White paper

# A smarter approach to Port Management

Addressing the challenges faced by the maritime industry while enhancing efficiency, sustainability, and safety in port operations.

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.

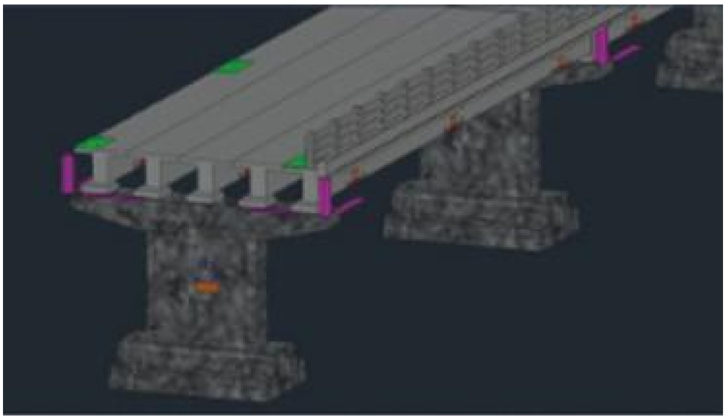
This whitepaper, thus, works in a broader company strategy and will be followed by other similar resources and activities, all of them aimed to inform our readers about infrastructure news, use cases, technological advancement, etc.  The port sector plays a crucial role in the economy of many regions, serving as a vital gateway for the transportation of goods and people. The System Authority is responsible for managing an extensive port area that demands efficient management of maritime traffic flows, both inbound and outbound. This is essential to ensure the optimal functioning of ports and reduce the environmental and social impact of traffic flows on the surrounding road network. In this context, the Sensoworks project presents itself as an intelligent IoT solution for digital port area management..

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 aims to optimize the movement of goods on roadways within port areas managed by the  System Authority. This objective will be achieved through the implementation of a real-time intelligent monitoring system, utilizing geolocation tools, video analysis, and predictive algorithms. Sensoworks gathers, monitors and interprets the data collected from sensors connected to vehicles and infrastructures. The solution comprises a centralized cloud platform and edge computing software deployed on devices within parking areas. It allows the customers to to reduce the environmental and social impact of traffic flows on urban and suburban roads in the vicinity of the ports, as well as on the main access routes.



## 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 infrastructures, 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 infrastructures 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. 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

The management of port areas and the movement of goods in and out of ports is a complex and challenging task that poses several significant problems for the industry. Sensoworks addresses these problems with its smart IoT solution.

Ports are often located in or near densely populated urban areas. The constant flow of cargo trucks, containers, and other vehicles can lead to severe traffic congestion, impacting not only the efficiency of port operations but also causing delays and disruptions on nearby roads. This congestion can have a detrimental effect on the entire region's transportation infrastructure. According to the American Society of Civil Engineers (ASCE), congestion in ports and transportation networks costs the United States billions of dollars annually in terms of productivity losses and increased operating costs.

The World Economic Forum's Global Competitiveness Report often includes statistics related to the efficiency of logistics and infrastructure, which can be indicative of the impact of congestion.

The high volume of vehicles and industrial activities within port areas can result in increased air pollution and carbon emissions. This has adverse effects on air quality and the environment, affecting the health of local residents and contributing to broader environmental concerns. Ports are responsible for a significant share of global greenhouse gas emissions. A study by the International Transport Forum (ITF) indicated that the emissions from global maritime transport could increase by up to 250% by 2050 if left unchecked.

Many ports worldwide are adopting green initiatives to reduce their carbon footprint, including electrification of port equipment and sustainable energy sources.

Ports are dynamic environments with various heavy machinery and vehicles operating in close proximity. This creates safety challenges, with the potential for accidents, injuries, and property damage. Ensuring the safety of workers and the surrounding community is a top priority. The International Maritime Organization (IMO) and various national authorities release annual reports on maritime safety, including statistics on accidents, injuries, and incidents in and around ports.

Inefficiencies in cargo handling, road traffic management, and overall port operations can result in increased costs and longer transit times for goods. These inefficiencies have financial implications for businesses and disrupt supply chains. The efficiency of port operations is often measured by metrics such as turnaround time for vessels and container dwell time.

Organizations like the International Association of Ports and Harbors (IAPH) and the American Association of Port Authorities (AAPA) may provide statistics on port performance.

The constant flow of goods and traffic in and out of ports affects the quality of life for local communities. Noise pollution, road closures, and traffic congestion can lead to a decrease in the overall well-being of residents living in the vicinity of the port areas.

Sensoworks addresses these challenges by offering a comprehensive solution that leverages IoT technologies, real-time data analysis, and predictive artificial intelligence. By doing so, Sensoworks aims to improve the efficiency and sustainability of port operations while mitigating the negative impact on the environment and local communities.

## B) TRADITIONAL SOLUTIONS

Traditional solutions for managing port areas and addressing the associated challenges have been in place for many years. These solutions often rely on established practices, manual processes, and basic technology.

Historically, traffic flow within and around port areas has been managed through manual control by traffic officers and port staff. This approach can be limited in its ability to handle the complexity and volume of traffic efficiently. In 2019, global container port traffic reached approximately 802 million twenty-foot equivalent units (TEUs), according to the United Nations Conference on Trade and Development (UNCTAD).

Traditional ports often rely on paper-based documentation for cargo manifests, customs paperwork, and other records. This manual system can be time-consuming and prone to errors.

Many ports use legacy data systems for tracking cargo, scheduling operations, and managing resources. These systems can lack real-time capabilities and advanced analytics, making them less effective for optimizing operations. The planning and scheduling of vessel arrivals, loading and unloading operations, and resource allocation are often managed manually. This can result in inefficiencies and delays. In 2019, global container port traffic reached approximately 802 million twenty-foot equivalent units (TEUs), according to the United Nations Conference on Trade and Development (UNCTAD). Port congestion can cost the global economy billions of dollars annually. A study by the World Economic Forum estimated that inefficiencies in the global supply chain and ports cost the world economy nearly $5 trillion annually.

Container dwell time (the time a container spends at a terminal) can vary significantly, but efficient ports aim to keep dwell times as low as possible. In some cases, container dwell times can range from several days to a few weeks. The global trend of automating port operations has been on the rise. In 2019, there were approximately 436 automated container cranes in operation worldwide, according to the International Association of Ports and Harbors (IAPH).

Traditional ports rely on safety regulations, training programs, and safety officers to manage and enforce safety protocols. However, these measures may not take full advantage of advanced safety technologies. The IMO reports that accidents in the maritime sector result in the loss of approximately 1,000 seafarers' lives each year.

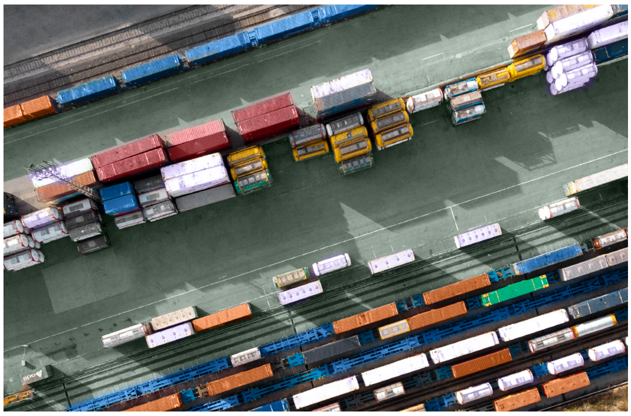
Traditional port management may not place as much emphasis on community engagement and addressing the concerns of local residents regarding noise, pollution, and traffic disruption. While some traditional ports have taken steps to reduce their environmental impact, many have been slow to adopt green technologies and sustainable practices. The International Maritime Organization (IMO) estimated that international shipping is responsible for around 2.2% of global greenhouse gas emissions.

As of 2018, the IMO adopted a strategy to reduce greenhouse gas emissions from ships by at least 50% by 2050 compared to 2008 levels.

Many traditional ports are in the process of transitioning to more advanced, technology-driven solutions to address the challenges they face. Sensoworks represents an example of how IoT, AI, and other advanced technologies can be employed to modernize port management and overcome the limitations of traditional solutions. These modern solutions offer real-time monitoring, predictive analytics, and automation to enhance efficiency, safety, and sustainability in port operations.

## 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. New solutions for port management are leveraging these advanced technologies and innovative approaches to address the challenges faced by the maritime industry. These solutions aim to improve efficiency, reduce environmental impact, enhance safety, and optimize port operations.



## 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 or vehicles to monitor. Video cameras, GPS tracker, 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 and real time monitoring

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. IoT is being used to collect real-time data from sensors and devices within port areas. This data includes information about cargo, equipment, environmental conditions and incoming vehicles. Real-time monitoring allows for better decision-making and resource allocation.

### 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.

### Digital Twin

Digital twin technology creates virtual replicas of physical port assets and operations. These digital twins enable port operators to simulate and optimize various scenarios, improving planning and maintenance.

### Integration of Data Platforms

Ports are integrating data from various sources and stakeholders, including shipping lines, trucking companies, and customs authorities. This improves information sharing and coordination.

### Security Enhancements

Ports are investing in advanced security technologies, including facial recognition, biometrics, and AI-driven surveillance systems to enhance the safety and security of port areas.

## 5. … To practice: a real use case

### A) ESSENTIAL ELEMENTS OF A MONITORING PROJECT

The offering system and the functionalities of the technology covered by this proposal include the collection and integration of data from different sources, such as GPS data from vehicles, information on road traffic, video data from video analysis systems and systems of scheduling access to the port. Vehicle geolocation and tracking allows you to track vehicle movements in real time, providing information on their position and allowing better traffic management and coordination. Integration with the cameras present outside and inside the port area allows you to extract useful information such as license plates, the detection of unauthorized vehicles or people, the monitoring of loading and unloading activities and the parking of heavy vehicles in the stalls provided at the port entrance, favoring the optimization of port operations. Furthermore, data-augmented dynamic simulation algorithms from data collected from these different sources allow the operator to test different strategies and scenarios, evaluate the impact of system changes and make informed traffic management decisions. These algorithms support the planning module which includes arrival time prediction, queue management and optimal route planning to reduce waiting times and improve overall traffic efficiency.

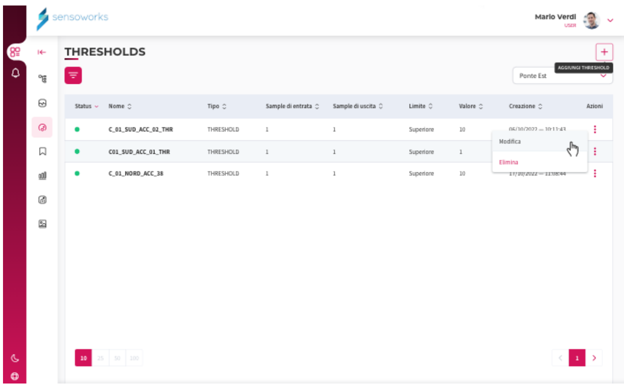
Here are the fundamental elements to monitor a Sensoworks project. As we'll see, the monitoring platform is only a piece of a larger puzzle, although a fundamental one to prepare and then implement an efficient solution:

- 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 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.

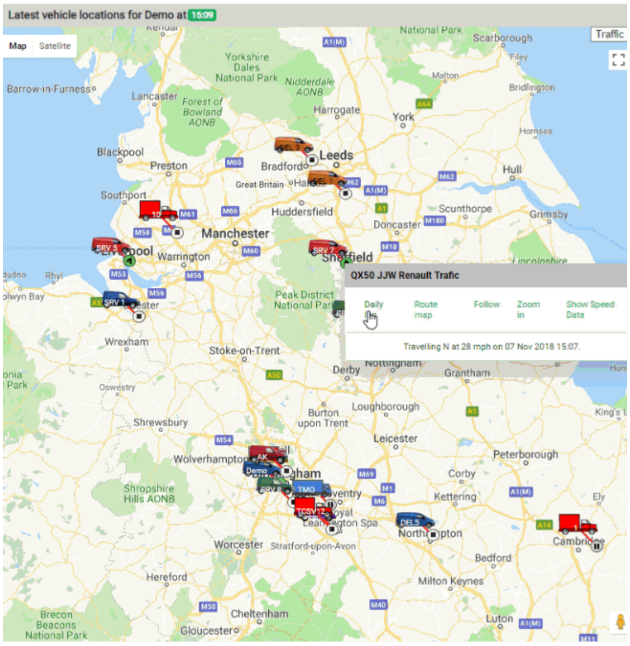
User Management: Creation, modification, deletion of users. It is possible to define different access roles and profiles (authentication and authorization). The platform supports the definition of different tenants, in a multi-tenant logic for the segregation of information relating to different customers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

Dynamic Vehicle Routing:

They are algorithms for the optimal dynamic (re)planning of carrier routes with respect to the impact on road resources and considering the induced environmental and social effects. Multi-objective optimization models have been developed for Dynamic Vehicle Routing (DVRP), through which to manage ongoing distribution activities in light of operational constraints and constantly changing conditions: real-time position of carriers, state and sustainability of road conditions facing port areas, delays in the supply chain, state of congestion at intermodal nodes, etc. The output is the optimal road route with indication of parking times in dedicated areas.

Vehicle Tracking:

Through a multi-platform mobile application, the transporter will be able to request the availability of access to manage an order, indicate the carrier's data (consumption, emissions, etc.), the expected duration of operations in port and the subsequent destination, as well as any special requirements deriving from the type of cargo envisaged (dangerous goods, exceptional transport, etc.). It will then be able to signal the start of transport, which will activate real-time GPS tracking of the carrier, allowing the system to constantly monitor the position of the vehicle during the journey and the actual expected time of arrival (ETA). During transport, the app will notify alerts in real time, with updates on the availability of goods to be loaded or unloading areas, the route to follow and any intermediate stop requests to allow the disposal of critical situations or identified needs.




# 6. 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).

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# 7. 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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