring and assessment based on output data, as these will be provided by the system and will refer to real-time data before and after each stage. Managing of these data will support feedback that is crucial for successful continuity. The structure of the proposed methodology has followed the standards integrated in urban and transportation planning studies (problem-solving workflow); and was based on the norms of contemporary smart city strategies and sustainable urban mobility plans (SUMP).

3 Categories and Special Policy Directions of Smart Mobility: The Case of Attica Prefecture

3.1 Introduction

Athens, being the case mostly explored in this research, has been largely affected by significant socio-economic changes in the recent decade. Urban development has been defined by sprawl and car-dependency; however the public transport system has been improved in terms of services and operational management. Although there are numerous fruitful discussions on the revitalization of the historic center, the re-development of old and upcoming inner-city neighborhoods and eventually the targeting of a transition to a compact city model, there is little progress in upgrading walking and cycling, two of the key pillars in the sustainable mobility discourse. Compact city models are discussed and legally established, but without the necessary adjustments in transportation terms. Athens has not implemented many efficient policies for road safety and sustainable mobility. Relevant policy directions as well as actions should involve a range of *traditional and innovative research tools* that would put an emphasis on participatory processes in order to raise awareness and effectively motivate citizens' engagement. Rising fuel prices along with severe income reduction can fortunately contribute to sustainable mobility promotion, since economic restraints force residents to consider transport alternatives. The particularities in the Athenian urban planning environment, such as the narrowness of the street form, the lack of an extended and organized on and off street parking spaces, the short distances and the sense of enclosure in existed inner-city neighborhoods, provide an ideal environment for combined smart

mobility tools. The five (5) key elements explored in the Prefecture of Attica, regarding its inadequate transportation environment are:

- Narrow streets that present non-fixed width regarding traffic lanes and pavements, which leads to illegal parking in the remaining dead spaces. Narrow sidewalks with several obstacles, preventing walking and social interaction.
- Although public transport has been improved, car remains the main mode of transport as neither incentive for multimodality have been provided nor severe and systematic car restriction policies have been formulated.
- Athens has not invested in cycling that has proven to be the key solution in moving and parking around for short to medium distances.
- Old and poorly maintained vehicles consist of the main car and bus fleet in the city, which downgrades the environment and increases carbon emissions.
- Very few digital technologies have been applied to adopt international and European applications in the transport environment.

Having explored the Prefecture of Attica in terms of needs and inefficiencies, Sustainable Mobility Unit (SMU) at the National Technical University of Athens has proceeded to the development of a certain methodology, the steps of which are presented in Fig. 5. At first, taking for granted the authorities' willingness to adopt smart mobility solutions (step 2), the current situation was explored (step 1) in terms of urban and transportation characteristics, including their consent in smart solutions (step 3). Assessing the eagerness of municipal authorities in dealing with information and communication technology (ICT) and promoting digitally-enabled policy directions and smart solutions in general, research has focused on prioritizing transportation problems (step 4) and exploring the potential effort and funding in the various choices (step 5).

As this is an *ongoing research*, the current objectives are centered on specific proposals regarding actions and policy directions. More specifically, research in the Prefecture of Attica has categorized the smart mobility actions required in *five groups*, further analyzed in a range of specialized actions tackling the major transport issues (see concept graphic scheme in Fig. 6). These groups focus on urban design interventions, smart systems and applications assisting mobility and quality of commuting, smart transportation schemes and vehicles, innovative policies in educating and awareness raising, and lastly smart management (data collection, processing and assessment) of data relating to trip patterns and environmental conditions.

Some of the suggested actions have already been applied to different urban environments, many of them following a holistic and systematic approach; while others a rather abstract way. Good examples of urban design interventions, in terms of urban mobility, can be found in Porto (Portugal), while recent smart systems and applications can be encountered in Valencia (Spain) and Rome (Italy). Numerous small and medium-sized cities in southern France and Italy, like Casalmaggiore, have introduced innovative policies for education and awareness raising, whereas smart data processes are applied to several cities (Rome, Venice, Athens, Heraklion,

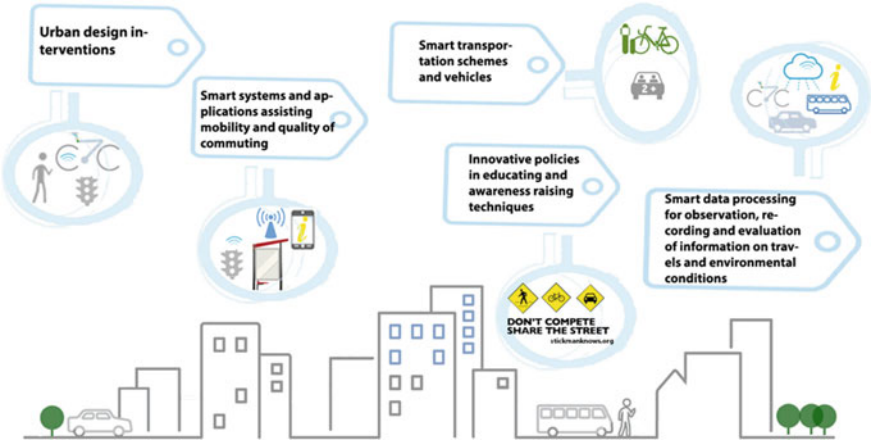

Fig. 6 The Athenian potential scheme with selected policies and tools in all five (5) categories

Thessaloniki, Madrid, Barcelona etc.), mainly due to funding opportunities provided by an increase in the relevant European funds.

3.2 Urban Design Interventions

Urban design interventions refer to hard infrastructure projects and implementation of policies and measures that do not necessarily contain digitally-enabled technologies and range from urban pilots, integrating urban and transport planning interventions to traditional traffic calming measures and speed reduction tools. Intersections, signaling, complete street design and case-specific solutions are at the core of this group of actions.

1st Policy Direction: Combined Urban and Transport Planning—Pilot Traffic Calmed Areas Inefficiencies in planning, operational issues in traffic safety and urban design cannot be addressed simultaneously throughout the overall urban area of Attica Region. Once street hierarchy is defined and parts that demand immediate intervention are identified, potential traffic calmed areas can be studied. Policies and measures will be studied for the specialized zones, prioritizing pedestrian and cyclists as well as specific areas will be converted to 30 km/h zones. 30 km/h zones have been successfully implemented in numerous cities in Germany, Belgium, and Netherlands; while recent pilot applications have shown positive results in Valencia (Spain) and Dublin (Ireland). These pilot areas in Athens will later form the norm for similar designs to be applied in the whole prefecture. The model for the pilot aims at identifying priority segments to be turned into traffic calmed, namely:

- The city center of Athens and a number of selected neighborhoods in each municipality.
- The surrounding areas of schools and other education and sports facilities, attracting young commuters.
- The surrounding areas of the main public transport stops and stations.
- The immediate surroundings of public spaces, such as squares, parks and community gathering places.
- The surrounding areas of shopping centers.
- Areas aiming to become living labs, experimental and gentrified neighborhoods that attract people for a specialized activity.

These pilot traffic calmed areas will become the start for a viable and socially comfortable new urban model that presents low cost traffic organization and its rules are in compliance to the European mobility agenda.

2nd Policy Direction: Speed Restrictions in Accordance to the Environmental Capacity of Street Sections and Downgrade of Studied Segments in the Street Hierarchy Plan This action applies to streets or street segments, which due to the existing land use pattern seem downgraded (i.e. extended asphalt paving) or have to accommodate dense pedestrian activity. These can be transformed to more active and complete streets, in accordance to NACTO guidelines (2013) and current European trends. Speed restrictions are justified and applied either for simple traffic safety reasons, or for holistic plans that add on the street bicycle lanes, prioritize pedestrians etc. The traditional Greek city has a unified speed limit in its overall surface, however sustainable policies ask for specialized limits according to the use and character of the street and the activities it accommodates.

Reducing the speed limit is also necessary in road sections that are designed to become the future "green routes", linking the regional municipalities with the center of Athens.

3rd Policy Direction: A System of One-Way Streets The one-way system is in favor of road safety and can restore human scale public spaces for several reasons:

- Avoidance of common frontal collisions.
- The number of movements at intersections is limited (at an intersection of a two-way street, the number of straight and turning movements is 12, which is limited to 4 in an one-way intersection).
- The one-way system allows the reduction of the street width and hence provides space for sidewalk widening, parking spaces and speed reduction.
- Converting two-way streets into one-way, while introducing bike lanes, encourages the overall sustainable mobility promotion policies:

- One-way street systems force cars to follow a specific path, complicating their move hence discouraging unnecessary trips and passing by local neighborhoods to shorten external journeys (through traffic).
- One way streets with clear signs and horizontal signaling eliminate on street parking in both sides, thus reducing accidents with low to medium severity.
- Crossing pedestrians have to check one side coming traffic.

An integrated one-way street system should be accompanied by a strong vertical and horizontal signaling system, which can also be assisted by digital services.

4th Policy Direction: Replacing Common Intersections with Traffic Lights with Small and Operational Roundabouts Traffic lights are a safe solution when respected, which has been proven to add delays and risk with Greek drivers that accelerate in the orange and many times in the redesign. Roundabout forces all vehicles to reduce their speed, and small roundabouts have been found as a very flexible solution in local street systems and congested arteries. Some roundabouts are assisted by digital technology to inform drivers approaching them to reduce speeds and help on free-flowing traffic.

5th Policy Direction: Smart and Case Specific Policies in the Road Network. Temporary Pedestrianization and Special Occasion Configuration This is an action that is largely applied in many European cities as well as in several tourist places in Greece. A temporary pedestrianization demonstrates that when removing car traffic, street environment stops to be hostile and attracts pedestrians and cyclists. This can also demonstrate that the road network is flexible and can still operate when segments or whole streets are removed from its service for a specific time period, provided that the necessary information to drivers is in place. Street safety issues in tourist areas and metropolises in Europe are very important, and common solutions such as the temporary pedestrianization are absolutely feasible. Attica Prefecture can try similar practices and extend urban tourism potential in the city center and other chosen places. Case specific policies require flexibility and a strong campaign for supporting and informing residents and visitors.

6th Policy Direction: Smart Enhancement of Pedestrian Movements|Elevated Crossings and Plateau The elevation of pedestrian crossings is the crucial infrastructure that promotes walking and recognizes pedestrian priority at intersections. Conventional intersection allows the car to pass uninterrupted, as nothing is used to physically reduce speed, and hence the pedestrian is forced to step down the road and up again to the opposite sidewalk. Elevated crossings can provide consistency in pedestrians and act as alternative speed bumps and obstacles to the car.

Raised junction areas (plateau) alter significantly the image of transition areas from car-oriented to people centric, since whole surface of the crossing is elevated between the curbs, contributing thus to a more visible pedestrian priority from drivers and a more readable street environment.

7th Policy Direction: Introduction of Special Chicane Islands Chicanes are curb extensions that alternate from one side of the street to the other, forming S-shaped curves. Chicanes can also be created by alternating on-street parking, either diagonal or parallel, between one side of the street and the other. Each parking bay can be created either by restriping the roadway or by installing raised, landscaping islands at the ends of each parking bay (Traffic Calming 2016).

These curb extensions can improve traffic safety in places like the front of public transport stops, close to intersections for speed reduction, which can also add to the social cohesion of neighborhoods, when proper urban furniture is installed on them. These surfaces can accommodate sensors or other information equipment and invite users to use them.

8th Policy Direction: Cycling Integration to Tackle Congestion The integration of cycling in Athens will contribute to the introduction of sustainable road conditions and will ease traffic flows in the main urban thoroughfares. The implementation of the Metropolitan Cycling Network along with the completion of local cycling networks will relieve the main arteries and drivers will be introduced to the coexistence with cyclists. The implementation of "bicycle streets", where the car is required to move at 20 km/h and remain behind the bicycle can help towards the same direction. The extended use of social networking and smartphone applications can boost further bicycle use and the formulation of a new society of drivers that choose their route depending on its urban/suburban characteristics, aesthetics, safety etc.

9th Policy Direction: Integrating Greek Particularities in the Traffic Environment: Motorcycles and Scooters Motorcycles and scooters are commonly used in Greece, due to the lack of parking but also good weather conditions. Motorists are in danger as they rush through car traffic, while at traffic lights they tend to stand on the sides of the cars. Similarly to bike-boxes in the Netherlands and Denmark, Athens needs motorcycle boxes at intersections allowing them to stand, while waiting for the traffic lights in front of cars in a dedicated surface where they will be protected and prioritized.

3.3 Smart Systems and Applications Assisting Mobility and Quality of Commuting

These systems refer to those promoted and accommodated by local authorities or private entities to detect and solve problems, as they use largely breakthrough or conventional technology to support a certain mobility aspect.

10th Policy Direction: Smart Parking System An important part of traffic congestion is created by drivers looking for a parking space. Information on empty spaces and the transmission of this knowledge through a platform can save unnecessary movements and inform about the real time and cost of a car journey,

suggesting alternative paths to destination and ideal parking spaces nearby. Such parking systems can also boost entrepreneurship, as drivers can be informed about coupons, discounts and other incentives in using peripheral private or public parking facilities.

11th Policy Direction: Smart Public Transport Stops and Stations Public transport is one of the key pillars in sustainable mobility and studies reveal that good transit systems raise the level of economic activity and prosperity in large cities (i.e. NBCRT 2003). Smart transport management schemes and applications to ease waiting and travel times and relating costs are evolving rapidly in developed cities, like Barcelona, Amsterdam, London and many more (EY 2015). Smart stops, on the contrary to conventional ones, are using vehicle positioning technology to inform passengers on arrival times, while integrated transport systems promote multimodal choices.

12th Policy Direction: Interactive Traffic Lights Conventional traffic lights have a fixed phase rotation schedule, irrespective of the existing traffic volumes and delays, which are constantly changing. Intelligent and interactive traffic lights are connected to counters, or become counters or sensors themselves, in order to adjust their schedule so that congestion will be relieved. ITS use these data to provide the drivers, through other platforms, alternative routes or inform them about waiting times etc.

13th Policy Direction: Public Transport Management Application Public transport management applications usually provide data to users for the overall operation and fares of the public transport. GPS technology tracks the user's location and provides nearest stop for their destination along with suggested time for departure and arrival.

3.4 Smart Transportation Schemes and Vehicles

These schemes promote collective use of vehicles or other alternative ways of commuting that aim at promoting further the advantages of technology in changing the traditional transportation model.

14th Policy Direction: Car Sharing Car sharing aims to attract residents, visitors and students who do not have a car either because they cannot afford one or because they do not want, but may periodically need to use one. Car sharing schemes need companies that have a car fleet and a system to charge its use and manage the clients. This is a convenient solution for cities with extended public transport and efficient walking and cycling infrastructure that want to decrease the number of cars and provide their residents with smart and collective transportation schemes. Smart phone technology and applications are essential for its successful use.

15th Policy Direction: Carpooling Carpooling is a sort of collective private car that aims at users willing to share a ride, usually for work commuting. It is very convenient for travels between the suburbs and the city center. Passengers share fuel costs and may use in rotation different cars. Digital technology can identify common origin—destination schedules and suggest users that could share their ride.

16th Policy Direction: Bike-Sharing Bike-sharing stations are usually installed in stations with a buffer zone of 300 m to serve cities that strongly promote bicycle use. Bike-sharing systems have been implemented in more than 600 cities (Vassi and Vlastos 2014) in the world with various systems to support their use. Technology evolution has of course improved their capacity, as new systems can now simply unlock bikes via smart phones, or provide integrated systems that allow interconnection and tracking of their location, allowing them to park even outside designated bike share stations.

17th Policy Direction: Management of the Taxi Fleet Taxis in Athens are a cheap alternative to public transport, hence their use differ from other European capital cities. Smart applications have changed the way communication between the driver and clients' works, informing about the available cars and their location, easing their pick up and eliminating unnecessary travels within the city centers. Moreover, the lack of a robust regional public transport network has made taxis to conduct fixed routes between regional areas in specified timetables, which if supported through mobile application can help both passengers and drivers.

3.5 Innovative Policies in Educating and Awareness Raising

These policies aim to tackle the knowledge gap for sustainable transportation, addressing both local authorities and citizens. Actions should inform about alternatives in commuting and their advantages as well as educate citizens in more environmentally responsible transport patterns.

18th Policy Direction: Sustainable Mobility and Traffic Safety Observatory The observatory will be managed by a sustainable mobility department (see action 19) and should be supported by an online interactive platform that:

- Will deal with the current situation in Attica Prefecture, recording common issues on the streets (maintenance issues, damages or inconsistencies regarding infrastructure and urban furniture, signage etc.), dangerous spots, malfunctions in public transport operation, short and long term traffic arrangements, short assessment of applied solutions, etc. Relevant experience of good practices and lessons learned from unsuccessful examples will be recorded. Black spots will be identified and mapped regarding accidents involving pedestrians and cyclists.

- Will be used as part of awareness raising, consultation and public participation procedures in planning. The platform will show the completed projects, as well as the proposed or under construction projects allowing citizens to suggest for improvement. The main advantage of such an observatory platform is that all data are visualized regarding their impacts on the specific areas of intervention.
- Will showcase good practices from other European and international cities that could be transferrable in the case of Attica Prefecture.

19th Policy Direction: Sustainable Mobility Department in Local Authorities Local technical authority services should include a specified departmental office dedicated to sustainable mobility. This office deals with issues related to: walking, cycling and public transport as well as urban and transportation planning. Special platforms should promote its operation and among its duties should be traffic management, introduction of ICT technologies, observation and assessment of new planning tools as well as management of participatory events for further engagement of citizens to the goals promoted.

20th Policy Direction: Awareness Raising Campaign in Schools Awareness raising campaigns in schools demand the cooperation of regional authorities and the relevant educational directorates as well as the Ministry of Education. Traffic safety campaigns and education about sustainable mobility issues are commonly implemented in European cities like Graz and Vienna (Austria), Rome (Italy), Malmo and Lund (Sweden), while Athens has completed some abstract similar application. Introduction of students into the way public transport networks operate and serve citizens, informing them about the driving code and explaining signs as well as letting them know about dangers and risks that can have a great impact on their interaction to the city. These campaigns aim at forming future grown-ups that respect their surrounding and their fellow citizens, making them responsible for their choices in the city. Technology, due to its attractiveness to students, can further engage them in such campaigns and several applications can help them realize any impacts caused by daily habits regarding transportation.

21st Policy Direction: Planning Collectively Actions that will Engage Students in Traffic Safety and Sustainable Mobility Regional and local municipalities should cooperate with Directorates and Ministerial authorities in order to organize collective actions addressing the engagement of students to traffic safety and promotion of sustainable urban mobility. Actions can include: collective school commuting with bikes or on foot (see: cycling and walking bus actions in United States of America, SafeRoutes 2015), training programs for bike use, field trips to areas or cities that present good case studies for cycling and walking integration.

Collective school commuting is organized in several cities of the world (i.e. St. Albans and Kent—United Kingdom, Lecco—Italy, Lyon—France), where accredited parents are accompanying students who walk or cycle to and from school through a specified route, which allows more and more students to join the so-called

"walking buses" (as the concept was named by David Engwicht in 1992) or cycling buses. Training programs that teach students how to walk or cycle with safety can really transform the culture of a city towards sustainable mobility and make next generation citizens more aware of the impacts of their travel behavior. Field trips to areas that promote walking and cycling (e.g. Karditsa-Greece) can show students a viable alternative to the common model of Athens and inform them about the benefits to following a viable city model.

Such actions demand careful planning regarding their technical and social parameters since they are used as the basis for increasing the interest of students in mobility behavior, and can engage a large amount of participants from local authorities and educational directorates, to students, their parents and educators.

22nd Policy Direction: Information and Awareness Raising Campaign The design and implementation of an information and awareness raising campaign regarding issues of road safety, environmental capacity and sustainable mobility should include all modern aspects of targeting controversial audiences. The minimum elements should include the development of audiovisual material, brochures, lectures and seminars. Events should be supported by Prefectures and Municipalities in any given chance and constant information must be provided to the citizens.

23rd Policy Direction: Innovative Education of New Drivers about Sustainable Mobility Traditional driver's license training is only focused on operational elements of the car, and simple driving rules regarding the interaction with other vehicles. This typical procedure presents a great opportunity for the state to educate drivers in further issues that are considered important for driving behavior, interaction with pedestrian, cyclists etc. Obtaining a driving license typically has to do with driving techniques, while driving is a rather forceful action in the city's environment, related to behavioral patterns, mobility choices, respect to vulnerable road users along with several impacts on the environment and the aesthetics of the city. Instructions on traffic safety, behavioral issues regarding vulnerable users, environmental and social impacts of a car-dependent lifestyle should be considered as equally important aspects on gaining the "ability" to drive. Education should include:

- The role of public transport, cycling and walking around the city.
- Suggestions in avoiding extended car use when not necessary.
- The need for choosing multimodal transportation i.e. car and public transport, car and bike, walking and cycling etc.
- The motion characteristics of pedestrians, disabled, children, elderly and cyclists in the street environment, so as to identify potential hazards from distraction or difficulty in moving.

A contemporary driving license should also improve the driver's ability to use digital tools for navigation, route planning, eco-driving, etc., as the driver's comfort in using them can be similarly important to the physical act of driving.

24th Policy Direction: Education on the Use of E-Bikes The electric bike market grows rapidly in Europe in recent years, due to the great improvements in battery technology and the considerable reduction of e-bike costs. The electric bike is changing significantly the cycling data and attracts more users, regardless of their age and physical condition, overcoming the barriers of inclined terrain and distance travelled. Prefecture's authorities can organize seminars on educating potential users and promoting electric bikes as a competent alternative to car and motorcycle drivers. In such attempts, technology can ease further their use regarding route planning and individual user preferences.

3.6 Smart Data Processing for Observation, Recording and Evaluation of Information on Travel and Environmental Conditions

As described earlier in the paper, there are numerous applications in cities that have already invested in urban and transportation planning and present consistent policies in improving transportation trends. Attica Prefecture can start with small paces by utilizing low cost information and investing in long-term infrastructure to assist its future transport planning.

25th Policy Direction: Smart Lighting "Smart" lights are becoming commonplace in Europe and abroad, improving energy efficiency and upgrading environmental performance. Led type technology can save money and energy, adjusting their use according to the daylight. Emerging smart lighting poles can also act as sensors to record and analyze data for air pollution, noise levels, temperature, humidity, as well as traffic, pedestrian and cyclist volumes.

26th Policy Direction: Crowdsourcing Application in Public Transport, Taxi and Car Fleet to Collect Emission and Traffic Data Crowdsourcing applications, based on the voluntary participation of interested citizens in data collection and sometimes evaluation of alternatives are highly emerging practices in the international arena and can easily be used similarly in Attica Region. Air pollution special counters (CO, NO_x, O_3, SO_x, PM, etc.) will be placed voluntarily on public transport, taxis and cars. Their participation will be preset to a specific operational framework and the data will be evaluated and feedback part of the afore-mentioned. The output of their processing will be presented in the Observatory and held in a special database.

4 Conclusions

Sustainable urban mobility is fundamental to European and Mediterranean cities' economy and social life. Safe, pleasant and affordable daily commuting is key to the everyday quality of life of citizens and can ensure equality, accessibility and increase of social cohesion. Smart city solutions in the field of urban mobility aim to address these issues, while involving citizens in action and removing barriers in their communication. The emerging trends in technology, business models and societal needs could and, in certain cases, have already affected the way current and future transport issues will be faced.

This paper has explored a collection of practices that focus on enabling sustainable mobility policy directions including traditional and innovative approaches, such as traffic calming measures, infrastructure, data collection tools and mobility services. Based on the current trends, the authors provide a first approach on their methodology of introducing and applying smart mobility solutions in cities by considering a number of facts and exploring what fits best in a city's profile depending on a number of factors that can contribute to an overall transportation upgrade. Moreover, the paper provides a short review on how some of the emerging trends could potentially be applied in the case of Attica Prefecture. Studying the experience of the Athenian city and its wider metropolitan region in terms of its technological advances, its alignment to smart solutions in administrative level and the implementation of urban mobility projects has led to the conclusions that smart mobility parameters have to be studied and applied in accordance to the city's particularities and deficiencies. The presented methodology, as applied through the case of Attica, develops a creative toolbox with actions that can lead to smart paradigms of shifts in a daily commuting base as well as in the prevailing transportation culture of car-oriented cities. The crucial element in the suggested study remains the applicability and its potential outcomes in the future modal share. Critical issues raised from the above may also include the adaptability of local authorities in such a new scientific perspective along with their eagerness to adopt strategies and tools to solve long-established traffic and transportation problems.

Finally, the discussed issues within the overall concept of the smart city are expected to raise several research questions related to travel and mobility behavior, approaches in different age groups and different mobility attitude groups and provide critical outcomes in future transportation studies.

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