BRIEFING

Requested by the AIDA committee

European Parliament

Artificial Intelligence in smart cities and urban mobility

How can Artificial Intelligence applications be used in urban mobility and smart cities and how can their deployment be facilitated

KEY FINDINGS

Artificial Intelligence (AI) enabling smart urban solutions brings multiple benefits, including more efficient energy, water and waste management, reduced pollution, noise and traffic congestions. Local authorities face relevant challenges undermining the digital transformation from the technological, social and regulatory standpoint, namely (i) technology and data availability and reliability, the dependency on third private parties and the lack of skills; (ii) ethical challenges for the unbiased use of AI; and (iii) the difficulty of regulating interdependent infrastructures and data, respectively. To overcome the identified challenges, the following actions are recommended:

- EU-wide support for infrastructure and governance on digitalisation, including high performance computing, integrated circuits, CPUs and GPU's, 5G, cloud services, Urban Data Platforms, enhancing efficiency and ensuring at the same time unbiased data collection.
- Inclusion of urban AI in EU research programs addressing data exchange, communication networks and policy on mobility and energy, enhancing capacity building initiatives, also through test and experimentation facilities.
- Harmonising AI related policies in the EU, taking into account the context specificity: necessary research.
- Adoption of innovative procurement procedures, entailing requirements for technical and ethically responsible AI.

Context and scope

The briefing analyses beneficial AI applications for smart cities and urban mobility, focusing on relevant use cases and challenges faced by the public sector when it comes to the uptake and deployment of such AI solutions. The briefing aims at providing valuable information to the AIDA special Committee, in order to enrich ongoing discussions concerning the difficulties faced by municipalities to deploy fundamental

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infrastructure enabling data analytics and AI solutions for the benefit of smart cities and urban mobility. The role of AI targets EU-wide urban challenges linked to accessibility, sustainability, mobility, quality of life and the management of public spaces. Among others, energy and water infrastructure need to make the low-carbon transition, while improving service quality. Regarding mobility, cities face congestion and emissions issues, requiring alternative, feasible, more efficient and sustainable solutions, and the growth of the related data economy.

To do so, the briefing relies on existing available data, studies and analysis from various sources, including, but not limited to, the latest official EU communications. Based on the above mentioned issues and sources of information, the briefing will cover the following questions:

- How can AI support new smart applications in smart cities, such as management of energy and water supply at district level, solutions for new services for inhabitants and businesses?
- How can AI be used to improve urban mobility (reducing traffic congestion and air pollution, increasing safety and inter-modality)?
- What type of hurdles do municipalities need to overcome to facilitate the deployment of these technologies?

Introduction – Artificial Intelligence applications in smart cities and urban mobility

Where smart city activities and technologies have commonly been about producing data and gaining new knowledge on the complexity and dynamics of a city, AI takes cities to the next step of utilising the data and knowledge to support decision-making. The concept of urban AI can be defined as: "*Artifacts operating in cities, which are capable of acquiring and making sense of information on the surrounding urban environment, eventually using the acquired knowledge to act rationally according to pre-defined goals, in complex urban situations when some information might be missing or incomplete*"[1]. By 2025, AI is expected to enable over 30% of smart city applications, among which urban mobility solutions[2], significantly contributing to resilience, sustainability, social welfare and vitality of urban life. AI applications in smart cities can be categorised in the following seven dimensions[1,3,4]:

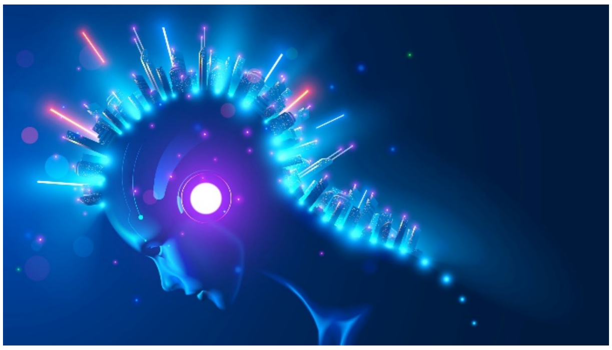
- ***AI for governance*** e.g.: urban planning, tailored subsidy provision, disaster prevention and management.
- ***AI for living and liveability, safety, security and healthcare*** e.g.: smart policing, personalised healthcare, noise and nuisance management and improved cyber security.
- ***AI for education and citizen participation*** e.g.: locally accurate, validated and actionable knowledge supporting decision-making.
- ***AI for economy*** e.g.: resource (cost and time) efficiency and improved competitiveness through, sharing services, efficient supply chains and customer tailored solutions.
- ***AI for mobility and logistics*** e.g.: autonomous and sustainable mobility, smart routing and parking assistance, supply chain resiliency and traffic management.
- ***AI for infrastructure*** e.g.: optimised infrastructure deployment, use and maintenance, including waste and water management, transportation, energy grids, and urban lighting.
- ***AI for the environment*** e.g.: biodiversity preservation, urban farming and air quality management.

Artificial Intelligence for smart cities

Among others, AI applications can improve and innovate water and energy infrastructures, urban services and promote empowered and resilient communities in smart cities. However, local governments, citizens and other smart city stakeholders face several challenges when it comes to the implementation of those applications.

AI for future proof infrastructure

Cities face great challenges to realise the acceleration of the energy transition, such as limited space availability, scarce labour capacity and materials and limited financial resources. To achieve the climate goals[5] and accelerate the energy transition **mass renovation and construction works** will be inevitable[6]. AI enables local governments, construction companies, utility companies and other stakeholders to tackle these challenges. For instance, AI for spatial object recognition based on satellite imagery, in combination with machine learning for route optimisation, can optimise infrastructure planning in the limited space, and support in prioritising work and aligning that with the limited labour and materials. Achieving the climate goals also entails that cities need to utilise all available local sources of sustainable energy, creating local energy systems with decentral renewable energy sources, impacting the grid with their intermittent character. As an example, innovative 5th generation district heating and cooling grids aim to integrate heat and electricity as energy carriers towards climate neutral heat and electricity provision in the built environment. In addition, these grids integrate the urban water networks as a potential source of low temperature heat, creating ***integrated multi-commodity grids*** in our cities. To support distribution system operators and energy providers, AI application can aid in understanding the intertwined energy grids and support in the cost efficient control of these grids. This calls for the integration in ***smart grids*** with a major role for integrated AI applications which can be the linking pin between previously isolated infrastructure systems in terms of planning and operation, and fill the gap of lacking monitoring and control of energy grids on the local level. On an AI enabled smart grid, functionalities include the prediction of renewable energy generation from intermittent sources such as the sun and wind, and other decentral sources such as geothermal and aqua-thermal energy for improved capacity utilisation and grid control.



On the consumer side, machine learning can be utilised to predict and disaggregate energy demand for ***improved energy efficiency***, while AI driven control of consumer energy use additionally enables ***demand side management*** for grid flexibility. Together these applications make the grid more resilient for decentral and uncertain generation, enabling the uptake of more renewable energy, while citizens are supported in adopting flexible and efficient energy consumption patterns which benefits the households and the grid. Examples are Netherlands based Quby, part of Eneco, developing these services for utility companies in the Netherlands, Belgium and Spain, and Germany based Tado[7].

Smart infrastructure and asset maintenance combines computer vision and automated Unmanned Aerial Vehicles (UAV or drones) for e.g. distributed energy generation assets (urban wind turbines which may be installed in hazardous locations such as on towers and bridges, integrated photovoltaics (PV) in dwelling facades), water treatment facilities, roads, tunnels and bridges. AI application contributes in damage detection, damage prediction, damage classification, damage localisation, condition assessment and life-time prediction[3]. This requires accurate and real-time data on the state of the assets, the utilisation of these assets, and on the environmental factors impacting these assets[8]. Due to the lower risks and costs of smart monitoring, these activities can increase in frequency, resulting in richer and more real-time asset data relative to manual monitoring, resulting in perpetual improvement of maintenance. While city's energy networks will face major changes in the coming years, water networks require adequate attention too. A total of 3.5 million kilometres in water pipelines in Europe, where often significant parts require drastic renewal, may pose significant challenges to utility companies and risks for the sustainable supply of save drinking water, and waste water management. These interventions will require up to 20 billion euros annually, while challenges such as draught and increased water demand call for the implementation of measures boosting the water grid's efficiency and sustainability[9]. AI applications may have a role in tackling these challenges, for instance, in the detection and prevention of leakage along the line of predictive maintenance in smart water networks. Rome's water grid experiences about 44% leakage annually, which is unacceptable in the light of increasing water demand, and draughts resulting in the rationing of water in the summer of 2018[10]. Other applications of AI are for improved catchment area management on e.g. water quality and the prevention of flooding and contamination, water efficiency on the demand side, draught forecasting and planning, and adequate sanitation[11]. Leading examples of AI applications in smart water management are found in Finland[12], the UK[13] and the Netherlands[14].

AI for innovative and smart services

Smart cities utilise innovative technology to support and transform conventional networks and services[15]. In this section we address two examples of smart services which can be improved by AI, namely smart urban lighting and smart waste management. EU cities are equipped with a total of up to 90 million street lights, accounting for 20 to 50% of a city's energy bill. Around 75% of these streetlights are older than 25 years and call for innovation. In addition to these street lights, cities contain several other types of lighting in public spaces such as parks and beaches. ***Smart urban lighting*** has often deemed the solution to start the smart city evolution of a city. By combining improved and efficient public lighting via remote monitoring and control, lampposts are an ideal object to equip with IoT devices which can collect, communicate and locally analyse data on traffic and pedestrian flows, environmental factors such as air quality, temperature, wind speed and humidity, and acoustic data for instance for gunshot detection, urban noise etc. To this end, the Humble Lamppost EC initiative is supporting cities towards 10 million smart streetlamps by 2025[16]. Innovative applications can be found in major cities such as Barcelona, Rotterdam, Munich and Copenhagen. In Barcelona, smart lighting infrastructure is utilised to monitor occupation of beaches and public areas for crowd management. It is utilised to contribute in the COVID-19 crisis by offering citizens insights on where they can enjoy these areas while respecting COVID-19 social distancing measures. AI is deployed to scan and analyse images of the beach on available areas instead of counting people in order to cope with privacy considerations[13].

Second example of innovative public services in a smart city is ***smart waste management*** entailing waste collection and processing. By adding sensors to waste containers which measure filling rate and irregularities in its operation, efficiency gains can be realised via smart routing of collection according to the filling rate, but also less nuisance for citizens caused by full containers or defective containers. AI can be applied to predict the patterns of how, when, and where waste is discarded, opening up possibilities for urban policy to stimulate efficient waste production and discarding among citizens. As part of the RUGGEDIZED smart city project this innovation was implemented in the city of Rotterdam[17]. Further efficiency gains are possible when AI enabled autonomous vehicles are utilised for waste collection. In addition, AI can be utilised to optimise sustainable urban waste processing. In situations where the separation of waste is not yet widely common in a city, computer vision can be utilised to separate waste flows for re- or upcycling towards a circular economy. These innovative public services are commonly connected and can be unified via urban data platforms (UDP), a trend observed in many European cities in reaction to the platform economy coming up with major digital platforms such as Uber, Airbnb, Google etc. and the acknowledgement that city solutions are only possible with trusted and efficient data and infrastructure collaboration. In these UDPs, the data collected in the city comes together[18]. A 2019 study among 80 European cities derives that 32 cities have an operational UDP, while the other cities are in the phase of exploring the establishment of a UDP or planning and implementing a UDP. The majority of these cities and experts consider a UDP as critical infrastructure in a smart city along the likes of energy grids, roads etc.[19]. These UDPs can provide the data and the platform to create AI for improved or new value adding public services. Moreover, increasingly smart city data is being opened up to other actors to benefit from via new and improved business models[20].

Towards autonomous cities[1] presents the ultimate form of AI taking the shape of the City's Brain as a central point of control. The City Brain AI makes the shift from specialised AI, e.g. for energy infrastructure maintenance, towards general AI applicable in multiple domains such as urban planning, health, safety & security and governance in an integrated and autonomous city. However, these are domains where human involvement is critical in making decisions between what is good and bad, sustainable and unsustainable, in short, ethical or unethical. Autonomous AI in the City Brain is subject to academic research and being developed by large enterprises such as Alibaba. However, local governments should be made aware of the risks of these applications, and to what extent it contradicts the EU's vision of human centric, ethical and secure AI. This is crucial in scenarios where enterprises are in the lead in implementing smart city solutions, and the local government has to guarantee public values as a client.

AI for resilient and empowered communities

After addressing AI applications to improve the infrastructure in cities and to improve services towards citizens, this section entails AI applications to enable and support resilient and empowered citizens in the city. ***Citizen Energy Communities (CEC)*** are introduced in the Clean Energy Package (CEP) and play an important role in the Green Deal as a new market party to engage and empower citizens and amplify the local enthusiasm and resources towards local, sustainable and reliable energy systems[21]. However, as the energy system is getting more complex and technically challenging due to decentralisation and diversification, there is a role for open data and AI, as they may enable CECs to adequately deploy and operate local energy systems independently or in collaboration with new market parties such as aggregators. From a citizen-science perspective, local initiatives take a more bottom up approach (thus control) over energy systems[22,23]. However, they often face the challenge of upscaling and professionalisation[23]. The role of digitisation and AI in such processes could be multiple: from aiding citizens initiatives with asset management and community platform building, to the development of alternative pricing and business models for local energy exchange.

In addition to a reliable and sustainable energy supply, a resilient society benefits from local, sustainable and reliable food supply. To this end, urban communities are engaged in activities such as **urban farming**,

often in combination with vertical farming. Like the local energy system, these local farming and agriculture systems are immensely complex and may be time and labour intensive in tight spaces and connected sub-spaces. To sustainably maximise the yield from urban farming, e.g. by being energy and water efficient, and to minimise the hassle for citizens, AI can play a major role. AI application relates to automation in crop monitoring and care, based on imagery and other environmental sensors[24]. As leading examples, California based start-up Plenty developed an AI and robotics run vertical farm in the city, resulting in a 99% reduction in land-use and 95% in water use[25], while in Amsterdam vertical farming company GROWx, together with Wageningen University, Signify and Be-bots build a robotic and AI driven vertical farm which automates the cultivation of crops[26].

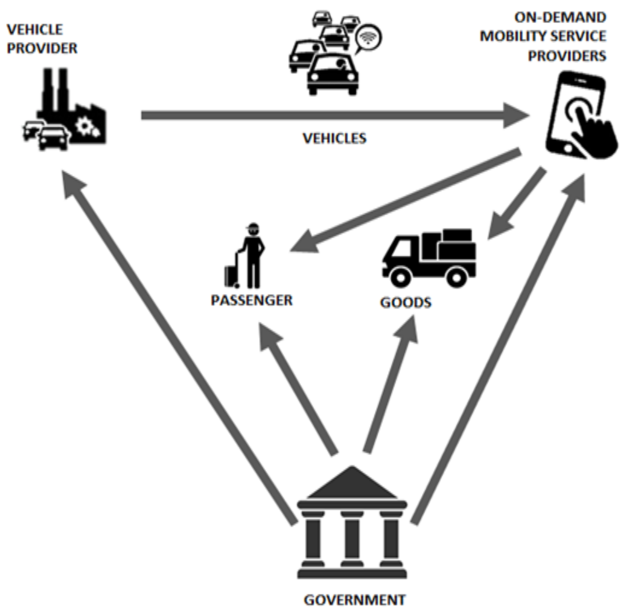
Artificial Intelligence for efficient urban mobility

Smart mobility solutions aim at increasing safety and efficiency, reducing traffic congestion, improve air and noise pollution and reduce costs. Smart solutions for mobility are also recognised as essential to further decarbonise the transport sector and reach the ambitious EU emission reduction goals. AI is a powerful emerging tool that boasts the potential to drive a sustainable transition to a more resource-efficient, liveable and human-centric mobility systems, especially in urban contexts.

The COVID-19 crisis has forced the society to realise that it is possible to drastically change mobility habits, especially in cities. The pandemic has indeed accelerated many existing trends, including home working; increased use of individual transport modes; and greater general awareness and concerns about health, safety, and environmental sustainability. Thanks to this acceleration, the next few years represent a unique window of opportunity for radical change toward more sustainable, resilient, and human-centric mobility systems[27]. In order to fully unlash the benefits enhanced by AI, a **holistic approach to public urban mobility planning and management needs to be adopted**. In particular, both transit mobility patterns and local urban function information should be considered, enabling decision-makers to make informed decisions on sustainable urban development and transit management[28]. AI applied to urban mobility can rely on data produced by existing infrastructures (e.g. traffic controller detection, urban centrals, video data, etc.), fleet data (car probe data, eBike fleets, public transports) and also third (public and private) party data. Public sector plays a crucial role to ensure the AI solution to be inclusive and secure, counting on reliable, non-biased, fairly shared data, still preserving EU citizens' privacy. Specifically, according to tech companies providing AI mobility solutions such as Nokia, there is a need for "*neutral city network to serve as a digital backbone for the smart cities, together with neutrally hosted data platform for creating those new digital applications*"[29].

The next-generation mobility is expected to transform automotive original equipment manufacturer (OEM), mobility services companies, and cities; furthermore, such a transition, to be successful, requires the mentioned actors to collaborate, engaging also financial services, insurance companies, telecommunication and utility companies to achieve the common goal of a new sustainable mobility. The shift toward AI-enabled smart mobility will impact all the value chains involved, that will abandon their linear and hierarchical traditional structure for a network-like one, as shown in the figure above. Extant literature highlights how increased public spending on urban mass transit means and growing incentives to entrepreneurial activities offering ride-

Smart mobility networked value chain



Source: Evangelos S.. Transportation Transformation: How Autonomous Mobility Will Fuel New Value Chains (2020).

sharing and autonomous vehicles must be complemented with data and AI-related skill development. Smart mobility solutions can be implemented by private or public players, with direct and indirect implications for both.

Private initiatives for smart urban mobility

Companies offering **self-service electric cars** provide users with an application allowing to book a car in self-service, choosing the duration of the rental. Typically, these operators own charging and parking facilities over the territory covered by the service. The self-service rental is often combined with a carpooling option, highlighting the collaborative nature of the service. Several companies take advantage of this service as alternative to owning a fleet of cars for the employees. Typically, the user is informed about the amount of CO_2 saved, increasing awareness on the environmental topic. Therefore, this AI-based smart mobility application boasts social (collaborative, economic - new vehicle ownership model - and ecological - electric cars only) benefits. Clem'[30], a French company active in more than 200 cities in France and abroad is an example of an operator offering this service. The company also has two demo-centres, in Philadelphia (USA) and Hangzhou (China). The former centre encompasses 13,000 employees and offers complementary mobility services, encouraging the transition toward electric engines in the Navy Yard urban area. The latter collaborates with the IDF (Ile de France) region and the Hangzhou government aiming at becoming a symbol and virtuous examples of smart city.

Mobility as a service (MaaS)

MaaS (tailored transport services offered via a unified platform) is a good alternative to personal transport since mobility on demand is synonym for freedom to go anywhere anytime. MaaS offers multiple mobility options, reducing congestion; enabling car-free cities and system-level optimisation of mobility investments and assets; leading to better integration between goods and passenger transport. MaaS with AI-based controllers can, for instance, optimise, monitor, and coordinate autonomous car fleets, while offering great options to individual users. AI-based MaaS enables ride-sharing users to share autonomous cars across an optimised route in a much cheaper and safe way, also offering greater social experience when riding with people of similar interests.

This can change traditional transportation networks and transform the way people commute. MaaS can significantly contribute to the sustainability and human-centricity goals. However, governance issues and difficulties for private-led MaaS platforms in devising sufficiently scalable and profitable business models are hampering its diffusion. In the future, municipalities are expected to play an increased role in framing and enabling the development of virtuous MaaS solutions.

Sources: adlittle.com, Finnish Center for Artificial Intelligence (FCAI).

Another relevant application is **short distance carpooling**, which relies on AI to bridge the gap between car travel and public transport, allowing for precision pricing and precision routing. This application is addressed to people commuting from and towards the same areas. Here again, this service is a god alternative for private companies car fleets. Klaxit[31], a French company which acquired the iDVroom platform, a former subsidiary of SNCF, is an example. The mentioned platform optimised the route of users sharing the ride. However, some shortcomings of this application concern the difficulty to predict if the driver will be punctual, and the social compatibility of the co-passengers, which can be intimidating for some people.

Smart parking management, thanks to AI, improves car parks accessibility and fluidity.

Specifically, parking management software allows to fully integrate a user's spaces into her/his overall mobility policy. Among other aspects, smart parking management enables the management of different type of access rights by prioritising certain categories of users according to, for instance, their function and means of travel. This application has a significant positive ecological impact, since it allows to anticipate a trip according to the car park availability, avoiding endless peregrination in search of a place. This application is quite spread worldwide, as testified by several companies such as Passport (USA), EasyMile (France), Anagog (Israel), Pod Point (UK), Cleverciti (Germany), SnappCar (Netherlands), UnaBiz (Japan).

Applications of current use of AI in public transport (2020)

Source: UITP (2020).

The three mentioned applications allow for reduced urban traffic and environmental impact of urban mobility. Nevertheless, private vehicles are considered sub-optimal sustainable solution for smart urban mobility, even if vehicles are electric, since the risk of traffic increase remains. According to the Finnish Center for Artificial Intelligence (FCAI), 38% of people would be willing to give up their car, if thanks to AI, a similar mobility service can be offered. Given that 20% of household expenditure goes to mobility, this opens up great business opportunities. This same money could be used to buy mobility as a service at flat rate. The service should cover 100% of the users' needs, which requires access to all different modes of transport"[32].

Public initiatives for smart urban mobility

Dubai boasts a long list of smart mobility initiatives, including a **bus on-demand service**, in selected area of the city, which success has been initially proved by a trial assessing response time, transit time, passengers accessibility, affordability, convenience, safety, residents opinions and user experiences. Recently, the Roads and Transport Authority (RTA) of Dubai started a collaboration with the UK company BeemCar to develop the futuristic transport system called **sky pod**, defined as "a cross between a monorail and ski lift." The objective of the project is to meet the Dubai Self-Driving Transport Strategy, which aims at reaching 25% of journeys in Dubai autonomous by 2030. Each sky pod is a four-seater suspended from a driveway unit that rests inside a hollow, lightweight beam. Linear motors power the pod, making it travel at 50 km/h in a network placed above the traffic in a criss-cross manner, covering 15 km with 21 stations and with the capacity to transport 8400 passengers/h. The sky pod is expected to reduce transportation costs by 44% and environmental pollution by 12%.

A study of **UITP Asia-Pacific Centre for Transport Excellence on Artificial Intelligence in Mass Public Transport**, co-funded by Land Transport Authority of Singapore, surveyed the most trending AI-based smart mobility applications, as shown in the figure above. The most important challenges experienced by the authorities involved in the deployment of the mentioned AI solutions concern, among others, the lack of an appropriate legal and policy framework in public transport and the need of unbiased AI to avoid implicit discriminations. In both cases, collaboration represents a key enabler.

Among the excellences in smart mobility in the old continent, it is worth mentioning **Reykjavik** for efficiency of its transport systems. Specifically, the app Strætó for a smart bus transport network has registered more that 85,000 downloads since its creation in 2014. **Copenhagen** aims at becoming a zero-carbon city by 2025 through an integrated system encompassing intelligent bus priority system, fully electrified car sharing, building infrastructure enhancing commuting by foot and by bike, including a network of 28 cycle superhighways. In addition, **Geneva** boasts a very efficient smart parking system, deployed through a network of sensors, lowering the number of vehicles searching for a place to park by 30%.

Deployment challenges for municipalities

Every change, even the most positive one, as it is the case of smart cities and urban mobility, implies **costs**. Those costs are not necessarily evenly and fairly distributed over those who enjoy the benefits of the change, leading to **conflicting interests** that need to be properly managed in order to achieve the envisaged betterment for all. These costs can be associated to the switch in the technological paradigm, and to the social acceptance of it.

The introduction of AI for smart solution in urban environments affects several established value chains, on top of the final users. In addition, as typically occur for emerging technologies and related fields of applications, an additional category of challenges concerns the creation of an appropriate **regulatory framework**.

Concerning the technological challenges, both AI-based applications for smart cities and urban mobility suffer from lack of computing power, trust, limited knowledge, biased data collection processes, together with privacy and security issues, especially at local level.

Concerning social challenges, it is often assumed that for rational or utility maximising consumers (or stakeholders in general), new technology will eventually replace the old one.

On the contrary, human history and relevant literature shows innovation adoption is everything but smooth and automatic, it indeed takes way more than an improved technology to ensure innovation uptake.

The main existing obstacles for the full deployment of smart cities and smart urban mobility solutions are related to the lack of understanding of the solutions proposed and, at times, the difficult access to those.

The new breed of AI-based solutions, "*despite their machine-orientation, needs to be a user-centred technology that "understands" and "satisfies" the human user, the markets and the society as a whole. Trust should be built, and risks should be eliminated, for this transition to take off*" [33]. Since the deployment of smart cities and smart urban mobility systems rely on similar technology to be applied in the same environment, local authorities will face the same kind of challenges for both.

The following table provides a detailed overview of the challenges currently hampering urban smart solutions.

Challenge category	Description
Technological	**Increased responsibility for citizens in local initiatives resulting in increased the risks of mistakes due to lacking skills or due to incorrect information**. Need of verification and validation of information, and stronger educational programs[34] and publicly initiated guidance of local energy grid initiatives.
	Scope creep of AI[35]: once the system is in place and the investments made, novel exploration are often done in what else the AI-based system, infrastructure or service can be used for. Such scope creep can lead to internal confusion on responsibility and accountability of the system.
	Commercial pressure: increased dependency on private parties as the developers and implementers of such services. As the algorithms they (co)develop, and the data they collect, and the software and hardware they apply is often proprietary, this poses accountability and transparency challenges for (local) governments and smart city councils due to lacking information on the third parties involved.
	Lack of skills: on AI within local authorities, the implementation is often outsourced towards commercial parties providing tailored AI as a service. However, digitalisation and AI related expertise is necessary for local governments to adequately assess internally or externally developed AI on their aspects of trustworthiness.
	Technology and data availability, and digital sovereignty: the implementation and scaling up of AI applications in cities face the following challenges: • Scarcity in technology, in computer chips for instance, can hamper the further roll-out and continuity of AI and IoT systems in smart cities. Local governments have limited to no leverage in this global challenge, subsequently requiring in harmonised EU efforts to overcome this challenge; • City-wide AI applications increase the computational requirements, to the point that high performance computing is necessary (supercomputers). Alternatively, edge AI decentralises computation at the asset level, taking away the need for supercomputers, however, increasing the importance of IoT infrastructure; • Rise of the platform economy and dominance by Tech Giants (e.g. Nvidia), bringing interoperability and efficiency, but also dependence on non-EU companies; • 93% of the AI adopters utilise **cloud solutions**[36], and the EU market for cloud services is dominated by non-EU firms (Amazon, Microsoft, Google, IBM).
	AI quality and reliability: missing or incomplete data, and subpar accuracy and availability of data. This impacts the quality and trust in urban AI systems.
Social	**Ethical challenges in the utilisation of AI**: The utilisation of AI for and with citizens, centrally positioning the public values, requires local government to manage ethical challenges relating to conflicts of interests and bias in decision-making, economic pressure (in platforms, procurement), inequalities, privacy and data ownership and trust and transparency.
Regulatory	**AI systems in cities will increasingly work in an open, dynamic, hyperconnected environment**, rather than a regulated environment, such as a factory. A **challenge** of AI application to integrate electricity, heat, water and mobility infrastructure relates to the increased impact of possible adverse effects of AI, as opposed to separated infrastructure.

Findings and recommendations

Urban AI is part of a greater stream of digital transformation of the intertwined physical, social and digital realities.

For effective and trustworthy AI, in addition to exemplary AI European regulation and Digital Strategy, we recommend to **include urban AI in EU research programs addressing data exchange, communication networks and policy on mobility and energy**, enhancing capacity building initiatives involving both private and public (especially local) stakeholders.

On the operational side, the sharing of infrastructure (sensors, hardware, software) and data is key for urban AI business cases. Better inclusion of AI in research and policy frameworks pertaining to, among others, European Data Spaces and Ecosystems, (inter)sectoral interoperability and harmonisation, is expected to facilitate urban AI implementation, also through the deployment of test and experimentation facilities as part of the Digital Europe Program, supporting the EU in tackling the digital transformation.

AI demands **regulation crossing the borders of technologies and domains**. At the time of writing, not all cities are equipped with the necessary expertise to guarantee public values in the digitalisation, leading to either non being involved as a local party, or not sufficiently being able to manage and control AI solutions implemented by commercial parties (e.g. large tech firms). EU-wide support for **infrastructure and governance on digitalisation**, e.g. Urban Data Platforms, is essential.

When it comes to new regulation, the ineliminable trade-off between efficiency and equity is key. In this respect, it is recommended to prioritise efficiency, in order to accelerate the uptake of smart solutions in urban context.

This approach is considered socially acceptable since also people without direct access to AI solutions will still benefit from those thanks to positive externalities, including more efficient infrastructures for energy, and waste management, reduced pollution, noise and congestions. In parallel, equity must be (partially) ensured by unbiased data collection.

Furthermore, **innovative procurement** should become the norm, entailing requirements for technical and ethically responsible AI.

This holds for local governments taking the lead in AI implementation where procurement entails technology supply, and for cities where enterprises are heavily involved in the provision of (AI-based) public services.

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