Port of the future

Addressing efficiency and
sustainability at the Port
of Livorno with 5G

ERICSSON

In collaboration with

Port Network Authority of the
North Tyrrhenian Sea
Ports of Livorno – Piombino – Portoferraio – Rio Marina – Cavo – Capraia Island

cnit

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Introduction

In this report, we examine how technology innovation can optimize port operations and what assessment models can be used to measure economic, social, and financial benefits.

Adapting traditional business models to be more cost-effective, and socially and environmentally sustainable – the triple bottom line of sustainable development – is becoming increasingly important. This applies to all industries, diverse and multidimensional sectors and activities, of which ports are a key example. This can be achieved by implementing sustainable port growth policies, through new or re-designed operational planning. As part of this, introducing new technologies into port processes and ecosystems that factor in the environment, but have wider-reaching benefits, will enable a move towards the port of the future.

Although the expected consequences of a changed climate are one of the reasons behind actions in coastal protection and port management, issues such as scarcity of prime building locations, use of resources, environmental impact and the lives of neighboring communities also

affect business decisions. 5G networks and digital technologies are crucial to addressing these challenges and transforming port operations to generate sustainable development.

Different methods can be used to measure the impact of technological advancements on competitiveness, efficiency and growth of the sector. In this report, however, we identify the UN Sustainable Development Goals (SDGs) and their corresponding measurable key port performance indicators that can be used to monitor sustainability performance and help make business decisions for port master plans.

Launched in 2015 as part of the 2030 Agenda for Sustainable Development, the 17 SDGs and their 169 associated targets represent an authoritative global guideline to achieving sustainability across different sectors. The agenda has many targets that can be directly

or indirectly linked to port operations. These include the protection and management of ecosystems, as well as goals related to infrastructure and the circular economy, sustainable cities and communities, principles of good corporate governance, and data transmissibility and partnership relations management. With a timeline stretching to 2030, port authorities have time and capacity to contribute to the accomplishment of the 2030 Agenda for Sustainable Development.

Achieving the SDGs also requires public and private sector partnerships. In such a setup, port community actors are engines for change. They not only facilitate the reduction of emissions, to enable energy transition and stimulate the circular economy, but are also points of dialogue with urban stakeholders and port cities.

Key findings

1. Historical ports must become more efficient, productive and sustainable.

2. A sustainable port has occupational and economic benefits for local communities, while also being environmentally responsible by minimizing its carbon impact and generating competitive, long-term value and wealth.

3. The UN's 17 SDGs are a global guideline for achieving sustainability across different sectors. To realize the SDGs related to ports, a smart port model has been developed, which considers the digital transformation enabled by 5G as the main lever.

4. Embedding technologies that incorporate environmental

considerations, firstly, but not only climate resilience, will enable a move towards the port of the future.

5. 5G networks and digital technologies are crucial in addressing this challenge and transforming port operations.

6. Introducing 5G, augmented reality (AR) and AI-based use cases in the port of Livorno leads to economic, social and environmental benefits, including:
   • Reducing the transit time of goods in the port
   • Decreasing vessel and unit operations
   • Maintaining safety conditions
   • Reducing environmental impact
   • Controlling system automation and easing service flow

Challenges for next-generation ports

How can historical ports evolve and adapt to become smart and sustainable ports? This is one of the greatest challenges that ports face today and requires a deep understanding of different fields of knowledge.

Technology tested in real port processes should be evaluated using several measurement methods.

When deploying new technologies within real environments, port authorities and institutions need to analyze and evaluate their impact on overall performance in terms of competitiveness, effectiveness and sustainability. However, port nodes often employ a short-sighted approach to innovation, with investment decisions based almost entirely on the cost and direct profit of technologies, rather than cost and time efficiency, and environmental impact.

Therefore, ports must take a broader, more sustainable approach to investments and innovation. Assessing performance in a multidimensional and consistent way is a difficult task that needs strong interrelations among technologies, processes and organizational procedures. The 2030 Agenda for Sustainable Development, combined with the Italian Government's National Sustainable Development Strategy (NSDS), sets out a new vision for achieving innovative and sustainable economic, social and environmental growth.

Sustainability is a multifaceted concept, which encompasses layers of environmental issues, long-term economic competitiveness and societal challenges. Factors to consider are:

- Climate change adaptation, which is vital to the survival of seaports. A recent study, published by ENEA, has shown that 21 Italian ports are at risk due to rising sea levels[1] and not responding effectively to the effects of climate change could have destructive consequences.
- Ports must work to reduce their greenhouse gas emissions in line with the Paris Climate Agreement and scientific recommendations, to halve emissions by 2030. It is estimated that the ICT sector can enable a 15 percent reduction of greenhouse gas emissions in other sectors worldwide, including mobility and logistics,[2] which implies that digital solutions in ports could help address their carbon footprint.
- Environmental considerations are increasingly on the agenda for businesses, and the current port

approach alone may not be sufficient to handle major environmental impact.[3] Various types of pollution and sources have adverse impacts, and port authorities must deal with them through monitoring tools, mitigating interventions and cooperating with stakeholders.
- Sustainability also refers to long-term socio-economic factors. A sustainable port not only has occupational and economic benefits for local communities, but also a business model capable of generating long-term value and wealth, strong enough to cope with competitors.

Therefore, current port industry Key Performance Indicators (KPIs) should take a broader perspective, that of the SDGs, and new technologies should be evaluated against those. By taking an integrated approach, technologies can be tested simultaneously in real port processes and evaluated by the integration KPIs and SDGs. The results of such evaluations then represent both a measurement of a port's competitiveness and the impact of its operations on sustainable development.

[1] www.ilsole24ore.com/art/l-allarme-dell-enea-porti-italiani-rischiano-finire-sotto-acqua-ACMgC7v (in Italian)
[2] Exponential Climate Action Roadmap 2019: https://exponentialroadmap.org/
[3] ESPO release Green Guide: www.espo.be/media/espopublications/espo_green%20guide_october%202012_final.pdf

The Port of Livorno

Located in the upper Tyrrhenian Sea in northern Tuscany, the Port of Livorno is one of the largest and most important Italian seaports.

With an annual traffic capacity of around 36 million tons of cargo and over 700,000 TEUs (the 20ft equivalent unit used to describe the capacity of container ships and container terminals), the port is a multipurpose point, equipped with the infrastructure and means to welcome any kind of vessel and handle any type of traffic. The port is also an important employer in the area, with more than 15,000 employees providing services to almost 9,000 ships every year. It ranks first for roll-on/roll-off traffic in Italy and third for general cargo.[4] Livorno is linked to industrial areas in Central and Northern Italy, and is subsequently a major gateway for both import and export flows. Today, it plays a pivotal role with the Americas,

Mediterranean and new car imports from the Far East, as well as ferry and cruise passengers, mainly from Europe.

Since 2015, the Port of Livorno has adopted an agenda towards a smarter and more standardized digital infrastructure, where digitalization and innovation are key elements for the port's competitiveness and development. Thanks to enabling data collection, increasing information reliability, and speeding up of data exchange, technologies can facilitate this evolution.

Digitalizing port operations with 5G and IoT began in 2016 when Ericsson Research in Italy and the Italian Interuniversity Consortium for Telecommunication (CNIT)

began cooperating to develop innovative "Port of the Future" use cases. The port has become a test bed for technology transfer partners to assess and verify new innovative solutions. Many cutting-edge activities have been carried out, placing Livorno among the most advanced ports in the Mediterranean for technology and innovation developments.[5] The port has established an innovation lab with CNIT and has attracted public and private players to test and invest in it.

Crane unloading shipping containers at the Port of Livorno.
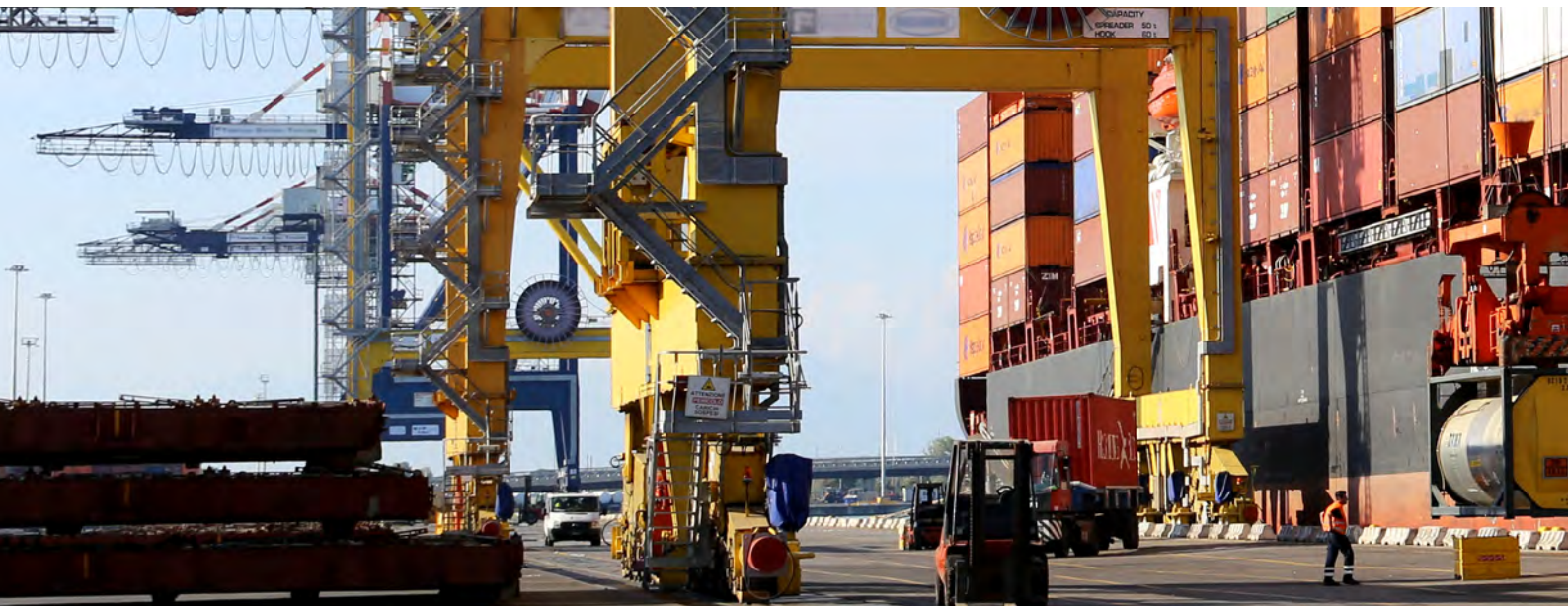
[4] See Assoporti, Italian seaports organization, statistics: www.assoporti.it/media/6298/adsp_movimenti_portuali_2019-agg-al-242020.pdf
[5] Livorno is the first Mediterranean port to host a Plugtest of ETSI in 2016. The port has been awarded two Horizon 2020 Port of the Future projects (COREALIS and PORTFORWARD) https://portal.etsi.org/Portals/0/TBpages/CTI/Docs/5th_ITS_CMS_PLUGTEST_REPORT_FINAL.pdf

5G connectivity: powering the port of tomorrow

The Port of Livorno is piloting 5G to transform the port's processes, leveraging real conditions in the port area. The end goal is to fully deploy 5G and support a sustainable port development.

With the new standards in cellular connectivity, cellular networks meet a range of requirements that support different transportation and logistics use cases as part of a Logistic 4.0 approach, making it possible to securely and efficiently optimize port variables with one communication system. This allows for massive real-time data collection and analytics, system optimizations and increasing intelligent automation in the port area. The result is better coordination between humans and devices, through augmented reality, video cameras, forklifts, trucks and sensors, controlling warehouses and inventories, and positioning goods and other aspects of the port's logistics.

The port of the future will need to use always-connected sensors and enhanced applications that control and make decisions in real-time, to provide intelligent insights into the port's condition and operations, and its potential for further optimization.

A fixed cable network is only able to support critical applications for static devices rather than the typical transportation and movement seen in port areas. Scaling of connected logistic operations is not feasible either, as cables are costly to install and maintain. The need for connectivity goes beyond the standard Wi-Fi connection. Therefore, robust communication for mobile-based IoT business-critical applications are required, to reliably meet time-critical communication through secure networks with carrier-grade data encryption and identity authentication.[6]

Thus, cellular technology (LTE/5G) is an excellent match because the port of the future will have a myriad of IoT devices deployed, which will have different connectivity demands.

Cellular capabilities include:
- Low and predictable latencies, even with a heavy load and many users
- Quality of service to guarantee low latency and bit rates
- More deployment flexibility for sparse and dense options
- Mobility capabilities to ensure a smooth handover between base stations
- Flexible scaling of network capacity, depending on demand
- Reliability of device interoperability
- The full deployment of multiple use cases, involving many sensors and devices, which require LTE/NB-IoT/5G cellular capabilities, to ensure reliability and security
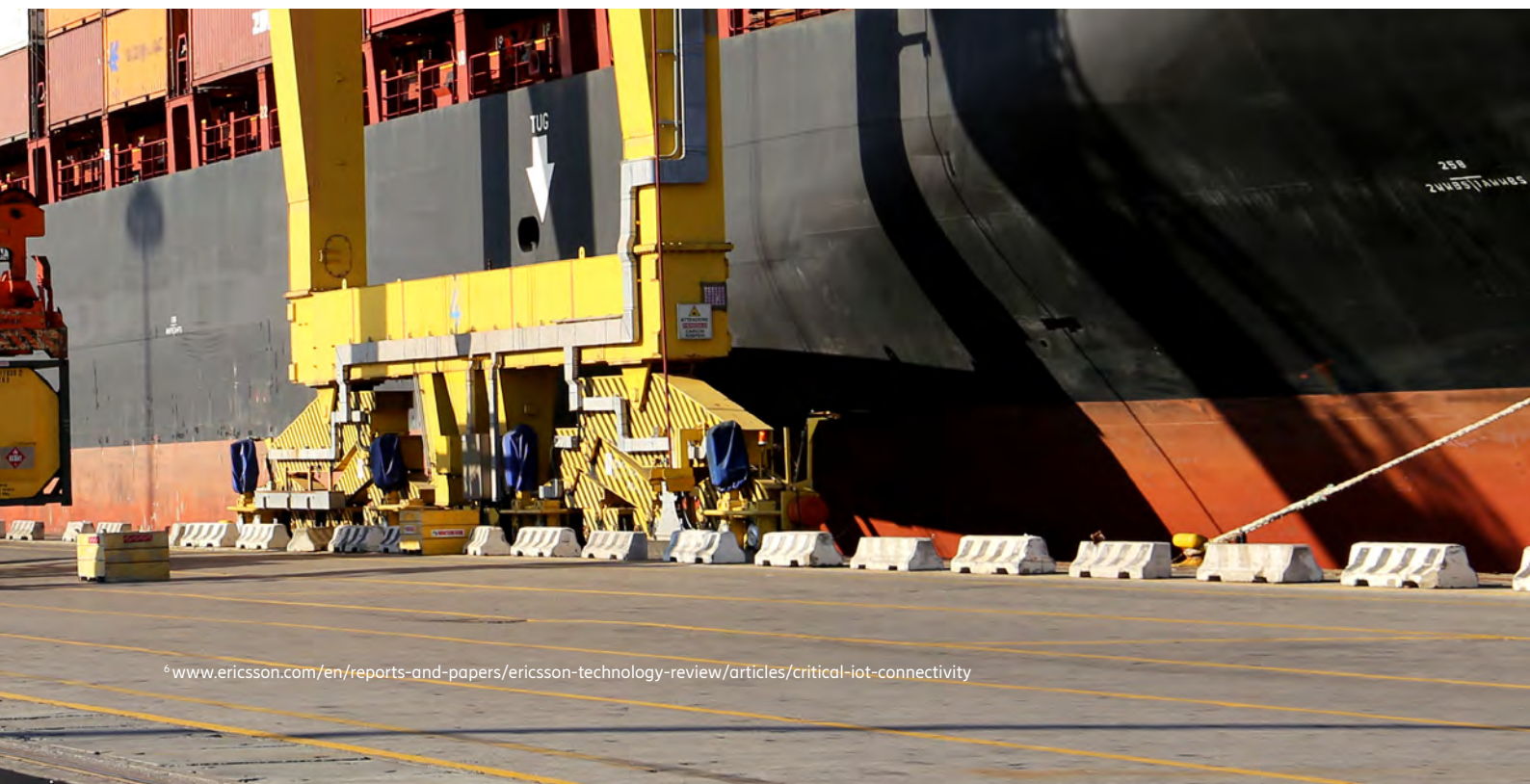
[6] www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/critical-iot-connectivity

Sustainability-aware assessment of technology readiness

To identify their digital readiness, ports need to adopt technology assessment tools that are capable of evaluating the technological impact on specific areas.

Each port should undertake a tailored assessment to determine its strengths and weaknesses, status and ambitions.

To meet this challenge, the Port of Livorno, Ericsson, Fondazione Eni Enrico Mattei (FEEM) and the National Inter-University Consortium for Telecommunications (CNIT) have proposed a new methodology for technology assessment, with sustainability considerations embodied. Each partner provided specific skills and knowledge to reach one common objective: creating a comprehensive model that evaluates cutting-edge and disruptive technologies and measures their sustainable impact.

The methodology includes three different steps, which are outlined on the next page:

Step 1: Identify relevant SDGs
Step 2: Identify port processes
Step 3: Technology assessment

The Port of Livorno is focused on evaluating the following areas for all operations at the port:
- Automation
- Transport and logistics
- Environmental sustainability and personnel safety
- Cybersecurity (IT systems and physical infrastructures)
- Smart port for a smart city

The relevant port processes considering each of these areas are:
- Warehouse management (goods management within the warehouse of departure/arrival)
- Gate-in/gate-out procedures (checking operations at both port and terminal gates)
- Container terminal operations (cargo loading/unloading operations within the container terminal)
- Verified gross mass management (specific for containers, weighing operations at specific sites)

8 SDGs

There are eight SDGs that are relevant for all port authorities.

- Ship practices (mooring, unmooring, piloting, waste management, bunkering, etc.)
- Goods practices (customs declarations, cargo manifest, single window, requests for dangerous goods authorizations, etc.)
- Control operations (physical controls on cargo by control bodies)
- Land transport and smart corridors (cargo multimodal transportation)

Decision-making process when introducing new technology

| Should the port invest in a new technology? | → | Application of the model and simulations | → | Impact analysis | → | Final decision and port planning |

5G antenna from the demo at the Port of Livorno.

The three-step methodology

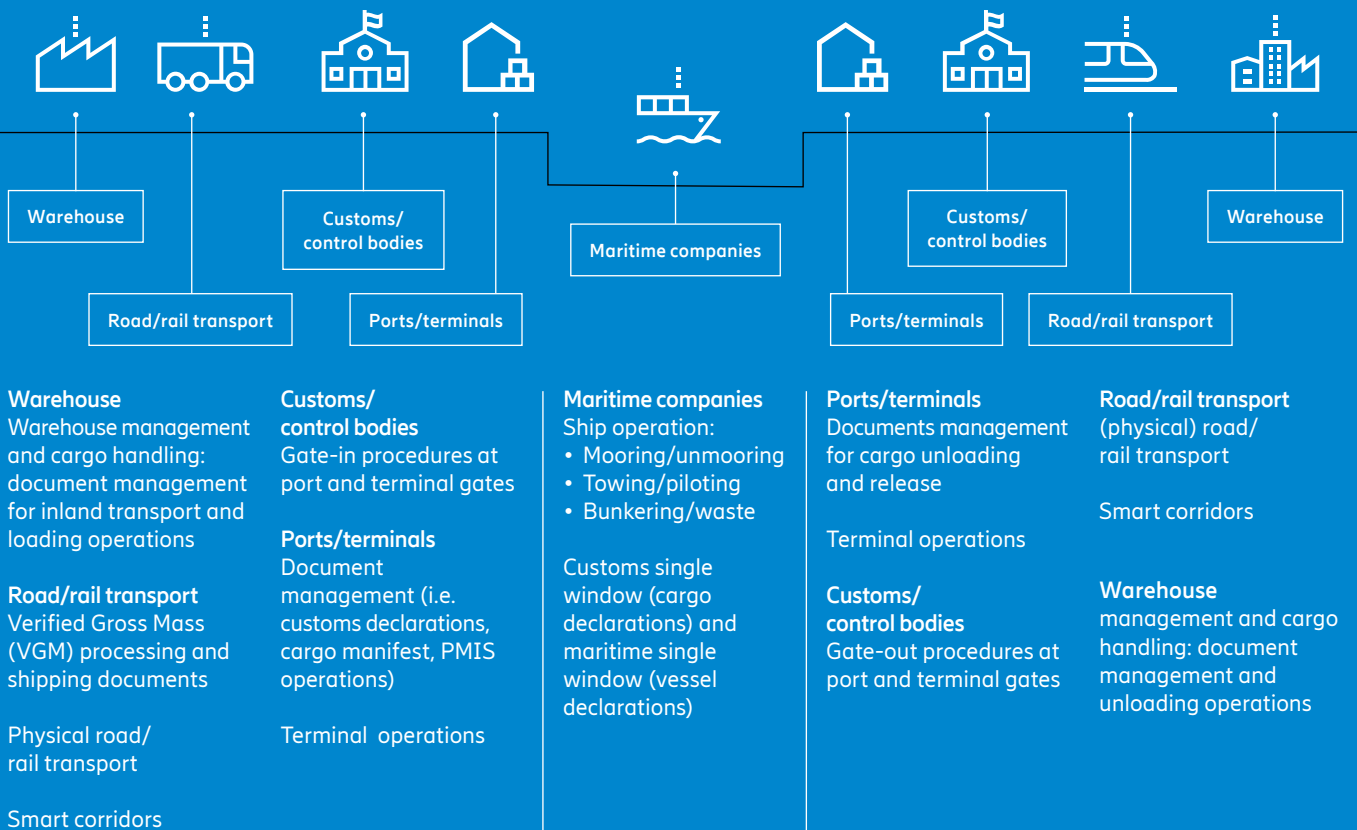|	
Step 1: Identify relevant Sustainable Development Goals	The first step is to identify the SDGs of relevance for sustainable port development. Which SDGs to focus on depends on the features and needs of the port in question, and the enabling technologies involved. According to the guidelines of the 2030 Agenda for Sustainable Development, direct and indirect impact on the goals are identified separately. Thereafter, the identified SDGs are studied, and the outcome is narrowed down to eight that are relevant for all port authorities. These SDGs are: • Quality Education (SDG 4) • Decent Work and Economic Growth (SDG 8) • Industry, Innovation and Infrastructure (SDG 9) • Sustainable Cities and Communities (SDG 11) • Responsible Consumption and Production (SDG 12) • Climate Action (SDG 13) • Life Below Water (SDG 14) The overall project is an example of a partnership that includes academia, public sector and business participants, which meets the target set out in SDG 17.
Step 2: Identify port processes	The next step is mapping all port processes where technology may bring transformative impact, with value-added services for operators and port communities.

Port of Livorno processes

Warehouse
Warehouse management and cargo handling: document management for inland transport and loading operations

Road/rail transport
Verified Gross Mass (VGM) processing and shipping documents

Physical road/ rail transport

Smart corridors

Customs/ control bodies
Gate-in procedures at port and terminal gates

Ports/terminals
Document management (i.e. customs declarations, cargo manifest, PMIS operations)

Terminal operations

Maritime companies
Ship operation:
• Mooring/unmooring
• Towing/piloting
• Bunkering/waste

Customs single window (cargo declarations) and maritime single window (vessel declarations)

Ports/terminals
Documents management for cargo unloading and release

Terminal operations

Customs/ control bodies
Gate-out procedures at port and terminal gates

Road/rail transport
(physical) road/ rail transport

Smart corridors

Warehouse
management and cargo handling: document management and unloading operations

Step 3: Technology assessment	Finally, the impact on port processes from the selected technology is assessed, using associated traditional KPIs and selected SDGs.

Connecting SDGs and disruptive technology

Analyzing the effect of bringing digitalization into each process to strengthen the port's competitiveness and sustainability is at the core of the methodology.

5G is the technology considered for the collaboration between the Port of Livorno, Ericsson, FEEM and CNIT. It is currently being tested in the Port of Livorno to speed-up the data exchange among actors involved in terminal operations.

FEEM has analyzed and identified all prospected direct and indirect 5G-enabled benefits on port processes. Results show that some port processes have been positively affected by 5G technology and digital solutions, such as IoT (Internet of Things), AR/VR (Augmented Reality/Virtual Reality) and Artificial Intelligence-based systems. All port processes are benefiting from cellular connectivity and digital solutions, and for most, 5G would be needed to enable innovative new use cases that require high latency, reliability, capacity and security.

The number of benefits linked to the SDGs is 65, divided among the Port of Livorno focus areas as follows:
- 15 direct and indirect benefits relating to automation
- 32 direct and indirect benefits relating to transport and logistics
- 13 direct and indirect benefits relating to environmental sustainability and personnel safety
- 5 direct and indirect benefits relating to smart port for a smart city

SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) are directly influenced by the 5G-enabled transformation of port processes. This is thanks to the direct effect on port logistic value chain growth, port infrastructure and innovation, responsible production and environmental impact. SDG 4.4 (Vocational Skills) states: "By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship". This is highly relevant to the port workforce, where the transformative role of 5G can enhance job tasks, tools and competence profiles.

SDG 14 (Life below water) is addressed as part of the port's ambition to protect the marine and coastal ecosystems.

SDG 17 (Partnerships for the Goals), fits perfectly with the Port of Livorno approach on public-private partnerships and cooperation aimed at achieving sustainable development that leverages diverse ideas, know-how and contributions.

The sustainable development goals

Results from the overall qualitative analysis

Port process	Focus area		Benefits enabled by 5G	Contributions to UN SDGs
Container terminal operations	Automation	Remotely controlled quay cranes (URLLC, mMTC)	Lower vessel completion time, improved personnel safety, fewer human mistakes and operational inefficiencies, and working profile upgrade	4, 8, 9, 11, 12, 13, 17
	Transport and logistics	Connected/smart ship with augmented navigation information, predictive maintenance for on-field machinery (cranes, forklifts, stackers and trucks) (URLLC, mMTC, network slicing)	Improved security/safety during navigation, new business models, increased number of stakeholders involved in data exchange, and reduced maintenance costs, CO2 and power consumption.	4, 8, 9, 11, 12, 13, 17
	Environmental sustainability and personnel safety	Personnel and environmental monitoring with potential critical and dangerous situations identification (URLLC, mMTC, network slicing)	Less exposure to polluting agents for on-field personnel, CO2 and environmental impact reduction, new job opportunities and shorter intervention time for specialized personnel	4, 8, 9, 11, 12, 13, 14, 17
	Cybersecurity	Unmanned aerial vehicles for potential real-time threat detection (eMBB)	Improved security for sensible data transmission, better capacity to identify potential threats, greater data reliability and new professional figures	4, 8, 9, 11, 12, 17
Verified gross mass management	Automation	Automated systems for container weighing (URLLC, eMBB)	Reduced weighing times, lower environmental impact and a higher number of weighing per time unit	9, 11, 13, 17
	Transport and logistics	Secured documental VGM practices (URLLC, eMBB)	Improved data integrity, faster data elaboration, better stowage planning and reduced truck waiting times	8, 9, 11, 12, 13, 17
Warehouse management	Automation	Remote and automated cargo handling, monitoring and tracking systems (URLLC, mMTC, network slicing, eMBB)	Lower time to find cargo, reduced accidents, less operational inefficiencies, fewer human mistakes, lower handling time per cargo unit, reduced economic costs and improved competitiveness	4, 8, 9, 11, 12, 13, 17
	Transport and logistics	Smart and autonomous vehicles for cargo handling and monitoring (URLLC, mMTC, network slicing, eMBB)	Lower time to find cargo, reduced accidents, less operational inefficiencies, fewer human mistakes, lower handling time per cargo unit, reduced economic costs and improved competitiveness	4, 8, 9, 11, 12, 13, 17
Ship practices - loading/unloading - trailer/piloting	Transport and logistics	Remote assistance and monitoring of ship practices through distributed sensors and cameras communicating in real-time to the MIoT system and with AR/VR assistance for drivers (URLLC, mMTC, network slicing)	Reduced risk of accidents and economic losses, lower time for maneuvers, operation optimization, greater safety, positive outcomes for updating education programs, and on-the-job and continuous training	4, 8, 9, 11, 12, 14, 17
	Environmental sustainability and personnel safety	Monitoring the seabed, terminals and other port infrastructures with a distributed sensor system and MIoT cameras (mMTC, URLLC, eMBB)	Major safety through 5G-enabled MIoT sensors and the reduction of accidents	4, 8, 9, 11, 12, 13, 14, 17
Controlled corridors	Transport and logistics	Cargo tracking truck appointment system with an MIoT network distributed over the entire area, connected with RSU, AR, control centers and other trucks (URLLC, mMTC, network slicing, eMBB)	Reduced traffic congestion, a decrease in pollution, increased visibility of load and road safety, positive consequences for updating education programs, and on-the-job and continuous training	4, 8, 9, 11, 12, 13, 17
	City/port relations	Smart corridors for real-time monitoring/control and infomobility services for passengers in the concept of Smart City (URLLC, eMBB)	Improved mobility, reduction of environmental impact, greater control over processes, positive consequences for updating education programs, and on-the-job and continuous training	4, 8, 9, 11, 12, 13, 17

eMBB: Ultra-Reliable Low-Latency Communications provides latencies of 1 ms or less with high reliability (99.999%) for mission-critical applications.

URLLC: Ultra-Reliable Low-Latency Communications refers to strict requirements on latency (1ms) and reliability (99,999%) for mission-critical applications

mMTC: Massive Machine Type Communications, refers to the need to support a very large number of connected devices (5G supports up to 1 million devices per Km2)

Flexible network operations: this refers to aspects such as Network Slicing (logical network partition), scalability, mobility, security, efficient content delivery and interworking

UN SDGs: Mentioned above with their name and link to UN SDGs page: https://sustainabledevelopment.un.org/sdgs

Case study: COREALIS

As part of the EU Horizon 2020 program, the container terminal operations process at Livorno is currently subject to a research innovation action project named COREALIS.

As 5G provides high flexibility, high bandwidth and low latency, it is considered a key enabling technology for the optimization of container terminal operations. The COREALIS[6] trial involves a 5G-based control module for managing general cargo. It performs real-time control of loading/unloading operations, collecting data via yard vehicles and implanted sensors (e.g. LIDAR, WDR cameras and tablets), and making operating decisions based on real-time analytical processing.

The control module can detect general cargo in a shorter time than usual human-driven communications, as well as enable better management of the cargo. The instantiation of a pervasive 5G network in a container terminal at the Port of Livorno, as well as the use of advanced AR/VR-based services, provides optimization of the intra-terminal operations.

**The 5G-based control module manages cargo operations in real-time**
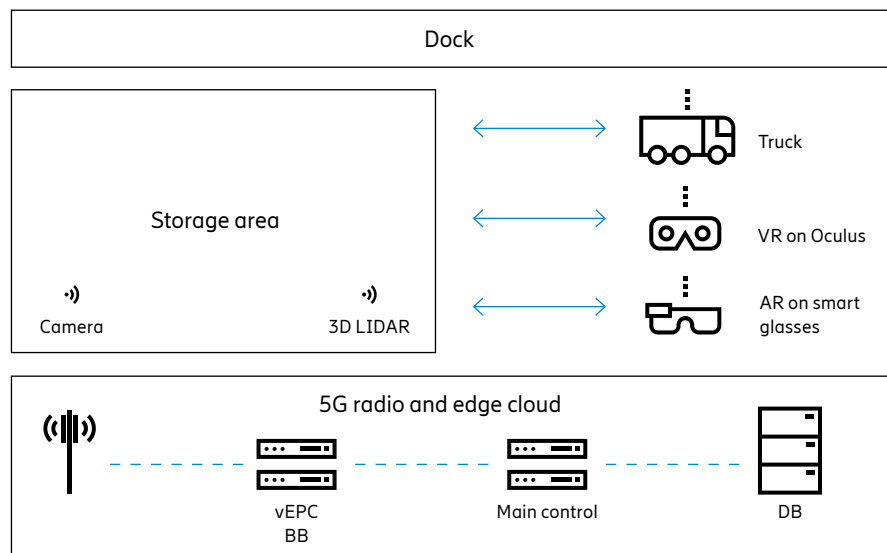
The results of the container intra-terminal operations process, enabled by 5G

Operation	KPI (average value)	KPI baseline	KPI Corealis target	What improved	Benefited Stakeholder	Environmental analysis	
						CO2 saving per container operation	What improved
Vessels' berthing time	Vessel operation completion time	18h	16h	Increased operational speed	Shipping company	-	
	Vessel idle time at berth	36h	34h			-	
Cargo release	Loading (on ship)/unloading (from a single truck) operations completion time	18h/40min	16h/30min	Increased operational speed	Haulers	8.2% CO2 saving	Fuel reduction
	Time to find a pallet on the yard	8min	7min				Fuel reduction
	Cargo registration completion time	3min	2min				Fuel reduction
	Percentage of cargo physical characteristics information registered electronically	0.9	0.95				Fuel reduction
Quays and yards operations	Forklift operation execution time	8min	7min	Reduced operational costs	Terminal operator		Fuel reduction
	Occupied space during the storage phase	5,000m2	4,500m2			-	
	Percentage time of activity/inactivity of the forklift	60%/40%	65%/35%			-	
	Total number of movements per cargo unit	4	3			-	

[6] Capacity with a positive environmental and societal footprint in the Port of the Future era: www.COREALIS.eu

Container terminals handle the movement of containers in the port.
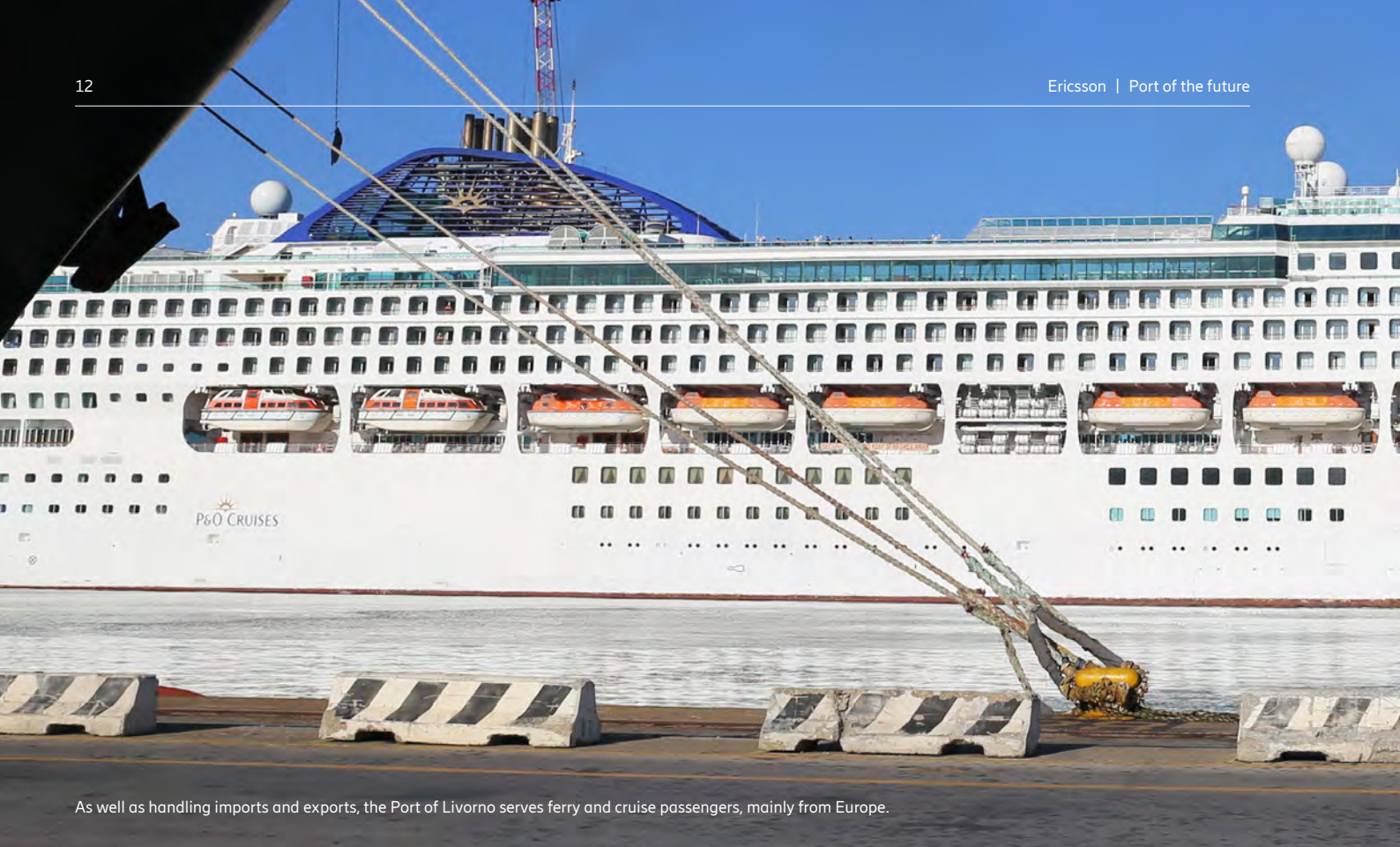
As well as handling imports and exports, the Port of Livorno serves ferry and cruise passengers, mainly from Europe.

Environmental impact of 5G and digital technologies

Activity	Machines	Measurement in 2017 (before 5G)[7]			COREALIS project (with 5G)		
		Hours activity/ year	Diesel/ year (m^3)	CO2/ year (ton)	Hours activity/ year	Diesel/ year (m^3)	CO2/ year (ton)
Vessel loading/ unloading	Tower crane	4,380	399	1,055	4,380	399	1,055
Truck loading/ unloading	Forklift	1,575	43	114	1,575	43	114
Yard movements	Forklift	3,681	235	622	2,805	179	474
Total		-	677	1,791	-	621	1,643 (-8.2%)

Environmental benefit analysis

The reduction in CO_2 emissions is estimated by considering the time needed to accomplish each terminal operation and the average fuel consumption of machines/vehicles. When 5G technologies facilitate the exchange of real-time information among actors in the terminal process, it leads to a reduction in movements in cargo handling. This optimizes the process and, lowers fuel consumption and associated CO_2 emissions.

Typically, tower cranes operate for 12 hours a day loading and unloading cargo from ships, while supporting vehicles such as forklifts operate for 14 hours a day. These forklift actions can

be optimized with 5G, reducing working time from 14 to 12 hours for the same amount of cargo, and matching that of tower cranes.

The reduction of CO_2 emissions in this scenario is calculated by taking the average amount of fuel consumed by forklifts per hour, and then multiplying that by the CO_2 emission coefficients supplied by ISPRA.[8] Under the assumption that forklift operating hours are reduced from 14 to 12 per day, the annual fuel consumption saving is estimated to be 56 m^3. This means that CO_2 emissions associated with the yard movements are reduced by 23.8 percent.

Based on this, it is estimated that due to the 5G technologies introduced in the Port of Livorno, CO_2 emissions for one terminal operation will decrease by 8.2 percent overall as a result of the improved yard movements in the container terminal processes and KPIs. This figure demonstrates an improvement in the environmental sustainability of the port and more specifically how it is contributing to a reduction in greenhouse gas emissions, saving cost, and meeting targets set out in SDG 13 (Climate Action).

[7] Carbon footprint technical report produced by the Port of Livorno in 2019. Source data refers to data observation during 2017
[8] Istituto Superiore per la Protezione e la Ricerca Ambientale: www.isprambiente.gov.it

Economic impact of 5G and digital technologies

Operation	What improved	Benefited stakeholder	COREALIS project	Enhanced automation in port's processes
			Savings per container terminal (EUR)	
Vessels' berthing time	Increased operational speed	Shipping companies	126.5k	2,500k
Cargo release	Increased operational speed	Haulers	164k	236k
Quays and yards operations	Quays and yards operations	Terminal operators	20k	195k
			70k	-

Economic benefit analysis

To assess the wider economic benefits of 5G deployment for port terminals/land operations, the Port of Livorno focused on the three main operational areas:

1. Faster ship turnaround at the quay, leading to lower ship costs for shipping companies
2. Faster freight release through port gates, implying lower costs for haulers serving the terminal
3. Gantry and quay cranes controlled remotely through 5G telecommunication, enabling efficiency for terminal operators

The following development patterns were identified:
- Reduction of operational costs, fuel consumption and machine working hours
- Increase of speed rate of operations, thanks to improved processes

It should be noted that investment costs are not included in this analysis, only operational savings are considered.

For the economic benefit analysis, we considered two scenarios: the "COREALIS project" scenario, which provides the estimated benefits of the COREALIS project's 5G-enabled use cases when applied to one container terminal; and the "Enhanced automation in port's processes" scenario, which refers to the estimated benefits of 5G when applied to one container terminal, together with further automated port equipment (e.g. automated cranes, RTG) and the port's IT applications.

Forklift actions can be optimized with 5G, reducing working time from 14 to 12 hours.

When it comes to vessels' berthing time, the time saving obtained by 5G-enabled use cases could either lead to more vessels calling at the port, or to a reduction of costs, due to less time spent on operations. In this analysis, we assume that the vessel number does not change, but there is a cost saving for berthing and overall time spent in port vessels calling at the selected terminal. With the use of further automated equipment provided by terminal operators, the automated quay cranes may increase time productivity by 20–25 percent,[9] estimated as a reduction of a quarter of berthing time of vessels.

In 2019, vessels spent 5,013 hours at berth in the selected terminal, leading to a potential reduction of 1,000 hours of global berthing time. This equals 25 hours of berthing time for each container vessel, which can be reduced to 20 hours on average.

As we have seen, the general cargo vessel category in the "COREALIS project" scenario (see Economic benefit analysis, page 13) is reduced from 36 to 34 hours, a 5 percent decrease. This decrease, however, has an impact on a lower number of vessels and, therefore, may be less significant as an expected saving. The projected saving time might lead to 41 fewer days in port which, due to average operating costs for ships of that size, is equal to 20 percent of total related costs over the year.[10] This could mean a saving of up to EUR 2.5 million per year.

For cargo release, 5G enables more precise detection and freight handling, thus reducing the time spent making mistakes or unnecessary movements. According to TEN-T funded B2MOS project analyses, enhanced digital technologies can reduce today's average mistake rate from 5 percent down to 1 percent, and this is further accelerated by 5G.

In the "Enhanced automation in port's processes" scenario (see Economic benefit analysis, page 13), the overall time spent checking cargo documentation for release can be optimized from 4 minutes on average, to a few seconds, thanks to 5G and enhanced digital applications for in/out documentation. In the COREALIS scenario, the time is expected to decrease from 3 to 2 minutes.

When assessing time savings related to quicker release of freight, the following assumptions are made:
- Estimated volume of each lorry entering and departing the terminal is 1.25 TEU
- A road modal share of 85 percent of total handling
- A projected 140,000 trucks are entering and leaving the terminal annually, leading to 8,400 hours saved for faster documental release and identification of the place to load/unload the cargo, while the impact in the short term stands at roughly 5,800 hours

Quays and yards operations: in the COREALIS scenario, with 5G applied to one container terminal, forklift use will be reduced by one unit out of fourteen. This will cut amortization costs and increase efficiency by 4 percent, which is estimated to be the same as the "Enhanced automation in port's processes" scenario. In this scenario, 5G can smooth out processes by converting cranes and RTGs (Rubber Tired Gantry Cranes) that are currently operated by dockers on-site to remote control. This will lead to high efficiency and better use of truck drivers' time, resulting in a yearly economic saving of EUR 195,000.

8.2%
There can be an 8.2 percent reduction in associated CO2 emissions per terminal operation.

€2.5M
Optimizing vessel berthing can lead to a 20 percent average cost reduction per year, which is approx. EUR 2.5 million.

>20%
Automated quay cranes increased productivity by 20–25 percent.

[9] See press release: https://port.today/automated-quay-cranes-trial-singapore/
[10] www.transportgeography.org/?page_id=5626 www.ec.europa.eu/transport/sites/transport/files/modes/maritime/studies/doc/2015-june-study-sss-final.pdf

In addition, in the COREALIS scenario the reduction in fuel consumption at the terminal is estimated to 56 m^3 per year and will lead to lower carbon emissions and costs.[11] The equivalent value in the "Enhanced automation in port's processes scenario" has not been quantified as it is highly dependent on several automation programs and associated capital investments.

The initial estimations will be validated based on further field data from the COREALIS project. However, the outcome clearly suggests that the annual benefits from 5G deployment at one site has high potential if scaled to the other container terminals. In addition, based on further capital investments in the port's processes, significant benefits in economic saving are expected.

Each improvement might be enabled by technologies that are already available. However, innovation in the port will only happen if all involved company stakeholders, both public and private, find sustainable conditions and new models to invest in, and jointly transform the port processes overall. 5G represents an innovative platform infrastructure for competitiveness and growth in the port-city area, which could enable the full range of use cases.

Projection of results and policy recommendations

Piloting technologies in a real port not only demonstrates innovative solutions and new models from an operational and efficiency perspective, but the assessment shows the sustainability value generated throughout the whole port system and territory.

Through this analysis, we can see the future positive effects of 5G technology when applied to a port's operational processes on growth, efficiency and sustainability, as well as the opportunity to forecast quantitative environmental and economical improvements today.

The technology assessment made using the proposed methodology is found to be an important decision-making tool for the public bodies in charge of port governance. The projections and evaluated benefits highlight relevant options in terms of investment, development, planning and zoning the different use and functions of port areas. These options are made visible, clarified and quantified through the piloted technology assessment method, which also covers a wide set of sustainability benefits that are not always understood at early stages or when using traditional approaches. As a result, the subset presented here shows that there are opportunities for better decision-making around mitigation and compensation measures, when evaluating the prospected benefits of new technologies like 5G. This can be achieved by using wider sustainability frameworks like the UN's Sustainable Development Goals, together with traditional economic analysis, governance and measurement models.

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[11] Confetra monthly release on average fuel costs in Italy
Source data: Confetra April 2020 monthly report www.confetra.com/prezzo-del-gasolio/

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