White paper

A smarter approach to Parking Management

Introducing a cutting-edge IoT solution that transforms parking management, offering real-time insights for both outdoor and indoor spaces, enhancing the overall parking experience.

sensoworks

SUMMARY

1. Acknowledgements

Sensoworks is what came out of a very happy equation between more than 20 years of expertise in the field of data and system integration and the interception of the many opportunities, challenges and solutions in the field of infrastructure monitoring.

We believe in a team of dedicated people to build a solid platform for companies that own or manage complex infrastructure and that are looking for - or should be looking for - new and innovative solutions and well: the rest is (going to make) history.

At Sensoworks, we work with the certainty that information and data are a must-have for today's companies. Indeed, being aware of what's happening across the organization's infrastructure helps teams to predict and prevent outages, to deliver better projects, to make infrastructure last longer and allows citizens to feel safer when making use of them.

Being these topics relatively recent and in constant change, we think that many of the decision makers inside companies and public institutions should be more aware of the infrastructure landscape: what are the new technologies, what they pledge to do, what are the benefits of structured monitoring solutions for all the involved stakeholders, and so on.

This is this whitepaper's goal as well. Not only this is a way for us to get to know companies that could be interested in our product.
It is a way to spread knowledge, to help companies become more familiar with these concepts, with common issues and potential solutions.

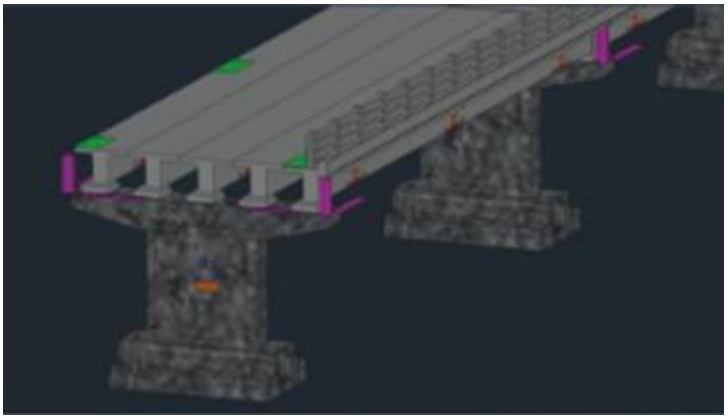
This whitepaper, thus, works in a broader company strategy and will be followed by other similar resources and activities, all of them aimed to inform our readers about infrastructure news, use cases, technological advancement, etc. In the context of growing urbanization and increasing parking demand, efficient parking management has become a critical challenge.
Sensoworks is an advanced IoT-based solution designed to enhance the management of both outdoor and indoor parking, reducing search time and optimizing available space utilization.

If this work of ours helps you and your companies to better understand what your infrastructure needs and where you should direct your efforts, we will have achieved our key goal.
Hold fast,

Niccolò De Carlo
CEO and co-founder of Sensoworks

2. What is Sensoworks

Sensoworks is the **IIoT solution** that integrates IoT devices with company systems and cloud infrastructures. It's a ready-to-use, "made in Italy" platform for the remote management and control of complex infrastructure systems.



Sensoworks gathers, monitors and interprets the data collected from sensors connected to machinery or infrastructure. The solution comprises a centralized cloud platform and edge computing software deployed on devices within parking areas. Sensoworks integrates smart sensors, real-time data analytics, and advanced management tools to optimize parking availability. It allows the customers to develop and manage their own IoT ecosystem simplifying the flow of data, communication among items, device management and, in general, enabling advanced application functionalities.

3. Our vision

As technology advances, devices and systems will become more advanced and sophisticated, with the ability to gather and analyze data, understand and respond to human behavior, and even predict and take actions to meet human needs. This can lead to more personalized and tailored experiences for users, and a more efficient and effective relationship between humans and technology.

The ability for humans to empathize with objects through the use of technology can have a significant impact on society by creating more efficient, reliable, and sustainable infrastructures and systems. For example, by using sensors and monitoring equipment to gather data on the condition and performance of buildings, engineers can identify areas where energy is being wasted and take steps to improve energy efficiency. This can help to reduce the environmental impact of buildings and lower energy costs for occupants, leading to a more sustainable built environment. Sensoworks allow humans to gather data from a variety of sensors and devices, such as temperature sensors, air quality sensors, and cameras. This data can be analyzed and interpreted in real-time, providing humans with a more comprehensive understanding of the object's condition and performance, and enabling them to make more informed decisions about the object's maintenance and repair.

4. From theory…

A) INDUSTRY PROBLEMS

One of the most prevalent issues in the parking industry is the congestion and inefficiency in both outdoor and indoor parking areas. Drivers often struggle to find available parking spaces, leading to wasted time, increased traffic congestion, and frustration. In the United States, it was estimated that drivers spend an average of 17 hours per year searching for parking, resulting in wasted time and fuel. (Source: INRIX Global Parking Scorecard, 2021).

Parking operators and facility owners face revenue loss due to the inability to maximize space utilization. Unoccupied parking spaces represent missed opportunities for generating income. Parking revenue losses due to theft and fraud in the global parking industry are estimated to be in the hundreds of millions of dollars annually. (Source: Parking Network, 2019).

Parking areas, especially indoor facilities, can be susceptible to safety and security issues, such as accidents, theft, and vandalism. Inadequate monitoring and surveillance can lead to these problems. Parking areas are common locations for crimes such as theft and vandalism. In the United States, vehicle break-ins occur roughly every 44 seconds. (Source: FBI Uniform Crime Reporting, 2019)

Many parking management systems lack the ability to provide real-time data and insights. This makes it challenging for operators to make informed decisions, manage demand, and address issues promptly that leads to ineffective parking management. Studies have shown that, on average, urban parking spaces are occupied only about 30% of the time, indicating significant underutilization.

Payment and access are still big challenges. Outdated payment methods and access control systems can inconvenience users and lead to inefficiencies in revenue collection and enforcement. Cash remains a common payment method in parking, but it is less secure and efficient than electronic payment options. Globally, the adoption of cashless payment methods is on the rise.

Parking management often needs to align with broader urban planning goals, such as reducing congestion, promoting public transit, and encouraging sustainable transportation options. Achieving this integration can be complex. Cities around the world are increasingly adopting policies to reduce the reliance on personal vehicles, promote public transit, and encourage cycling and walking as part of urban planning efforts.

From the environment perspective, inefficient parking systems contribute to increased vehicle emissions and fuel consumption as drivers circle in search of parking spots. This not only harms the environment but also exacerbates urban pollution and traffic congestion. In densely populated cities, up to 30% of urban traffic congestion is attributed to vehicles searching for parking.

Parking facilities must comply with various regulations, including ADA accessibility, environmental standards, and local parking ordinances. Ensuring compliance can be a cumbersome task. Compliance with regulations related to parking accessibility and environmental standards varies widely from region to region, leading to challenges for parking operators.

Providing a positive and user-friendly experience for parking customers is essential. Inadequate signage, confusing layouts, and lack of information can lead to a poor user experience.

B) TRADITIONAL SOLUTIONS

Traditional solutions for parking management typically rely on manual processes and legacy technologies. While these methods have been in use for many years, they often face limitations and challenges that modern IoT-based solutions like Sensoworks aim to address.

In many parking facilities, especially smaller ones, parking enforcement relies on manual patrols by attendants or security personnel. These individuals monitor parking spaces, issue tickets, and ensure compliance with parking regulations. Traditional parking management systems often lack the ability to collect and analyze real-time data on parking space availability and usage, hindering efficient space utilization and management.

Traditional parking facilities often use pay-and-display systems where users must purchase a parking ticket from a machine and display it on their vehicle. These systems may not offer real-time availability information. Users of traditional parking facilities often encounter issues with finding available spaces, leading to a less-than-optimal user experience. Users often rely on signage and visual cues to find available parking spaces, which can be confusing and frustrating. The lack of real-time information can result in a

poor user experience.

Barrier gates and ticket-based access control systems are common in parking garages. Users collect a ticket upon entry, and payment is made upon exit. These systems can be prone to congestion during peak hours.

Cash payments are still widely accepted in traditional parking facilities, which can lead to inefficiencies, security risks, and slower transaction processing compared to cashless options. Many traditional parking facilities still rely heavily on cash payments, which can slow down transaction processing and increase security risks. The adoption of cashless payment methods varies by region and facility. Parking revenue losses due to theft, fraud, and underutilization in traditional parking systems are estimated to cost parking operators millions of dollars annually.

Security in traditional parking facilities may depend on manual surveillance and periodic checks. This can make them vulnerable to security incidents such as theft and vandalism. Traditional parking facilities, particularly in poorly monitored areas, are susceptible to security incidents such as vehicle theft, break-ins, and vandalism. Incidents can vary significantly by location and security measures in place.

C) NEW SOLUTIONS

The great tech developments at the IT (new software programs for data processing, incredible speed for internet data transfer) and technical levels (data storage, manufacturing of miniaturized sensors to be installed in the most peculiar contexts) allowed for the development of technological solutions we could not even imagine just 10 years ago.

To the traditional manual and visual solutions, today, we can add an innovative and completely automated solution based on, for instance, the platform we developed and named after our company, Sensoworks. In line with the industry's technological developments, Sensoworks and similar infrastructure monitoring platforms allow for the constant gathering of information from the infrastructure they are installed on.

They also allow the immediate processing of the gathered data (through advanced algorithms increasingly reliant on machine learning to train autonomously). Thanks to such a pervasive solution, even the answer can be as immediate. Not only, the platform can give us an extremely precise answer.

The speed of gathering and processing the information it's important not only to cut the maintenance costs (which are important nonetheless), but also for the safety of users (residents of a building, passersby on a road) who can have a timely notification in case of potential issues.

D) NEW TECHNOLOGIES

New technological solutions are based on many little innovative pieces. Base technologies, or components, unavoidable for the construction of a successful monitoring solution are:

Sensors

Sensors are the foundation of our platform, the long antennas we gather relevant information with. Information which we then translate in real value for companies that have complex parking areas to monitor. Video cameras, occupancy, lights perception, smart park meters, and various kinds of hardware allow us extremely precise, timely, constant and reliable monitoring. For example, we built our architecture to simplify the process of "adding" and "changing" sensors in the whole monitoring activity, whenever you want, whenever you need, with the least impact on your IT infrastructure.

IoT

Internet of Things is not just a trendy word for us. It is also the pillar upon which all the data collection, storing and alert activities are based. New broadband technologies, mobile communications, these are all components that

make information available in real time and infrastructure monitoring possible.

Cloud/On-Premise

Every company is different, with different needs and specific, internal safety guidelines, sometimes with different national or international laws to follow according to the installation location.

A new monitoring solution must foresee what kind of technology will be necessary to integrate the customer digital infrastructure while maintaining the right flexibility to choose where and how to install and use our whole product, besides the degree of dependency on external servers.

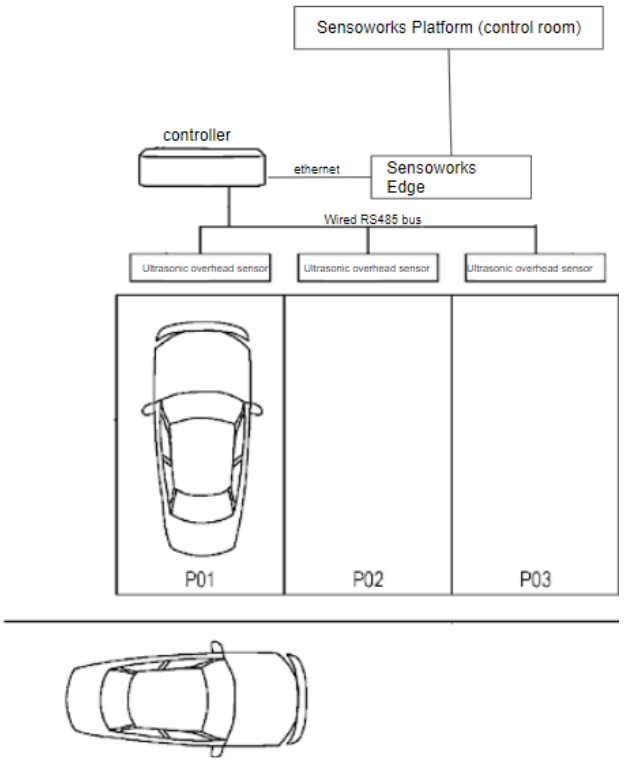
New platforms such as Sensoworks are usually as flexible as it gets to allow their customers to modify their infrastructure according to the evolving market needs.

5. … To practice: a real monitoring project

A) ESSENTIAL ELEMENTS OF A MONITORING PROJECT

Here are the fundamental elements to monitor a Sensoworks project. As we'll see, the monitoring platform is only a piece of a larger puzzle, although a fundamental one to prepare and then implement an efficient solution:

- An initial brief with the customer to verify their monitoring requests and consequent delivery of the monitoring activity.
- Collection of the specifications for the item to monitor.
- Structural analysis of the item and involvement of technical consultants for each aspect of the analysis.
- Design of the hardware monitoring system and set up of the necessary integrations to implement on Sensoworks's platform.
- Installation of smart sensors and specific tech devices for the monitoring activity.
- Provision of Sensoworks's platform, set up together with the customer.
- Continuous monitoring service with alerts and checks arranged with the customer.

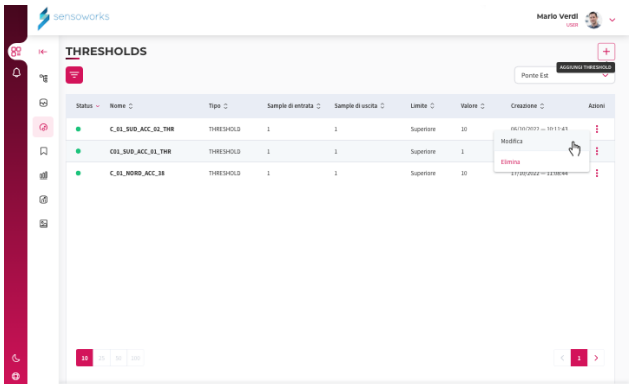


The proposed monitoring system (as for the case study we'll see later) integrates different measurement kinds and technologies:

Data Acquisition: The measurement data is stored within a data lake. The master data (asset) is stored in a relational database. Through Sensoworks IIoT Edge it is possible to acquire data in real-time from devices that implement protocols such as SCADA, OPC-UA, Modbus, Backnet, IP. The edge is useful when it is necessary to connect devices that implement low-level protocols, when it is necessary

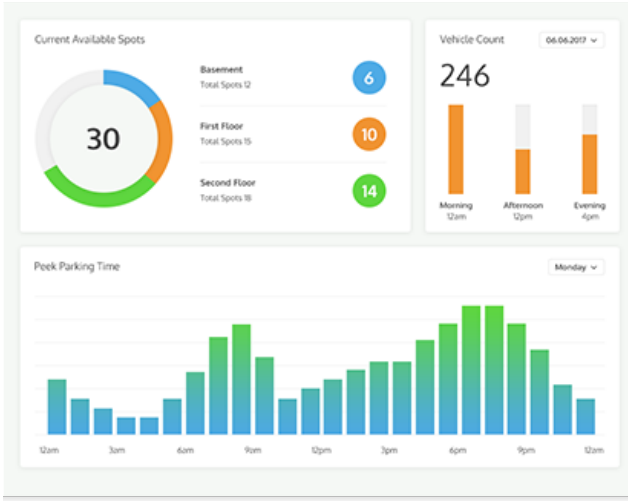
to carry out local analysis to avoid sending a large amount of data to the platform, filtering it.

Event Management: Support for configuring events and alarms based on static or dynamic thresholds. Static thresholds involve the evaluation of the measurements acquired by park meters, occupancy sensors, video cameras and IoT sensors based on user-defined thresholds.
Dynamic thresholds instead allow the operator to define thresholds that "adapt" according to the trends observed in relation to the acquired data. They are very useful in an initial observation phase, before defining static thresholds.



Automatic Actions: It is possible to configure automatic actions that the platform performs when certain conditions occur. Actions can be linked to an event/alarm, so when an event occurs the platform performs an action. Among the possible actions there are: reconfiguration of assets, sending commands via HTTP and/or MQTT, calls to external systems (Integration)

Data Analysis and reports The platform offers the user the possibility of creating dashboards aimed at analyzing data acquired from the field (Data Acquisition) or from third-party systems (Integration). It is possible to create different widgets for individual dashboards in order to observe data through graphs, tables, 2D models, 3D models, GIS maps.



User Management: Creation, modification, deletion of users. It is possible to define different access roles and profiles (authentication and authorization). The platform supports the definition of different tenants, in a multi-tenant logic for the segregation of information relating to different customers such as individual municipalities.

Payments: The platform acquires information relating to the payment made for the start and end of the parking from the park meters or mobile application. The platform does not manage the payment itself but integrates with the payment system used in order to acquire the start and end parking data.

B) CASE STUDY - PROPOSAL FOR A SMART PARKING SOLUTION

The following case study is about different kind of public parking areas located in several cities managed by an international parking operator.

- 5 cities
- +3000 park meters
- +7500 occupancy sensors
- +700 video cameras

The solution we proposed - based on Sensoworks's integrated system - is characterized by the opportunity to optimize and maximize the value of data and information, allowing for a more reliable and less subject to external factors behavioral analysis.

By working with our partner, Sync Lab (https://www.synclab.it/) we built the DyMo platform to provide a smart parking solution to our customer. DyMo is based on Sensoworks IIoT Platform, exenting its functionalities implementing the client's requirements.

Sync Lab is a technological Innovative Company that follow the paradigms of digital transformation and realize products and solutions for different markets such as: Healthcare, Industry, Energy, Telco, Finance and Transportation & Logistics.

6. Sensoworks's way

Sensor Monitoring

Our platform connects to all the installed sensors and park meters to allow you to set up your infrastructure and to customize it straight on the platform. Once set up, all the assets are immediately monitored in real-time. All the data are gathered, registered and structured to be analyzed by our powerful predictive algorithms.
For the case study presented, the installation of the following sensors was provided:

- +3000 park meters
- +7500 occupancy sensors
- +700 video cameras

Sensoworks can be easily configured to set up utterly automatic actions, based on stored information and configured algorithms and according to the customer's specifications. The customer is free to choose what action triggers when something specific happens, for instance, when values exceed a threshold or an alarm has ceased. In case it occurs, Sensoworks will alert who is in charge via SMS, email or ticket, according to the customer's preference.

Permit Portal

A permit portal system is a functionality that simplifies the application, approval, and tracking of permits and licenses. It offers users a user-friendly interface for submitting applications, automates approval workflows, manages payments, and provides real-time tracking and communication capabilities, streamlining the entire permit management process.

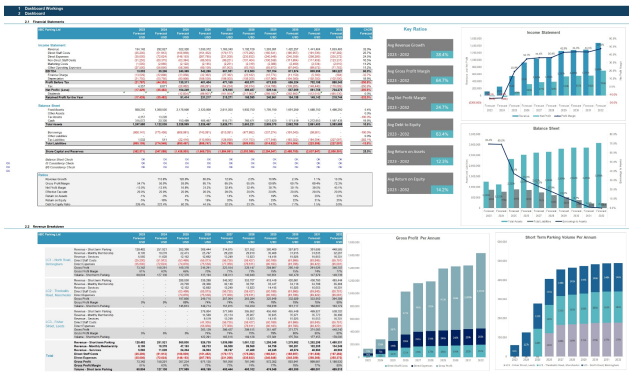
Tariff & Rates

Tariff and rates functionality refers to a feature that enables the client to set and manage the pricing structures and rates for parking spaces. This functionality enables operators to establish different pricing strategies based on factors such as location, time of day, duration of parking, and vehicle type. It ensures efficient revenue management and helps

optimize parking space utilization while offering transparency to users regarding the cost of parking.

Financial Dashboards

A digital tool that provides real-time insights and data visualization related to the financial aspects of a parking facility's operations. It offers an overview of revenue, occupancy, and transaction details, allowing parking operators and managers to make informed decisions about pricing strategies, occupancy optimization, and financial planning. It serves as a valuable tool for enhancing revenue management and operational efficiency in the smart parking industry.

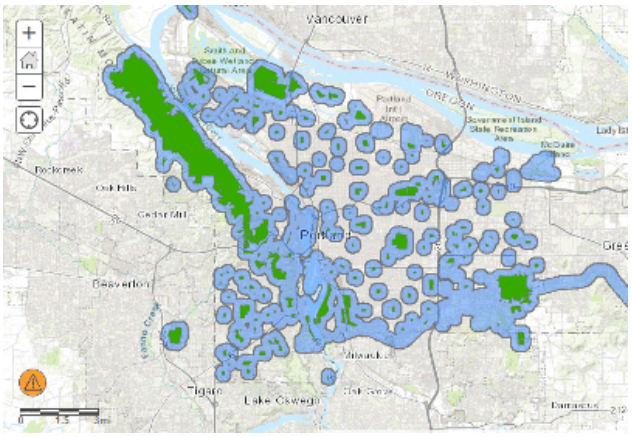


Asset Dashboards

A digital interface that offers a consolidated view of key assets and infrastructure within a parking facility. It provides real-time information and insights regarding the status, health, and performance of various assets, including parking spaces, sensors, surveillance equipment, payment terminals, and access control systems. This dashboard assists parking operators and facility managers in monitoring asset conditions, optimizing maintenance schedules, and ensuring the efficient operation of the parking facility, ultimately enhancing the overall user experience and operational efficiency.

GIS, parking area allocation

The GIS (Geographical Information System) or geographic information system, is a tool that allows you to analyze the territory by collecting large amounts of data of different nature.
GIS are IT tools designed for land management and planning. Geographical systems make it possible to carry out analyzes and representations of space and the events that occur in it; in geographic software, the common operations that can be carried out on databases (such as searches, statistical analyzes, graphs etc.) are added the features of a GIS, such as the storage of territorial data, their treatment and above all their representation in the form of cartograms or tables cut out on more or less extended portions of territory.



Reporting

A sophisticated inquiry and reporting module functionality designed to empower parking administrators and facility managers with comprehensive insights into the operations of a parking facility. This module acts as the data hub, enabling users to access, scrutinize, and extract valuable information from the vast reservoir of data generated by the smart parking infrastructure.

7. Project timeline

The implementation typically involves several distinct phases to ensure a successful deployment. These phases are essential for planning, designing, implementing, and maintaining a smart parking system. Here's an overview of each phase:

Project initiation:

- Objective Definition: we define the goals and objectives of the smart parking project, including what the customer aims to achieve, such as reducing congestion, optimizing space utilization, or increasing revenue.
- Feasibility Study: Assess the feasibility of the project, considering factors like budget, resources, technology, and regulatory requirements.
- Stakeholder Identification: Identify all stakeholders, including city authorities, parking operators, technology vendors, and end-users.

Planning and requirements gathering

- Scope Definition: Clearly define the scope of the project, including the number of parking spaces, locations, and the expected user base.
- Requirements Gathering: Collect detailed requirements for the smart parking system, including hardware, software, sensors, mobile apps, and payment processing.
- Budget and Resource Planning: Develop a budget and allocate necessary resources for the project.

Design and System Architecture

- System Architecture: Develop a detailed system architecture that outlines the components, connectivity, and data flow within the smart parking system.
- Hardware and Sensor Selection: Choose the appropriate hardware components, such as sensors, cameras, and payment terminals, based on project requirements.
- Software Development: Develop or customize the software for the parking management platform, including the user interface, data processing, and reporting modules.
- Integration Planning: Determine how the smart parking system will integrate with existing infrastructure, such as payment gateways and city traffic management systems.

Deployment and Installation

- Physical Installation: Deploy sensors, cameras, signage, and other hardware components in the parking areas according to the design plan.
- Software Implementation: Install and configure the software components, including the central management system, edge computing devices, and user interfaces.
- Testing and Quality Assurance: Conduct thorough testing to ensure that all components of the system function correctly and are integrated seamlessly.

User Training and Adoption

- User Training: Provide training to parking attendants, administrators, and other stakeholders who will interact with the system.
- User Adoption: Promote the use of the smart parking system among drivers through marketing and communication efforts.

Monitoring and Optimization

- Real-Time Monitoring: Continuously monitor the system's performance, including

occupancy data, transaction processing, and system health.
- Optimization: Use the data collected to optimize parking space allocation, pricing strategies, and user experience.

Maintenance and Support

- Routine Maintenance: Implement a maintenance schedule to ensure the ongoing functionality of hardware and software components.
- User Support: Provide customer support for drivers and parking operators who use the system.

Data Analysis and Reporting

- Data Analytics: Analyze data collected from the system to gain insights into parking patterns, trends, and usage.
- Reporting: Generate regular reports to assess the performance of the smart parking system and make informed decisions.

Scaling and Expansion

- Scalability: Plan for the system's scalability to accommodate future growth in terms of additional parking spaces or new features.
- Expansion: Consider expanding the smart parking system to cover more areas or integrate with other smart city initiatives.

Continuous Improvement

- Feedback Loop: Establish a feedback mechanism to gather input from users and stakeholders, allowing for continuous improvement and adaptation to changing needs.

These project phases ensure a systematic approach to implementing a smart parking system, from initial planning and design to ongoing maintenance and enhancement. Successful execution of these phases leads to improved parking management, enhanced user experiences, and optimized revenue generation.

A) TYPICAL PROJECT COSTS

The monitoring systems consist of different components, from the purchase of sensors and their installation to licensed platforms and softwares. Plus any kind of system integration activities related to the integration of the smart parking system with other IT elements.

Some costs are relatively simple to quantify and can be measured on the basis of the data available on the market or on site.

Others are not so easily measurable, (eg.. final labor costs associated with inspections and data processing time). For these, an in-depth analysis of the specific case is indispensable to estimate the market costs of the necessary technologies.

A final cost database is, thus, strictly depending on the specific project and the data about hypothetical costs in the field, enquiries with the suppliers and further research.

In general, the elements weighing on the potential, final cost can be listed as follows:

- Supply of sensors, devices and data logger (HW for data acquisition);
- On-site installation of the tools;
- Acquisition software development and integration;
- Operating expenses (design/engineering costs);
- Third-party expenses (Cloud storage/HW connectivity).

These project phases ensure a systematic approach to implementing a smart parking system, from initial planning and design to ongoing maintenance and enhancement. Successful execution of these phases leads to improved parking management, enhanced user experiences, and optimized revenue generation.

8. Conclusion

The pressure to improve the economic performance of the infrastructural Italian environment, and the safety of citizens and operators, has sparked the necessity of data driven projects and stimulated the creation of new and advanced infrastructure Management Systems (i.e. Sensoworks's IoT platform).

These necessities, together with technological progress, are leading to improved structure management actions (i.e. preventive or predictive maintenance, preservation, rehabilitation, replacement decisions). The use of remote sensing technologies presents a potential alternative to improve current practices by providing both qualitative and quantitative measures.

The benefits and costs of deployed remote sensing technologies and procedures largely depend on specific locations, types and number of infrastructural complexes, density of traffic and other aspects.

While the cost effectiveness of remote sensing technologies is highly dependent on the success of the integration with existing inspections and with the standardization of data collection techniques, on the simplification of data processing steps, and on the development of reporting procedures to increase the overall benefits of structure monitoring and to diminish the impact of potentially high initial fixed costs.

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