1 General information

Seaport: Port of Antwerp-Bruges

Country: Belgium

Project title: APICA Digital Twin

WPSP theme: Digitalization

2 Introduction

The Port of Antwerp-Bruges has embarked on an ambitious digital transformation strategy to support its role as a sustainable, innovative, and efficient global logistics hub. Central to this vision is the creation of APICA (Advanced Port Information & Control Assistant), a groundbreaking Digital Twin platform that mirrors the physical port territory in real-time through an interactive, 2D/3D interface.

APICA enhances operational decision-making, safety, and environmental monitoring by fusing live data from a vast network of sensors, drones, cameras, and other smart infrastructure. With APICA, the Port of Antwerp-Bruges is setting new international benchmarks for how digitalization can serve as a core enabler of port sustainability and performance.

3 Description of the project

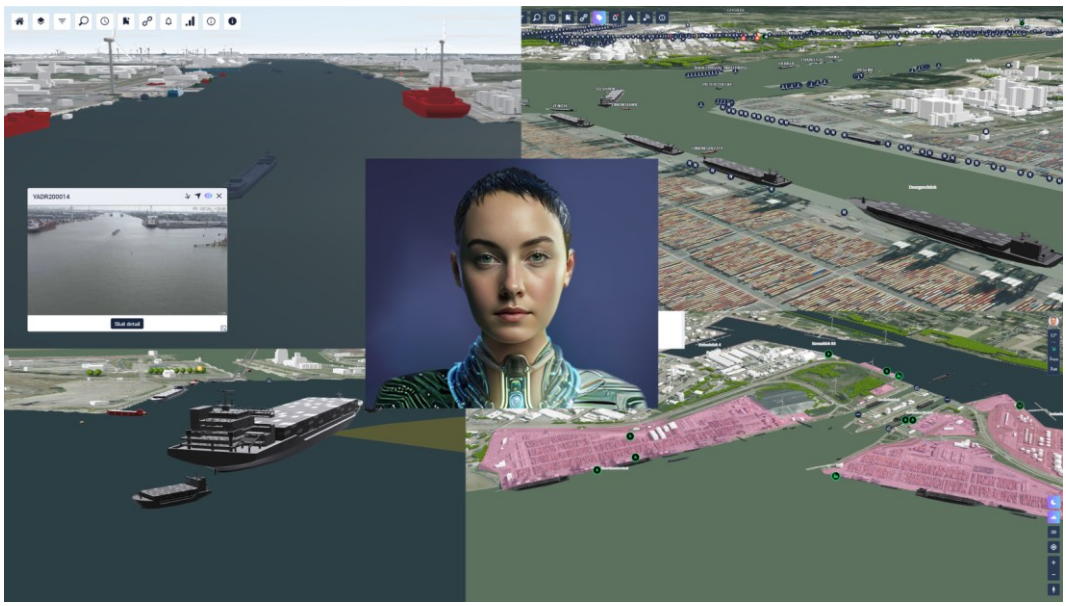
APICA (Advanced Port Information & Control Assistant) is the Port of Antwerp-Bruges' Digital Twin, a digital replica of the port area. It is a dynamic, real-time, 2D/3D virtual representation of the entire port environment, aimed at monitoring all business operations and providing real-time information about the port area. It is developed to create situational awareness, support decision-making, and enhance sustainability across all domains of port activity.

Unlike traditional monitoring systems, APICA integrates live data from a wide network of sources—including IoT sensors, drones, smart cameras, and digital 'noses'—to create a highly detailed, interactive model of current port conditions. This system allows port stakeholders to visualize infrastructure conditions, track ship movements, detect environmental threats, and simulate future scenarios. The APICA platform is accessible to all employees of the Port of Antwerp-Bruges, ensuring that safety-critical information and operational insights are available across all levels of the organisation. The overarching vision is to create a digital nervous system that mirrors the complex operations of the physical port, offering a shared situational awareness across teams, systems, and use cases.

Key components of the APICA Digital Twin include:

- **3D Geographic Interface**: APICA offers strong real-time visualization of the entire port environment in both 2D and 3D views. Its user-friendly and intuitive interface enables stakeholders to interact directly with assets, ships, infrastructure, and sensor data, making complex information easily accessible for various roles.
- **Real-time Data Integration**: The platform continuously aggregates real-time information from a wide range of sources such as IoT sensors, drones, weather stations, smart cameras, and 'iNoses'—digital sensors that detect harmful gases and odors. It also includes data feeds from maritime infrastructure like bridges and locks, ensuring a comprehensive and up-to-date overview of port activities and conditions.
- **Simulation Capabilities and Decision-Making Support**: APICA enables short-term forecasting of traffic congestion, vessel movements, and other port dynamics using AI and historical data. Combined with prescriptive analytics and historical playback functionality, it supports enhanced decision-making, proactive risk management, and effective incident analysis.
- **Open Architecture and Stakeholder Community Engagement**: Designed to be modular and open, APICA can integrate with third-party applications and evolving data sources. APICA allows for continuous integration of improvements from internal teams and feedback from external stakeholders to ensure that the digital twin aligns with operational needs and user expectations.

By combining these features, APICA transforms how the port is monitored and managed—enabling safer, greener, and more responsive operations every day.



4 Vision and leadership deployed by the port's management

The Port Management of Antwerp-Bruges has exhibited proactive and visionary leadership by embedding digitalization at the core of its strategy to become a sustainable, smart port. Recognizing the scale and complexity of managing a 120 km² industrial and logistical hub, the port authority envisioned APICA not just as a technical innovation, but as a foundational transformation tool.

Rather than treating digitalization as a series of isolated initiatives, the port has embraced a holistic approach, embedding APICA as a foundational element of its operational and strategic framework. It is positioned as a Digital Twin of the Organization (DTO), aligning technological progress with sustainable and efficient port operations.

CEO Jacques Vandermeiren has emphasized this commitment, stating:

"Port of Antwerp-Bruges is aiming to build a digital nervous system to fully manage the port remotely. By working with innovative partners and opening up the port as an innovation platform, we are making our port smarter, safer and more efficient."

This vision is realized through the fusion of digital infrastructure, AI-driven insights, and open architecture — enabling scalable growth and collaboration across port services. The leadership has fostered a culture of experimentation, openness, and continuous improvement. APICA is thus not only a technological enabler but a strategic backbone for the port's ambition to remain a global sustainability and logistics leader.

5 Engagement of societal and commercial stakeholders

The development and success of APICA have been shaped by active collaboration with both internal teams and external partners. Internally, multidisciplinary teams from the Port of Antwerp-Bruges—including departments for IT, operations, environment, and security—worked closely to define functional needs, design user experiences, and test real-time features of the platform. Accessibility was a key design principle, and APICA is made available to all employees of the port, reinforcing its role as an inclusive, organisation-wide decision-support tool[1].

Externally, APICA was co-developed with technology partners such as Superlinear[2] and Axxes[3], who contributed to the design and technical architecture of the application. These collaborations ensured the integration of advanced features while maintaining a user-

[1] Port Technology – APICA: The Digital Twin Solution Transforming the Port of Antwerp-Bruges
[2] Port of Antwerp-Bruges & Superlinear leading the smart port revolution
[3] Port of Antwerp-Bruges

centric and intuitive interface. The port's digital team also worked in alignment with academic and innovation partners under EU-funded programs like Horizon 2020 and Interreg, which promote knowledge exchange and support technological innovation across the logistics sector[4]. APICA has also been the subject of multiple academic studies exploring the potential of digital twins in port environments, and academic and research institutions have contributed to the development and validation of simulation models and use cases within the platform.

In addition, APICA supports coordination with public services and emergency responders by providing real-time overviews of the port, aiding in incident prevention and response. The port community, including logistics companies and terminal operators, was engaged through feedback sessions to ensure that APICA meets operational needs and improves efficiency and transparency.

The Port of Antwerp-Bruges fosters these relationships through open innovation workshops, stakeholder consultation, and pilot testing. This participatory approach ensures that APICA continuously evolves in line with user feedback and real-world challenges. Ultimately, APICA enhances value for the wider port community by promoting operational transparency, improving environmental compliance (e.g. detection of unauthorized generator use), and supporting safer and more sustainable practices.

6 Contribution to sustainability and the UN SDGs

The initiatives undertaken by the Port of Antwerp-Bruges exemplify a strong commitment to sustainability and the United Nations Sustainable Development Goals (SDGs). APICA contributes meaningfully to several SDGs.

SDG 9: Industry, Innovation, and Infrastructure – APICA is a big leap forward in the digital innovation of the Port of Antwerp-Bruges, one of Europe's largest industrial and logistics hubs. By integrating state-of-the-art technologies, AI-driven analytics, and a highly visual, intuitive 3D interface, APICA showcases increasingly innovative use of data in daily port operations. It strengthens vital port infrastructure by improving operational efficiency, ensuring greater continuity, and enhancing risk management—making the it safer, more reliable, resilient, and sustainable in the face of growing logistical and environmental demands. In doing so, it also supports cleaner, more efficient industrial activity in the port, helping detect and mitigate the impacts of potential spills and pollution.

[4] Subsidized projects | Port of Antwerp-Bruges

SDG 13: Climate Action – By detecting harmful emissions in real time, monitoring and maximizing clean energy production (e.g. wind turbines), tracking environmentally friendly practices (e.g. use of shore power instead of diesel generators), facilitating greater energy efficiency across operations, and issuing early alerts for environmental hazards (e.g. spills and pollution), APICA supports the port's efforts to mitigate its climate impact and adapt proactively to environmental challenges.

SDG 11: Sustainable Cities and Communities – By limiting noise, air pollution, and other environmental impacts, APICA helps the port operate more harmoniously alongside nearby communities and cities such as Antwerp and Bruges. It provides early warnings for incidents like gas leaks and odour nuisances, thereby protecting the quality of life in surrounding urban areas. This contributes to a more sustainable and livable interface between port infrastructure and urban environments, bridging industrial operations with community well-being

SDG 8: Decent Work and Economic Growth – APICA significantly enhances health and safety conditions for people working in the port area. Its real-time sensor network and simulation capabilities help detect and prevent hazardous situations—such as gas leaks, pollution, or mechanical failures—before they escalate. The system also facilitates rapid and efficient emergency responses by providing accurate location-based data and automated alerts. These functions contribute to safer, more precise, and more efficient working conditions in a high-risk industrial setting, aligning strongly with Target 8.8, which promotes safe and secure working environments for all. The tool's accessibility to all employees ensures that these safety and efficiency benefits are broadly distributed throughout the organisation.

These contributions reflect how APICA serves not only as a digital infrastructure upgrade, but as a tool for responsible port governance, improved environmental performance, and long-term social and economic sustainability. how smart digital infrastructure can serve not only operational efficiency but also human well-being and environmental stewardship in a complex, high-impact industrial setting.

7 Results

Since its implementation, APICA has yielded both measurable and transformative results across the Port of Antwerp-Bruges. Its ability to integrate and visualize complex operational data in real time has enhanced decision-making, operational safety, environmental monitoring, and stakeholder coordination.

One of the most immediate impacts has been the reduction in incident response times. Thanks to predictive alerts and automated workflows, response times for detecting environmental anomalies or infrastructure failures have been cut by several hours—

sometimes even days. This capability plays a crucial role in preventing small disruptions from escalating into crises, contributing to more stable and sustainable port operations.

In 2023 alone, APICA helped monitor over 1,000 assets and infrastructure components in real time, including bridges, locks, and key energy systems such as shore power and wind turbines. The integration of over 70 iNoses across the port has significantly improved air quality monitoring[5]. These digital noses detect harmful gases and odor nuisances, enabling real-time enforcement of environmental rules and immediate action where needed—enhancing health protections for both employees and residents in surrounding urban areas.

For employees, APICA has revolutionized the way fieldwork is conducted. By offering centralized, real-time data through an intuitive digital interface, workers now spend less time patrolling large areas and more time focusing on targeted interventions. This transition to knowledge-based work improves safety, efficiency, and job satisfaction. The digital twin has become a virtual assistant, guiding teams with insights like: "A chemical is detected near Dock X—shall I dispatch a drone to investigate?"[6].

From a community perspective, APICA's predictive capabilities are particularly valuable. By detecting early signs of odour nuisance, gas leaks, or water pollution, the system plays a preventative role in safeguarding the health and well-being of people living near the port. This proactive environmental management reinforces the port's commitment to being a good neighbor to the cities of Antwerp and Bruges.

In sum, APICA is no longer just a technical tool—it is a mission-critical platform shaping the port's transformation into a data-driven, responsive, and sustainable hub for global logistics.

[5] Air quality, odour and noise | Port of Antwerp-Bruges

[6] Gartner - Case Study: Digital Twin Optimized for Value Delivery With Artificial Intelligence

8 Relevant information

- Smart port | Port of Antwerp-Bruges
- Port of Antwerp-Bruges
- Port of Antwerp-Bruges & Superlinear leading the smart port revolution
- Gartner - Case Study: Digital Twin Optimized for Value Delivery With Artificial Intelligence:

  Gartner - Case Study
  Digital Twin Optimize

- Port Technology – APICA: The Digital Twin Solution Transforming the Port of Antwerp-Bruges:

  Port Technology -
  Smart Digital Ports of

9 Contact information

Danny Van Dessel

Digital & Analytics Manager

Port of Antwerp-Bruges

danny.vandessel@portofantwerpbruges.com

+32 475 69 40 14