10 SmartPort Trends
2030-2050

BASED ON 6 YEARS OF SMARTPORT RESEARCH IN COOPERATION WITH VARIOUS KNOWLEDGE INSTITUTES AND UNIVERSITIES AND MORE THAN 400 COMPANIES.
SmartPort is a partnership between the Port of Rotterdam Authority, Deltalinqs, the Municipality of Rotterdam, TNO, Marin, Delft University of Technology, Erasmus University Rotterdam and Delft University of Technology. By inspiring, initiating and entering into alliances, SmartPort stimulates and finances scientific research for and by the companies in the Port of Rotterdam, in collaboration with knowledge institutions.

It is about developing, sharing and using knowledge based on one collective ambition.

The transition to the best and smartest port can only succeed if all parties involved jointly put forward solutions for changes in the future. We are convinced that the greatest impact in knowledge development is based on specific demands from the market and that the best results are achieved by making the most of the cooperation between trade and industry, governments and science.
10 SMARTPORT TRENDS
2030-2050

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The Port of Rotterdam Authority founded SmartPort in April 2015 together with the Erasmus University Rotterdam, Delft University of Technology, Municipality of Rotterdam and Deltalinqs. TNO, Deltares and Marin later joined as partners to strengthen the expertise within SmartPort. As a knowledge hub for the Port of Rotterdam, SmartPort has one main objective: knowledge development for the port of the future (2030-2050) based on questions from within the Rotterdam business community and to accelerate innovation. Six years after its foundation, we can look back on a successful collaboration, in which added value was created for all parties in the triple helix (government, business and science).

More than 100 studies have been conducted in collaboration with over 400 companies. Joint scenarios of the port have been mapped out, including the stepping stones needed to get there. In addition, SmartPort has developed scenarios for accelerating the energy transition, developed tools to better visualise the infrastructure reinforcement options and demonstrated where opportunities exist for new cluster development in the port. SmartPort has also formed the basis for an integrated vision of challenges in the port, from which companies have particularly benefited. For example, SmartPort took an important first step in the development of an integrated hydrogen vision (CEO Dinner - Hydrogen Hub Rotterdam; 2018). SmartPort also signalled the urgency for an integrated view of port development based on various studies. This has ensured that research is being conducted with a consortium into the spatial challenge of the port and the usefulness and necessity of port infill and/or expansion.

The trends described in this report are – looking at the objective of SmartPort – actually an added bonus! Based on the 100 surveys, it is possible to determine the 10 most important trends for the port. By this means, Rotterdam is taking an extra step towards becoming the Smartest Port: a port where cooperation, knowledge exchange and innovation are central.

I hope that on the basis of these trends, the discussion about the future of the port will be strengthened and that the port business community will encourage more intensive cooperation with each other, the government and academia.

Vivienne de Leeuw
CFO, Port of Rotterdam Authority
SmartPort board chairperson
INTRODUCTION

As the busiest port in Europe and the second-largest petrochemical cluster, the Port of Rotterdam is a world-class player. More than 3,500 companies are active in Rotterdam ‘city and port’. These account for more than 384,500 jobs and 6.2% of the added value in the Netherlands. However, the developments that the port will encounter require a radical change of course. In order to benefit and not suffer from the rapid digitisation and automation, the energy transition and climate change, a different mindset is needed. The 10 trends in this report show the latest knowledge of the future of the Port of Rotterdam based on SmartPort research and aim to accelerate innovation and sharpen the knowledge agenda!

The port is on the move in all its aspects. The increase in scale in logistics and the emergence of (booking) platforms are putting current revenue models and the market under pressure. Furthermore, the CO₂ reduction targets (Paris Climate Agreement) and phasing out the use of petrochemical products have far-reaching consequences for the refineries, petrochemical industry and storage in Rotterdam. In addition, climate change causes extreme periods of high and low water on the Rhine – the aorta of the Port of Rotterdam – which puts pressure on inland shipping traffic.

Rotterdam cannot wait, but must be proactive in order to benefit from the trends that the port will be facing. For example, there are great opportunities for Rotterdam to become a virtual director of worldwide throughput. The production, storage and transhipment of clean fuels, such as hydrogen and green synthetic fuels, also offers opportunities to transform Rotterdam into a green fuel cluster. Rotterdam can also take a leading role in dealing with climate change, for example through digitisation and greening.

The independent knowledge hub SmartPort was established in 2015 to gain insight into the issues facing the port business community in Rotterdam. The facts and figures of the ensuing studies have provided a wealth of demand-driven knowledge about the opportunities for Rotterdam. In this report, the more than 100 studies have been scaled back to reveal the 10 most important trends of today* that will affect the Port of Rotterdam and offer major opportunities for port business until 2050. These trends describe developments that are occurring now and where Rotterdam must make specific choices in order to (continue to) benefit from this. We hope that you will find this inspiring and pleasant to read!

*SmartPort research must meet five conditions: it must be precompetitive, meet scientific standards, be supported by at least two companies active in the Port of Rotterdam, fit in with the predefined Roadmaps and have a focus on 2030-2050. The trends based on this are a snapshot and may, of course, change over time in strength and form. Flexibility is paramount for the SmartPort knowledge agenda, and we are always open to adding new promising trends.
Companies all over the world are confronted with digitisation, automation, the energy transition and climate change. These are developments that can threaten current business models but also offer great opportunities. SmartPort's research focuses specifically on the port business community that is active in and around the Port of Rotterdam. With one goal: to identify new business opportunities and thereby accelerate innovation. Based on more than hundred studies in the past 6 years, we have identified the 10 most important trends. Each of these are developments that offer opportunities specifically for the Rotterdam port business community.
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TREND 1

Growth in online platform technologies within the logistics

The online platform model as an incentive for data-driven logistics where value propositions from (traditional) logistics players are variable.

Platform technologies turn existing markets upside down by using new business and revenue models. Take, for example, the largest hotel booking platform (Booking.com) or taxi company (Uber). What these platforms have in common is that they enter a market but have no assets. The largest taxi company in the world does not have its own taxis, the hotel booking platform does not have its own hotels.

In the logistics world, booking platforms are also gaining ground, for example Cogoport and Flexport. What does the emergence of these platforms mean for the logistics world? Platforms are on the rise, but the disruptive effect of platform models on the logistics sector is still unclear.

To understand the disruptive effect of platforms, SmartPort, together with TNO, Erasmus University Rotterdam and Fenex, initiated a survey of the impact of booking platforms on the freight forwarding market. Digitally transformed traditional freight forwarders and the digital freight forwarders bring a wide variety in transport capacity, end-to-end visibility and coordination of logistics schedules. This survey can serve as a basis for initiating a discussion of the roles and positions of companies in future chains and what you as a company need for this. It also raises the question about sharing data with platforms. Which data do you dare to share and which not?

The advance of online platforms in the logistics sector is unstoppable. Parties’ activities may broaden within the chain. Will a logistics company still have logistics assets in the future? In that case, who is in charge of the assets? Will the large maritime companies still have vessels in the future? These digital platforms have an impact on current logistics chains and companies. Companies or certain activities change drastically or even disappear.
TREND 2

Growth of transport via alternative routes

New competition in freight transport is growing rapidly, and alternative routes to the hinterland of Rotterdam are emerging. What does this mean for Rotterdam’s position as a gateway to Europe?

The Port of Rotterdam had a record year in container throughput in 2018 and 2019 due to the capacity at the deep-sea terminals, excellent hinterland connections and investments in (digital) infrastructure. The port has a leading position and wants to further strengthen this by being a better, faster and smarter port. But what impact do developments in other European ports have on the activities and strength of the Port of Rotterdam? Several alternative routes to inland Europe are starting to become economically attractive. For example, China is investing heavily in the Belt and Road initiative (BRI), where investments are not only made in the southern European ports, but also in a rail connection to European inland ports. The inland ports can serve as gateways to Europe via these railways. In addition, the polar route also seems to have great potential. It was recently announced that this route is becoming increasingly more navigable. What does this development mean for Rotterdam as a gateway to Europe?

Recently, Duisburg, the largest European inland terminal, has developed as an important container mainport. About 30 percent of trade between Europe and China is transported by freight train via Duisburg. To explore the developments of this Belt and Road connection, SmartPort initiated a study in collaboration with Erasmus University Rotterdam. The study shows which developments in Duisburg influence the unique points of sale of Rotterdam as a Mainport. While Duisburg is strongly committed as a logistics hub by facilitating infrastructure and goods, Rotterdam is equally committed as an innovative and logistics knowledge centre. In this respect, it is important that Rotterdam closely monitors the developments of Duisburg at its unique points of sale. Because not only developments in Duisburg affect the Port of Rotterdam, but also developments in southern European ports or alternative route developments (polar route, Trans-Siberian railway). The European port playing field is subject to change, and this raises questions such as: What agreements are there with other major European seaports, such as Port of Antwerp-Bruges, Port of Hamburg and North Sea Port? Which aspects can Rotterdam apply to distinguish itself?

The BRI research provides insight into the developments, challenges and, perhaps more importantly, the opportunities of the Port of Rotterdam. What will change for the Port of Rotterdam and the companies? What opportunities can new collaborations between European ports offer? How can current assets be used for a possibly new business model? Because the train is running; the question is what knowledge and strategic provisions the Port of Rotterdam should take on board.
TREND 3

Increasing spatial challenge

To enable the energy transition in the Port of Rotterdam, companies need more physical, social and environmental space. This space is becoming increasingly scarce.

When Maasvlakte 2 was officially put into use in 2013, one thing was clear to everyone: for the time being, no port expansion was needed anytime soon. With the increase in the port area by 20% (1000 hectares net), the Port of Rotterdam was once again well within its limits. And it still is. But for how long? The energy transition is accelerating the need for strategic physical space. To meet the government's CO₂ reduction targets, companies are working hard on plans to make processes more sustainable and there are opportunities for the development of a new sustainable industrial cluster. This requires extra space for both (energy) infrastructure and industry.

Space is needed for the construction of infrastructure. New raw materials flow through the port and existing ones increase (hydrogen and CO₂). The current transport of electricity, for example, is also increasing, with an industry focusing on CO₂ reduction and therefore having to electrify processes. This creates an enormous increase in both electricity demand and consumption. Some experts assume an increase of a factor of 10, others even of 20. This requires a great deal of extra 'copper wire' in the port of Rotterdam. In November 2020, SmartPort, companies, relevant grid operators, governments and knowledge institutes TU Delft and TNO joined forces (Gridmaster HIC research project). The aim is to develop a dynamic scenario planner that can help in the discussion with the relevant Rotterdam parties to jointly achieve a well-functioning network (Gridmaster).

In addition to space for energy infrastructure, space is also needed to develop a sustainable industrial cluster. The question is, how much? The E-Fuels study (2020), conducted by TNO, calculated this for a fuel cluster that focuses entirely on e-methanol (produced with green electricity, hydrogen and CO₂). Conclusion: up to approximately 600 hectares of extra space is needed by 2050. To give an idea of how much space that is, 600 hectares is an area almost as large as the Botlek or 2/3 of Maasvlakte 2. Before it is clear which volumes and compositions will predominate in the Rotterdam Port Industrial Complex (HIC) in the longer term, much depends on variables and the choices that are made. In addition, the available social and environmental space (for example, the nitrogen and PFAS issues) and, in the long term, the (climate) adaptation space also play an important role in the choices that can be made.

Developing space for companies is one of the main tasks of a port. The energy transition now presents an extra challenge. It requires relevant building up of new activities while at the same time other activities have to be modified and phased out. This makes for a tricky puzzle under the influence of time. It is precisely this puzzle that SmartPort will investigate together with the Port of Rotterdam Authority, DeltaLinx and refineries. The aim is to explore with the port's business sector, and based on possible scenarios, what the hectare development will look like in the period up to 2050. This joint fact-finding creates a joint picture of the impact of companies' wishes and choices on the use of space in the port. This research is the first step in gaining insight into the spatial issue of the Port of Rotterdam and should help to answer questions such as 'is a Maasvlakte 3 needed'?
TREND 4

Self-organising goods

*With the developments surrounding digitisation and automation, the route is no longer determined by the modality but by the cargo that will organise itself through the chain.*

In recent years, there has been a shift in management within logistics chains. Where the focus used to be on the chain level, such as synchromodal transport\(^{15,16}\) (offering an integrated transport solution by utilising the various modalities), and the modality\(^{17}\), it is now shifting to management at container level. In 2019, the Port of Rotterdam Authority presented ‘Container 42’\(^{18}\). This smart container is equipped with sensors and other equipment to fill in customs forms, measure cargo experience and communicate with other port operations (e.g. a crane). On the one hand, the data from the containers enable more efficient management and additional services, and on the other, logistics chains as a whole are optimised through the efficient use of smart containers\(^{19}\).

With the further scaling up of the modalities and the containers, a first step is being taken towards control at cargo level. Projects such as IoT4Agri\(^{20}\) show how added value is offered to companies and authorities. Sensors on containers offer the possibility to intervene in the logistics process or chain based on real-time data (quality of products over time\(^{21}\), process completion, another route). Digitisation and automation offer opportunities in which cargos are organised throughout the network and arrive at the right place via the most optimal route\(^{22}\). It is not the planner or the carrier but the cargo itself that determines where the cargo should go. How the cargo arrives at the right place and at the right time is discussed in the Physical Internet project. This project provides an example of how cargos can be transported more efficiently and how infrastructural networks can be better used. To control cargo, parties in the chain have to be able to respond to changes in the chain. How the parties involved can respond more efficiently to changes in the chain is being investigated in the Swarm Port\(^{23}\), for example. By planning at goods level, a lot of information is available at local level, which creates local intelligence. Control at cargo level offers added value, as companies that ship goods internationally are looking for reliability, speed and certainty.

In the move towards a logistics system where goods organise themselves through the chain, four follow-up steps can be formulated. (1) Demonstrating the added value of control at cargo level, company level and system level. (2) Determining the transition route how different companies devise a schedule at goods level. (3) Setting up management strategies for goods at chain level and (4) gaining insight into the availability, reliability and security of data sharing. Controlling cargo is not only dependent on the availability of data. It can also be subject to the market and what the customer demand is. Take, for example, e-commerce. These developments are crucial when it comes to cargo management, but is that not the driving force behind the logistics trend above?
TREND 5

Self-organising (sea-going vessel) hub(s)

Seamlessly connecting water, road and rail by making local information available and thereby making logistics processes more efficient and sustainable (Seamless Port).

The strong development of digitisation and automation of the Port of Rotterdam offers opportunities to make logistics chains more sustainable, reliable and competitive. For example, the APM Terminals and Rotterdam World Gateway (RWG) located in Rotterdam are already the most automated container terminals in the world. Another example is the Container Exchange Route on Maasvlakte 2, where logistics facilities are connected via a special infrastructure by means of autonomous vehicles. Local information enables logistics processes within the fences to run autonomously. This can even be enhanced by applying smart algorithms in the logistics chain. Artificial intelligence (hereinafter AI) can, for example, help to coordinate the coordination of the activities of a terminal with inland vessels, taking waterway water levels into account. From a systems perspective, AI offers opportunities for further developing a self-organising logistics system. Local information is used to make predictions that make the network more robust.

Two projects that focus on self-organisation are SOLport and Reimagining Logistics with Autonomous Trucking. The SOLport project investigated what a self-organising system means for logistics parties and what the possible advantages and disadvantages are. The ‘Reimagining Logistics with Autonomous Trucking’ project examines the social impact as well as the technical impact of smart algorithms. In short, what is the impact of AI on business models and humans. So instead of traditional planning of truck journeys, there is a new approach with dynamic planning based on real-time information and algorithms, where trucks schedule themselves. What will be the planner’s responsibility? And who is liable if things go wrong; the algorithm or the human?

A self-organising (maritime) hub offers companies opportunities to increase the reliability and robustness of the logistics process, create a seamless port (predict ETA) and choose sustainable transport options.

In logistics, many organisations work together to ensure that goods are delivered under the right conditions, at the right time and at the right location. A number of follow-up steps are required to arrive at a self-organising system in which logistics processes are autonomously controlled. (1) Collaboration between the companies, (2) further refining essential and reliable data and (3) setting up pilots with various chain parties to investigate the impact of technologies on business models, organisational and social level.
Intelligent inland corridor

(Digital Twin)

The Rotterdam inland shipping corridor is becoming smarter by using smart algorithms to connect knowledge about water movement, infrastructure and shipping logistics.

The smarter inland shipping corridor is becoming increasingly important due to increasing competition from ports like Hamburg and Antwerp, and the expansion of land transport and transport via the southern European ports (i.e. the Belt and Road Initiative). Since 2015, SmartPort has been developing studies on optimising hinterland connections, with the aim of finding answers to the question: What does it take to become a seamless port? For example, research projects such as Synchrogaming challenged planners of chain partners to make smarter choices between road, water and rail. The aim was to reduce delays and lower emissions. Efforts were also made to improve data collection of the depth of rivers. For example, together with CoVadem, we worked on optimising inland vessel data streams, so that in theory the depth of the waterways can be measured 24/7, without additional use of measuring vessels. Finding optimal routes for inland vessels requires both logistics and environmental data (e.g. future water level, water depth, etc).

The research project Climate Change and Inland Navigation (2017-2021) shows how historical data from both the environment (depth, currents, bridges, locks, etc) and logistics (location of vessels, sailing times, etc) give enormous added value to companies and governments. By predicting what climate change will do to water levels (during both drought and heavy precipitation), strategic advice can be given about interventions in the river, fleet composition and loading factor. This project gave rise to a digital twin of the waterways – a digital replica of reality – that can be used for strategic issues. The first application for this was planning the ‘best’ route for Danser and NPRC inland vessels.

The next step is to arrive at a strategic and operational application with which companies can work in practice based on real-time data, model simulations and self-learning algorithms. SmartPort will work on 3 goals within the Flagship project ‘Artificial Intelligence and data sharing’: (1) improving the digital twin by focusing on data purity, (2) establishing showcases & simulations with companies in the chain and (3) strengthening cooperation between government and business to increase support for a smart corridor.
Rise and growth of sustainable fuels

The importance of reduction of emissions from heavy transport with trucks and inland shipping and from industrial processes with high temperatures is becoming more and more a requirement, and the importance of the development of new sustainable fuels is increasing.

In the period 2008-2019, steps have already been taken to make inland shipping (-12% CO₂ emissions) and road transport (-10% CO₂ emissions) more efficient and sustainable. However, the climate targets (55% reduction in 2030, 98% in 2050) will not be achieved by improving efficiency alone. Green Deals have therefore been concluded since 2011 to accelerate the steps towards 2030 and 2050. The first step to reduce emissions in the transport sector is in many cases driving/sailing electrically (in combination with hydrogen). For example, a hydrogen tractor has been in operation in the Port of Rotterdam since 2020 and steps are being taken to make hydrogen inland vessels possible. In addition, DAF and other OEMs (truck builders) have agreed not to build trucks that run on fossil energy from 2040. Although the costs of hydrogen and fuel cell technology are still too high (approx 300% too high compared to current techniques) and lacks a good tank infrastructure, it offers a lot of potential for the future. However, these options do not provide the required power for all transport. For example, long-distance transport by road (from 1000 km) or sea-going and inland vessels that have to sail upstream for a long time. One of the bottlenecks in this case is the tank space that hydrogen occupies on the vehicle (based on an energy density that is 3 to 7 times lower than that of diesel). A possible solution can be found in the so-called e-fuels: fuels that are both sustainable and can supply enough power in the future. E-fuels are synthetic fuels that are produced on the basis of green hydrogen, electricity and CO₂. These ‘green’ fuels have major advantages: they take up less space than hydrogen, are easier to store and transport and, in some cases, they can be used directly in existing combustion engines. However, they are not yet available at a competitive rate, which is why both pilots and more research are needed. The Electrification field lab at PlantOne, which was opened on 10 February 2021, aims to test the production of e-fuels within a consortium of companies. This offers the Port of Rotterdam opportunities to develop into a sustainable fuel hub from 2030.

SmartPort sees three challenges coming together around the development of new sustainable fuels for the port industry: (1) Sharpening the timeline for the development of new fuels, (2) infrastructural development and (3) technical development. When investing in sustainability, it is important for a carrier that there is a balance between costs and the emission reduction to be achieved and that the CO₂ reduction can be demonstrated. For fuel manufacturers and ship and truck builders, factors such as production costs also play a role. The STRIVE project shows the added value e-fuels can offer for heavy road transport and what common steps are needed to develop affordable e-fuels. The use of e-fuels also requires conversion and build-up of storage, transport and refuelling infrastructure. The Gridmaster study shows which reinforcement of transport and storage infrastructure is necessary for the Rotterdam port region up until 2080. Subsequent steps are to broaden the geographic focus of the study and to broaden the focus on, for example, tank infrastructure. Finally, in order to accelerate the adoption of e-fuels, there are still major steps to be taken in the technical field, especially the most cost-efficient way of production. The research projects MOOI:eCOform, Interreg and E2CB are being used in this challenge.
Large-scale industrial electrification and hydrogen integration

For a successful energy transition, it is necessary to electrify industrial production processes and to replace fossil (industrial) fuels with more sustainable alternatives. Large-scale electrification of industry and the use of hydrogen offer great opportunities.

In the Netherlands and in the North Sea, a lot of work is currently being done on the upscaling of green wind energy for large-scale electrification of, among others, the HIC in Rotterdam. Work is also being done on techniques for producing hydrogen and combining it with other molecules such as CO₂, CO and nitrogen using electrons. These revolutionary new conversion techniques provide excellent opportunities for an industrial area such as the Port of Rotterdam. In addition, the industrial complex has the potential to serve as an energy buffer in periods of high wind energy landings. The right research in these areas supports the transition to a climate-neutral and optimally competitive industrial port complex in the future.

These future significant changes in industrial production processes will change the position of the Port of Rotterdam. The port is currently the second-largest fossil fuel cluster in Europe for production and bunkering. The conventional fossil value chain can be made more sustainable by adapting industrial systems, for example by installing e-boilers, industrial heat pumps or CO₂ capture (Porthos). However, converting these systems does not offer a solution for reducing fossil dependence during the production of basic industrial chemical building blocks and achieving the required high industrial process temperatures. Both are needed for end products that society will make full use of in the near future, such as the majority of fuels, glass, building materials and even (blue) hydrogen (H-vision).

Electrochemical (conversion) processes using green electrons create opportunities here. These processes are popular for climate-neutral production of basic chemical industrial building blocks and the necessary energy storage. Unfortunately, these techniques are still a long way from the market. For this reason, various studies are underway that are looking at further development based on green hydrogen and industrial waste streams. In addition, pilots are under development that offer a platform for small-scale demonstrations of the young techniques. With the large-scale implementation of these techniques, direct integration with offshore wind energy (generation-at-sea hubs) offers a possible solution for the current lack of space in the port. In addition to these conversion processes, (green) hydrogen offers a suitable sustainable alternative for reducing fossil dependence while reaching the required high temperature during industrial processes.
As stated, the current processes in the second-largest fossil fuel cluster in Europe will change significantly. How will this affect the set-up of this chain and which part of this changing value chain will remain or land in the Port of Rotterdam? With this question in mind, SmartPort initiated the CHAIN (2020-2021) study in collaboration with TNO, the Port Authority and Sohar Freezone Port. In addition to the adjustments in the supply side (electrochemical processes), the demand and infrastructure aspects also offer opportunities for large-scale electrification. With flexible industrial energy demand and efficient exchange of energy between companies, peak demand on the electricity network can be levelled off.\textsuperscript{49} Despite this, the net load on the network is increasing considerably and future reinforcements are necessary. Dynamic simulation models offer valuable tools to make the right network investment decisions.\textsuperscript{50} In addition to large-scale electrification and hydrogen integration, the trend towards circularity in the industrial complex will also be further refined towards 2050.
TREND 9

Emergence of life cycle management

The construction of sustainable energy generation and distribution assets is an important condition for achieving the climate objectives in 2050, but the exploitation and decommissioning of the assets used for this is not sustainable. The decommissioning of offshore wind farms is a concrete example of this.

Offshore wind energy has recently been transformed from a young ambitious renewable energy source into one of the cornerstones of the energy transition. The Netherlands is expected to install up to 60 GW of capacity to meet the 2050 climate targets. Paradoxically enough, little account is taken of sustainability during the construction and decommissioning of these offshore wind farms.

Currently, only 2 GW of offshore wind energy is available, and the number of wind turbines is increasing significantly. In addition to the number of turbines, there is also an increase in the size of magnetic turbines, composite wind blades and steel support structures. A typical 750 MW wind farm requires more than 10,000 tons of composite and 100,000 tons of steel. With the current approach, the construction of a wind farm produces emissions of more than 2,400 tons of CO₂ equivalents and 5,100 tons of oil equivalents per year. Life cycle management can lead to a truly sustainable and socially responsible top sector. With a concrete strategy based on cross-company input from the sector, it should be looked into how this can be achieved. Cooperation in the chain offers relief here.

Offshore wind turbines have an operational life of 20-25 years. At the end of its lifespan, a wind farm must be decommissioned in a responsible manner. At present, however, little practical experience has been gained in this area. When this disposal task is planned and executed on an ad-hoc basis, this leads to an increase in negative ecological impact due to inefficient logistics processes and irresponsible processing of the residual material flows. The Decommissioning Offshore Wind Farms project clearly demonstrates the potential of these residual material flows. There are opportunities for the Port of Rotterdam and chain partners to sustainably harvest this potential. For example, optimisation of the decommissioning task can yield both ecological and economic benefits.
TREND 10

Predictable and sustainable asset management

Management & maintenance of the infrastructure of the Port of Rotterdam is becoming smarter and more predictable due to a better understanding of the condition of the existing infrastructure, new monitoring and maintenance techniques and digitisation. This offers opportunities for optimal use of assets in a changing environment, reduction of emissions and cost savings.

SmartPort sees an increasing focus on smart and predictable management and maintenance of port infrastructure. In the field of quays, various studies have been carried out to better understand the strength and degradation of quay walls. We can use this knowledge to make better use of existing quays and for longer and design new quays more sharply. SmartPort is conducting comparable research for the strength of soil protection. This leads to cost savings for management & maintenance for quay managers and an increase in the added value and (multifunctional) use of the quays for quay users. By combining data and models in so-called digital twins, we can make quays smarter. This is not only relevant to make the current management & maintenance of quays more predictable, but also to be able to anticipate different use of the quays and other environmental conditions in the future;

In the management & maintenance of the waterways, the emphasis is on dredging maintenance to maintain the depth of the navigation channels and port basins. With smart and sustainable sediment management, the port will remain safe and navigable in the future at acceptable maintenance costs and reduced greenhouse gas emissions. SmartPort facilitates research into sailing through silt in order to determine the effects of the silt on the manoeuvrability of vessels. Understanding the properties of the silt in the port is crucial for this, because the silt properties partly determine the nautical depth and the navigability of the silt. When vessels can navigate safely through silt, this can significantly reduce the dredging maintenance of the port of Rotterdam. In addition, research is being conducted into new measuring techniques to measure the silt properties in real time in the future. Research has also been carried out to measure the depth of the waterway in real time using inland vessels (CoVadem). With all this information, the depth of the waterway and the status of the silt can be monitored and maintenance can be scheduled at the right and most efficient time.

SmartPort sees the following challenges for smart and predictable maintenance of the port infrastructure. (1) Determining the value cases to determine which studies offer the most added value for the managers and users of the infrastructure. (2) Better sharing, management and use of the infrastructure data and models to determine its condition in real-time (e.g. in digital twins). (3) Making management and maintenance more sustainable: climate neutral, circular and taking ecology into account. (4) Phased adaptation of the infrastructure to the effects of climate change and changing use of the quay. (5) Connecting the chain in order to be able to actually put the developed knowledge and innovations into practice (including any amendments to guidelines and legislation and regulations).
What will be Rotterdam’s source of income in 2050?

What will Rotterdam’s source of income be in a self-organising and autonomous logistics and a world with a sharp decline in the use of oil? SmartPort has identified 10 trends. Each one an opportunity that the Port of Rotterdam can seize to distinguish itself from competitors in 2050. This is decisive, because the competition is not standing still. But what can we do now with these trends in mind?

For SmartPort, the trends are a guideline for sharpening the studies towards 2030-2050. Which routes are disregarded and which are seen as promising by the port business community? Subsequently, in the coming years work will be done on further boosting innovation through research, accelerating technology development, exploring value cases and mapping out which government policy and skills are needed to allow an innovation to land in Rotterdam. This provides decision information for companies, for their strategy and their operations.

The success of SmartPort is the success of the Rotterdam port business community. Three elements are seen as most important to support companies in innovation. Firstly, SmartPort will focus on demonstrating the value of data sharing. Secondly, SmartPort focuses as much as possible on system research. This is research done by a business chain, because radical or disruptive innovations only get off the ground when all traffic lights in a chain are green. Radical or disruptive innovations are completely new services or products that are also new to the market. In view of the trends, the port must prepare for this in particular. Doing research and developing knowledge together (joint fact finding) lays the foundation for these innovations. Thirdly, SmartPort supports living labs, places where consortia of companies are experimenting with new techniques in order to lay the foundation for scaling up.

Entrepreneurship is investing now with the confidence that it will pay off later. Rotterdam faces one of the greatest challenges in decades. Business models have to radically ‘reverse’ to take advantage of the trends that are heading towards the port. This requires major investments, not only from companies, but also from the government. The government in particular needs a coherent vision in one area such as the Rotterdam region in order to invest in infrastructure, port expansions and stimulating business innovation. Positioning is more important than ever before. SmartPort is convinced that scientific research with the port’s business sector can lay the foundation for this positioning and lay the foundation for the Rotterdam of 2050.
Acknowledgement

This report was written by the SmartPort project development team: Dirk Koppenol, Anique Kuipers, Mel Valies and Wiebe de Boer. The trends are based on the knowledge of the more than one hundred SmartPort-supported studies into the port of the future. We would therefore like to thank all researchers who have contributed to this and in particular the partner knowledge institutions: Erasmus University Rotterdam, Delft University of Technology, TNO, Marin and Deltares. These studies would not have been possible without the expertise of the more than two hundred and fifty companies directly involved and hundreds of companies indirectly involved. Thank you! We are also grateful for the support from authorities such as the Province of South Holland, the Municipality of Rotterdam and TKI Dinalog. Finally, a direct thank you to the collaboration partners: Port of Rotterdam Authority, Municipality of Rotterdam, Deltalings, TNO, Marin, Deltares, Erasmus University Rotterdam and Delft University of Technology. We hope that this report contributes to accelerating the innovations of the future for the Port of Rotterdam.
Endnotes


2 SmartPort study: Impact of (Booking) platforms on the forwarding market (2020). The aim of this research is to conduct an initial exploration of platform models in the logistics sector. The operation, the ecosystem and the application of the booking platforms in the logistics sector were examined. By means of interviews and expert sessions, the impact of platforms on the forwarding market was investigated. This research was carried out in collaboration with TNO, Erasmus University Rotterdam and FENEX.


6 SmartPort study: Belt and Road Initiative (2020). This study explores Duisburg's strategy around the Belt and Road initiative. An inventory is made of not only the possible threats that may arise for the Port of Rotterdam, but also which opportunities. This study is being conducted in collaboration with Erasmus University Rotterdam, DHL global Forwarding, Municipality of Rotterdam, ECT, Port of Rotterdam Authority.


9 SmartPort study: PoR Raw Material Study (2021). Conducted by the Wuppertal institute in cooperation with the Port of Rotterdam Authority and SmartPort.

10 SmartPort study: Gridmaster (2021) focuses on developing a new method for adequate, thorough and above all future-proof investment decisions in the field of energy infrastructure in the Port of Rotterdam. This project is being carried out and supported by a consortium of TenneT, Gasunie, Stedin, Province of South Holland, Port of Rotterdam Authority, Municipality of Rotterdam, SmartPort, Siemens Netherlands, TU Delft, Quintel Intelligence and TNO.


12 SmartPort study: CIEP and TNO, Exploring the spatial challenge of energy transition in Rotterdam (2021). The aim of this study is to determine, on the basis of 3 scenarios, how great the spatial challenge is for the port and which strategic reservations need to be made. This project is being carried out and supported by the Port of Rotterdam Authority, Deltalinqs and approximately 20 port operators (mainly refineries and tank storage companies).

13 Synchronomodality as subject in the lean & green deals, [https://topsectorlogistiek.nl/synchronomodaal-transport/](25-03-2021).

14 SmartPort study: Synchrogaming (2015-2018). Improving cooperation in the chain to increase the flexibility of the chain. Research was carried out by ProRail, the Port of Rotterdam Authority, Port of Amsterdam, the Directorate-General for Public Works and Water Management, The Barn and TKI Dinalog.

15 SmartPort studies: Several studies have been conducted where the emphasis has been on modality. Truck platooning (2015-2018). Conducted quick scan and developed value case increased the sense of urgency
among stakeholders and demonstrated the impact of the technology. Project was carried out in collaboration with the Port of Rotterdam Authority, Directorate-general for public works and water management, TNO, BVB Logistics, H.N. Post & Zonen, De JongGrass Transport, Kamps Transport, Overbeek Int. Transport, PostKogeko, De Rijke Trucking, Starmans Transporten, Van der Wal Transport, DHL Global Forwarding, Kloosterboer, Maersk Line and Yusen Logistics. INDEEP project (2018-2019). Mapping out the innovation eco-system (stakeholders, resistance, interests) and offering stakeholders insights into how problematic an innovation process can be. This project was carried out together with Deltalinqs, EUR, the Port of Rotterdam Authority, TNO, TU Delft, NWO. Barge-Port Stay predictor (2017). Improving the predictability (reliability) of inland shipping handling in the Port of Rotterdam. The research has shown that public data is a good basis for arriving at a reliable forecast. This research was carried out in collaboration with the Port of Rotterdam Authority, Erasmus University Rotterdam and TNO.

19 SmartPort study: EURECA (2016-2020). The study provides insight into the competitive position of the Port of Rotterdam in the (reefer) container market. This study was carried out in collaboration with ECT, ABB, the Port of Rotterdam Authority, DL, Seamark.
20 SmartPort study: IoT4Agri project (2020-2021). Sensors measure the quality of goods during transport and where stakeholders can intervene in the logistics chain (process handling, routing). This research is being carried out in collaboration with TNO, Wageningen University, Van Oers United, Theromking Transport Cooling, Sensor Transport, the Internet House and Euro Pool Systems.
21 The IoT4Agri project examines perishable products, such as melons and avocados. This could possibly also be extended to high-value products, such as IT products.
22 SmartPort study: Physical internet project (2015-2020). Research into the feasibility of the physical internet model where container loads are distributed throughout the chain over the various modalities based on available capacity and customer needs (speed, price, sustainability). This research offers opportunities to gain insight into the implementation of the physical internet concept, through which loads are transported more efficiently and infrastructural networks are utilised better. This project is being carried out by Groningen Seaports, the Port of Rotterdam Authority and the University of Groningen.
23 SmartPort study: SwarmPort (2018-2021). The SwarmPort project investigates which data can be used to make good models for future-proof nautical traffic management. This research is being conducted in collaboration with the Port of Rotterdam Authority, KRVE, Loodswezen, intertransis, tug companies, Swarmlab TNO, TKI Dinalog, and TU Delft.
25 SmartPort study: SOLport (2019-2020). The aim of this project is to investigate under which circumstances and for which type of chains which form of management (self-organising system, central/decentralised form of management) is most suitable. In addition, it is examined what a self-organising system means for the parties involved in the logistics chain and what exactly the advantages and disadvantages are. This project is being carried out in collaboration with TNO, University of Twente, Port of Rotterdam Authority, NPRC Pharo, Intel, Distribute, and Ab Ovo.
26 SmartPort study: Reimagining Logistics with Autonomous Trucking (2020-2021). This project investigates the added value of applying smart algorithms to an inland terminal. The impact on business models and the transport planner is examined. This research offers a first stepping stone towards scaling up smart algorithms in logistics chains. This research is being conducted in collaboration with TNO, DHL Global Forwarding and Van Berkel Groep.
27 SmartPort study: Synchrogameing (2015-2018). Improving cooperation in the chain to increase the flexibility of the chain. Research conducted in collaboration with ProRail, Port of Rotterdam Authority, Port of Amsterdam, Directorate-general for public works and water management, The Barn, TNO, TU Delft and TKI Dinalog.
28 SmartPort study: CoVadem-+ (2 studies) (2017 & 2018-2020). Research into the opportunities for combining depth measurements of, among other things, inland shipping vessels for 24/7 depth determination of waterways and harbour basins. In this study, together with the Port of Rotterdam Authority, it was established that the data is very useful for the rivers, but that tides, temperature and salinity closer to the mouth create major calibration challenges. Improving the calibration will require more research. Study conducted in cooperation with CoVadem, Port of Rotterdam Authority and Deltares.
29 SmartPort study: Climate change and inland shipping (2017-2021). The aim of the study is to increase the predictability of periods of extreme high and low water and the measures to be taken (infrastructure, fleet composition and logistics concept). Based on this study, in which Danser, Directorate-general for public works and water management, CBRB, EICB, NVB, Deltas and the Port Authority participate, various follow-up studies have been started to arrive at a digital twin of the rivers to make better predictions. The study was
conducted by the TU Delft.

30 SmartPort study: Digital twin (2020). This study builds on Climate Change and inland shipping and the Covadener studies to arrive at a digital twin of Rotterdam’s waterways to the hinterland. The aim is to determine the best route for inland vessels based on real-time data. This has been conducted with Danser and the NPRC, and a follow-up study is in under way. The study was conducted by Deltares and the TU Delft. SmartPort study: SmartPort Data Dashboard (2020-2021). Set-up of a simple web framework in which important basic data on cargo transport across rivers is automatically updated. This framework should provide input to the digital twin and the Flagship project to be set up on Artificial Intelligence. The study was conducted by Deltares and the TU Delft.

31 SmartPort study: Flagship Artificial Intelligence and data sharing (is being developed).

32 CBS: transport emitted more CO2 compared with national trend.

33 Trouw, EU increases climate objective: 55 percent less CO2 in 2030

34 More than 200 green deals have been signed by various sectors since 2011

35 An average hydrogen-powered heavy truck has a range of 400 km compared to more than 2,200 km for a diesel truck. In addition, the storage and transport of hydrogen is complex. There is therefore a need for a different fuel. https://www.tml.nl/trucks/waalhaven-groep-rietert-terberg-waterstof-terminaltrekker-in-rotterdamse-haven/130126-06-11-2020 en https://www.loopsectorenergie.nl/spotligth/eerste-bioenervartship-op-waterstof-komt-eraan (06-11-2020).

36 Purely clean DAF trucks are on the horizon; by 2040, the truck industry no longer wants to build trucks powered by fossil fuels. (Eindhoven | ed.nl) (05-02-2021).


38 Good overview: NRC, This is how synthetic fuel is made, https://www.nrc.nl/brandedcontent/shell/zo-wordt-synthetische-brandstof-gemaakt (25-03-2021).

39 SmartPort study: E-fuels: towards a more sustainable future for truck transport, shipping and aviation (July 2020). The study was conducted by TNO and Voltachem.

40 Fieldlab Industrial Electrification collaboration commences: Fieldlab Industriële Elektrificatie (fieldlabindustrielelektrificatie.nl) (05-02-2020).

41 Apart from this, safety, price development, financing, and legislation and regulations need attention. Specific to legislation and regulations: all parties in the chain are currently charged separately for their CO2 emissions. However, the potential to reduce CO2 is much higher when looking at the system. E-fuels are relatively easy to transport, store and refuel, but are not carbon neutral at the exhaust (tank to wheel). However, it is circular, because exactly this amount of CO2 is needed to produce the fuel again (well to wheel). This makes it a fuel that is emission neutral at system level.

42 Example: The sustainable biofuel platform is conducting a feasibility study for setting up Clean Fuel Contracts. This concerns a system in which fuel suppliers and fuel users make agreements about the renewable fuels to be used in their vehicles, giving the end user more insight into the climate savings achieved. https://platformduurzamebrandstofen.nl/infoheek-item/kick-off-clean-fuel-contracts (20-11-2020).

43 SmartPort study: STRIVE (2021). In this follow-up to the E-fuels study, the added value of e-fuels for long-distance transport (heavy trucks) by road is examined together with fuel producers, hauliers, shippers and truck manufacturers. The study is being conducted by the TU Delft. SmartPort study: Power-2-Gas-2-Refineries (2017). The benefits and costs of investing in electrolyser were examined together with BP, Uniper, the Port of Rotterdam Authority and Joule. Conclusion: (1) it is technically possible to use electrolyser, but scaling up is the biggest challenge and (2) European regulations explicitly prescribe the incorporation of biofuel. If these regulations were converted into a target scheme, with the aim of limiting CO2 emissions, the use of green hydrogen could be used in business cases in an equivalent way. The study was conducted by TNO.

SmartPort study: Greenpower (2021-2025). The aim of the study is to develop a quantitative method to compare the performance of alternative (green) energy for inland vessels with other modalities and with
FlexI (2017)

The research was conducted by TU Delft.

SmartPort study: Gridmaster (2021) focuses on developing a new method for adequate, thorough and above all future-proof investment decisions in the field of energy infrastructure in the Port of Rotterdam. This project is being carried out and supported by a consortium of TenneT, Gasunie, Stedin, Province of South Holland, Port of Rotterdam Authority, Municipality of Rotterdam, SmartPort, Siemens Netherlands, TU Delft, Quintel Intelligence and TNO.

SmartPort research: eCOform (pending approval) focuses on TRL increase in electrochemical conversion of CO2 waste streams to CO and Formic acid and further downstream conversion to formaldehyde and glycolic acid. This project is being carried out by Voltachem, Hygear, COVAL Energy, Avantium, TNO, TU Delft, University of Amsterdam, DMT, Braskem, New Energy Coalition, Twence, SmartPort, Brightlands Chemcom and an Industrial Interest Group. The study was conducted by TNO.

SmartPort study: Electrons-2-Chemical Bonds (2020-2025) focuses on the efficiency and scalability of electrochemical processes for the production of fuels and chemical building blocks. This project is being carried out and supported by TU Delft, Leiden University, Twente University, Wageningen University, Groningen University, Utrecht University, Eindhoven University of Technology, Shell, Proton Ventures, TNO, Tata Steel, Nuon, SmartPort, Avebe Chemelot and Yara. The study is being conducted by the TU Delft.

SmartPort study: Gridmaster (2021) focuses on developing a new method for adequate, thorough and above all future-proof investment decisions in the field of energy infrastructure in the Port of Rotterdam. This project is being carried out and supported by TU Delft, Municipality of Rotterdam, SmartPort, Siemens Netherlands, TU Delft, Quintel Intelligence and TNO.

SmartPort study: Interreg-2-zeeen-E2C (2018-2021) focuses on the implementation of indirect and direct CO2 electrochemical conversion to fuels and chemical building blocks and on setting up pilots for further scaling up. This project is being carried out and supported by TNO, ECN, Vito, University of Antwerp, University of Exeter, TU Delft, Port of Rotterdam, SmartPort and Port of Antwerp. The study is being conducted by the TU Delft.

SmartPort study: Electrons-2-Chemical Bonds (2020-2025) focuses on the efficiency and scalability of electrochemical processes for the production of fuels and chemical building blocks. This project is being carried out and supported by TU Delft, Leiden University, Twente University, Wageningen University, Groningen University, Utrecht University, Eindhoven University of Technology, Shell, Proton Ventures, TNO, Tata Steel, Nuon, SmartPort, Avebe Chemelot and Yara.

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SmartPort study: North Sea Energy Integration (2020-2021) focuses on the development of energy hubs at sea and synergy between dismantling the current oil and gas platforms. This project is being carried out and supported by TNO, SmartPort and 25 other stakeholders.

Chemcom and an Industrial Interest Group.

DOSTA (2020-2025) focuses on facilitating large-scale offshore wind energy production by developing offshore storage and transport alternatives. Legislation is also taken into account. This project is being carried out and supported by Groningen University, Utrecht University, SmartPort, Ocean Graer, Siemens, Bogat, Noordgastransport, NeVER, Loyens & Loeff, NOGEPA, New Energy Coalition, TNO, TenneT and Vattenfall.

SmartPort study: HAPSISH (2017-2021) focuses on the exchange of energy between companies and in a chain. This project is being carried out and supported by TU Delft, Port of Rotterdam and SmartPort.

Flexi (2017-2021) focuses on the energy flexibility of industrial production processes by means of algorithm developments. This project is being carried out and supported by TU Delft, Port of Rotterdam, Systems Navigator, Uniper and SmartPort.

SmartPort study: Gridmaster (2021) focuses on developing a new method for adequate, thorough and above all future-proof investment decisions in the field of energy infrastructure in the Port of Rotterdam. This project is being carried out and supported by a consortium of TenneT, Gasunie, Stedin, Province of South Holland, Port of Rotterdam Authority, Municipality of Rotterdam, SmartPort, Siemens Netherlands, TU Delft, Quintel Intelligence and TNO.

SmartPort study: Decommissioning Offshore Wind Farms (2019-2020) focuses on exploring the residual material flows from the decommissioning task and how the Port of Rotterdam can approach this task pragmatically for ecological and economic gain. This project was carried out and supported by TNO, SmartPort, TU Delft, Innovation Quarter, Province of South Holland, Port of Rotterdam and 13 other partners.

SmartPort study: ‘Enhancing reliability-based assessments of quay walls’, PhD thesis Alfred Roubos (2016-2019): approach to better include the ‘proven strength’ in assessments in quay wall design and testing. The research was conducted by TU Delft.

Building on the PhD research of Alfred Roubos to actually apply the scientific insights in practice. In collaboration with the Port of Rotterdam Authority, Port of Amsterdam, Directorate-general for public works and water management, North Sea Ports, Groningen Seaports, Port of Den Helder, Port of Moerdijk, Municipality of Rotterdam and Municipality of Amsterdam. The research is being conducted by TNO and Deltares.

54 Roadmap propeller jet study by Directorate-general for public works and water management and CROW (2019-2023) for new draft directive for soil protection. In collaboration with the Port of Rotterdam Authority, North Sea Ports, Deltares, MARIN, DEME, Boskalis and BAM.


56 SmartPort study: IJkkade research programme (2019-2020), in which the research questions and development lines for the quay wall of the future have been formulated. In collaboration with the Port of Rotterdam Authority, Witteveen + Bos, RoyalHaskoningDHV and TU Delft. The research was conducted by Deltares.

57 SmartPort study: ‘Port Metatrends’ (2018), impact of long-term trends on requirements for activities, use of space and maritime infrastructure in the Port of Rotterdam. The research was conducted by TU Delft.

58 PRISMA study by Deltares, Port of Rotterdam Authority and the Directorate-General for Public Works and Water Management (2019-2020).

59 SmartPort study: PhD Stefan Lovato (2017-2021) on the navigability of silt. The study was conducted by the TU Delft.

60 SmartPort study: Post-doc Alex Kirichek (2016-2018), research into the rheological properties of silt in relation to navigability. The research was conducted by TU Delft.

61 SmartPort study: Post-doc Xu Ma (2018-2021) and iPhD Menno Buijsman (2020-2022) on measuring the sludge strength with acoustics and glass fibre. The study was conducted by the TU Delft.

62 SmartPort study: Covadem+ (2 studies) (2017 & 2018-2020). Research into the opportunities for combining depth measurements of, among other things, inland shipping vessels for 24/7 depth determination of waterways and harbour basins. In this study, together with the Port of Rotterdam Authority, it was established that the data is very useful for the rivers, but that tides, temperature and salinity closer to the mouth create major calibration challenges. Improving the calibration will require more research. The research was conducted by Deltares.