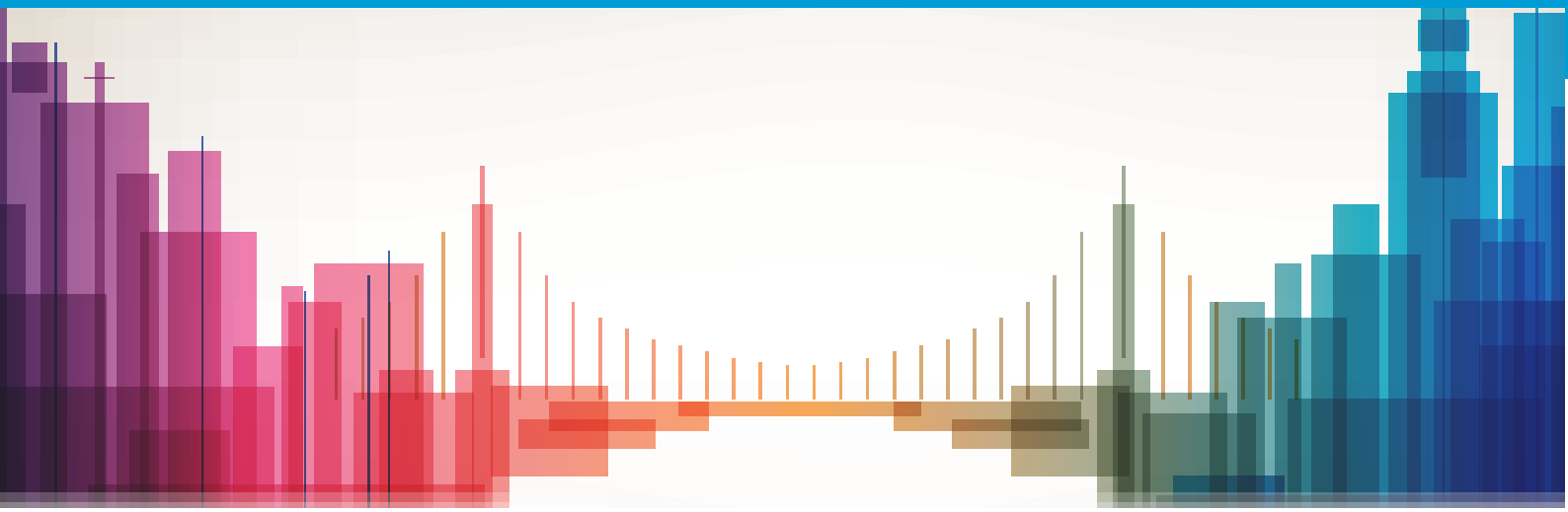
AI-driven autonomous urban systems in Valencia, Spain

Case study of the U4SSC Guide to autonomous cities and AI: The next frontier of urban transformation



Convention on Biological Diversity

United Nations ECLAC

Food and Agriculture Organization of the United Nations

UNIDO

ITU

UNDP

United Nations Economic Commission for Africa

UNECE

UNESCO United Nations Educational, Scientific and Cultural Organization

UN environment programme

UNEP FINANCE INITIATIVE

United Nations Framework Convention on Climate Change

unitar United Nations Institute for Training and Research

UN HABITAT FOR A BETTER URBAN FUTURE

United Nations Department of Economic and Social Affairs

UN 4 PARTNERSHIPS

UNU EGOV

UN Tourism

UN WOMEN

WORLD METEOROLOGICAL ORGANIZATION

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Foreword

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Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations or U4SSC members. In line with the U4SSC principles, this report does not promote the adoption and use of Smart city technology. It advocates for policies encouraging responsible use of information and communications technologies (ICTs) that contribute to the economic, environmental and social sustainability as well as the advancement of the 2030 Agenda for Sustainable Development and the Pact for the Future and its Global Digital Compact.

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Contents

Abbreviations and acronyms

Abbreviation	Full Form
AI	Artificial intelligence
EU	European Union
IoT	Internet of Things
KPI	Key performance indicator
SDG	Sustainable Development Goal
SUMP	Sustainable Urban Mobility Plan
U4SSC	United for Smart Sustainable Cities
Wi-Fi	Wireless fidelity

Executive Summary

This case study explores the adoption of smart city initiatives in Valencia, Spain, with a particular emphasis on the integration of autonomous systems and cutting-edge technologies. Through the application of AI-driven innovations, Valencia aims to optimize urban planning, enhance operational efficiency, improve sustainability, and elevate the quality of life for its residents. The study examines the strategic development, implementation, and outcomes of these initiatives, evaluating their impact on urban mobility and assessing the challenges and opportunities presented by the deployment of autonomous systems in a culturally vibrant yet forward-looking urban environment. Valencia's dedication to smart city development highlights its role as a leader in technological innovation, serving as a model for future urban transformation.

1 Introduction

Valencia, the vibrant capital of the Valencian Community in Spain, is a city renowned for its rich cultural heritage, stunning architecture, and dynamic urban life. Straddling the Turia River and bordered by beautiful Mediterranean beaches, Valencia combines historical charm with modern innovation. The city is home to iconic landmarks such as the City of Arts and Sciences, the historic Silk Exchange, and the picturesque old town, making it a popular destination for tourists and residents alike.

In recent years, Valencia has embraced the concept of a smart city, positioning itself as a leader in sustainable urban development. The city has implemented a range of innovative technologies and initiatives aimed at enhancing the quality of life for its citizens, promoting environmental sustainability, and optimizing urban management. Through projects like public Wi-Fi networks, intelligent waste management systems, and real-time traffic monitoring, Valencia not only addresses contemporary urban challenges but also sets a benchmark for other cities worldwide.

Valencia's commitment to becoming a smart city is further exemplified by its dual certification in measuring progress towards the Sustainable Development Goals (SDGs). This case study explores the strategies, implementations, and outcomes of Valencia's smart city initiatives, providing insights into how technology and innovation can be harnessed to create a more livable, efficient, and inclusive urban environment.

2 Background and context

Valencia has embarked on a transformative journey towards becoming a smart city, driven by a clear vision to enhance urban living through digital innovation. The city's initiatives are grounded in its commitment to sustainability, efficiency, and improved quality of life for its residents. Key strategies include the integration of advanced technologies across various sectors such as transportation, waste management and public services. Valencia's smart city programme focuses on leveraging data to optimize resource allocation, reduce environmental impact, and promote citizen engagement, positioning the city as a model for digital transformation.

In recent years, Valencia has witnessed significant advancements in its technological landscape, particularly in the adoption of emerging technologies like artificial intelligence (AI), the Internet of Things (IoT) and big data analytics. These technologies are being utilized to enhance urban infrastructure and services, from smart traffic management systems that alleviate congestion to intelligent waste bins that optimize collection routes. The city has also embraced AI in various applications, including real-time monitoring of air quality and public safety initiatives. This evolution reflects Valencia's proactive approach to harnessing technology, ensuring that it remains at the forefront of the smart city movement while addressing the challenges of urbanization and sustainability.

3 AI strategy (approach) in the city

Valencia has embraced a comprehensive AI strategy aimed at transforming its urban landscape into a more efficient, sustainable, and citizen-centric environment. This strategy aligns with the city's broader Smart city initiatives and was formalized in recent years as part of its commitment to leveraging technology for social and environmental benefits. The approach focuses on integrating artificial intelligence across various sectors, including transportation, waste management, and public services.

The city's AI strategy is designed to enhance operational efficiency and improve decision-making processes through data-driven insights. Key components of this strategy include the use of AI for real-time monitoring of urban conditions, such as air quality and traffic flow, enabling proactive responses to emerging challenges. For instance, Valencia's public buses are equipped with sensors that gather environmental data, allowing the city to monitor air quality and adjust policies accordingly. Additionally, intelligent waste bins equipped with sensors inform management about their fill levels, optimizing collection routes and reducing operational costs.

Valencia's AI strategy is centered on creating a data-driven ecosystem that enhances public services, reduces carbon emissions, and optimizes resource allocation. The city's AI framework focuses on key areas:

- **Smart mobility** – AI algorithms manage traffic flows, predict congestion, and optimize public transportation.
- **Energy efficiency** – AI monitors energy consumption across public buildings to enhance efficiency and reduce waste.
- **Health care and safety** – Predictive analytics are used in health care planning and emergency response.
- **Citizen engagement** – AI chatbots and platforms provide real-time communication and services to residents.

By prioritizing collaboration with technology partners and engaging citizens in the development of AI applications, Valencia aims to foster innovation and ensure that technological advancements align with the needs of its residents. The city's commitment to responsible AI deployment reflects its dedication to enhancing quality of life while meeting sustainability goals, positioning Valencia as a leader in the global smart city landscape.

4 Autonomous system adopted by the city

Valencia has implemented several autonomous systems as part of its Smart city initiatives, focusing on enhancing urban efficiency and sustainability.

Key implementations include:

- **Autonomous buses** – Valencia launched autonomous electric buses to reduce emissions and enhance mobility.
- **Smart waste management** – Autonomous waste collection vehicles optimize routes and schedules based on AI analysis of waste production.
- **Drone surveillance** – Drones monitor coastal areas, parks, and urban centers to enhance public safety and environmental protection.

One notable example is the deployment of intelligent waste management systems that utilize sensor-equipped bins to monitor fill levels in real time. This system autonomously communicates data to waste collection services, optimizing routes and reducing unnecessary pickups. Additionally, the city is developing smart parking solutions that provide real-time information on available spaces, allowing drivers to locate parking spots through a mobile app, thus minimizing traffic congestion. These autonomous systems not only streamline operations but also contribute to environmental sustainability by reducing emissions and enhancing the overall quality of life for residents. Through such innovations, Valencia continues to position itself as a leading example of how technology can be harnessed to create smarter, more efficient urban environments.

5 Implementation of the autonomous system

The implementation of autonomous systems in Valencia's Smart city framework has been a phased approach focused on enhancing urban management and sustainability.

The implementation process has been phased:

- **Phase 1: Pilot Projects (2019–2020)** – Initial testing of smart waste and parking systems in selected neighborhoods.
- **Phase 2: City-Wide Deployment (2021–2023)** – Expansion of successful pilot initiatives across Valencia, integrating data into a centralized management system.
- **Challenges**: Technical integration with existing infrastructure and ensuring public acceptance were significant hurdles. These were addressed through stakeholder engagement and public awareness campaigns.

Initially launched in 2019, the city introduced intelligent waste management systems that utilized sensor-equipped bins to monitor fill levels. This pilot project, which began with 262 bins, aimed

to optimize waste collection routes and minimize overflow issues. Over subsequent phases, the system expanded to include intelligent parking solutions set to deploy over 1 000 smart parking spaces, allowing citizens to locate available spots via mobile applications. These initiatives directly contribute to the Sustainable Development Goals (SDGs), particularly Goal 11, which promotes sustainable cities and communities.

However, the implementation process faced challenges such as technical integration with existing infrastructure and ensuring public acceptance of new technologies. To address these issues, the city engaged in extensive community outreach and education campaigns, ensuring residents understood the benefits of these systems. Additionally, partnerships with technology providers facilitated seamless integration and troubleshooting, allowing for iterative improvements based on user feedback. This proactive approach has enabled Valencia to not only overcome initial obstacles but also to create a more responsive and efficient urban environment that aligns with its sustainability objectives.

6 Results and outcomes

The implementation of autonomous systems in Valencia has yielded notable results, significantly enhancing urban efficiency and sustainability. Key performance indicators (KPIs) reveal a 30 per cent reduction in operational costs associated with waste collection due to the intelligent waste management system, which utilizes sensor-equipped bins to optimize collection routes. Additionally, the introduction of smart parking solutions has decreased the average time spent searching for parking by 40 per cent, alleviating traffic congestion and improving air quality.

Valencia's autonomous systems have yielded tangible benefits, including:

- **Reduced traffic congestion** – Autonomous buses decreased commute times by 15 per cent.
- **Lower carbon footprint** – Emissions from public transport reduced by 20 per cent.
- **Operational efficiency** – Smart waste management saved the city 12 per cent in operational costs.
- **Enhanced safety** – Drone surveillance improved response times for emergencies by 25 per cent.

The impact of these systems extends beyond operational metrics; socially, they have fostered greater community engagement by providing residents with real-time data on urban conditions, such as air quality and transportation options. Economically, the reduction in costs and improved efficiency contribute to a more sustainable urban infrastructure, potentially attracting investment and tourism. Environmentally, these initiatives align with Valencia's goals to reduce emissions and promote cleaner urban living, showcasing how technological innovations can drive progress towards a more sustainable and resilient city.

7 Assessment of the autonomous system

The assessment of Valencia's autonomous systems reveals a significant advancement in urban management, characterized by a blend of human-machine collaboration. The intelligent waste management system exemplifies this, operating with a high degree of autonomy through real-time monitoring and data analysis. This system primarily functions in a human-machine augmentation mode, where sensors in waste bins communicate fill levels, allowing operators to optimize collection routes without manual checks.

Furthermore, the forthcoming smart parking initiative will further enhance autonomy, enabling drivers to locate available spaces via a mobile app, thus streamlining the parking process with minimal human intervention. However, not all components operate independently; human oversight remains crucial for addressing anomalies and making strategic decisions based on the data collected. Overall, the assessment indicates a progressive shift towards greater machine autonomy, while also recognizing the indispensable role of human involvement in ensuring the systems function effectively and responsively within the urban environment.

8 Conclusion

The implementation of autonomous systems in Valencia has provided key insights and lessons that can inform future urban initiatives. One of the primary lessons learned is the importance of integrating technology with human oversight. While the systems have achieved significant autonomy, the collaboration between human operators and automated processes has proven essential for optimizing urban services and addressing unexpected challenges.

Critical success factors include strong governmental support, effective stakeholder engagement, and a commitment to sustainability. The city's proactive approach in establishing frameworks for data-driven decision-making has also been pivotal. These elements have fostered an environment conducive to innovation and responsiveness to citizen needs.

However, challenges remain, particularly in ensuring equitable access to technology and addressing cybersecurity concerns. As the city continues to expand its smart initiatives, maintaining public trust and engagement will be crucial.

The transferability of Valencia's model to other cities is promising, yet context is vital. Factors such as local governance structures, existing infrastructure, and community engagement strategies will significantly influence the adaptability of these systems elsewhere. Overall, Valencia's experience underscores the potential for smart city technologies to enhance urban living, provided they are implemented thoughtfully and inclusively.

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