Using Smart Equipment to Collect Data Required in Developing Sustainable Urban Mobility Plans

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Abstract. Sustainable Urban Mobility Plans (SUMPs) play a crucial role in the development strategies of urban transport infrastructures. Their implementation requires the collection of traffic data from the city's main streets. However, the high costs associated with this process often lead to a reduction in both the number of monitoring points and the duration of data collection. To enhance data acquisition efficiency, smart equipment was developed to record vehicle counts, classify vehicle types, and process route information. The authors of this study contributed to the development of this equipment. The necessary types of sensors, the local structure of the equipment, and its computational capacity were analyzed. Additionally, the city's topological structure was identified to determine the optimal placement of the smart equipment. The data obtained through its implementation were used to create a transport model for a medium-sized city. The modeled values were compared with real traffic data to validate the model. The technology and results confirmed the utility of such smart devices in traffic studies and the development of Sustainable Urban Mobility Plans.

Keywords: Urban Mobility · Smart Equipment · Data Collecting · Transport Model

1 Introduction

Sustainable Urban Mobility Plans (SUMPs) aim to guide the development of cities based on sustainable growth principles. Although they are strategic documents, the proposed action lines must be tested using standardized, calibrated, and validated transport models. The JASPERS (Joint Assistance to Support Projects in European Regions-a joint initiative of the European Commission and the European Investment Bank) guidelines provide the fundamental principles for developing such models; however, the practical implementation falls under the responsibility of transport experts. One of the main challenges they face is the extensive volume of data required, which must be collected from the city's urban transport infrastructure. Technological advancements have introduced Smart City concepts, in which smart devices play an increasingly significant role in traffic monitoring and control.

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Within the framework of smart city planning and development, smart transportation represents the integration of advanced technologies into conventional transportation infrastructures to promote sustainability, safety, and operational efficiency. Intelligent transportation systems utilize sensors, artificial intelligence, and data analytics to collect and interpret data related to vehicle flows, traffic dynamics, and other relevant parameters. This data-driven approach enables the optimization of transport networks, leading to reduced emissions, enhanced road safety, mitigated traffic congestion, and improved urban living conditions. As such, intelligent transport systems have the potential to significantly enhance the sustainability, efficiency, and security of urban mobility, thereby contributing to higher standards of living in smart urban environments [1].

The rapid advancement of smart technologies has led to the emergence of a wide range of smart electronic components which, when integrated, can form a complete smart device. Building upon this concept, the authors' research aimed to develop a smart device capable of collecting traffic data related to vehicle flow, vehicle classification by category (bicycles, passenger cars, vans, light goods vehicles, heavy goods vehicles, buses, others), license plate recognition, parking space usage and traffic incident detection. The device, named SmartHub, was designed to feature both a distributed architecture across the urban territory and a centralized control unit. The data collected by SmartHub was used in the development of a transport model within the Sustainable Urban Mobility Plan (SUMP) created for the pilot city in which the devices were installed. At this moment we don't have a commercial price for the product but is estimated to 5000 Euro. After first large project we will improve the research with economic analyse.

The article is structured as follows:

- Literature review-A review of the relevant literature in the field of the conducted research;
- Structure of smart equipment-A concise presentation of the smart device, focusing on its architecture and traffic monitoring capabilities;
- Data collected-An overview of the datasets collected to support the development of the SUMP;
- Study case. Recording data for a SUMP-A presentation of the main results obtained using the developed transport model;
- Conclusions-A set of conclusions drawn from the research conducted by the authors.

The need for the research presented in this article was identified by the research team in light of an increasing demand to collect data on the urban road infrastructure, as well as to quantify vehicle flows necessary for developing transport models that inform decision-making processes at the municipal and local government levels. Existing methods have relied on equipment installations that were temporary and required continuous personnel presence. Moreover, following the data collection phase, video streams had to be processed in order to convert visual information into numerical values—an operation that involved significant additional costs. Technological advancements, however, have enabled the identification of innovative solutions to bridge this gap, with some of the results presented here.

2 Literature Review

In recent years, the development and implementation of Sustainable Urban Mobility Plans (SUMPs) have increasingly relied on accurate and extensive traffic data collection. Traditional methods of data acquisition—often involving manual counts or the use of temporarily deployed monitoring equipment—have proven costly, labor-intensive, and limited in both coverage and duration [2, 3]. As urban mobility becomes more complex and data-driven planning is prioritized, the need for innovative, scalable, and cost-efficient data collection methods has become increasingly evident.

Smart equipment and intelligent transportation systems (ITS) have emerged as viable solutions to address these challenges. ITS integrate various technologies—such as sensors, communication protocols, and advanced data processing—to enable real-time monitoring and control of transportation systems [4, 5]. Numerous studies have highlighted the potential of ITS to enhance traffic flow analysis, vehicle classification, incident detection, and environmental monitoring [6, 7].

According to Barceló (2010), data-driven models are essential for simulating transport scenarios and informing policy decisions. However, the accuracy and usefulness of these models are directly linked to the quality, resolution, and continuity of the input data [8]. Traditional surveillance systems, including inductive loop detectors and standard CCTV-based systems, often lack adaptability and require frequent maintenance or human oversight, contributing to increased operational costs [9, 10].

The emergence of Smart Cities has further fueled the integration of edge computing and AI into traffic monitoring devices, allowing them to process data locally and reduce latency and bandwidth demands [11, 12]. These systems can autonomously detect vehicle categories, recognize license plates, and even identify traffic anomalies such as congestion patterns or accidents [13]. In this context, smart sensor networks become essential tools in facilitating real-time decision-making and supporting long-term urban mobility strategies.

Recent studies have emphasized the role of low-power wide-area networks (LPWAN), such as LoRaWAN and NB-IoT, in enabling the deployment of city-wide distributed sensing systems that offer a favorable trade-off between energy efficiency and communication range [14, 15]. Such infrastructures support long-term data collection and contribute to the development of high-fidelity transport models aligned with the goals of SUMPs.

Furthermore, modular smart devices that integrate multiple sensing capabilities—vehicle flow detection, category-based classification (e.g., bicycles, cars, vans, heavy goods vehicles), parking occupancy, and environmental monitoring—have been successfully implemented in pilot projects across various cities [16, 17]. These devices facilitate automated, real-time data processing and reduce dependence on post-processing tasks, thus decreasing total system costs [18].

Despite these advancements, some challenges persist, particularly in terms of data standardization, system interoperability, and user privacy. However, the overall body of research confirms that the benefits of using smart equipment for urban mobility planning, particularly in terms of cost-effectiveness, scalability, and data richness—are substantial [19, 20].

The present study builds on these foundations by introducing a newly developed smart device: SmartHub designed to meet the specific data requirements of SUMPs in medium-sized cities. This device integrates multiple sensor types, a distributed architecture, and centralized data management, offering an innovative and efficient approach to traffic monitoring and mobility planning.

3 Structure of Smart Equipment

The structural system consists of a central control unit and a network of SmartHub devices distributed throughout the urban area. The SmartHub device is designed to collect various types of data required to support the six key components of a smart city support system. These components align with the foundational pillars of the Smart City concept: smart mobility, smart people, smart governance, smart economy, smart living, and smart environment. The architecture was developed with the aim of addressing data needs across all six domains, enabling comprehensive monitoring and informed decision-making within the context of urban digital transformation.

The SmartHub device operates as part of a network of interconnected units, ensuring broad coverage of the urban area. This SmartHub network is characterized by two primary features: first, it enables the connection of individual devices to a central control point, facilitating efficient network management and centralized oversight; second, it supports inter-device connectivity, which provides the infrastructure necessary for decentralized operation and the delivery of intelligent services across the city. This dual-layered architecture enhances the system's scalability, resilience, and ability to support smart city functionalities in a dynamic urban environment (Fig. 1).

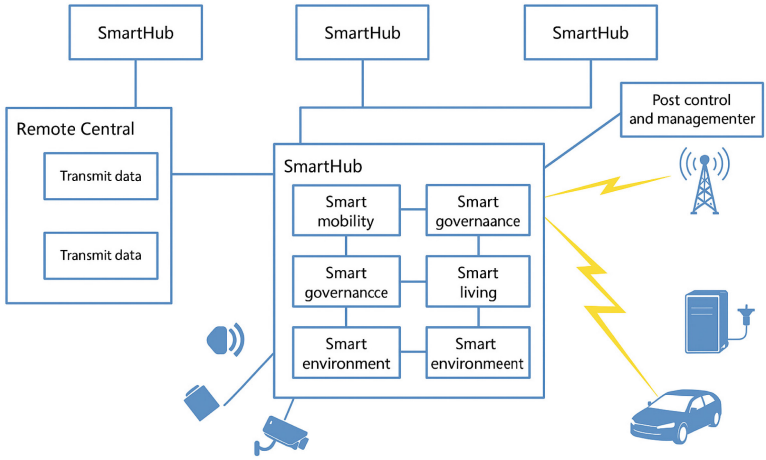

Fig. 1. The conceptual structure of SmartHub network

At the local level, the SmartHub device, when deployed in an area designated for data collection in support of the transport model required for a Sustainable Urban Mobility Plan (SUMP), serves multiple functions. These include traffic counting, parking space management, air quality monitoring, and vehicle license plate recognition. The SmartHub system is composed of electronic components responsible for data acquisition and processing, communication modules, power supply units, and protective devices, as well as internal and external sensors (such as video cameras and various types of detectors). The system's components are detailed in Table 1.

Table 1. Hardware components of SmartHub

Hardware components	Location	Power supply
Primary Processing Module	In SmartHUB box	From SmartHUB
LoRa Gateway	In SmartHUB box	From SmartHUB
5G Gateway	In SmartHUB box	From SmartHUB
Switch	In SmartHUB box	From SmartHUB
Video Camera with Vehicle/Pedestrian Detection	*Outdoor, on pole*	From SmartHUB
Surveillance Camera	*Outdoor, on pole*	From distribution box
LoRa Parking Sensor (Magnetometer)	*Outdoor*	Battery powered
Bluetooth Wi-Fi Sensor	*Outdoor, on pole*	From distribution box
Temperature, Humidity, PM Sensor	*Outdoor*	From SmartHUB
Temperature, Humidity, Atmospheric Pressure, CO_2 Sensor	*Outdoor*	From SmartHUB
PIR Detector with LoRa Communication	*Outdoor*	From SmartHUB
Lighting System Monitoring with Local Post and LoRa Communication	*Outdoor*	Battery powered
5 VDC Power Supply	In SmartHUB box	From SmartHUB
24 VDC Power Supply	In SmartHUB box	From SmartHUB
48 VDC Power Supply	In SmartHUB box	From SmartHUB
Smart Power Supply with GSM Communication	In SmartHUB box	From SmartHUB
Information Display Panel Assembly	*Outdoor, on pole*	From distribution box

General hardware architecture and physical architecture are presented in Figs. 2 and 3.

4 Data Collected

The need for smart equipment capable of collecting data on road traffic has emerged from the difficulty of obtaining such data through traditional means. Developing a transportation model to support strategic decision-making in sustainable mobility plans requires

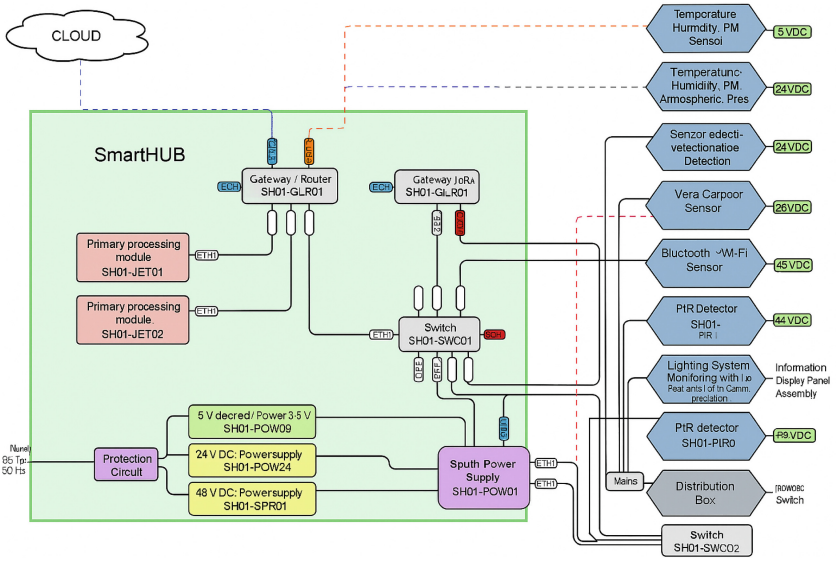

Fig. 2. General hardware architecture of SmartHub



Fig. 3. Physical architecture of SmartHub (photo made during implementation of prototype)

the collection of specific data that are often difficult to acquire through manual or human-operated methods. These data are typically categorized into statistical data and traffic data. The first category generally includes information obtained from local municipalities, statistical reports, surveys aimed at assessing user behavior, and other similar sources. The second category, however, comprises information that must be collected dynamically. This process involves a high volume of data, usually gathered on-site in traffic or through video footage analysis. Stakeholders in the field are thus compelled to allocate significant resources for the collection and processing of such data—resources

that may be human or, more frequently, financial, especially when outsourcing the digital processing of recorded video images. Unfortunately, these challenges often lead to a common issue observed in many Romanian municipalities and beyond: finalized sustainable mobility plans enter a state of stagnation, and the transport model is not continuously updated, as recommended by experts in the field. Consequently, public authorities lose access to a vital decision-making tool necessary for the development strategies they must formulate annually for the short, medium, or long term.

Taking these challenges into account, the SmartHub device has been equipped with sensors and video processing components designed to collect, process, and store a wide range of data essential for the creation and continuous updating of transport plans. These data types are presented in Table 2, along with the specific processes in which each type is utilized.

Table 2. Data collected using SmartHub

Attribute	Description	Process
Private transport (PrT)	The data set comprises vehicle counts categorized by mode of transportation, including pedestrians, bicycles, cars, light-duty vehicles, heavy-duty vehicles, and other types.	The process includes step-by-step calibration of the demand model, validation of model, and periodic recalibration to ensure continued accuracy and reliability.
Public Transport (PuT)	Monitoring of public transport systems operating on predefined schedules through vehicle identification based on license plate number and mode of transport (bus, tram, trolleybus, light rail, and others)	Modeling the transport supply within the model. Monitoring of the public transport system and identification of deviations from the predefined operating schedule
License plate numbers of freight vehicles	Identification and storage of information related to freight vehicles through the automatic determination of vehicle type, license plate recognition, and database querying to assess access rights within the area monitored by the SmartHub.	Monitoring the access rights of freight vehicles in designated zones as defined within the transport model, along with verification of permitted access times.
License plate numbers	The system records the license plate number and timestamp of each vehicle passage and subsequently aggregates this data to support the construction of Origin-Destination matrices.	This includes the identification and estimation of key parameters within the computational procedures of the transport model, as well as the subsequent calibration and validation of the model to ensure its accuracy and reliability.

5 Study Case. Recording Data for a SUMP

A Sustainable Urban Mobility Plan (SUMP) provides a comprehensive, vision-driven, flexible, and resilient framework that serves as a long-term mobility strategy. It encompasses integrated packages of measures aligned with defined objectives and short-term targets, whose implementation can be accelerated in response to evolving needs and changing urban dynamics.

To support the development of the Bolintin Vale Sustainable Urban Mobility Plan (SUMP), a network of SmartHub devices was deployed during the transport modeling phase. These devices were strategically installed along the main roads of the city, including both central areas and key access points. Data on vehicle counts by time intervals were collected, and subsequent processing enabled the classification of vehicle types. Additionally, for public transport, the arrival times of buses at designated stops were recorded, allowing for the analysis of deviations from the scheduled timetable.

Using a specialized software tool for macroscopic traffic modeling (PTV Visum), a digital map of the transport infrastructure network was created (Fig. 4). Traffic flows were determined using a demand model that was designed, calibrated, and validated based on traffic volume data recorded by SmartHub equipment.



Fig. 4. The transport network used in the modeling of private transportation

The traffic volume values for an entire day, as well as for the morning peak hour (7:00–8:00) and the afternoon peak hour (17:00–18:00), are illustrated in Figs. 5, 6, and 7.

The model calibration was performed using traffic volume data recorded using SmartHub equipment at the access points of the Bolintin Vale administrative area. The model parameters were estimated through nonlinear modeling using the Solver application. This nonlinear approach enabled the achievement of a maximum deviation level of 3.5%. The values used for calibration are presented in Table 3.

The use of data recorded by SmartHub equipment proved highly beneficial in the development, calibration, and validation of the transport model. Traditionally, collecting such data through conventional methods would require significant material and financial

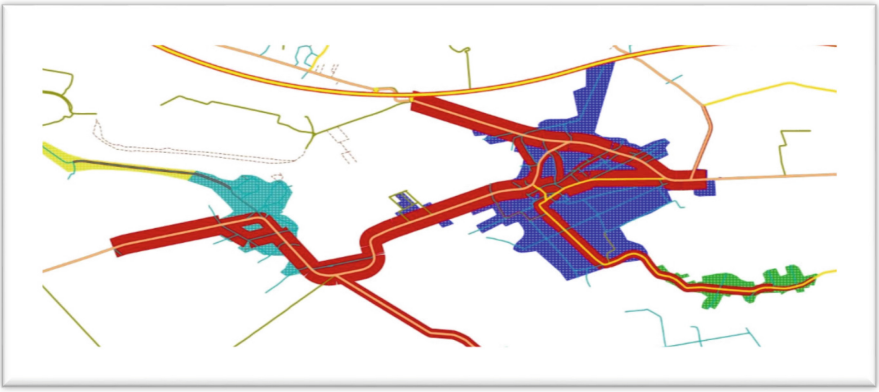

Fig. 5. Traffic Flow Patterns Over a Typical Day

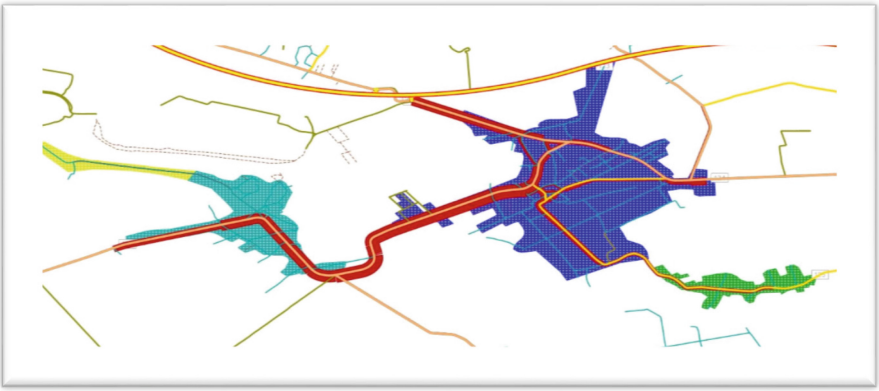

Fig. 6. Traffic Flow Patterns During the Morning Peak Period (7:00–8:00)

resources. The deployment of SmartHub devices enabled simultaneous data collection from 10 monitoring points, covering both traffic directions and spanning the entire day. Moreover, the integration of video processing algorithms allowed for vehicle counting based on predefined categories. Therefore, the primary advantage of utilizing SmartHub technology in the context of Sustainable Urban Mobility Plan (SUMP) development lies in the enhanced reliability and credibility of the transport model outcomes.



Fig. 7. Traffic Flow Patterns During the Afternoon Peak Period (17:00–18:00)

Table 3. Parameter Values Used for Model Calibration

SmartHub	Entry to city	Exit from city	Recorded Value [veh/day]	Model output [veh/day]	Deviation Level [%]
SmartHub1A	YES		3250	3185	2
SmartHub2A	YES		1340	1380	3
SmartHub3A	YES		694	710	2.3
SmartHub4A	YES		5870	5782	1.5
SmartHub5A	YES		5876	5811	1.1
SmartHub1B		YES	3124	3193	2.2
SmartHub2B		YES	1384	1345	2.8
SmartHub3B		YES	744	718	3.5
SmartHub4B		YES	5095	5151	1.1
SmartHub5B		YES	4737	4642	2

6 Conclusions

The development of smart equipment capable of locally collecting traffic data—both on vehicle circulation and public transport schedule adherence—is increasingly recognized by experts as a pressing necessity. Until the emergence of smart components in recent years, however, achieving this goal was technically challenging. The innovation process, coupled with the implementation of Artificial Intelligence technologies, has enabled the creation of integrated devices composed of multiple smart components that, working together, significantly enhance traffic monitoring and control processes.

In the research presented in this article, the objective was to develop a device capable of collecting traffic data and analyzing it based on predefined vehicle categories. Additionally, the equipment allows for the identification of vehicle travel routes within the monitored area through license plate association. Importantly, the system also facilitates the detection of deviations from the scheduled operation of public transport vehicles.

The study is primarily aimed at the field of urban mobility development through the use of smart equipment for collecting the data necessary to develop mobility plans. The research results were materialized in the creation of a physical product, the SmartHub, which was implemented in a medium-sized city and used to collect the data required for the sustainable urban mobility plan.

The main outcome of the conducted research was the development of the SmartHub equipment, equipped both with sensors for collecting real-time traffic data from the city's road infrastructure and with modules for processing this data to generate the numerical indicators required for the development, calibration, and validation of transport models used in Sustainable Urban Mobility Plans (SUMPs).

The main limitations identified by the authors were as follows:

- The quality of the acquired data depends on the method of video capture, the positioning of the cameras on the road infrastructure, and the reliability of the traffic sensors.
- The use of license plate data in constructing mobility patterns and Origin-Destination matrices may be restricted by legislation and requires the beneficiary to obtain specific government licenses.
- Weather conditions can also impact the quality of the collected data, either by causing information loss or by generating false traffic entities.
- Sustainable Urban Mobility Plans are strategic documents, meaning that any transport model represents only a snapshot of the current situation. Therefore, the use of SmartHub equipment enables dynamic adaptation of the transport model through the real-time integration of traffic data.

Future research will focus on the development of dynamic models for traffic monitoring and control, aiming to increase the capacity of transport infrastructure networks, reduce traffic congestion, and improve road safety through faster reporting of traffic incidents.

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Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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